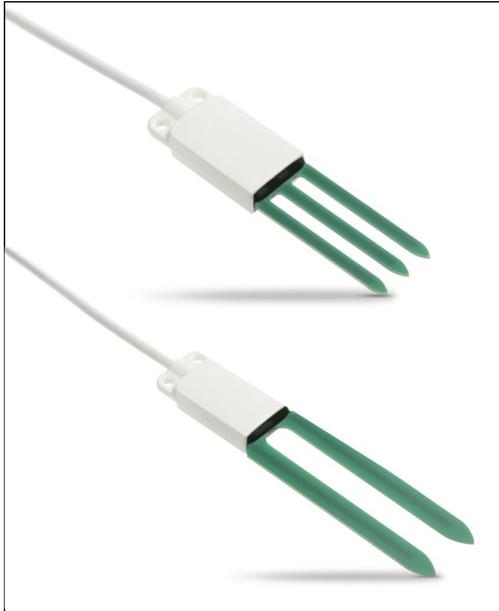


# HD3910.1 – HD3910.2

## Probes for soil volumetric water content measurement



- Measurement of the soil volumetric water content with 2 electrodes (**HD3910.1**) or 3 electrodes (**HD3910.2**) for restricted volumes
- Measurement of the soil temperature
- Various output options available (depending on model): digital RS485 with MODBUS-RTU protocol, digital SDI-12 or analog voltage
- Accurate and stable measure over time
- Degree of protection IP 67
- Minimal invasiveness in the soil
- Easy to install

### APPLICATION

- Agriculture
- Hydrology
- Geology

### DESCRIPTION

The probes **HD3910.1** (two electrodes) and **HD3910.2** (three electrodes) measure the soil volumetric water content (VWC) by using a capacitive measurement principle which allows fast measurements in the field and with minimal invasiveness.

The three-electrode probe **HD3910.2** is particularly suitable for the measurement in small volumes, for example for cultivations in pots.

The probes are factory-calibrated and do not require any further calibration by the end user.

The circuit board is protected inside a housing made of plastic material and sealed with epoxy resin which allows achieving reliable measurements even in harsh environmental conditions.

The version with **RS485** digital output with **MODBUS-RTU** protocol allows the use of even very long connection cables. It can be connected to the data loggers HD32MT.1 and HD32MT.3 or to any other data logger with RS485 MODBUS-RTU input.

The version with **SDI-12** digital output is compatible with version 1.3 of the protocol and can be connected to the data logger HD32MT.3 or to any other data logger with SDI-12 input.

The version with analog output has two 0.5...3 V standard voltage outputs: one for the volumetric water content and one for the temperature. On request, 0...2.5 V, 0...5 V or 0...10 V outputs.

The probes are equipped with a fixed cable, 5 or 10m standard length, with open wires at the end.

### VOLUMETRIC WATER CONTENT

The moist soil is composed of a solid part (minerals), a liquid part (generally water) and a gaseous part (air, water vapor).

The Volumetric Water Content (VWC) is defined as the ratio between the volume occupied by the water ( $V_w$ ) in a certain portion of the soil and the total volume of the soil portion ( $V$ ):

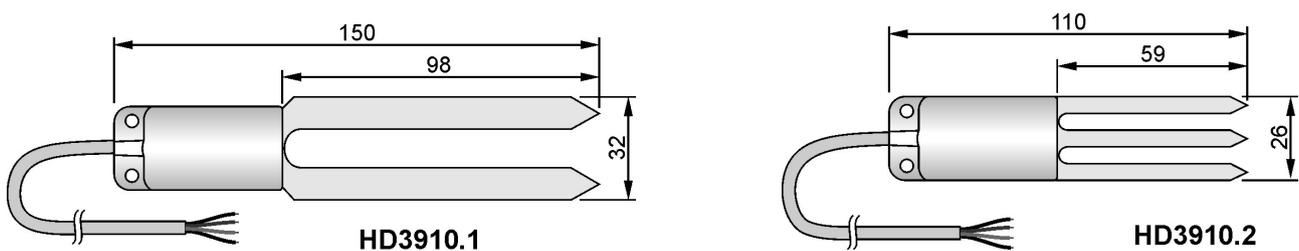
$$VWC = \frac{V_w}{V}$$

It can also be expressed as a percentage (% VWC) of the water volume in the total volume.

