libelium

Behind the change. Beyond the challenge.

Libelium One

Technical guide

Index

1. Introduction

The new Libelium One node is an ultra-low power wireless IoT gateway. Designed for continuous monitoring of a huge range of parameters covering the most relevant IoT applications. Thanks to automatic sensor detection, no programming is needed for deployment. Remote configuration can be done wireless through the Libelium platform. Easy and quick installation on walls or poles in combination with a solar panel to maximize its performance.

This guide shows how to use the Libelium One platform.

The Libelium One main node

2. Libelium One main node

As an evolution of the Waspmote platform and the Plug & Sense! encapsulated line, the Libelium One main node is the result of more than ten years of experience in IoT deployments.

Programming skills are not needed to achieve full deployment of your sensors in the field. The One node comes already programmed, fully functional and ready to be installed. Just connect the sensors, configure your node through the Libelium Cloud and start reading. Moreover, cellular connectivity is also provided for most countries. These facts remove the need for skilled technicians for node deployment and maintenance.

The Libelium One main node

Besides, there is only One model of the datalogger and all the sensor sockets are equal, meaning the One sensors could be plugged into any available sensor socket, even if they are from different verticals. Thanks to that, there is a high level of flexibility which allows covering all sensing needs with low effort.

In the next sections of this guide, the main parts of the Libelium One main node and its accessories will be described in depth. Besides, the next table compares the main Libelium One node features with the Waspmote Plug & Sense! platform.

Feature	Plug & Sense!	One
Sensor sockets	6	4
Models	8-10 (Xtreme lines, Cities PRO...)	Only one model
Radio Connectivity	LTE CAT-4, NB-IoT / Cat-M, LoRaWAN, Sigfox, 802.15.4, WiFi, ZigBee, 868, 900	LTE CAT-4
Charging options	USB, solar panel (up to 18V) and EBM	USB or solar panel (up to 24V)
Battery	6,6 A·h	10,2 A·h
Sleep mode consumption	36uA	<10uA
Enclosure	Industrial, standard	Custom design
Size	124 x 122 x 85 mm	132 x 115 x 60
Magnetic reset	Yes	Yes
Antenna	External	Internal

Coding / programming	Yes, through Waspmote IDE + API or cloud	No. Only configuration
Wired configuration	Yes, using P&S programmer	Yes, through Smart APP
Remote configuration	No	Yes, through Libelium Cloud
Open Source libraries	Yes	No
SIM card for cellular connectivity	Yes, optional.	Yes, already included
OTAP	Only on certain radio modules	Yes
Data visualization	Yes	Yes
Certifications	CE, FCC, IC-ISED, ANATEL, RCM, PTCRB, AT&T	CE, FCC, UKCA, IP65
OEM version	Yes, Waspmote	No
Extension cords	1.5 and 3 meters	1.5 meters
Solar panel	3W	5.5W

Comparison between Libelium One and Waspmote Plug & Sense!

2.1. Specifications

Mechanical

Dimensions: 135 x 135 x 60 mm
IP Grade: IP66 / IP67
Operating temperature: -20ºC to +50 ºC
Material: Polycarbonate
Accessories: Solar panel, installation kit, power cables, extension cords, service board
Weight: 490 g (without sensors)

General

Sensor sockets: 4
Power sockets: 1
Remote configuration: Through Libelium Cloud
OTAP: Yes
Visual indication: LEDs for connectivity, status and charge monitoring.
Sensors: Wide range of sensors.
Other: Magnetic contactless reset, Maintenance / debug through power socket

Connectivity

Wireless communications: Worldwide LTE Cat 4, UMTS/HSPA+ and GSM/GPRS/EDGE coverage
GNSS: Yes
Antenna: Internal
SIM card: 4FF Global SIM. Provided by Libelium

Power

Power supply: 5 to 24 VDC 800 mA
Internal battery: 3.6V - 10.2 Ah Li-Ion. Rechargeable
Consumption: Ultra-low power consumption

Sleep mode: <10uA
Solar panel: 6.6V - 5.5W Size:185 x 185 mm with installation accessory

The next picture shows a diagram with the Libelium One node dimensions.

One physical dimensions

One physical dimensions

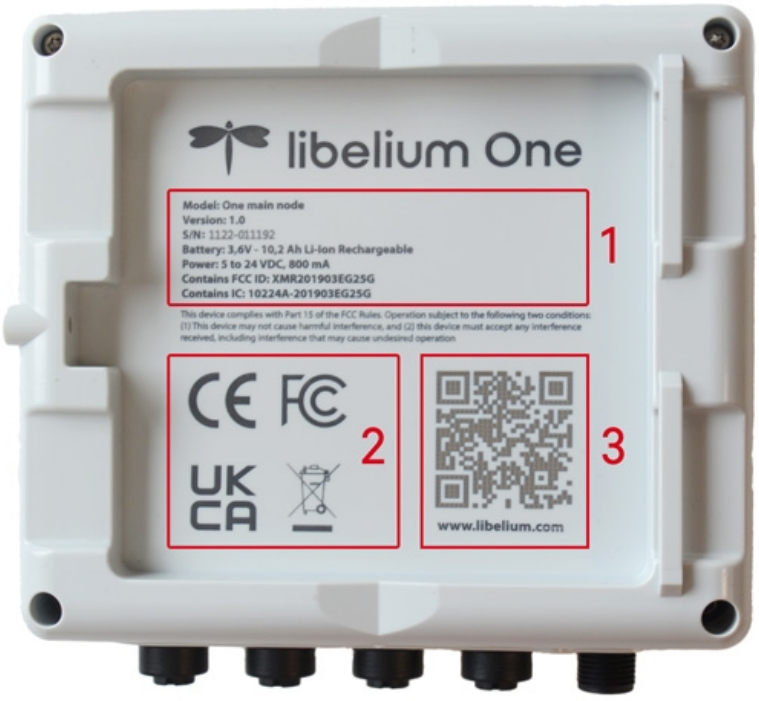
2.2. Parts included

The next picture shows Libelium One node and the accessories that are always included by default. Refer to the accessories section for a description of those which are optional and may not be included by default.

One main node's default content

As shown in the previous diagram, the node includes by default an installation accessory, two metal cable ties for pole mounting, and the USB power cable for easy powering the node.

The labeling information is at the back of the device, containing relevant information for node identification, like a unique serial number, powering, certifications or a QR code for easy provisioning.



One back cover with identification information

1. Contains general information about the node, like the serial number, model and version, battery specifications or powering requirements.
2. Certifications.
3. The QR code contains a link to the device tab in the Libelium Cloud platform. Scan it to see the current device configuration and readings

2.3. Node description

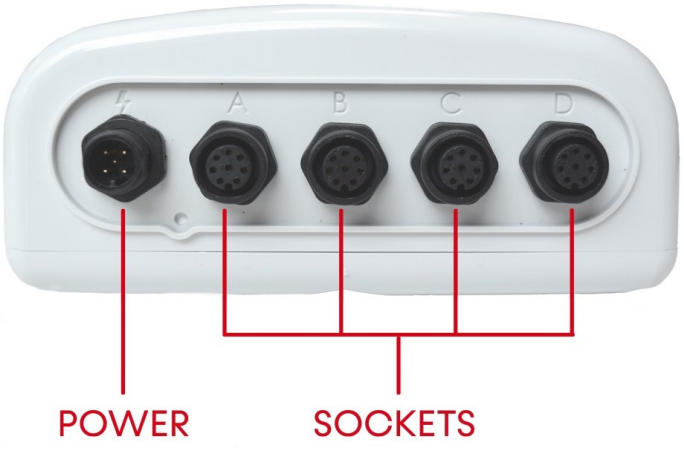
On the left side of the enclosure, there is a zone for visual indications. Its meaning and behavior will be later explained. This zone is also used for a contactless reset with the external magnet.

Left side with LEDs

On the right side, there is a mounting screw used to fix the enclosure to the installation accessory.

Right side with mounting screw

Up to 4 sensors can be connected to the node using the bottom connectors labeled from A to D. All sensor sockets are equal, so they can accept any of the One sensor probes offered by Libelium.



Bottom side with sensors and power socket, without caps

Every sensor socket comes with a waterproof cap. If the socket is not going to be used, remember to keep the cap plugged into the socket and correctly screwed to ensure a good waterproof level.

Notice that the waterproof cap of the power socket is female, whereas the caps for the sensor sockets are male.

Detail of socket side with caps

A vent plug is located between the power socket and the A socket. Vent plug reduces the adverse effects of humidity in the environment circulation by preventing pressure increase inside the enclosure and limiting temperature increase through air.

detail of vent plug

The enclosure has four screws on the back cover, one on each corner. By default, it is not needed to open the Libelium one main node, so please do not manipulate them because the waterproofness of the enclosure could be compromised.

Enclosure screws

Finally, there are two sticker seals (warranty stickers). Do not remove them. Their integrity is proof that the node has not been opened. If they have been handled, damaged or broken, the warranty will be affected.

