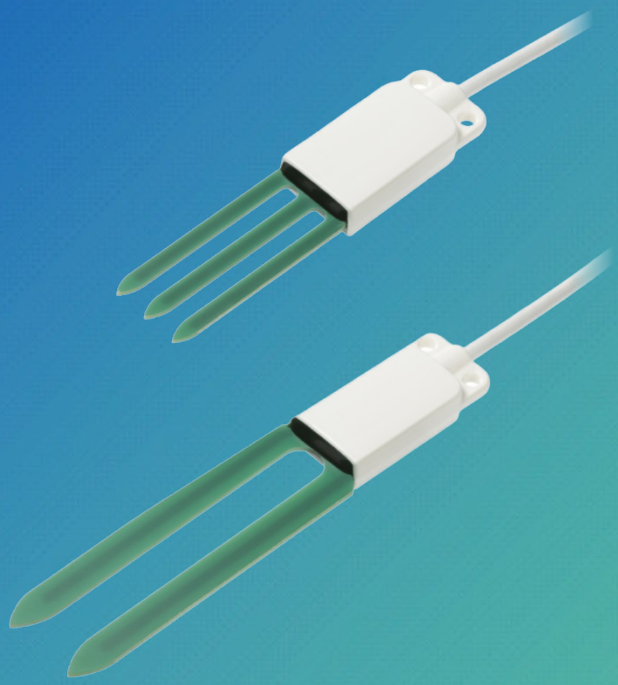
OPERATING MANUAL

HD3910 series

Soil volumetric water content (VWC) probes



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V1.0

senseca

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1 Introduction

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 is particularly suitable for the measurement in small volumes, for example for cultivations in pots.

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.

RS845 Modbus-RTU, SDI-12 or voltage analog output depending on model.

The version with analog output has two voltage outputs: one for the volumetric water content and one for the temperature. Analog output range 0.5…3 V, 0…2.5 V, 0…5 V or 0…10 V depending on model.

The probes are supplied factory calibrated and do not require any calibration by the user.

Fixed connecting cable, length 5 m (HD3910.xx.5) or 10 m (HD3910.xx.10), ending with open wires.

Models are distinguished by the numbers of electrodes and the type of output available:

HD3910. .

Cable length:
5 = 5 m
10 = 10 m

Analog output range:
Blank = 0.5...3 V
2 = 0...2.5 V
5 = 0...5 V
10 = 0...10 V

Type of output:
Blank = RS485 Modbus-RTU
A = Analog
S = SDI-12

Number of electrodes:
1 = 2 electrodes
2 = 3 electrodes

2 Technical specifications

Volumetric water content

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 (HD3910.**1**…) ∅=80 mm x H=110 mm (HD3910.**2**…)
Sensor operating temperature	-40…+60°C

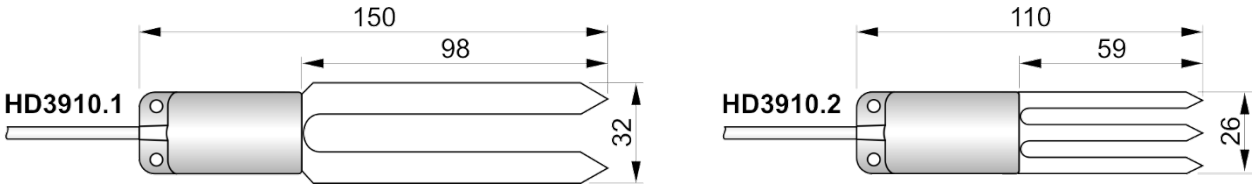
Temperature

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

General characteristics

Power supply	• 3,6…30 Vdc (HD3910.x**A2**.x) • 5…30 Vdc (HD3910.x.x and HD3910.x**A**.x) • 6…30 Vdc (HD3910.x**S**.x) • 7…30 Vdc (HD3910.x**A5**.x) • 12…30 Vdc (HD3910.x**A10**.x)
Consumption	• 2 mA average / 15 mA peak @ 12 Vdc (HD3910.x.x) • 2.5 mA average / 15 mA peak @ 12 Vdc (HD3910.x**A**x.x) • 300 µA in standby / <15 mA in measurement @ 12 Vdc (HD3910.x**S**.x)
Output	• RS485 Modbus-RTU (HD3910.x.x) • SDI-12 (HD3910.x**S**.x) • 2 x analog voltage 0,5…3 V, 0…2,5 V, 0…5 V or 0…10 V depending on model
Cable	4 poles ending with open wires, length 5 or 10 m depending on the model
Materials	Handle: PP Electrodes: copper on glass epoxy substrate, thickness 2 mm
Weight	150 g approx. (including the 5 m cable)
Protection degree	IP 67