The volumetric water content is a parameter used in hydrology for the study of the hydraulic properties of the soil, and in agriculture to determine the need to irrigate crops.

## TECHNICAL SPECIFICATIONS

<b>Volumetric water content</b>	
Measuring principle	Capacitive
Measuring range	0...60% VWC
Resolution	0.1%
Accuracy (@ 23 °C)	± 3 % between 0 and 50% VWC (standard mineral soil, EC < 5 mS/cm)
Measuring volume	∅= 100 mm x H=150 mm for the 2-electrode probe ∅= 80 mm x H=110 mm for the 3-electrode probe
Sensor operating temperature	-40...+60°C
<b>Temperature</b>	
Sensor	NTC 10 kΩ @ 25°C
Measuring range	-40...+60°C
Resolution	0.1°C
Accuracy	± 0.5°C
Long-term stability	0.1°C / year
<b>Power supply</b>	3.6...30 Vdc for versions with 0...2.5 V analog output 5...30 Vdc for versions with RS485 output and versions with 0.5...3 V analog output 6...30 Vdc for versions with SDI-12 output 7...30 Vdc for versions with 0...5 V analog output 12...30 Vdc for versions with 0...10 V analog output
<b>Consumption</b>	<i>Versions with RS485 output:</i> 2 mA average / 15 mA peak @ 12 Vdc <i>Versions with analog output:</i> 2.5 mA average / 15 mA peak @ 12 Vdc <i>Versions with SDI-12 output:</i> 300 µA @ 12 Vdc in standby <15 mA @ 12 Vdc during measurement
<b>Output</b>	Depending on model: <ul style="list-style-type: none"> <li>• RS485 with MODBUS-RTU protocol</li> <li>• SDI-12</li> <li>• 0.5...3 V analog voltage (0.5 V=0 %VWC or -40 °C , 3 V=60 %VWC or +60 °C, minimum load resistance 10 kΩ)</li> </ul>
<b>Materials</b>	Handle: thermoplastic material and epoxy resin Electrodes: epoxy glass, thickness 2 mm
<b>Connection</b>	Fixed cable with open wires at the end, length 5 or 10 m standard
<b>Protection degree</b>	IP 67
<b>Weight</b>	150 g approx. (including the 5 m cable)



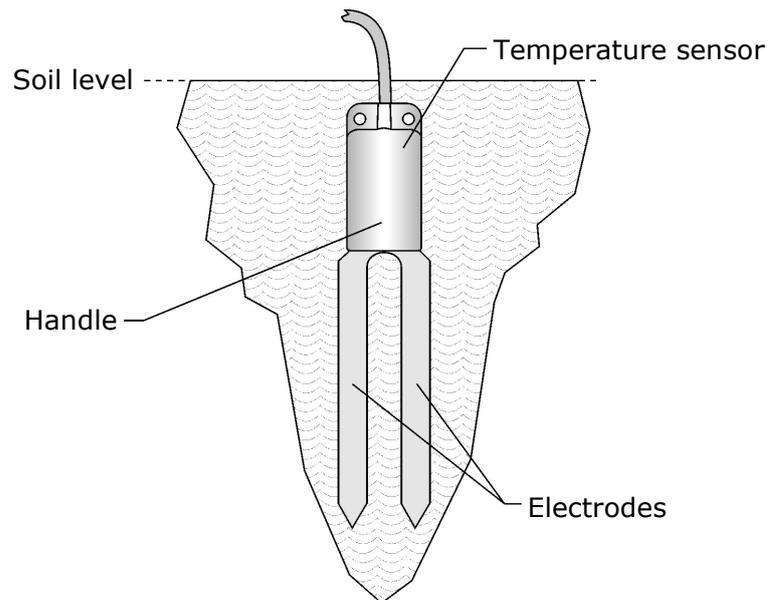
**Fig. 1: dimensions (mm)**

## INSTALLATION

By means of an accessory, perform a hole into the soil deep enough to accommodate the probe. Never use the probe to make the hole in the soil, in order to avoid mechanical damage to the probe itself.

