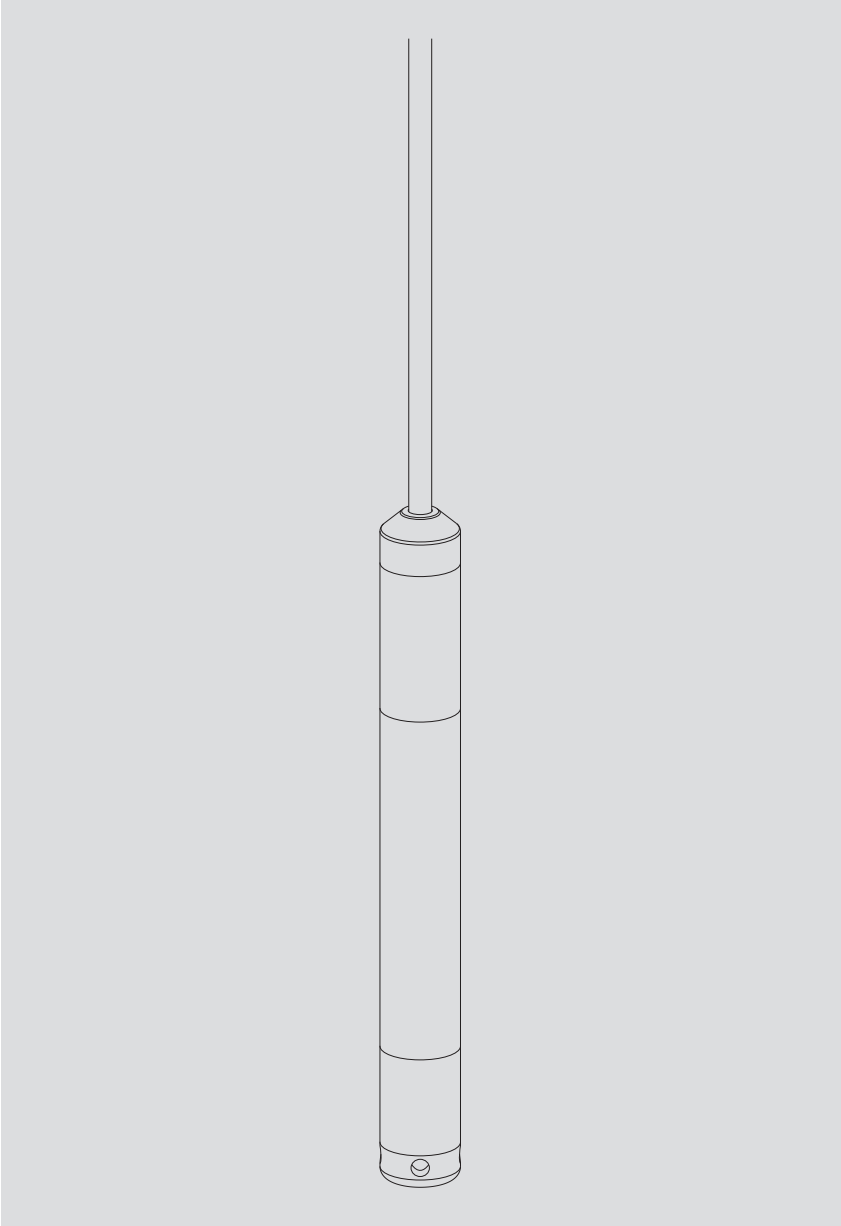
Operating instructions

Pressure Probe OTT PLS 500



English

We reserve the right to make technical changes and improvements without notice!