2.4. Visual indications

With the aim of simplifying the node and keeping it robust, small and cost-efficient, buttons or displays are removed. Only the necessary visual indications are present.

The Libelium One main node has three LEDs located on the left side of the enclosure for power, state and connectivity indications. They are intended to make the first sensor setup, deployment and installation easier. Each one is identified with a symbol, as shown below.

One visual indications

The power LED

It lights in red when the internal battery is being charged through the solar panel or the power USB cable. If the power LED is off, then the battery is not being charged.

This LED could be particularly useful when checking the cable connections during installations, but remember that if a battery is fully charged, the LED will be off.

The state LED

This LED has different light patterns and shows which operations or events are happening one the node. It is RGB and it is used for different scenarios:

- **Sensor registration**: The LED will start blinking once the sensor is plugged and detected by the node.
- **OTAP** - It will light with a dedicated pattern during the process.
- **Reset**: Another pattern will show a correct initialization after a reset.

The connectivity LED

It lights in green showing when the node is sending information to the Libelium Cloud. If this LED is on, cellular communication is taking place.

The LTE communication errors are coded using the number of blinks of the state LED in red. The next table helps to identify them:

Nº Blinks	Error code
1	Get device profile error
2	Put initial shadow error
3	Context activation error
4	Context configuration error
5	SIM not inserted
6	SIM failure
7	Wrong SIM
8	Not connected to network
9	Invalid token

Table with connectivity blink patterns

LED patterns of the state LED

The next visuals show the LED patterns for each situation.

- Libelium One - Activation
- Libelium One - App launch
- Libelium One - Connecting the power cable
- Libelium One - Disconnecting the power cable

- Libelium One -Sensor connection and registration process
- Libelium One -Sensor disconnection and deregistration process
- Libelium One -OTAP process

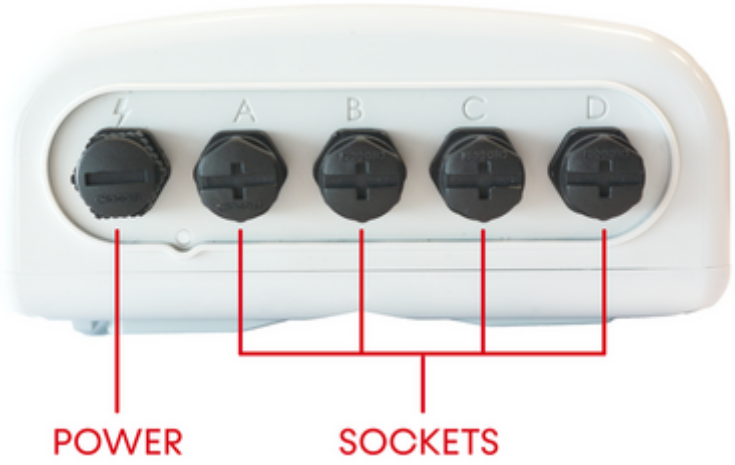
Notice that the LED indications are easily viewed indoors, so the user could get familiarized with the device behavior and a quick test could be done before field deployment. However, during the sensor deployment outdoors, the visualization will be more difficult if direct sunlight hits them.

As the Libelium One main node is an ultra-low power platform, the brightness of the LEDs has been reduced to the strictly necessary. Moreover, to keep the consumption as low as possible, they will be disabled a few loops after the last event on the deployment, like a sensor probe connection.

3. Sensor Probes

The sensing capabilities of Libelium One main node are provided by the sensor probes. Each sensor probe contains one sensor, some necessary protections against outdoor environmental conditions and a waterproof male connector.

Each node has four dedicated sockets to connect sensor probes, located on the bottom side, as shown below. When one of the four sensor connectors is not used, be sure the cap is correctly screwed to protect the connector.



One power and sensor sockets

Each sensor is identified by a letter A to D on the enclosure, as shown in the picture above. There is no restriction when plugging a sensor into a socket, therefore any One sensor probe could be plugged into any sensor socket.

One node with sensors

Please use only sensors officially provided by Libelium. Any other sensor could damage the node and void the warranty.

Note: Plug&Sense! sensor probes are not compatible with the One node and vice-versa.

3.1. How to connect a sensor

One of the most powerful features of the Libelium One main node is **automatic sensor detection**. There is no need for a previous configuration on the node nor the sensor, resets or any other action to be done rather than physically connecting the sensor.

Firstly, It should be understood that the sensor probe connectors have only one matching position with a sensor socket. The user should align the sensor probe connector by looking at the little notch of the connector.

Align the connector before trying to connect the sensor

Notice that the sensor probe connector has male pins and the enclosure sensor connector is female type. The next video shows the process.

- Libelium One -Sensor connection and registration process

Ensure that the sensor probe is correctly plugged and the nut is correctly screwed. Then, pay attention to the LED patterns If the sensor is connected correctly, then the node will start the auto-detection process to identify which sensor has been connected, download the necessary drivers from the Libelium Cloud and, after a few seconds, the sensor will start being measured according to the configuration.

On top of that, another relevant feature is that the same sensor could be connected to another node without any previous configuration. This is typically useful for maintenance labors on the sensors, like cleaning or calibration that could be carried out more comfortably in a laboratory rather than in the field. Besides, it also avoids the need of removing the node installed with screws, cable ties or solar panels, or even other sensors. Just disconnect the sensor, go to the laboratory and check the sensor readings with another Libelium One main node.

3.2. Available sensor probes

General comments

In order to keep this guide as short as possible, some manufacturer information has been omitted. Libelium encourages the reader to visit the manufacturer's websites and to spend some time studying all the technical papers and application notes provided for each sensor. Measured parameters on the great majority of Smart Agriculture applications require a deep knowledge of the environmental parameters and, what is more, sophisticated measurement techniques to obtain the best accuracy.

Additionally, Libelium highly recommends carrying out comprehensive laboratory tests before installing the system on the field, as well as proof of concepts on the field during a reasonable period, before going to a real deployment. Thanks to these good practices, the user will have an idea of the platform behavior, which will be very close to reality. Parameters like accuracy over time or battery drain can be only measured with real tests.

Finally, always take into account a maintenance factor for each sensor probe. The environmental conditions could affect the sensor behavior and accuracy therefore it will become mandatory periodic maintenance for each sensor probe, to watch out for things like dirt on sensor probes, and measure position or wire connections. The period between these maintenance actions will be different for each application. Contact our Sales department if you require more information.

Generic sensor probes

Reference	Sensor
40028-O	Air Temperature and Humidity

Agriculture Xtreme sensor probes

Reference	Sensor
9463-O	Weather station GMX-240 (W-PO)
9482-O	Weather station GMX-550 (W-x-T-H-AP)
9483-O	Weather station GMX-551 (W-x-T-H-AP-R)
9600	Tipping Bucket Accessory for GMX Weather Stations
9465-O	Soil water potentials TEROS 21
9468-O	Non-contact surface temperature measurement SI-411
9469-O	Soil oxygen level SO-411
9471-O	Vapor pressure, humidity, temperature, and atmospheric pressure in soil and air VP4
9496-O	Solar radiation and temperature Datasol MET2
9499-O	Conductivity, water content and soil temperature TEROS12
9512-O	Volumetric water content and soil temperature TEROS 11
40030-O	Leaf Wetness for One
40031-O	Solar radiation for One

9499-V-O	Virtual Cond, water content and soil temp. TEROS 12 for One
9463-V-O	Virtual Weather station GMX-240 (W-PO) for One

Water Xtreme sensor probes

Reference	Sensor
9353-O	Turbidity and temperature NTU
9485-O	pH, ORP and temperature PHEHT
9486-O	Conductivity, salinity and temperature C4E
9487-O	Inductive conductivity, salinity and temperature CTZN
9488-O	Optical dissolved oxygen and temperature OPTOD
9489-O	Titanium optical dissolved oxygen and temperature OPTOD
9490-O	Suspended solids, turbidity, sludge blanket and temperature MES5
9500-O	COD, BOD, TOC, SAC254 and temp StacSense, 2 mm path
9501-O	COD, BOD, TOC, SAC254 and temp StacSense, 50 mm path
9514-O	Radar level VEGAPULS C21
9353-V-O	Virtual Turbidity and temperature NTU probe for One

3.3. Agriculture Xtreme sensors

The sensors included in the Agriculture Xtreme vertical are listed in the next sections.

To keep this guide short and avoid duplicating information, the information about the usage, maintenance and calibration of these sensors is kept in the Smart Agriculture Xtreme technical guide. It is recommended to take a further reading of that guide to understand all sensor features.

3.3.1. Weather stations

The MaxiMet series offers a compact solution for weather forecasts. The user can choose easily the best configuration thanks to the modularity that they offer, keeping the robustness, easy installation and low maintenance features. In other words, any of the different weather sensors can be combined in a custom model.