Dimensions (mm)



3 Measuring principle

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 (Vw) in a certain portion of the soil and the total volume of the soil portion (V):

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

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

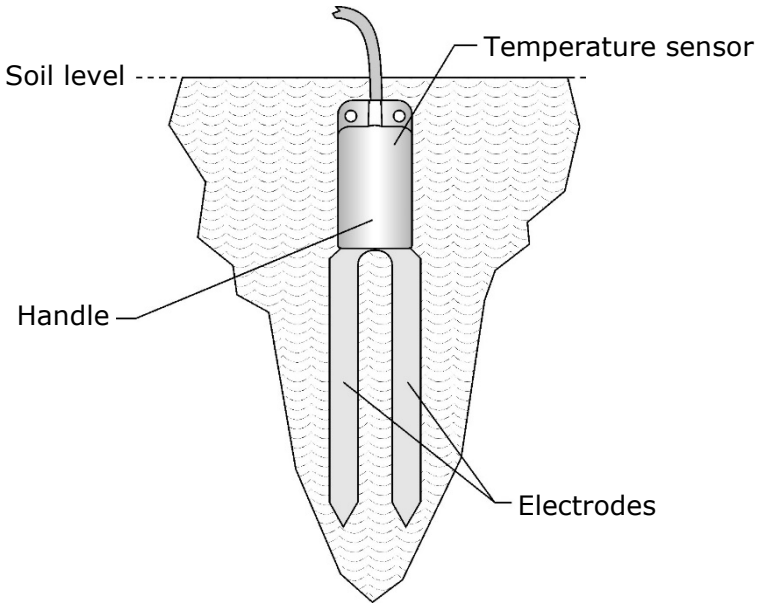
The volumetric water content is a parameter used in hydrology for the study of the hydraulic properties of the soil, and in agriculture to determine the need to irrigate crops.

4 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, to avoid mechanical damage to the probe itself.

Once the hole is 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.



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

Caution!

- Do not use excessive force when introducing the probe, so to avoid irreparable damage to the electrodes.
- 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.**

Attention!

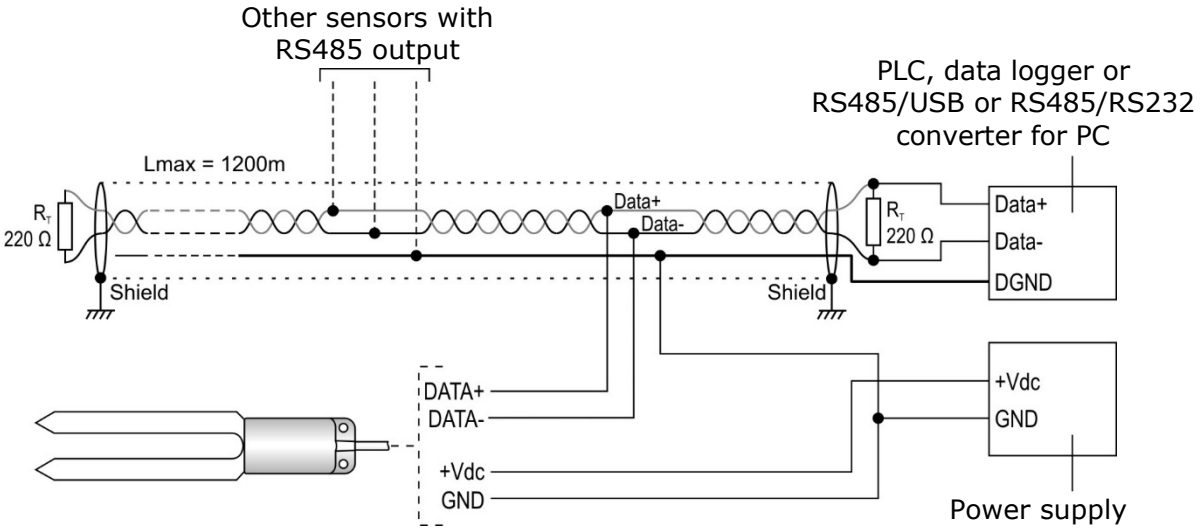
- The portion of soil in which the probe is inserted must be uniform, without air gaps, and not too compact as it would make the introduction of the probe difficult.
- Pay attention to the presence of roots, stones or other objects present in the subsurface that may come between the electrodes and affect the measure.
- 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.).