Table of contents

1 Scope of supply

▶ OTT PLS 500

– 1 Pressure probe with a ceramic, capacitive, relative pressure measuring cell and shielded pressure probe cable with pressure compensation capillary and Kevlar-strain relief for length stabilization; SDI-12- and RS-485 interface; pre-fabricated cable end with transport protection against moisture
– 1 Factory acceptance test certificate (FAT)

2 Order numbers and variant code

▶ OTT PLS 500 **Pressure probe** 63.039.001.9.0

required order information (variant code):

– Protocol RS-485 interface	SDI-12	S
	Modbus	M
– Preset units	metric	M
	imperial	I
– Measuring range	0 … 10 m · 33 ft WC / 0 ... 1 bar	1
	0 … 20 m · 66 ft WC / 0 ... 2 bar	2
	0 … 40 m · 131 ft WC / 0 ... 4 bar	3
	0 … 100 m · 328 ft WC / 0 ... 10 bar	4
– Cable length	2 … 200 m · 6.5 … 656 ft	xxx.x
– Humidity absorber	without	0
	including FAD 4PF	4
	including FAD 6	6
– Operating instructions	without	0
	German	D
	English	E
	French	F
	Spanish	S

▶ Accessories

Humidity absorbing system OTT FAD 4PF 63.025.021.4.2
– Desiccant cartridge in wide-necked bottle with connection hose for pressure compensation capillary

Humidity absorbing system OTT FAD 6 63.039.025.3.2
– connecting box (pressure probe cable ↔ connection cable data logger/voltage supply) with desiccant cartridge in wide-necked bottle

Desiccant cartridge 97.100.066.4.5
– replacement cartridge in transport container

Cable suspension 97.140.253.9.5

Connection cable 97.000.040.9.5
– twisted pair construction; LiYY
– PVC, black
– 2 x 2 x 0.75 mm²
– unshielded

Connection cable 97.000.039.9.5
– twisted pair construction; FD CP (TP)
– PVC, grey
– 2 x 2 x 0.5 mm²
– shielded

OTT USB/SDI-12 Adapter 65.050.002.9.2
– for temporary connection of OTT sensors with SDI-12 or RS-485 interface to a PC
– USB connection cable included; USB plug A to USB plug B; 3 m

3 Basic safety information

3.1 Markings and symbols used in the instruction

■ This bullet point indicates an instruction relating to a specific action.

▶ This bullet point indicates an item in a list.
– This bullet point indicates a sub-item in a list.

Remark: …
▶ Information on easier and more efficient work
▶ Further information
▶ Definition

Please note: …
Information that prevents potential damage or malfunction on the OTT PLS 500.

3.2 Explanation of safety information used

The safety information used in these operating instructions is classified according to the nature and severity of a particular hazard. The hazard levels defined are indicated by the signal words **Warning/Caution** and associated pictograms **orange/yellow warning triangle** in these operating instructions:

WARNING

Warning of a hazardous situation with a medium level of risk

The safety information specifies the nature and source of the hazard. If you fail to carry out the specified actions, the hazardous situation can result in **death** or **serious injuries**.

▶ Action to prevent the hazardous situation!
▶ Action to prevent the hazardous situation!

CAUTION

Warning of a hazardous situation with a lower level of risk

The safety information specifies the nature and source of the hazard. If you fail to carry out the specified actions, the hazardous situation can result in **minor** or **moderately severe injuries**.

▶ Action to prevent the hazardous situation!
▶ Action to prevent the hazardous situation!

3.3 Note the following for safe and trouble-free operation

! ▶ Read these operating instructions before using the OTT PLS 500 for the first time! Become completely familiar with the installation and operation of the OTT PLS 500 and its accessories! Keep these operating instructions for later reference.

▶ Only use the OTT PLS 500 as described in the operating instructions! The intended use of the OTT PLS 500 is to measure the water level and water temperature of natural ground and surface waters (hydrometry). Any other use is not permitted! For further information → see Chapter 4, "Introduction".

▶ Only install and maintain the OTT PLS 500 if you are appropriately qualified to do so! If necessary, arrange training by OTT HydroMet.

▶ Please note all safety and warning information given with the individual work steps.

▶ Ensure that the electrical, mechanical, and climatic specifications listed in the technical data are adhered to!
For further information → see Chapter 13, "Technical data".

▶ Handle the pressure probe cable with care: do not kink the cable or pull it across sharp edges! Minimum bending radius of pressure probe cable: 49 mm.

▶ Only operate the OTT PLS 500 with a humidity absorber installed!
Service the humidity absorber at regular intervals!