Parameters related with wind, precipitation, solar radiation, dew point, air temperature, air humidity or atmospheric air pressure can be measured with these weather station probes.

MaxiMet GMX-240 (W-PO) sensor probe

The MaxiMet GMX-240 is a weather station that provides accurate meteorological information about wind and precipitation (optical method).

Three ultrasonic sensors provide wind speed and direction measurements and the addition of an electronic compass provides apparent wind measurement. Average speed and direction together with WMO averages and gust data are also provided.

An integrated optical rain gauge that senses water hitting its outside surface provides measurements based on the size and number of drops.

The optical rain gauge and the wind ultrasonic sensors have no moving parts so possible mechanical problems are avoided.

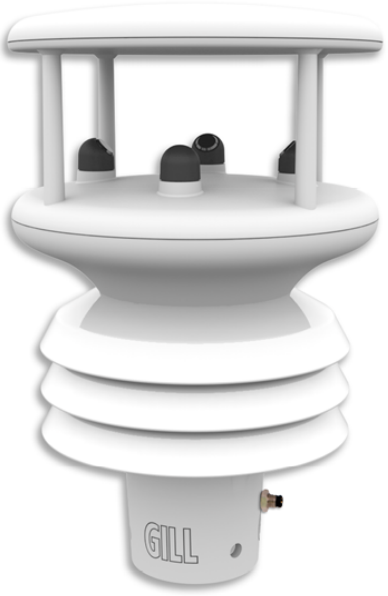
MaxiMet GMX-240 (W-PO) sensor probe

MaxiMet GMX-550 (W-x-T-H-AP) sensor probe

The MaxiMet GMX-550 sensor probe provides accurate information about wind, precipitation (with an accessory), air temperature, air humidity and atmospheric air pressure.

This model is basically a solar shield with no moving parts which allows high performance over large time periods. On the top of the solar shield, three ultrasonic sensors are placed to provide wind speed and direction measurements. Besides, an electronic compass provides apparent wind measurement. Average speed and direction together with WMO averages and gust data are also provided. Finally, an inclinometer is also included to allow a precise installation.

On top of that, an integrated connector allows the user to connect a tipping bucket rain gauge to measure precipitation.



MaxiMet GMX-550 sensor probe

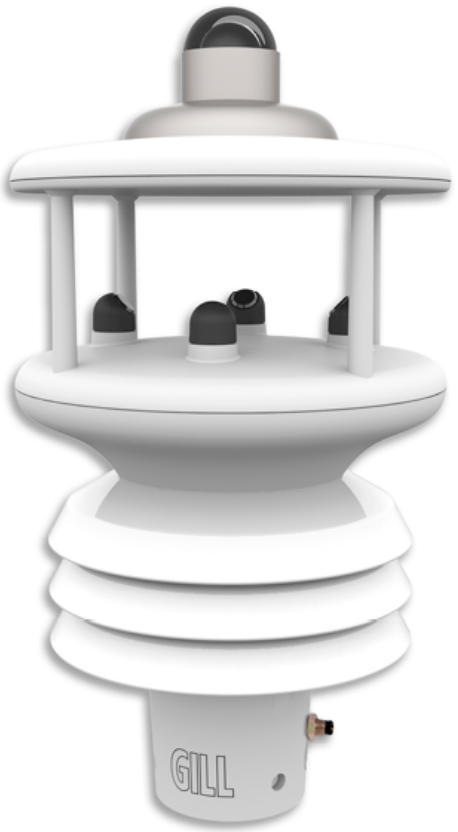
MaxiMet tipping bucket accessory for GMX550 and GMX551.

MaxiMet GMX-551 (W-x-T-H-AP-R) sensor probe

The MaxiMet GMX-551 sensor probe provides accurate information about wind, precipitation (with an accessory), air temperature, air humidity, atmospheric air pressure and solar radiation.

This model is basically a solar shield with no moving parts which allows high performance over large time periods. On the top of the solar shield, three ultrasonic sensors are placed to provide wind speed and direction measurements. Besides, an electronic compass provides apparent wind measurement. Average speed and direction together with WMO averages and gust data are also provided. Additionally, an integrated pyranometer protected by a single glass measures solar radiation. Finally, an inclinometer is also included to allow a precise installation.

On top of that, an integrated connector allows the user to connect a tipping bucket rain gauge to measure precipitation.



MaxiMet GMX-551 (W-x-T-H-AP-R) sensor probe

Specifications for each weather station sensor

General specifications

- Operating temperature: -40 to 70 ºC
- Operation humidity: 0 ~ 100% RH
- Weight (approximate, depends on models): 0.5 kg
- Dimensions (approximate, depends on models): 141 x 209.5 mm
- Protection Class: IP66 **Wind speed**
- Range: 0.01 m/s to 60 m/s
- Accuracy: ±3% to 40 m/s; ±5% above 40 and up to 60 m/s
- Resolution: 0.01 m/s
- Threshold: 0.01 m/s

Wind direction

- Range: 0-359º
- Accuracy: ±3º to 40 m/s; ±5º above 40 and up to 60 m/s
- Resolution: 1º
- Starting threshold: 0.05 m/s

Compass

- Range: 0-359º
- Accuracy: ±3º
- Resolution: 1º

Precipitation: optical method

- Range: 0 to 300 mm/h
- Precipitation resolution: 0.2 mm
- Repeatability: 3%

Precipitation: mechanical, tipping bucket method (Kalyx rain gauge)

- Range: 0-1000 mm/h
- Precipitation resolution: 0.2 mm
- Accuracy: 2%

Air temperature and dew point

- Range: -40 ºC to +70 ºC
- Resolution: 0.1 ºC
- Accuracy: ± 0.3 ºC @ 20 ºC

Air humidity

- Range: 0 - 100%
- Resolution: 1%
- Accuracy: ± 2% @ 20 ºC (10%-90% RH)

Atmospheric air pressure

- Range: 300 to 1100 hPa
- Resolution: 0.1 hPa
- Accuracy: ± 0.5 hPa @ 25 ºC

Global solar radiation

- Wavelength sensitivity: 300 to 3000 nm
- Range: 0 to 1600 W/m^2
- Resolution: 1 W/m^2

WS-3000

This weather station consists of three different sensors, described in detail below: a wind vane, an anemometer and a pluviometer.

Figure: Image of the Weather station WS-3000 mounted

Anemometer

Figure: Anemometer

Specifications

Sensitivity: 2.4km/h / turn
Wind Speed Range: 0 ~ 240km/h
Height: 7.1 cm
Arm length: 8.9 cm

Wind vane

Figure: Wind vane

Specifications

Height: 8.9 cm
Length: 17.8 cm
Maximum accuracy: 16 positions (22.5º)

Pluviometer

Figure: Pluviometer

Specifications

Height: 9.05 cm
Length: 23 cm
Bucket capacity: 0.28 mm of rain

Figure: Image of the Weather station WS-3000 mounted

3.3.2. VP4

The ATMOS 14 (previously VP-4) sensor probe is an accurate tool to measure air temperature, relative humidity (RH), vapor pressure, and barometric pressure in soil and in air. A microprocessor within the sensor calculates vapor pressure from the RH and temperature measurements. The sensor uses a sensor chip to measure both air temperature and RH and a secondary chip to measure barometric pressure.

Although this sensor can be installed in dry soils with a good performance, it is not recommended for saturated soils. The humidity measurements could saturate and could give a drift. Moreover, if the soil is completely saturated, it will not make sense to measure barometric pressure because there will not be air in the soil.

Vapor pressure, humidity, temperature, and atmospheric pressure in soil and air VP-4

Specifications

- **Operating temperature**: -40 to 80 ºC
- **Measurement time**: 300 ms
- **Dimensions**: 1.96 cm (diameter) x 5.4 cm (h)
- **Cable length**: 5 m

Vapor pressure

- **Range**: 0 to 47 kPa
- **Resolution**: 0.001 kPa
- **Accuracy:** See diagram below

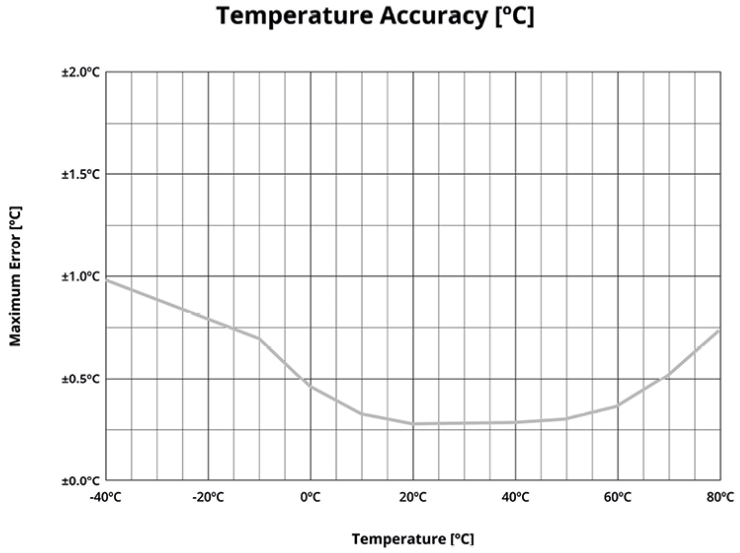
Vapor Pressure Accuracy [%RH]