Once the hole was done, insert the probe **completely** into the soil so that the entire handle is covered by the ground: the temperature sensor is located inside the handle, close to the electrodes; therefore, it is necessary that the handle is immersed in the soil for a correct detection of the temperature.

After the introduction of the probe, fill in the empty spaces between the soil and the probe with some soil made powder. To obtain accurate measurements, the soil should be in contact with the electrodes and the probe handle.



**Fig. 2: Installation**

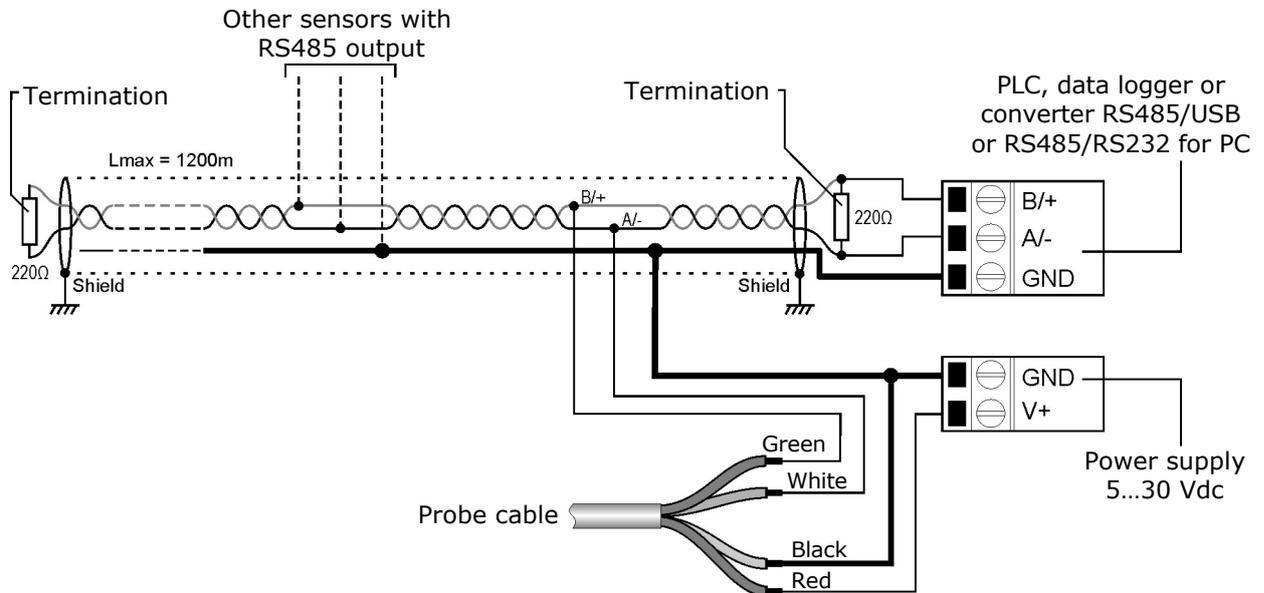
The probe can be oriented in any direction, but it is advisable to place it vertically into the ground, so to not hinder the flow of water downward and to minimize the influence of the probe in the soil behavior.