▶ Do not make any changes or retrofits to the OTT PLS 500! If changes or retrofits are made, all guarantee claims are voided.

▶ Have a faulty OTT PLS 500 inspected and repaired by our repair center!
On no account carry out repairs yourself!
For further information → see Chapter 11, "Repair".

▶ After putting the OTT PLS 500 out of service, properly dispose of the device.
On no account put the OTT PLS 500 into the normal domestic waste.
For further information → see Chapter 12, "Notes about the disposal of old units".

! ▶ The product has only the approvals listed and the registrations, certificates and declarations officially provided with the product. The usage of this product in an application for which it is not permitted is not approved by the manufacturer.

4 Introduction

The pressure probe OTT PLS 500 is used for precisely measuring water level of ground and surface waters. The pressure probe uses the hydrostatic pressure of the water column above a relative pressure measuring cell. A pressure compensation capillary in the pressure probe cable gives the measuring cell the current ambient air pressure as a reference. Erroneous measurement results due to atmospheric air pressure fluctuations are thus eliminated.

The OTT PLS 500 can be supplied with various measuring ranges:

- 0 … 10 m water column (0 ... 1 bar)
- 0 … 20 m water column (0 ... 2 bar)
- 0 … 40 m water column (0 ... 4 bar)
- 0 … 100 m water column (0 ... 10 bar)

The pressure probe has two interfaces that can be used in parallel:

- SDI-12 interface
- EIA-485 (RS-485) interface (SDI-12 or Modbus (RTU) protocol)

The OTT PLS 500 can be configured in many ways via the SDI-12 transparent mode of a data logger or with the aid of the "OTT USB/SDI-12 Adapter" interface converter. For example, a reference or offset value can be entered upon initial setup

A particular feature is that the pressure probe measures the water temperature as well as the hydrostatic pressure of the water column and thus yields highly precise and reproduceable measurement results by compensating effects of temperature, specific density or salinity of the water and the local gravitational acceleration at the specific station. (For this, the specific density or the salinity and the local gravitational acceleration must be entered upon the initial setup.)

The OTT PLS 500 performs four individual measurements within one second; duration 250 milliseconds each. An OTT PLS 500 measurement interval is defined as the arithmetic mean of individual measurements over an adjustable averaging time. The averaging time is 0.5 … 59.5 seconds (corresponding to 2 … 238 individual measurements; factory setting: 1.5 seconds).

At the SDI-12 and RS-485 interfaces, the OTT PLS 500 outputs either the water level (compensated) or the hydrostatic pressure as well as the water temperature. Measurement units can be set with SDI-12 commands as m · cm · mm · ft · inch (water level measurement), bar · mbar · kPa · psi (pressure measurement) and °C · °F · K (temperature measurement). The pressure probe is available with preset metric or imperial units by using a variant code.

Two different humidity absorbing systems are available as accesories for drying the ambient air entering the pressure compensation capillary.

