Bodenfeuchte-Sensor

Soil moisture sensor

Minimal invasiver Sensor / *minimal invasive sensor*

Schnelle Bodenfeuchtebestimmung / *fast detection of soil moisture*

Gleichzeitige Bodentemperaturmessung / *simultan soil temperature measurement*

Wasserdicht / *waterproof*

Analogausgang 0,5….3V; RS485 Schnittstelle /*analog output 0,5...3V; RS485 Interface*

Für weitere Informationen / for further questions

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[GB] Characteristics

- 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.
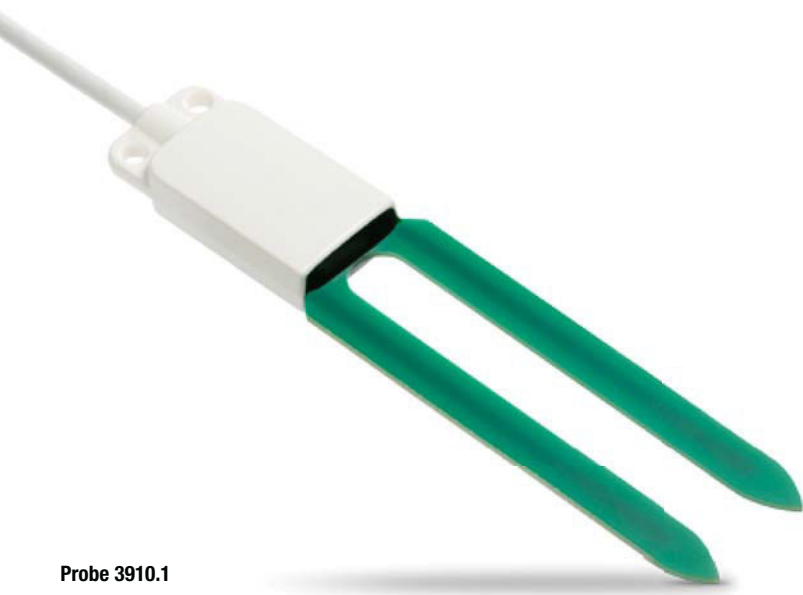
Volumetric Water Content

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):

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

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.