### Warnings:

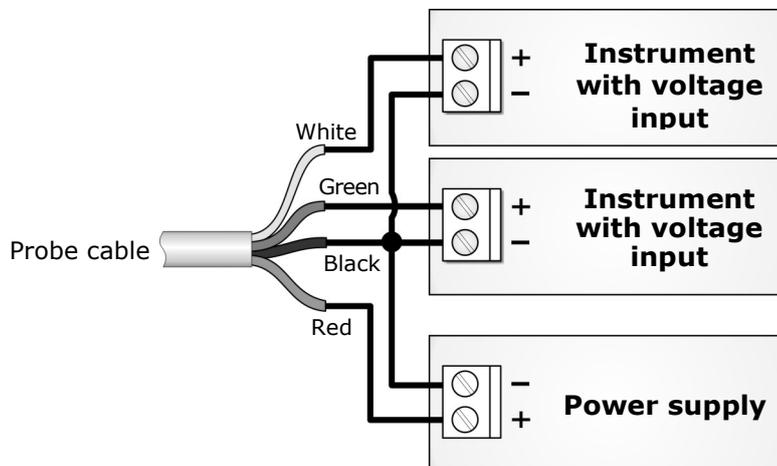
- The portion of soil in which the probe is inserted must be uniform, without air gaps, and not too compact as it would make the introduction of the probe difficult.
- Pay attention to the presence of roots, stones or other objects present in the subsurface that may come between the electrodes and affect the measure.
- Do not use excessive force when introducing the probe, so to avoid irreparable damage to the electrodes.
- The probe measures the water content of the soil volume immediately surrounding the electrodes: position the probe so that there are no objects close to the probe, such as metal poles for example, that may affect the field of action of the probe itself.
- Indicate the presence of the probe during the maintenance operations of the soil (e.g. lawn mowing, ploughing, mechanized harvesting, etc.).
- In order to remove the probe from the soil, grab the handle and pull it upwards. **During the extraction, remove the probe vertically, by avoiding tilt that would damage the electrodes.**
- **Do not remove the probe by pulling the cable.**

## CONNECTIONS

Wire color	Function		
	RS485 output	SDI-12 output	Analog output
Black	Negative power supply	Negative power supply/output	Negative power supply/output
Red	Positive power supply	Positive power supply	Positive power supply
White	RS485 A/-	Positive SDI-12 output	Positive %VWC output
Green	RS485 B/+	---	Positive temperature output



**Fig. 3: RS485 connection**



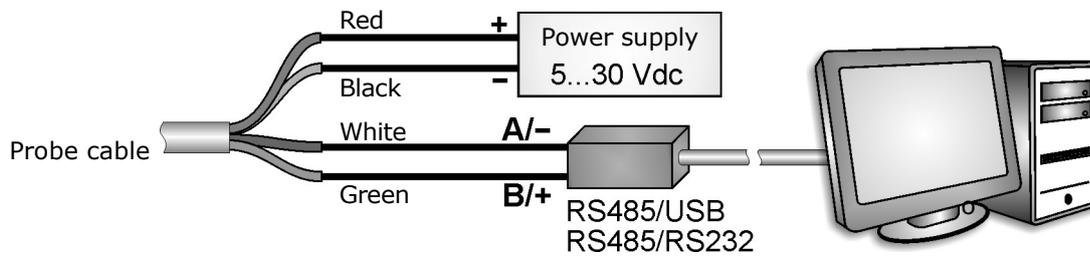
**Fig. 4: analog outputs connection**

Connect the cable shield to the negative of power supply.

## SETTING OF RS485 COMMUNICATION PARAMETERS

Before connecting the probe to the RS485 network you must assign an address and set the communication parameters, if different from the factory preset.

The parameter setting is performed by connecting the probe to the PC by using a RS485/USB or RS485/RS232 converter. The probe must be powered separately. If RS485/USB converter is used it is necessary to install the appropriate USB drivers in the PC.



**Fig. 5: connection to PC**

**NOTES ON THE INSTALLATION OF UNSIGNED USB DRIVERS:** before installing unsigned USB drivers into operating systems starting from Windows 7, it is necessary to restart the PC disabling the driver signature request. If the operating system is 64-bit, even after installation, it is necessary to disable the request of the driver signature every time the PC is restarted.