Humidity [%RH]	0°C	10°C	20°C	30°C	40°C	50°C	60°C	70°C	80°C
100%	±0.05	±0.09	±0.16	±0.29	±0.49	±0.81	±1.30	±2.62	±6.32
95%	±0.05	±0.09	±0.14	±0.24	±0.41	±0.68	±1.08	±2.26	±5.27
90%	±0.05	±0.07	±0.09	±0.15	±0.33	±0.54	±1.06	±2.23	±5.20
85%	±0.05	±0.07	±0.08	±0.15	±0.33	±0.53	±1.05	±2.19	±5.13
80%	±0.04	±0.07	±0.08	±0.15	±0.32	±0.53	±0.83	±1.84	±4.07
75%	±0.04	±0.07	±0.08	±0.14	±0.31	±0.52	±0.82	±1.80	±4.00
70%	±0.04	±0.07	±0.08	±0.14	±0.31	±0.51	±0.81	±1.77	±3.97
65%	±0.04	±0.07	±0.08	±0.13	±0.30	±0.50	±0.79	±1.73	±3.86
60%	±0.04	±0.05	±0.07	±0.13	±0.22	±0.36	±0.57	±1.38	±3.30
55%	±0.04	±0.04	±0.07	±0.13	±0.22	±0.35	±0.56	±1.34	±3.23
50%	±0.03	±0.04	±0.07	±0.12	±0.21	±0.34	±0.55	±1.31	±3.16
45%	±0.03	±0.04	±0.07	±0.12	±0.20	±0.33	±0.53	±1.27	±2.60
40%	±0.03	±0.03	±0.07	±0.12	±0.20	±0.33	±0.52	±1.24	±2.53
35%	±0.03	±0.05	±0.06	±0.11	±0.19	±0.32	±0.50	±1.20	±2.46
30%	±0.03	±0.05	±0.06	±0.11	±0.19	±0.31	±0.49	±1.17	±2.39
25%	±0.03	±0.04	±0.06	±0.10	±0.18	±0.30	±0.48	±1.14	±2.32
20%	±0.03	±0.06	±0.06	±0.10	±0.25	±0.41	±0.67	±1.10	±2.25
15%	±0.03	±0.05	±0.05	±0.10	±0.24	±0.40	±0.85	±1.39	±2.67
10%	±0.05	±0.07	±0.08	±0.14	±0.31	±0.52	±0.84	±1.67	±4.08
5%	±0.05	±0.10	±0.12	±0.22	±0.38	±0.64	±1.03	±1.96	±5.00
0%	±0.08	±0.15	±0.12	±0.22	±0.45	±0.75	±1.22	±3.21	±5.92

Temperature [°C]

Temperature

- **Range:** -40 to 80 ºC
- **Resolution:** 0.1 ºC
- **Equilibration time:** < 400 s
- **Long term drift:** < 0.04 ºC/year typical
- **Accuracy**

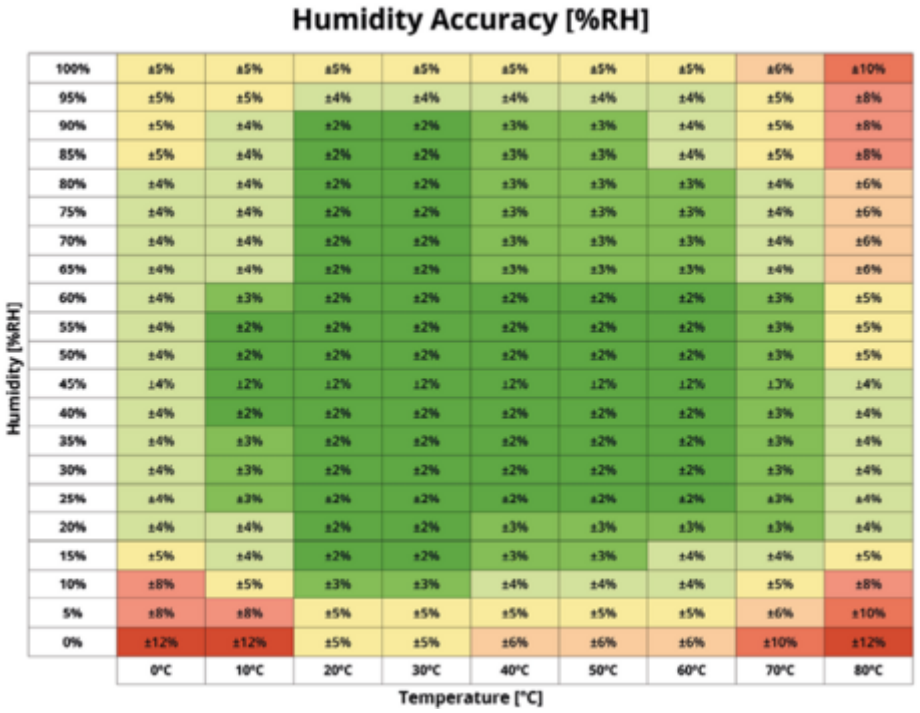


Barometric pressure

- **Range**: 49 to 109 kPa
- **Resolution**: 0.01 kPa
- **Accuracy**: 0.4 kPa

Relative humidity

- **Range**: 0 to 100% RH
- **Resolution**: 0.1% RH
- **Equilibration time**: <40 s
- **Hysteresis**: <1% RH typical
- **Long term drift**: <0.5% RH/year typical
- **Accuracy**



3.3.3. Teros 21

There are 2 basic parameters that describe the state of water in soil: one is soil water content, or the amount of water per unit of soil, and the other is soil water potential, or the energy state of water in the soil. Although water content is useful when trying to describe the water balance of soil, i.e. how much water is moving in, out, or being stored, water potential is often preferred over water content because it determines how water moves in soil or from the soil to the plant. In addition, you can use water potential to determine plant availability of water, schedule irrigation, or determine the mechanical stress state of the soil.

The Soil water potential sensor probe (Meter TEROS 21) measures the water potential and temperature of a wide range of soil and other porous materials without user maintenance and factory calibration. Its extended range makes this sensor ideal for measuring the water potential in natural systems or other drier systems. The added temperature measurements can be used to determine approximate soil water potential in frozen soils.

Soil water potentials TEROS 21

Specifications

General specifications

- Operating temperature: -40 to 60 ºC (no water potential measurement
- below 0 ºC)
- Operation humidity: 0 ~ 100% RH
- Dielectric measurement frequency: 70 MHz
- Measurement time: 150 ms
- Dimensions: 9.6 cm (L) x 3.5 cm (W) x 1.5 cm (D)
- Sensor diameter: 3.2 cm
- Cable length: 5 m

Water potential

- Range: -9 to -2000 kPa*
- Resolution: 0.1 kPa
- Accuracy: ±(10% of reading + 2 kPa) from -9 to -100 kPa

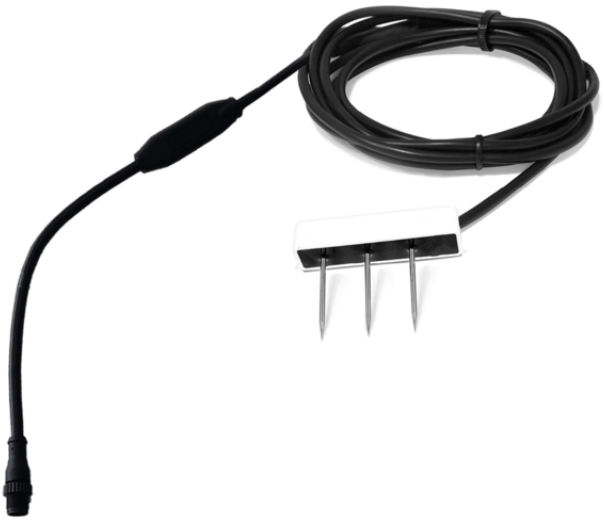
Temperature

- Range: -40 to 60 ºC
- Resolution: 0.1 ºC

*** Note**: TEROS 21 sensors with serial numbers up to T21-00009999 have a water potential range of -9 to -100,000 kPa.

3.3.4. Teros 11

The Volumetric water content and soil temperature sensor probe (Meter TEROS 11) can measure many types of growing media, especially in greenhouse applications where the probe can be inserted easily into different types of soilless substrates. The TEROS 11 sensor determines volumetric water content (VWC) using capacitance / frequency-domain technology and the temperature using a thermistor.