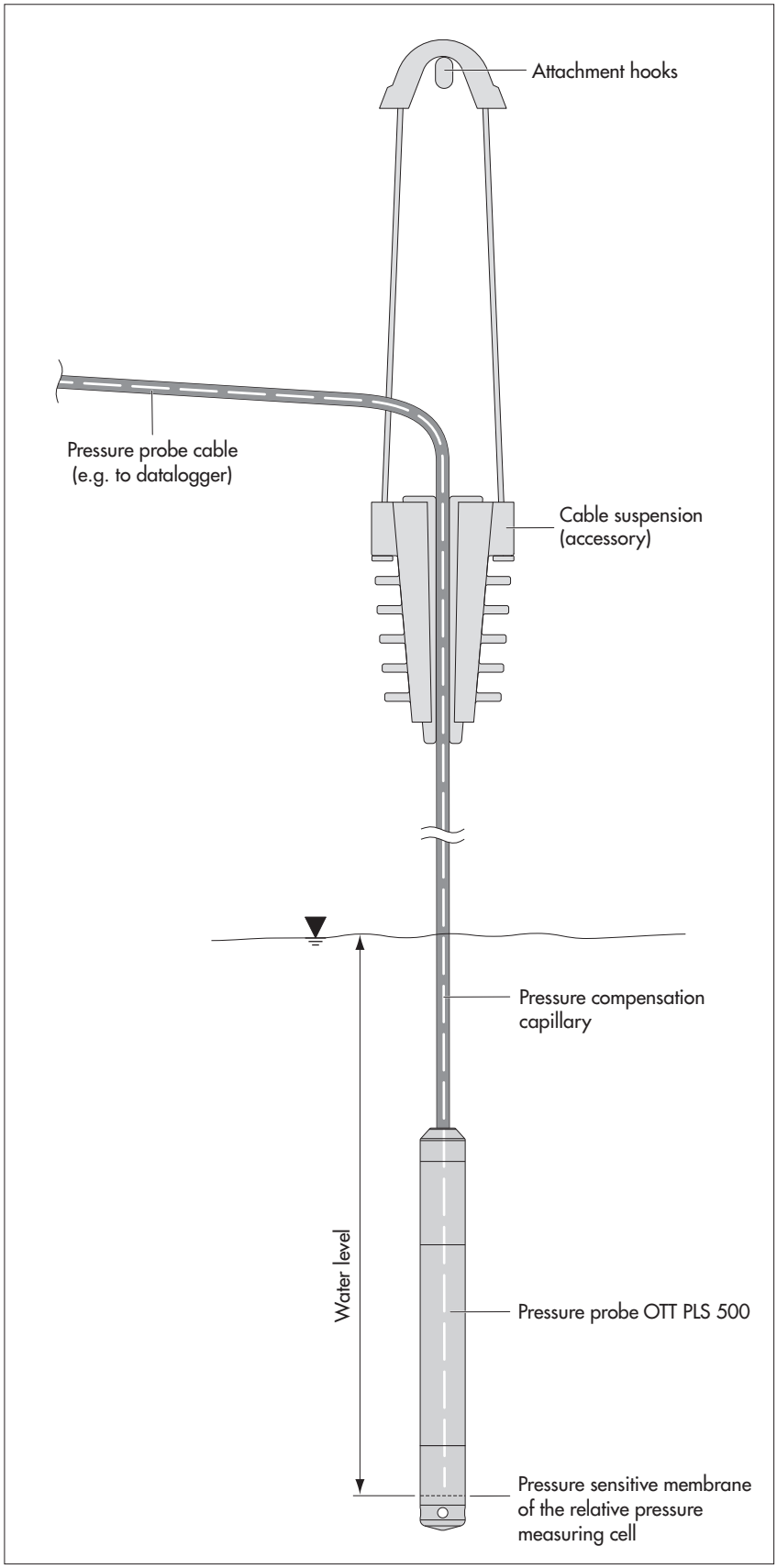
The pressure probe is installed either in an individual protective device adapted to the respecive installation site and to be provided by the customer or suspended from the pressure probe cable. A cable suspension specially adapted to the pressure probe cable is available as accessory.

In addition to the actual measured values water level and temperture, the OTT PLS 500 records additional operating parameters and makes them available as meta data. This enables comprehensive remote monitoring of the pressure probe. Also, statistical data within each measurement interval will be determined.

The OTT PLS 500 can also calculate the current discharge of a water course from the measured water level. This is a special function that can be activated as an option. To use this function, a rating table or the factors of the exponential formula according to ISO 1100-2-standard must be entered upon the initial setup.

Fig 1: Principal setup of a water level measuring station with pressure probe OTT PLS 500.

(Shown as example: Installation type B – pressure probe suspended; see Chapter 5.2.)



5 Installing the pressure probe

WARNING **Risk of explosion due to spark formation and electrostatic charge**

If the OTT PLS 500 is operated in an explosive atmosphere, there is a risk of the atmosphere igniting. This can cause an explosion involving a risk of very severe injury and damage.

- Never operate the OTT PLS 500 in potentially explosive areas (e.g. waste water channels). The OTT PLS 500 does not have EX protection (explosion protection)!

WARNING **Risk of strangulation by pressure sensor cable!**

Hanging a pressure sensor cable around the neck during transportation/installation can lead to strangulation if sufficient care is not exercised.