Probe 3910.1

Technical specifications

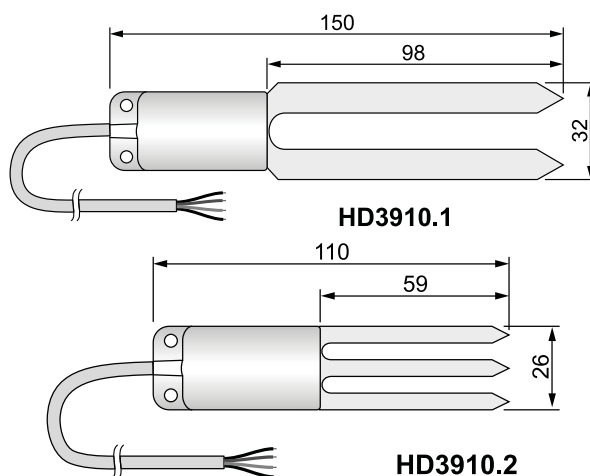| Volumetric water content	
Measuring principle	Capacitive
Measuring range	0…60% VWC
Resolution	0.1%
Accuracy (@ 23 °C)	± 3 % between 0 and 50% VWC (standard mineral soil, EC < 5 mS/cm)
Measuring volume	$\varnothing$= 60 mm x H=150 mm for the 2-electrode probe $\varnothing$= 40 mm x H=110 mm for the 3-electrode probe
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
Power supply	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
Consumption	*Versions with RS485 output:* 2 mA average / 15 mA peak @ 12 Vdc *Versions with analog output:* 2.5 mA average / 15 mA peak @ 12 Vdc *Versions with SDI-12 output:* 300 µA @ 12 Vdc in standby <15 mA @ 12 Vdc during measurement
Output	Depending on model: • RS485 with MODBUS-RTU protocol • SDI-12 • 0.5…3 V analog voltage (0.5 V=0 %VWC or -40 °C , 3 V=60 %VWC or +60 °C, minimum load resistence 10 kΩ)
Materials	Handle: thermoplastic material and epoxy resin Electrodes: epoxy glass, thickness 2 mm
Connection	Fixed cable with open wires at the end, length 5 or 10 m standard
Protection degree	IP 67
Weight	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.
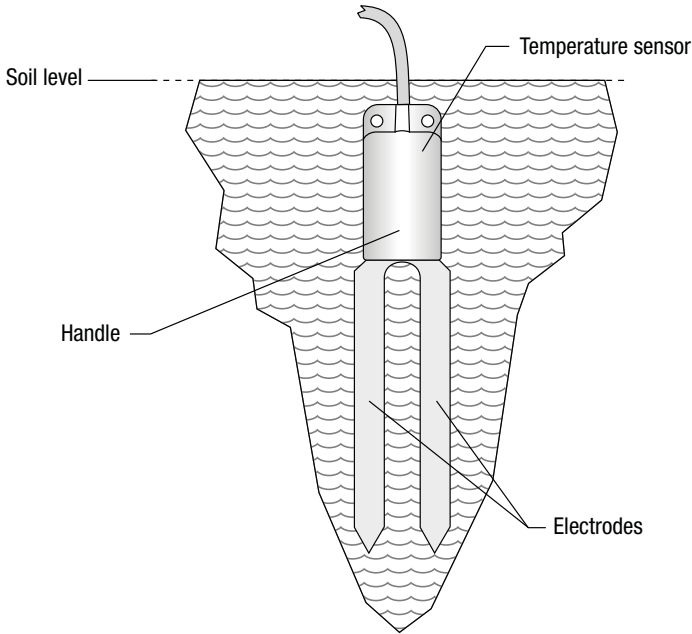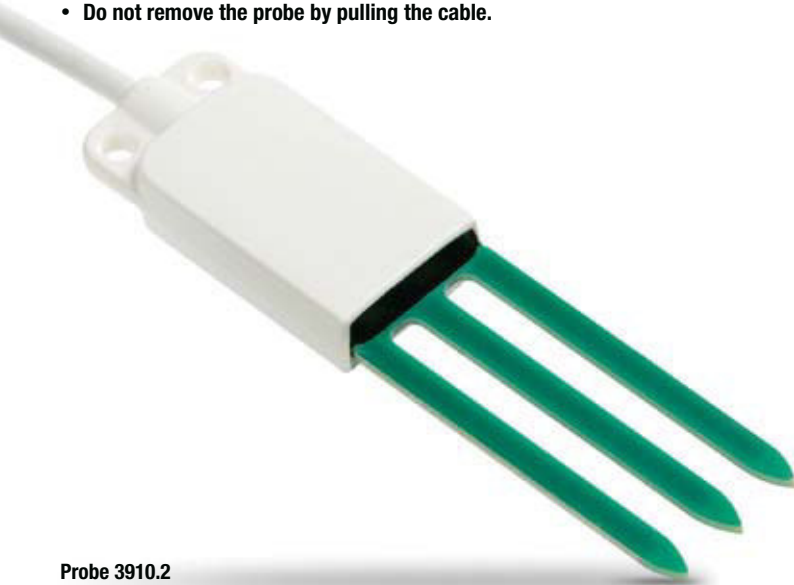