**Procedure for setting the parameters**

1. Start a serial communication program, HyperTerminal for example. Set the communication parameters the same as those set in the instrument. By default, the parameters are:

Baud Rate = 19200  
 Data Bits = 8  
 Parity = Even  
 Stop Bits = 1

In the program, set the number of the COM port to which you connect the probe.

2. Type three times the character | (124 decimal code ASCII character). The probe replies with @.
3. Within 10 seconds from the probe reply, send the command @ (64 decimal code ASCII character followed by the Enter key). The probe replies with &.  
*Note:* if the probe does not receive the @ command within 10 seconds, the Modbus mode is activated again.
4. Send the command **CAL USER ON**.  
*Note:* the CAL USER ON command is disabled after an inactivity of 5 minutes.

5. Send the following serial commands to set the RS485 MODBUS parameters:

Command	Reply	Description
CMAnnn	&	Set address RS485 to nnn Ranging from 1 to 247. Preset on 1
CMBn	&	Set RS485 Baud Rate: n=0 ⇒ 9600, n=1 ⇒ 19200 Preset on 1 ⇒ 19200
CMPn	&	Set RS485 transmission mode (data bits, parity, stop bits): n=0 ⇒ 8N1, n=1 ⇒ 8N2, n=2 ⇒ 8E1 n=3 ⇒ 8E2, n=4 ⇒ 8O1, n=5 ⇒ 8O2 Preset on 2 ⇒ 8E1
CMWn	&	Set receiving mode after RS485 transmission: n=0 ⇒ Violate protocol and go in Rx mode right after Tx n=1 ⇒ Respect protocol and wait 3.5 characters after Tx Preset on 1 ⇒ Respect the protocol

6. It is possible to check the settings of the parameters by sending the following command:

Command	Reply	Description
RMB	<i>b p w a</i>	Baud Rate: <i>b=0</i> ⇒ 9600, <i>b=1</i> ⇒ 19200 RS485 transmission mode: <i>p=0</i> ⇒ 8N1, <i>p=1</i> ⇒ 8N2, <i>p=2</i> ⇒ 8E1, <i>p=3</i> ⇒ 8E2, <i>p=4</i> ⇒ 8O1, <i>p=5</i> ⇒ 8O2 Read reception mode after RS485 transmission: <i>w=0</i> ⇒ violate protocol and go in Rx mode right after Tx <i>w=1</i> ⇒ respect protocol and wait 3.5 characters after Tx <i>a</i> = RS485 address

Note: the command CAL USER ON is not required for reading the settings.

## MODBUS MODE

The probe enters RS485 MODBUS-RTU mode immediately after power on.

### Reading the measurements

In MODBUS mode, it is possible to read the measured values by using the function code 04h (Read Input Registers). The following table shows the MODBUS Input Registers available:

### MODBUS Input Registers

Register Number	Register Address	Datum	Format
1	0	Status register	16-bit integer
2	1	Volumetric water content in % VWC [x10]	16-bit integer
3	2	Apparent dielectric permittivity [x1000]	16-bit integer
4	3	Soil temperature in °C [x10]	16-bit integer
5	4	Soil temperature in °F [x10]	16-bit integer

## STATUS REGISTER

The 16-bit status register gives the following information:

Bit	Description
0	If equal to 1, an error occurred
1	If equal to 1, data memory overflow
2	If equal to 1, data memory error
3	If equal to 1, program memory error
4...5	Always 0
6	If equal to 1, VWC measurement error
7	If equal to 1, temperature measurement error
8	If equal to 1, power cycle
9...14	Always 0
15	If equal to 1, probe not ready (invalid measures)

## SDI-12 PROTOCOL

The probes with SDI-12 output are compliant with the version 1.3 of the protocol.