- Never hang the pressure probe cable around the neck!

CAUTION **Risk of crushing fingers/hands during installation**

Fingers/hands can become trapped or crushed when lowering the pressure probe into the observation well/fixing the pressure probe in a protection device.

- Wear protective gloves during installation!

The OTT PLS 500 pressure probe can be used in a variety of ways, for example, in observation wells and boreholes from 1" diameter, in shafts, open waterways, and in waterways that do not always hold water.

The pressure probe can be installed in two ways:
- **Installation type A:** fixed in an individual protection device (e.g. plastic pipe), adapted to the respective instatllation site and to be built on site
- **Installation type B:** hung on the pressure probe cable

! **Please note:** We do not recommend installing the pressure probe in the vicinity of port facilities, industrial waste water discharges or areas with heavy chemical contamination. The pressure probe is constructed from high-quality stainless steel and plastic. However, depending on the mounting location, damaging corrosion can arise. For more information on the materials used, see Chapter 13 "Technical data".

Required accessories

- Humidity absorber OTT FAD 4PF or OTT FAD 6
- Installation type A: protection device; possibly fixing pin (see Fig. 2)
- Installation type B: OTT cable suspension (see Fig. 1)

Required tools

- Screwdriver

! **Please note:** No moisture should be allowed to enter the pressure compensation capillary of the pressure probe cable during installation! Very high humidity can lead to condensed water drops in the pressure compensation capillary due to temperature fluctuations. This results in unusable measurement results! Therefore, leave the transport protection on the cable end during the entire installation phase of the pressure probe cable.

5.1 Installation type A: fixing the pressure probe into a protective device

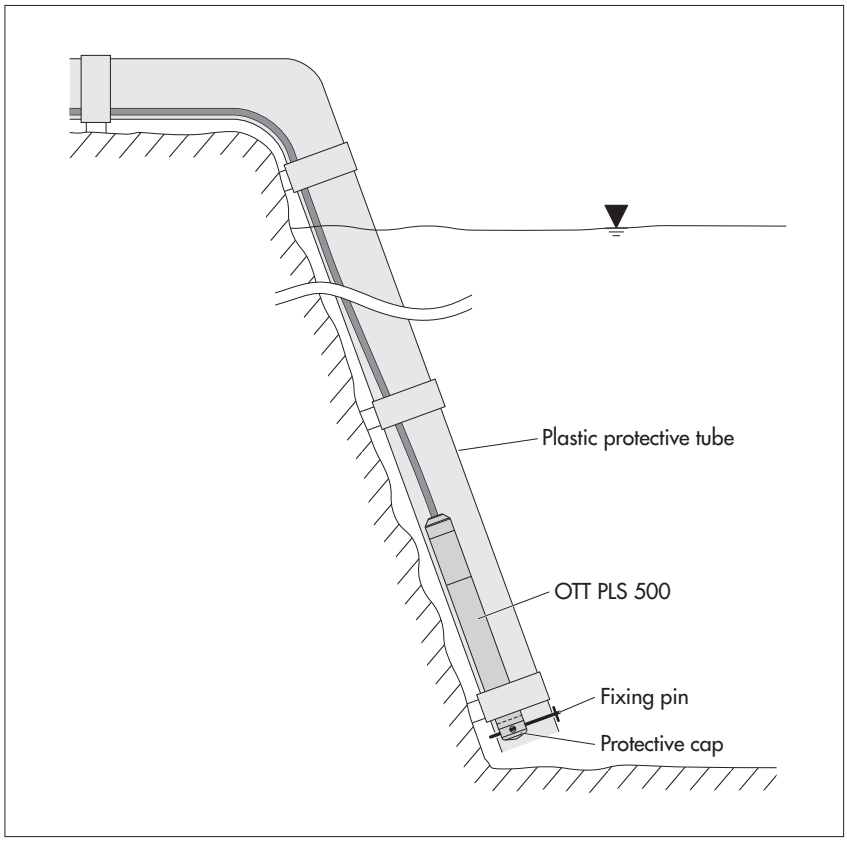
In flowing waters or waterways with a swell, the pressure probe must be fixed. With strong currents (> 0.5 … 1 m/s) the hydrodynamic influences of the station have to be considered in the installation. Depending on the version and mounting of the individual components, overpressure or negative pressure can arise that can affect the measurement result.