Volumetric water content and soil temperature TEROS 11

Specifications

- **Operating temperature**: -40 to 60 ºC
- **Dielectric measurement frequency**: 70 MHz
- **Measurement time**: 150 ms (maximum)
- **Dimensions**: 9.4 x 2.4 x 7.5 cm
- **Needle length**: 5.5 cm
- **Cable length**: 5 m

Volumetric water content:

- **Accuracy**: ±0.03 m^3/m^3 typical in mineral soils that have solution electrical conductivity < 8 dS/m
- **Resolution**: 0.001 m^3/m^3
- **Range**: Mineral soil calibration: 0.00-0.70 m^3/m^3; Soilless media calibration: 0.0-1.0 m^3/m^3

Temperature

- **Accuracy**: ±1 ºC from -40 to 0 ºC, ±0.5 ºC from 0 to 60 ºC
- **Resolution**: 0.1 ºC
- **Range:** -40 to 60 ºC

3.3.5. Teros 12

The Conductivity, water content and soil temperature sensor probe (Meter TEROS 12) can measure many types of growing media, especially in greenhouse applications where the probe can be inserted easily into different types of soilless substrates. The TEROS 12 sensor determines volumetric water content (VWC) using capacitance / frequency-domain technology, the temperature using a thermistor, and electrical conductivity using a stainless steel electrode array.

Conductivity, water content and soil temperature TEROS12

Specifications

- **Operating temperature**: -40 to 60 ºC
- **Dielectric measurement frequency**: 70 MHz
- **Measurement time**: 150 ms (maximum)
- **Dimensions**: 9.4 x 2.4 x 7.5 cm
- **Needle length**: 5.5 cm
- **Cable length**: 5 m

Volumetric water content:

- **Accuracy**: ±0.03 m^3/m^3 typical in mineral soils that have solution electrical conductivity < 8 dS/m
- **Resolution**: 0.001 m^3/m^3
- **Range**: Mineral soil calibration: 0.00-0.70 m^3/m^3; Soilless media calibration: 0.0-1.0 m^3/m^3

Electrical conductivity

- **Accuracy**: ± 5% from 0 to 10 dS/m, ±10% from 10 to 20 dS/m
- **Resolution**: 0.001 dS/m
- **Range**: 0 to 20 dS/m (bulk)

Temperature

- **Accuracy**: ±0.5 ºC from -40 to 0 ºC, ±0.3 ºC from 0 to 60 ºC
- **Resolution**: 0.1 ºC
- **Range:** -40 to 60 ºC

3.3.6. SI-411

The Non-contact surface temperature measurement sensor probe is able to measure the electromagnetic radiation that every object with a temperature above absolute zero emits, which is used to calculate the surface temperature from a distance. Thanks to this, the temperature of the object's surface is not altered in any way when measuring it.

Non-contact surface temperature measurement SI-411

Specifications

- **Operating environment**: -45 to 80 ºC
- **Operation humidity**: 0 ~ 100% RH (non-condensing)
- **Calibration uncertainty (-20 to 65 ºC)**: when target and detector temperature are within 20 ºC: 0.2 ºC
- **Calibration uncertainty (-40 to 80 ºC)**, when target and detector temperature are different by more than 20 ºC: 0.5 ºC
- **Measurement repeatability:** less than 0.05 ºC
- **Stability (long-term drift)**: less than 2% change in slope per year when germanium filter is maintained in a clean condition
- **Field of view**: 22º (half angle)
- **Spectral range**: 8 to 14 µm; atmospheric window
- **Dimensions**: 23 mm diameter; 60 mm length
- **Mass**: 190 g (with 5 m of lead wire)
- **Cable length:** 5m

3.3.7. SO-411

Oxygen is the second major constituent of Earth's atmosphere and it is crucial for the development of life. There are sensors that measure oxygen in 2 states: dissolved in a solution and in a gaseous state. The Soil oxygen level sensor probe measures gaseous oxygen.

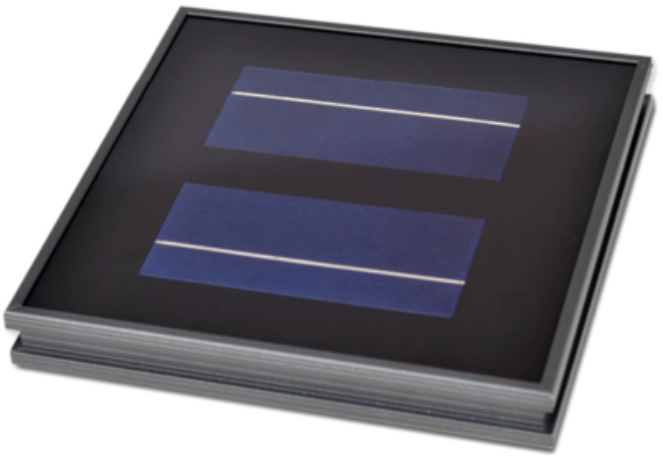
Soil oxygen level SO-411

Specifications

- **Operating environment**: -20 to 60 °C; 60 to 114 kPa
- **Operation humidity**: 0 ~ 100% RH (non-condensing)
- **Measurement range**: 0 to 100% O2
- **Measurement repeatability**: less than 0.1% of mV output at 20.95% O2
- **Non-linearity**: less than 1%
- **Long-term drift (non-stability)**: 1.0 mV per year
- **Oxygen consumption rate**: 2.2 µmol O2 per day at 20.95% O2 and 23 °C
- **Response time**: 60 s
- **Dimensions**: 32 mm diameter, 68 mm length
- **Mass**: 175 g
- **Cable:** 5m

3.3.8. Datasol MET2

The Datasol MET is a precision device that allows to visualize and acquire solar radiation, peak sun hours (PSH), the temperature of the cell and the ambient temperature. The radiation measurement of the Datasol MET incorporates compensation with the temperature of the cell. Additionally, an anemometer can be added as an accessory to obtain wind speed.
This sensor is especially focused on owners of a photovoltaic system looking for maximum performance.



Datasol Met sensor

General specifications

- Operating temperature: -20 to 50 ºC
- Weight: 1.2 kg
- Dimensions: 266 x 266 x 35 mm
- Protection Class: IP54

Temperature

- Range: -20 ºC to +100 ºC
- Accuracy: ±0.8 ºC

Radiation

- Range: 0 to 1400W/m^2
- Intrinsic measurement error: ±0.2%
- CIEMAT reference standard measurement error: ±2%

3.3.9. Leaf wetness

The One Leaf wetness sensor utilizes the dielectric constant of its upper surface to accurately measure the wetness of leaf surfaces. This sensor provides both relative humidity and temperature values. By precisely measuring the moisture content on leaf surfaces, it becomes possible to monitor trace moisture levels or the presence of ice crystal residue. The sensor's design incorporates a simulated leaf surface shape, enabling it to provide a more precise reflection of actual leaf conditions.

Leaf wetness for One

Specifications

Humidity

- **Range**: 0-100%RH
- **Resolution**: 0.1%RH
- **Accuracy**: ±3%RH

Temperature

- **Range**: -40-80ºC
- **Resolution**: 0.1ºC
- **Accuracy**: ±0.5ºC

3.3.10. Solar radiation

The solar radiation sensor for One is an advanced sensor, specifically calibrated to accurately measure sunlight and incorporates an automatic correction factor for underwater measurements, known as the immersion effect.

The applications for this versatile sensor are vast, including measuring PPFD (Photosynthetic Photon Flux Density) over plant canopies in outdoor environments, greenhouses, and growth chambers. Additionally, it can be used to assess reflected or under-canopy (transmitted) PPFD measurements in the same settings. Quantum sensors are also highly beneficial for measuring PAR (Photosynthetically Active Radiation)/PPFD in aquatic environments, such as saltwater aquariums dedicated to coral cultivation.

Solar radiation sensor SQ-421

Specifications

- **Calibration Uncertainty**: ± 5 %
- **Measurement Repeatability**: Less than 1 %
- **Long-term Drift (Non-stability)**: Less than 2 % per year
- **Non-linearity**: Less than 1 % (up to 2500 µmol m^{-2} s^{-1})
- **Spectral Range**: 370 to 650 nm (wavelengths where response is greater than 50 % fo maximum)
- **Directional (Cosine) Response**: ± 5 % at 75˚ zenith angle
- **Temperature Response**: Less than 0.5 % from -20 to 50 °C
- **Operating Environment**: -20 to 60 C; 0 to 100 % relative humidity; can be submerged in water up to depths of 30 m

The sensor includes a nylon mounting screw on the base in order to mount the sensor on a solid surface. Besides, it can be mounted on poles using the Solar Sensor Mounting accessory to get a secure fasting and accurate readings.

3.3.11. Multilevel soil moisture (and conductivity) for One

The multilevel soil moisture and conductivity sensor for One is an advanced instrument designed for precise and comprehensive sub-surface monitoring of soil properties. This probe offers continuous, reliable, and repeatable measurements of soil moisture, temperature, and salinity (in terms of electrical conductivity) at multiple depths.