The communication parameters of the protocol are:

baud rate: 1200, data bits: 7, parity: Even, stop bits: 1

The communication with the probe is performed by sending a command in the following form:

**<Address><Command>!**

with <Address> = address of the probe the command is sent to

<Command> = type of operation requested to the probe

The probe reply is as follows:

**<Address><Data><CR><LF>**

with <Address> = address of the probe which replies

<Data> = information sent by the probe

<CR> = ASCII character *Carriage Return*

<LF> = ASCII character *Line Feed*

The probe comes with a factory address preset to 0. The address can be modified by using the proper SDI-12 command reported in the following table.

The following table reports the SDI-12 commands available. For consistency with the documentation of the SDI-12 standard, the probe address is indicated in the table with the letter **a**.

### SDI-12 Commands

Command	Probe reply	Description
<b>a!</b>	a<CR><LF>	Verifies the presence of the probe.
<b>aI!</b>	allccccccmmmmmmvvvsssssss<CR><LF> with: a = address of the probe (1 character) II = SDI-12 compliant version (2 characters) ccccccc = manufacturer (8 characters) mmmmmm = probe model (6 characters) vvv = firmware version (3 characters) sssssss = serial number (8 characters)  ⇒ Example of response: 013DeltaOhmHD3910A0013201518 with: 0 = probe address 13 = SDI-12 version 1.3 compliant DeltaOhm = manufacturer's name HD3910 = probe model A00 = firmware version 13201518 = serial number	Requests for information from the probe.
<b>aAb!</b> Where: b = new address	b<CR><LF>  Note: if the b character is not an acceptable address, the probe responds with a instead of b.	Modification of the probe address.
<b>?!</b>	a<CR><LF>	Request of the address of the probe. If more than one probe is connected to the bus, a conflict occurs.

Command	Probe reply	Description
<b>Type M (start measurement) and type C (start concurrent measurement) commands</b>		
<b>WVC and temperature</b>		
<b>aM!</b> <b>aC!</b>	atttn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM!, 2 characters for aC!) Note: ttt = 000 means that datum is immediately available.	Request to execute the measurement.
<b>aD0!</b>	a+n+w...w+t...t<CR><LF> with: n = content of the status register w...w = volumetric water content (m <sup>3</sup> /m <sup>3</sup> ) t...t = soil temperature in °C ⇒ Example of response: 0+0+0.325+17.6 probe address = 0 content of the status register = 0 volumetric water content = 0.325 (m <sup>3</sup> /m <sup>3</sup> ) = 32.5% soil temperature = 17.6 °C	Reads the measurement.
<b>Permittivity</b>		
<b>aM1!</b> <b>aC1!</b>	atttn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM1!, 2 characters for aC1!) Note: ttt = 000 means that datum is immediately available.	Request to execute the measurement.
<b>aD0!</b>	a+n+p...p<CR><LF> with: n = content of the status register p...p = apparent dielectric permittivity ⇒ Example of response: 0+0+0.029 probe address = 0 content of the status register = 0 apparent dielectric permittivity = 0.029	Reads the measurement.
<b>Signal level and temperature</b>		
<b>aM2!</b> <b>aC2!</b>	atttn<CR><LF> with: ttt = number of seconds necessary for the instrument to make the measure available (3 characters) n = number of detected variables (1 character for aM2!, 2 characters for aC2!) Note: ttt = 000 means that datum is immediately available.	Request to execute the measurement.
<b>aD0!</b>	a+n+v...v+t...t<CR><LF> with: n = content of the status register v...v = signal internal level in V t...t = soil temperature in °C ⇒ Example of response: 0+0+0.095302+17.6 probe address = 0 content of the status register = 0 signal internal level = 0.095302 V soil temperature = 17.6 °C	Reads the measurement.