- Determine the minimum and maximum water level at your station (e.g. staff gauge, contact gauge). Use both values to specify the probe position. The following conditions must be fulfilled:
  – position the probe below the minimum water level if possible;
  – difference between max. water level and position of the probe < measuring range of the probe.
- Fix the pressure probe according to your individual requirements in a protective device, as shown in Fig. 2 for example.

Note: The fine setting of the probe position is carried out, for example, by entering a reference or offset value (see Chapter 6, "Configuring/testing the OTT PLS 500") or using a scaling function of the data logger connected.

Fig. 2: Installation example of the OTT PLS 500 in open waterways.

With waterways with currents or swell, a fixing pin is used to securely fasten the probe.
Push the fixing pin through the holes in the black protective cap.



5.2 Installation type B: hanging the pressure probe

See also Fig. 1.

- Determine the minimum and maximum water level at your station (e.g. staff gauge, contact gauge). Use both values to specify the probe position. The following conditions must be fulfilled:
  – position the probe below the minimum water level if possible;
  – difference between max. water level and position of the probe < measuring range of the probe.
- Fix the cable suspension (accessory) at a suitably sized attachment point.
- Carefully lower the pressure probe on the pressure probe cable to the specified depth. There are markings on the cable every 0.25 m to assist orientation.
- Lay the pressure probe cable in the opened clamping jaws of the cable suspenstion as shown in Figure 1 and secure the pressure probe cable by pushing the clamping jaws together. The mechanical longitudinal stability required is provided by the Kevlar-strain relief inside the pressure probe cable.

! **Please note:** maximum hanging depth: 150 m!
(greater depths on request).

i **Note:** The fine setting of the probe position is carried out, for example, by entering a reference or offset value (see Chapter 6, "Configuring/testing the OTT PLS 500") or using a scaling function of the data logger connected. Therefore, in many applications it is sufficient to position the pressure probe approximately.

5.3 Connecting humidity absorbing system

A humidity absorbing system must be installed for drying the surrounding air that enters the pressure compensation capillary of the pressure probe cable!

The humidity absorbers OTT FAD 4PF and OTT FAD 6 are available as accessories (see Chapter 2, "Accessories"). The OTT FAD 6 humidity absorber also serves as connection box (pressure probe cable ↔ connection cable data logger/voltage supply).

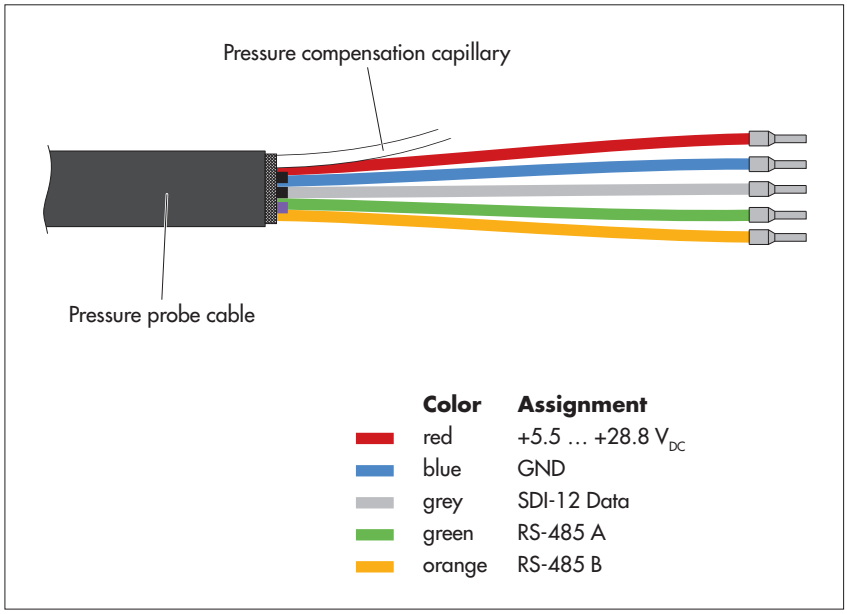
- Install the humidity absorber at a dry place and connect the pressure compensation capillary to the humidty absorber; observe the operating instructions of the humidity absorber used!