4.1 Electrical connections

Wire color	Function		
	RS485 output (HD3910.x.x)	**SDI-12 output (HD3910.xS.x)**	**Analog output (HD3910.xAx.x)**
Black	GND	GND	GND
Red	+Vdc	+Vdc	+Vdc
White	RS485 A/-	DATA	+Vout_W (%VWC)
Green	RS485 B/+	---	+Vout_T (Temperature)

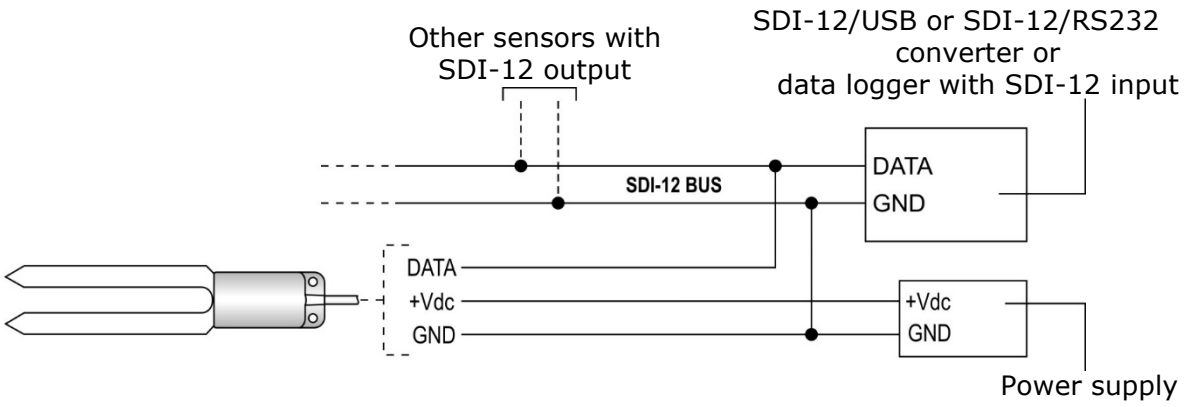
Connect the cable shield to the negative of power supply.

RS485 connection (HD3910.x.x):



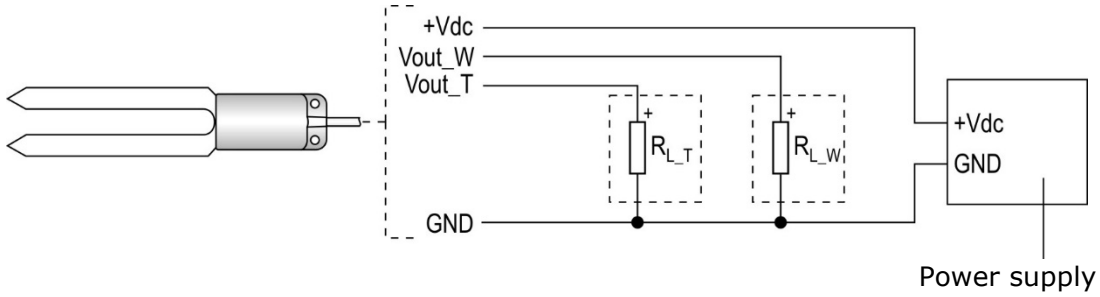
Before connecting the probe to the network, set the address and the communication parameters, if different from the factory preset (see "Setting of RS485 Modbus-RTU parameters" on page 9).

SDI-12 connection (HD3910.xS.x):



Before connecting the probe to the network, set the address (see "SDI-12 protocol" on page 11).

Analog output connection (HD3910.xAx.x):



Load resistance RL > 10 kΩ.

The Vout_W output corresponds to 0…60% VWC.

The Vout_T output corresponds to -40…+60 °C.

5 Setting of RS485 Modbus-RTU parameters

By default, the probe has Modbus address **1** and communication parameters 19200, 8E1. The address and the communication parameters can be changed as shown below.

1. Connect the probe to the PC, via an RS485/USB or RS485/RS232 converter, and start a standard serial communication program.
2. In the serial communication program, set the communication parameters of the probe (default 19200, 8N2) and the COM port number to which the probe is connected.
3. Type three times the character **|** (124 decimal code ASCII character). The probe replies with **@**.
4. Within 10 seconds from the probe reply, send the command **@** (64 decimal code ASCII character). The probe replies with **&**.

   Note: if the probe does not receive the **@** command within 10 seconds, the Modbus mode is activated.
5. Send the command **CAL USER ON** to enable the configuration change. The command CAL USER ON is not required only for reading the settings. The command CAL USER ON is automatically disabled after a few minutes of inactivity.
6. Send the following serial commands.