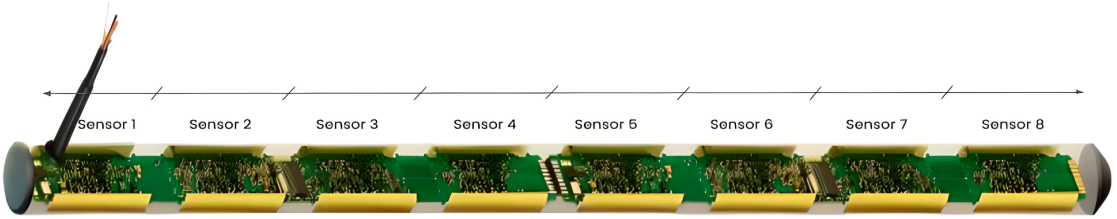
The One platform offers two different variants for the multilevel soil moisture probes: **EP100GL-08** and the **EP100G-08.** Both models utilize salinity error correction in their moisture measurements, but salinity measurement is specifically and only available in the EP100G-08 model.

While the salinity error correction feature is essential as it ensures that capacitive soil probes accurately measure the actual moisture content even in saline soil conditions. Saline soil can potentially lead to inaccurate moisture measurement.

Multilevel soil moisture and conductivity for One

Note: Only EP100G-08 model outputs salinity in terms of EC.

In these models, there are 8 sensors placed sequentially shifted 10 cm from the top of the probe. Each sensor measures moisture (with and without salinity compensation), temperature and salinity (only EP100G model) in order to have different measurements referring to different depths into the soil.



Internal distribution of the multilevel soil moisture sensors

EnviroPro sensors are specifically engineered to have an expanded field of influence, enabling them to sample a larger area of soil. Each probe is individually calibrated in factories ensuring accuracy and providing reliable data. Additionally, the multilevel soil moisture probes are designed to be long-life and fully encapsulated. This means that they are highly resistant to environmental degradation and no maintenance is needed.

Typical applications are monitoring conditions of field soil, water use efficiency for irrigation and smart farms.

Specifications

- **Diameter**: 33.5 mm ± 0.2 mm
- **Length**: 86.5 cm
- **Cable length**: 5m
- **Sensing**: 8 sensors
- **Field of Influence**: 55 mm from wall of probe
- **Total Soil Volume Detected**: 12.8 liters
- **Moisture resolution** : 0.01 %
- **Moisture accuracy**: ± 2 % @ 0% VWC to 50% VWC (with respect to dielectric)
- **Salinity resolution**: 0.001 dS/m
- **Salinity accuracy**: ± 5 % @ 0-4 dS/m at 10%-30% VWC
- **Useable salinity range**: 0 to 6 dS/m (Upper limit of non-contact capacitance sensors)
- **Temperature resolution**: 0.01 °C
- **Temperature accuracy**: ± 1°C @ 25 °C
- **Operation temperature**: -20 to +60 °C
- **Parameter units:**
    - Soil moisture (VWC) with salinity compensation: %
    - Soil moisture (VWC) without salinity compensation: %
    - Temperature: °C
    - Salinity (only in EP100G-08 model): dS/m

Installation

For achieving the highest level of accuracy, it is recommended to install the multilevel soil moisture probes using slurry. This method offers two significant advantages. First, it ensures optimal sensor-to-soil contact, allowing for more precise measurements and data collection. Second, slurry also plays a crucial role in controlling the surrounding soil. When slurry is not used, there is a risk of voids being present, which can be filled with air or water. These voids can significantly affect the probe's readings due to the substantial differences in dielectric properties between their contents. To address this issue, two types of slurry are commonly used. The recommended type is made with bentonite and fine sand, as it provides better control and stability. The alternative option involves creating a slurry using soil obtained from the augered hole or its surroundings. Both types of slurry help minimize the presence of voids and ensure more accurate readings by maintaining consistent soil conditions around the probe.

How to prepare Bentonite Slurry

1. Combine 100g of Bentonite with 900g of fine sand in a bucket, making sure to mix them together without adding water.
2. Transfer the dry mixture into a two-liter plastic bottle (or a similar container) using a funnel.
3. Pour 1L of clean water into the bottle.
4. Secure the lid and vigorously shake the contents until they are thoroughly blended.

5. Allow the Bentonite to swell for approximately 30 minutes, resulting in a mixture with a smooth and creamy texture.
6. If the slurry is not used right away, remember to shake it well before pouring.

Note: quantities listed before are enough to install two 80 cm multilevel soil moisture probes.

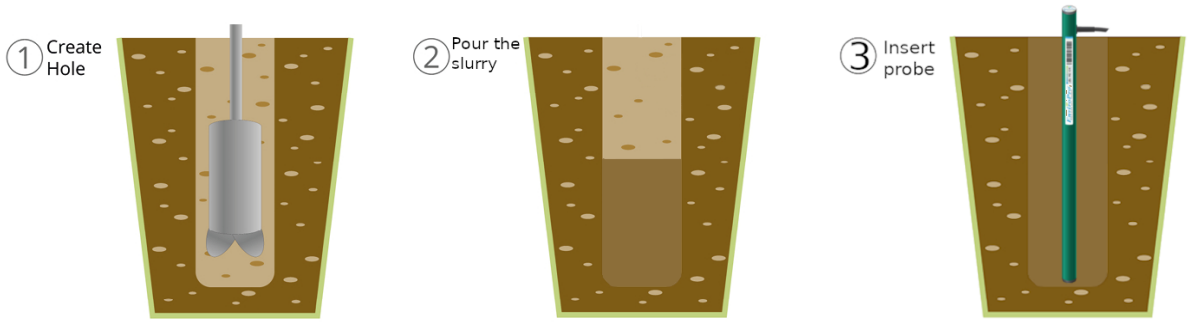
How to prepare a Soil Slurry

1. Sift the soil through a sieve to eliminate any rocks and organic matter.
2. Slowly incorporate an adequate amount of water until a creamy paste is formed.

Note: for this type of slurry, it is recommended to use approximately 1 liter of clean water for every kilogram of soil.

Installation method

1. Take the measurement of the probe's length using a tape measure. Then, utilize adhesive tape and the tape measure to mark the auger, making it 3.5 cm longer than the length of the probe that will be installed.
2. Using the auger, dig a hole that is 3.5 cm deeper than the probe. Once the auger is extracted, employ a tape measure to verify the depth of the hole. This step is essential to ensure that no additional material has fallen into the hole.
3. To effectively clean out the bottom of the hole, you pour a small quantity of Bentonite Slurry into the bottom of the hole. The loose soil will adhere to the Bentonite, allowing you to use the auger to retrieve the soil more easily.
4. Pour the slurry into the hole until it reaches the halfway mark, filling it up to that point.
5. Gently push the probe into the hole until the top of the probe is positioned approximately 35 mm (or 3.5 cm) below the surface of the soil. Take care not to apply excessive pressure, ensuring that it does not exceed 15 kg maximum. Additionally, avoid creating sharp bends in the cable where it enters the probe to prevent any damage or strain on the equipment.
6. The slurry should slowly rise up around the probe and slightly overflow from the hole. If you do not observe any slurry, carefully extract the probe. Mix up an additional batch of slurry and add it to the hole to ensure proper coverage and contact with the probe.
7. Utilize the soil previously removed to backfill the hole, ensuring that the probe is covered.
8. Dig a trench with a depth of at least 100 mm (or deeper) to protect the cable. Lay the cable within the trench, ensuring it is positioned securely. Leave a loop of cable in the trench, which will act as a "strain relief" mechanism, preventing potential damage.



Note: Images are only a graphic representation, NOT the full installation method, please read carefully and follow all the steps above.

Finally, when performing an extraction, it is crucial to remove the probe as vertically as possible. Applying forces in directions other than vertical may result in damage to the probe.

3.4. Water Xtreme sensors

The sensors included in the Water Xtreme vertical are listed in the next sections.
To keep this guide short and avoid duplicating information, the information about the usage, maintenance and calibration of these sensors is kept in the Smart Water Xtreme technical guide

3.4.1. NTU

The Turbidity and temperature NTU sensor probe is based on infrared light reflections which allow measuring turbidity in a great range of applications. Besides, the sensor measures suspended solids and also an internal temperature sensor is included for temperature compensation of the turbidity measures.

Some sensors in the market calculate the suspended solids from the turbidity value. By contrast, the NTU sensor probe takes its own measure. However, to measure suspended solids correctly, the NTU sensor probe is directly calibrated on the material to be measured and an external laboratory is needed to analyze the sample. This service is not provided by Libelium.

The NTU sensor probe measures according to DIN EN ISO 7027, required in many Smart Water quality applications.

Note: The optical windows of the NTU sensor probe are vulnerable to chemicals (organic solvents, acids and strong bases, peroxide and hydrocarbons). Avoid using the sensor if they are present in your application.