Please note: Humidity entering the pressure compensation capillary of the pressure probe cable leads to unusable measurement results!

5.4 Wire assignment of the pressure probe cable

Fig. 3: Wire assignment of the OTT PLS 500 pressure probe cable.

Note: The pressure probe cable has a cable shield which is shortened to the cable sheath at the factory during stripping. The cable shield must not be connected to earth/ground when installing the OTT PLS 500!



Please note: The factory assembled pressure probe cable should only be shortened with a suitable wire stripping tool (see accessories)! Danger of damaging the cable! Recommendation: if required, store a slightly too long pressure probe cable in loops – taking into account the minimum bending radius. Find instructions how to shorten the pressure probe cable in Annex A.

If necessary, the pressure probe cable can be lengthened. For this purpose, use a suitable junction box (e.g. humidity absorber OTT FAD 6). This should be large enough to hold the humidity absorbing system! The maximum cable length for the RS-485 interface is 1,000 m; for the SDI-12 interface 200 m! Recommended cable type for the RS-485 interface: twisted pair cable (paired stranded wires); shielded. The wires provided for the voltage supply can, but do not have to be twisted pairs. Recommended cable type for the SDI-12 interface: unshielded low-voltage cable.

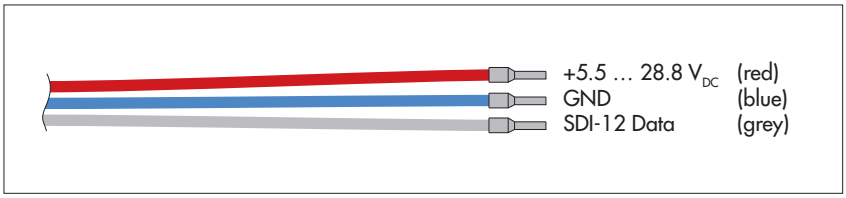
Suitable wire sizes:

- up to 500 m cable length: 2 x 2 x 0.5 mm² (41 Ohm/1000 m)
- 500 to 1000 m cable length: 2 x 2 x 0.75 mm² (27 Ohm/1000 m)

5.5 Connecting the OTT PLS 500 to any data logger using an SDI-12 interface

- Connect the OTT PLS 500 to an SDI-12 input of the data logger. Follow the data logger handbook when doing this. Refer to Fig. 4 for the wire assignments of the OTT PLS 500; wires used: red, blue and grey. The maximum cable length is 200 m!

Fig. 4: Wires used with an SDI-12 interface



Note: In an SDI-12 bus, the supply voltage (12 volt line) is 12 volts according to the standard, max. 16 volts. Take this into account if there are other sensors in the SDI-12 bus in addition to the OTT PLS 500!

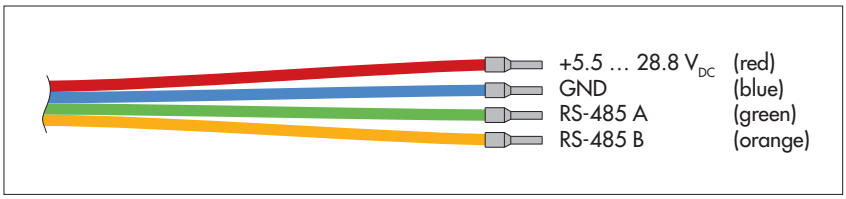
Refer to Chapter 5.7 or 5.8 for detailed information on connecting the OTT PLS 500 to OTT/Sutron data loggers.

The SDI-12 commands and responses used with the OTT PLS 500 can be found in Chapter 7, "SDI-12 Commands and Responses".