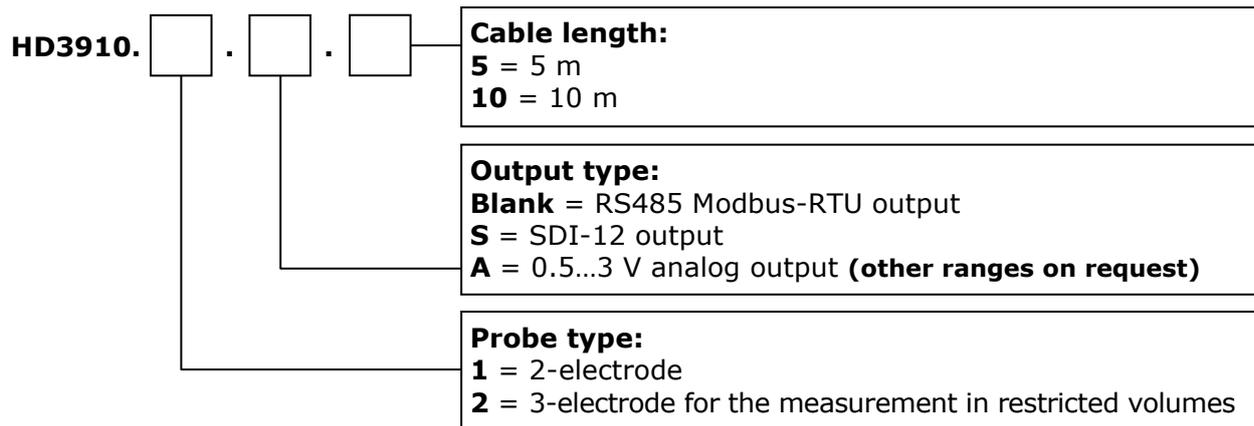
In addition to the above-mentioned commands, the probe also implements the corresponding

commands with CRC, that require to add a 3-character CRC code at the end of the reply before <CR><LF>. The format of these commands is obtained from the previous by adding the letter C: aMC!, aMC1!, aMC2!, aCC!, aCC1!, aCC2!. The probe does not implement the type R (Continuous Measurements) commands.

## MAINTENANCE

The probe does not require any special maintenance. We recommend a periodic cleaning with water and normal detergent of the electrodes in order to avoid the accumulation of substances that may alter the measures.

## ORDERING CODES



## WARRANTY

The manufacturer is required to respond to the "factory warranty" only in those cases provided by Legislative Decree 6 September 2005 - n. 206. Each instrument is sold after rigorous inspections; if any manufacturing defect is found, it is necessary to contact the distributor where the instrument was purchased from. During the warranty period (24 months from the date of invoice) any manufacturing defects found will be repaired free of charge. Misuse, wear, neglect, lack or inefficient maintenance as well as theft and damage during transport are excluded. Warranty does not apply if changes, tampering or unauthorized repairs are made on the product. Solutions, probes, electrodes and microphones are not guaranteed as the improper use, even for a few minutes, may cause irreparable damages.

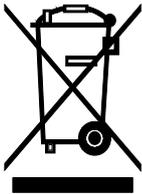
The manufacturer repairs the products that show defects of construction in accordance with the terms and conditions of warranty included in the manual of the product. For any dispute, the competent court is the Court of Padua. The Italian law and the "Convention on Contracts for the International Sales of Goods" apply.

## TECHNICAL INFORMATION

The quality level of our instruments is the result of the continuous product development. This may lead to differences between the information reported in the manual and the instrument you have purchased.

We reserves the right to change technical specifications and dimensions to fit the product requirements without prior notice.

## DISPOSAL INFORMATION



Electrical and electronic equipment marked with specific symbol in compliance with 2012/19/EU Directive must be disposed of separately from household waste. European users can hand them over to the dealer or to the manufacturer when purchasing a new electrical and electronic equipment, or to a WEEE collection point designated by local authorities. Illegal disposal is punished by law.

Disposing of electrical and electronic equipment separately from normal waste helps to preserve natural resources and allows materials to be recycled in an environmentally friendly way without risks to human health.