Fig. 2: Installation

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.**

Probe 3910.2

Connections

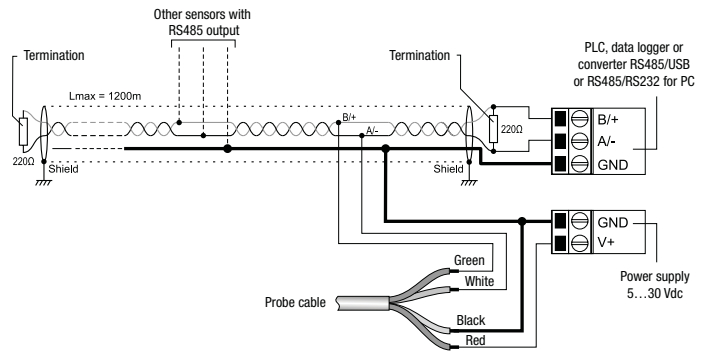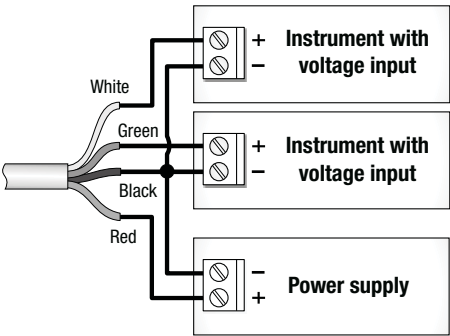| Wire color	Function		
	RS485 output	SDI-12 output	Analog output
Black	Negative power supply	Negative power supply/output	Negative power supply/output
Red	Positive power supply	Positive power supply	Positive power supply
White	RS485 A/-	Positive SDI-12 output	Positive %VWC output
Green	RS485 B/+	---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

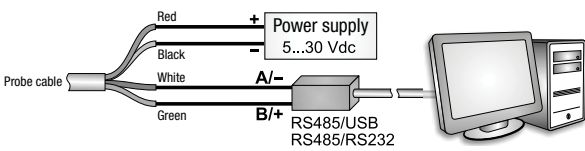**Fig. 5: connection to PC**

Notes on the installation of unsigned USB drivers: before installing unsigned USB drivers in 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	*b p w a*	Baud Rate:
		  b=**0** ==> 9600, b=**1** ==> 19200
		RS485 transmission mode:
		  p=**0** ==> 8N1, p=**1** ==> 8N2,
		  p=**2** ==> 8E1, p=**3** ==> 8E2,
		  p=**4** ==> 8O1, p=**5** ==> 8O2
		Read reception mode after RS485 transmission:
		  w=**0** ==> violate protocol and go in Rx mode right
		      after Tx
		  w=**1** ==> respect protocol and wait 3.5 characters
		      after Tx
		a= 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 modifed 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
a!	a<CR><LF>	Verifes the presence of the probe.

aI!	allccccccccmmmmmmvvvsssssssss<CR><LF>
	with:
	    a = address of the probe (1 character)
	    ll = SDI-12 compliant version (2 characters)
	    cccccccc = manufacturer (8 characters)
	    mmmmmm = probe model (6 characters)
	    vvv = firmware version (3 characters)
	    ssssssss = 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.

aAb! 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.	Modifcation of the probe address.
?!	a<CR><LF>	Request of the address of the probe. If more than one probe is connected to the bus, a conflict occurs.
Type M (start measurement) and type C (start concurrent measurement) commands		
VWC and temperature		

aM!
aC!
	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.

aD0!	a+n+w…w+t…t<CR><LF>
	with:
	n = content of the status register
	w…w = volumetric water content (m3/m3)
	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 (m3/m3)
	                                    = 32.5%
	    soil temperature = 17.6 °C
		Reads the measurement.

Permittivity		

aM1!
aC1!
	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.

aD0!	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.

Signal level and temperature		

aM2!
aC2!
	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.

aD0!	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

HD3910.☐.☐.☐

Cable length:
5 = 5 m
10 = 10 m

Output type:
Blank = RS485 Modbus-RTU output
S = SDI-12 output
A = 0.5…3 V analog output **(other ranges on request)**

Probe type:
1 = 2-electrode
2 = 3-electrode   for the measurement in restricted volumes

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