Turbidity and temperature NTU sensor probe

Specifications

Turbidity sensor:
Technology: Optical infrared (IR 880 nm)
Ranges NTU: 0 to 4000 NTU in 5 ranges:

- 0 - 50 NTU
- 0 - 200 NTU

- 0 - 1000 NTU
- 0 - 4000 NTU
- AUTOMATIC

Ranges mg/l: 0 to 4500 mg/l

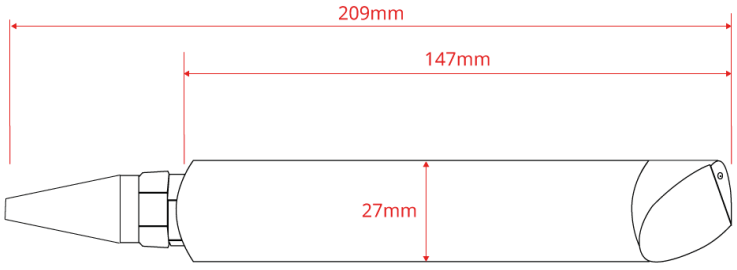
- Range 0 - 500 mg/l according to NF EN 872
- Range >500 mg/l according to NF T 90 105 2

Resolution: 0.01 to 1 NTU - mg/l
Accuracy: <5% of the reading
Response time: <5 s

Temperature sensor:
Technology: NTC
Range: 0 ºC to +50 ºC
Resolution: 0.01 ºC
Accuracy: ±0.5 ºC

Common:
Default cable length: 15 m
Maximum pressure: 5 bars
Body material: DELRIN
IP classification: IP68
Storage temperature: 0 ºC to +60 ºC

Sensor parts: (1) temperature sensor, (2) optical window, (3) sensor body



Dimensions of the NTU sensor probe

3.4.2. PHEHT

The pH, ORP and temperature PHEHT sensor probe combines 3 sensors in one probe, which has been designed to measure under hard conditions like pure snow melting water with low conductivity, lakes, rivers, seawater or even wastewaters with high conductivity values.

The PHEHT sensor probe is based on measuring the difference of potential between a reference electrode and a measuring electrode. It includes a long-life reference which increases its lifetime and also it has a high interference immunity. The ORP sensor is thought for normal or modest accuracy applications (fine accuracy is not provided).

Besides, the sensor has a temperature compensation for pH measures carried out by its internal NTC temperature sensor.

Oxidation-reduction potential (ORP) and Reduction / Oxidation (Redox) are equivalent terms.

pH, ORP and temperature PHEHT sensor probe

Specifications

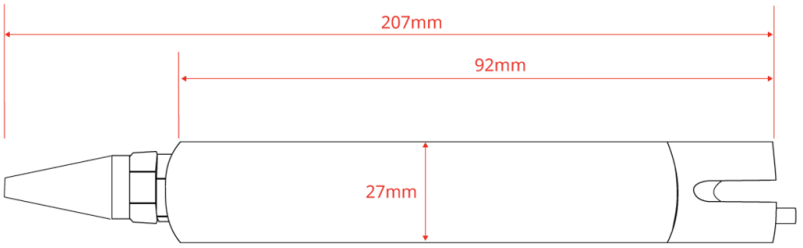
pH sensor:
Technology: Combined electrode
Measurement range: 0~14 pH
Resolution: 0.01 pH
Accuracy: ±0.1 pH

ORP sensor:
Technology: Combined electrode
Measurement range: -1000 to +1000 mV
Resolution: 0.1 mV
Accuracy: ±2 mV

Temperature sensor:
Technology: NTC
Range: 0 ºC to +50 ºC
Resolution: 0.01 ºC
Accuracy: ±0.5 ºC
Response time: < 5 s

Common:
Default cable length: 15 m
Maximum pressure: 5 bar
IP classification: IP68
Storage temperature: 0 ºC to +60 ºC

Sensor parts: (1) protection strainer, (2) cartridge (consumable part), (3) clamp, (4) sensor body



Dimensions of the PHEHT sensor probe

3.4.3. C4E

The Conductivity, salinity and temperature C4E sensor probe use a four-electrode technology that offers great accuracy with low maintenance. For this, the electrolytes do not need to be replaced. Besides, calibration intervals are long due to the low drift of its measures.

The conductivity values are internally compensated with the temperature provided by the embedded sensor. Moreover, it does not consume oxygen and therefore does not require a minimum inflow.

Conductivity, salinity and temperature C4E for one

Specifications

Conductivity sensor:
Technology: 4 electrode (2 graphite, 2 platinum)

Ranges:

- 0 - 200 µS/cm
- 0 - 2 mS/cm
- 0 - 20 mS/cm
- 0 - 200 mS/cm

Resolution: 0.01 to 1 according the range
Accuracy: ±1% of the full range
Measurement range (salinity): 5 - 60 g/kg
Measurement range (TDS - Kcl): 0 - 133 000 ppm

Temperature sensor:

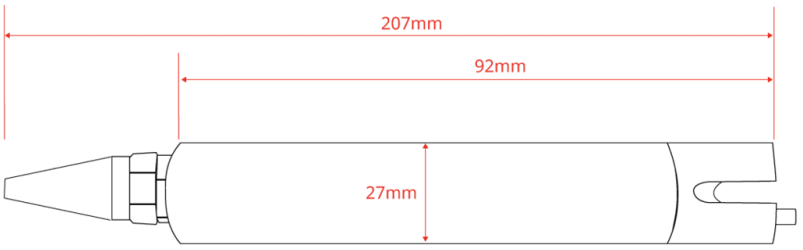
- **Technology**: NTC\
- **Range**: 0 ºC to +50 ºC\

- **Resolution**: 0.01 ºC \
- **Accuracy**: ±0.5 ºC \
- **Response time**: <5 s

Common:

- **Default cable length**: 15 m
- **Maximum pressure**: 5 bars
- **Body material**: PVC
- **IP classification**: IP68
- **Storage temperature**: 0 ºC to +60 ºC

Sensor parts: (1) temperature sensor, (2) head with 4 electrodes, (3) sensor body



Dimensions of the C4E sensor probe

3.4.4. CTZN

The Inductive conductivity, salinity and temperature CTZN sensor probe has a ring-type coil to measure the conductivity. This technology allows the sensor to avoid biofilm interferences, increasing the time between calibration periods and even avoiding most of the maintenance tasks.

In addition to conductivity, the CTZN sensor probe is able to measure salinity and temperature, all included in a compact and robust probe suitable for the most typical applications.

Inductive conductivity, salinity and temperature CTZN for one

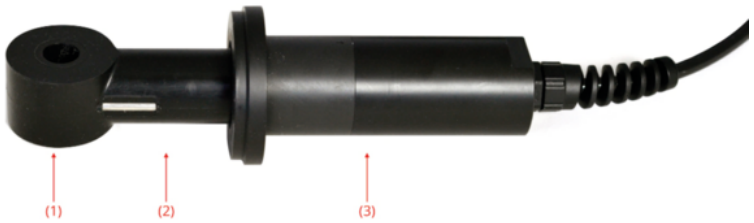
Specifications

Conductivity sensor:
Technology: Inductive coil
Ranges: 0 - 100 mS/cm
Resolution: 0.1 mS/cm
Measurement range (salinity): 5 - 60 g/kg
Working temperature: 0 to 50 ºC
Response time: 90% of the value in less than 30 seconds

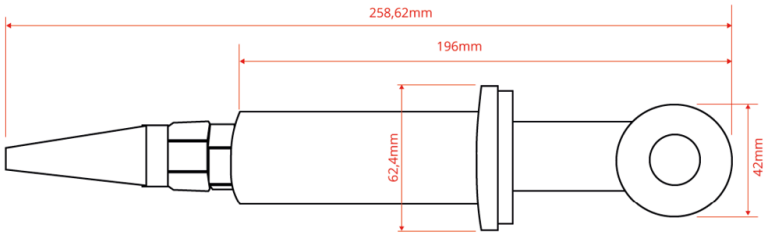
Temperature sensor:
Technology: NTC
Range: 0 ºC to +50 ºC
Resolution: 0.01 ºC
Accuracy: ±0.5 ºC

Common:
Default cable length: 15 m

Maximum pressure: 5 bars
Body material: PVC
IP classification: IP68
Storage temperature: -10 ºC to +60 ºC



Sensor parts: (1) conductivity coil, (2) temperature sensor, (3) sensor body



Dimensions of the CTZN sensor probe

3.4.5. OPTOD

The Optical dissolved oxygen and temperature OPTOD sensor probe, based on a luminescent optical technology, meets the demands of long-term smart water applications. The OPTOD sensor probe measures accurately without oxygen consumption, especially with very low concentrations and very weak water flow. It is designed in a compact, robust and light probe with a stainless steel body.

It is often recommended to use an atmospheric pressure sensor together with the OPTOD sensor probe, due to the degree of solubility of oxygen in water being dependent on the atmospheric pressure. Moreover, the salinity is also related.