Command	**Reply**	**Description**
CMAn	&|	Sets the Modbus-RTU address (1…247) to n. Default=1
CMBn	&|	Sets the Baud Rate: ▪ 9600 if n=0 ▪ 19200 if n=1 (*default*)
CMPn	&|	Sets parity and stop bits (data bits = 8 fixed): ▪ 8N1 if n=0 ▪ 8N2 se n=1 ▪ 8E1 if n=2 (*default*) ▪ 8E2 se n=3 ▪ 8O1 if n=4 ▪ 8O2 se n=5
CMWn	&|	Sets waiting time after transmission with Modbus-RTU protocol: ▪ Immediate reception if n=0 (violates protocol) ▪ Waiting 3.5 characters if n=1 (respects protocol) *Default* : Waiting 3.5 characters (n=1)
RMB	*b p w a*	Reads the probe Modbus-RTU setting: *b* = Baud Rate index (0 ⇒ 9600, 1 ⇒ 19200) *p* = Parity and stop bits index (e.g., 2 ⇒ 8E1) *w* = Waiting time index (e.g., 1 ⇒ wait 3.5 char.) *a* = Address

6 Modbus-RTU protocol

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

Below is the list of registers.

Input Registers:

Address	Description	Format
0	Status register	16-bit Integer
1	Volumetric water content (VWC) in % [x10]	16-bit Integer
2	Apparent dielectric permittivity [x1000]	16-bit Integer
3	Soil temperature in °C [x10]	16-bit Integer
4	Soil temperature in °F [x10]	16-bit Integer

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)

7 SDI-12 protocol

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

The communication parameters of the protocol are "1200, 7E1".

By default, the SDI-12 address is **0** and can be changed by using the appropriate SDI-12 command.

Communication with the probe is performed by sending a command in the following format:

<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*

Below is the list of SDI-12 commands. To comply with the SDI-12 standard, the instrument address is indicated in the table by the letter **a**.

SDI-12 Commands

Command	Reply	Description
a!	a<CR><LF>	Checks for the presence of the probe.
aI!	allccccccccmmmmmmvvvsssssssss<CR><LF> where: a = address of the probe (1 character) ll = compatible SDI-12 version (2 characters) cccccccc = manufacturer (8 characters) mmmmmm = probe model (6 characters) vvv = firmware version (3 characters) ssssssss = serial number (8 characters)	Request for probe information.
aAb! where: b =new address	b<CR><LF> Note: if character "b" is not an acceptable address, the probe replies with "a" in the place of "b".	Modification of the probe address.
?!	a<CR><LF>	Request for probe address. If more than one probe is connected to the bus, a conflict will occur.

Type M (start measurement) and type C (start concurrent measurement) commands

Command	Reply	Description
VWC and temperature		
aM! aC!	atttn<CR><LF> where: a = probe address (1 character) ttt = number of seconds needed by the probe to make measurements available (3 characters) n = number of detected quantities (1 character for aM!, 2 characters for aC!) Note: ttt = 000 means data immediately available.	Request to detect the measurements.
aD0!	a+n+w…w+t…t<CR><LF> where: a = probe address n = content of the status register w…w = volumetric water content (m^3/m^3) 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^3/m^3) = 32.5% soil temperature = 17.6 °C	Request for measured values.
Permittivity		
aM1! aC1!	atttn<CR><LF> where: a = probe address (1 character) ttt = number of seconds needed by the probe to make measurements available (3 characters) n = number of detected quantities (1 character for aM1!, 2 characters for aC1!) Note: ttt = 000 means data immediately available.	Request to detect the measurements.
aD0!	a+n+p…p<CR><LF> where: a = probe address 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	Request for measured values.

Command	Reply	Description
Signal level and temperature		
aM2! aC2!	atttn<CR><LF> where: a = probe address (1 character) ttt = number of seconds needed by the probe to make measurements available (3 characters) n = number of detected quantities (1 character for aM2!, 2 characters for aC2!) Note: ttt = 000 means data immediately available.	Request to detect the measurements.
aD0!	a+n+v…v+t…t<CR><LF> where: a = probe address 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	Request for measured values.

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.

The probe does not implement the type R (Continuous Measurements) commands.

For additional information regarding the protocol, visit the website "www. sdi-12.org".

8 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 could alter the measurement.

9 Safety instructions

The probe proper operation and operating safety can be ensured only in the climatic conditions specified in this manual and if all standard safety measures as well as the specific measures described in this manual are followed.

Do not use the probe in places where there are:

- Corrosive or flammable gases.
- Direct vibrations or shocks to the instrument.
- High-intensity electromagnetic fields, static electricity.

User obligations

The instrument operator shall follow the directives and regulations below that refer to the treatment of dangerous materials:

- EU directives on workplace safety.
- National law regulations on workplace safety.
- Accident prevention regulations.

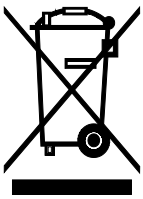
WARRANTY

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 reserve 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.

CE RoHS

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