Optical dissolved oxygen and temperature OPTOD sensor probe

Specifications

Dissolved oxygen sensor:
Technology: Optical luminescence
Ranges:

- 0 to 20.00 mg/l
- 0 to 20.00 ppm
- 0 - 200%

Resolution: 0.01
Accuracy:

- ±0.1 mg/l
- ±0.1 ppm
- ±1%

Response time: 90% of the value in less than 60 seconds

Frequency of recommended measure: > 5 s
Cross sensitivity: Organic solvents, such as acetone, toluene, chloroform or methylene chloride. Chlorine gas.

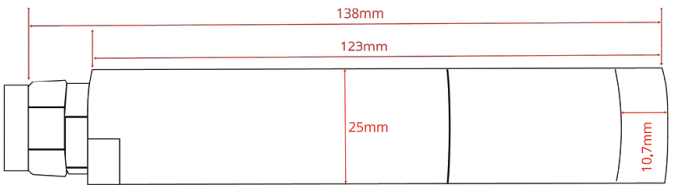
Temperature sensor:

- **Technology**: NTC
- **Range**: 0 ºC to +50 ºC
- **Resolution**: 0.01 ºC
- **Accuracy**: ±0.5 ºC
- **Response time**: < 5 s

Common:

- **Water flow is not necessary**
- **Default cable length**: 15 m
- **Maximum pressure**: 5 bars
- **Body material**: Stainless steel (titanium option available on demand for sea water applications)
- **IP classification**: IP68
- **Storage temperature**

Sensor probe parts: (1) membrane cap (consumable), (2) membrane screw and seal, (3) sensor body



Dimensions of the OPTOD sensor probe

3.4.6. MES5

The Suspended solids, turbidity, sludge blanket and temperature MES5 sensor probe gives 4 different parameters in a single probe. It is based on the attenuation of an infrared signal through an optical path in the probe's head. The given measures are temperature compensated to increase the accuracy.
However, to measure suspended solids, the MES5 sensor probe is directly calibrated on the material to be measured (sample of sludge) and an external laboratory is needed to analyze the sample. This service is not provided by Libelium.

Suspended solids, turbidity, sludge blanket and temperature MES5 sensor probe

Specifications

Turbidity sensor:
Technology: Optical infrared (IR 870 nm)
Ranges:

- SS : 0 - 50 g/l
- Turbidity : 0 - 4000 FAU
- Sludge blanket : 0 - 100%

Resolution:

- SS : 0.01 g/l
- Turbidity : 0.01 to 1 FAU
- Sludge blanket : 0.01 to 0.1%

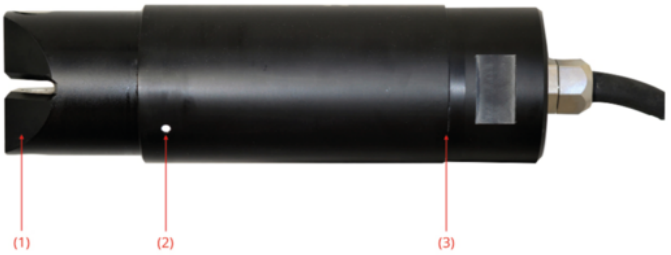
Accuracy:

- SS <10%
- Turbidity : ±5% (range 200 - 4000 FAU)
- Sludge blanket : ±2%

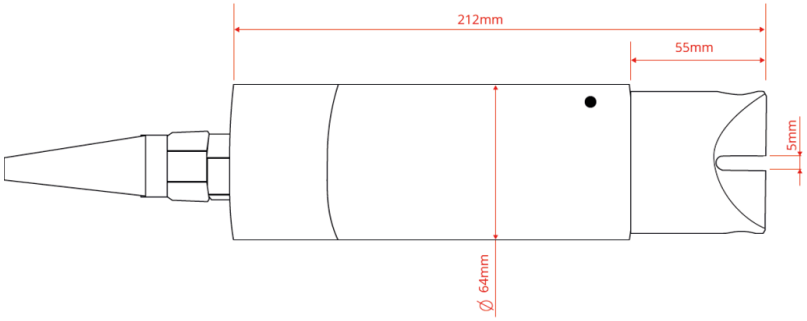
Response time: < 35 seconds

Temperature sensor:
Technology: NTC
Range: -5 ºC to +50 ºC
Resolution: 0.01 ºC
Accuracy: ±0.5 ºC

Common:
Default cable length: 15 m
IP classification: IP68
Maximum pressure: 5 bars
Body material: DELRIN
Storage temperature: 0 ºC to +60 ºC



Sensor parts: (1) optical window, (2) temperature sensor, (3) sensor body



Dimensions of the MES5 sensor probe

3.4.7. StacSense

Normally, there are several components related to organic life, so it is usual to obtain the organic matter through parameters like Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Organic Carbon (TOC) and Spectral Absorption Coefficient at 254 nm (SAC254).

Note: The StacSense probes are not recommended for seawater applications. Contact your Sales agent for more information.

Specifications

- **Measurement principle**: UV 254 nm absorption
- **Compensation**: Turbidity at 530 nm. Internal temperature
- **Wavelengths**: 254 nm (turbidity correction at 530 nm)
- **Type of detector**: Silicon photodiode
- **Optical paths**: 2 mm (wastewater) and 50 mm (drinking water)
- **Maximum sample rate**: 2 seconds
- **IP classification**: IP68
- **Maximum immersion depth**: 50 meters
- **Maximum pressure**: 5 bars
- **Operating temperature**: 0-40ºC
- **Storage temperature**: -10ºC to +50ºC
- **pH range**: pH2 to pH12
- **Dimensions**: 420 x 50 mm

Measurement ranges:

Optical path	Parameter	Range	Units	Detection limit	Quantification limit	Accuracy
2 mm	SEC254	0-750	Abs/m	44743	5	1 or ±3%
	CODEQ	0-1300	mg/l	3	9	2 or ±3%
	BODEQ	0-350	mg/l	1	3	1 or ±3%
	TOCEQ	0-500	mg/l	44682	4	1 or ±3%

	TurbidityEQ	0-500	FAU	44682	5	5 or ±5%
50 mm	SEC254	0-30	Abs/m	0.2	0.3	0.1 or ±3%
	CODEQ	0-50	mg/l	0.15	0.6	0.2 or ±3%
	BODEQ	0-15	mg/l	0.1	0.2	0.1 or ±3%
	TOCEQ	0-20	mg/l	0.1	0.2	0.1 or ±3%
	TurbidityEQ	0-40	FAU	0.4	44593	1 or ±7%

3.4.8. Vegapuls C21

The Radar level VEGAPULS C21 sensor provides reliable measurement results under all conditions thanks to its 80 GHz radar technology. Compared to ultrasonic measuring instruments, radar sensors measure unaffected by temperature fluctuations, vacuum or high pressures and are insensitive to contamination.

Due to the high focusing of the 80 GHz technology, the radar beam can be aligned almost precisely to the medium to be measured. It is suitable for use in water treatment, pumping stations and rain overflow basins, for flow measurement in open channels and level monitoring. In bulk solids the sensors are used in small bulk solids silos or open containers.

Radar level VEGAPULS C21 for One

Specifications

- **Operation frequency**: 80 GHz
- **Maximum detection distance**: 15 m
- **Accuracy**: ±2 mm
- **Operating temperature**: -40 to 80 ºC
- **Usage**: water or bulk solid tanks
- **Protection rating**: IP66/IP68 (3 bar), type 6P
- **Cable length:** 5m

3.5. Generic sensors

3.5.1. Temperature and humidity for One

The Air temperature and humidity sensor for One comes with a solar shield and a bracket for easy installation outdoors.

Air temperature and humidity sensor for One

Specifications

- **Measuring range**: -40ºC to 60ºC, 0 to 100%RH
- **Accuracy**: +-0.3ºC at 25ºC, +-3%RH at 25ºC and 20%-80%RH.
- **Long term stability**: <0.5℃/year, <3%RH/year
- **Response time**: < 15s, <12s (63%)
- **Working temperature**: -40～60℃
- **Storage environment**:-40～80℃ (No condensation)
- **Protection level**: IP65
- **Material**: ABS

3.5.2. Noise Level Sensor

The Noise Level sensor for One has an integration window size from 2 - 15 mins with 1Hz of sample rate and 1 mins of window size with 8Hz of sampling rate. Each measurement has inherent the sound pressure Level with the A-weighting filter in dB.

Specifications

- **Measuring range:** 40 to 115 dB
- **Frequency Weghting:** IEC 61672-1 A Filter
- **Time Weighting:** IEC 61672-1 Slow (S) and Fast (F)
- **Measurements:**
  - *LAS*
  - *LASmin*
  - *LASmax*
  - *LAF*
  - *LAFmin*
  - *LAFmax*
  - *LAEq*
  - *LA10*
  - *LA20*
  - *LA30*
  - *LA40*
  - *LA50*
  - *LA60*
  - *LA70*
  - *LA80*
  - *LA90*
  - *LA99*