5.6 Connecting the OTT PLS 500 to any data logger/electronic control system using an RS-485 interface

- Connect the OTT PLS 500 to an RS-485 input of a data logger/an electronic control system. Follow the handbook of data logger/electronic control system when doing this. Refer to Fig. 5 for the wire assignments of the OTT PLS 500; used wires: red, blue, green and orange. The maximum cable length is 1000 m! Required wire cross section, see Chapter 5.4.

Fig. 5: Wires used with an RS-485 interface



Note on using the physical RS-485 interface:
Depending on the probe variant, the RS-485 supports the SDI-12 or the Modbus (RTU) transmission protocol. The RS-485 interface in combination with the SDI-12 protocol is designed and tested for use on OTT and Sutron data loggers! OTT Hydromet provides no guarantee of functionality if you connect the OTT PLS 500 via the RS-485 interface (SDI-12 protocol) to a data logger of a third-party manufacturer.

Refer to Chapter 5.7 or 5.8 for detailed information on connecting the OTT PLS 500 to OTT/Sutron data loggers.

The SDI-12 commands and responses used with the OTT PLS 500 can be found in Chapter 7, "SDI-12 Commands and Responses"; find information on the Modbus (RTU) transmission protocol in Chapter 8, Modbus protocol (RTU).

5.7 Connecting the OTT PLS to the IP data logger OTT netDL using an SDI-12 or RS-485 interface

Variant A: Connecting the OTT PLS 500 using an SDI-12 interface (protocol and physical interface: SDI-12). The maximum cable length is 200 m!

- Connect the OTT PLS 500 to the IP data logger OTT netDL as shown in Fig. 6 (right). Also follow the operating instructions of the OTT netDL.

Variant B: Connect the OTT PLS 500 using a physical RS-485 interface (SDI-12 protocol via physical RS-485 interface). The maximum cable length is 1000 m! Required wire cross section, see Chapter 5.4.

- Connect the OTT PLS 500 to the IP data logger OTT netDL as shown in Fig. 6 (left). Also follow the operating instructions of the OTT netDL.

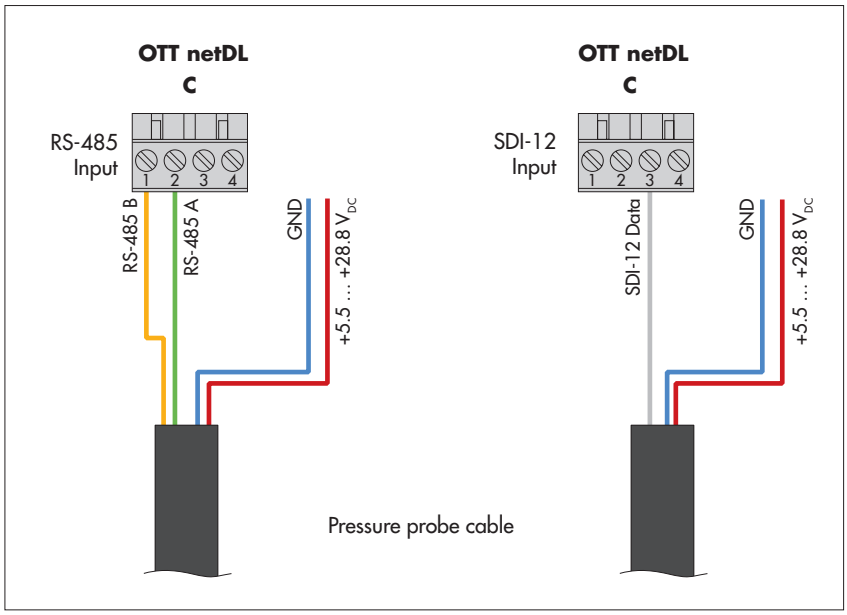


Fig. 6: Connecting the OTT PLS 500 to an OTT netDL using the RS-485-interface (SDI-12 protocol; left) or using the SDI-12 interface (right).

The letters above the screw terminal strips identify the connectivity options available on the OTT netDL.

The other (not used) wires of the pressure probe cable are not shown.

- Configure the OTT netDL IP data logger as described in the operating instructions of the device and in the online help of the "OTT Data Logger Operating Program".

5.8 Connecting the OTT PLS 500 to the Sutron XLINK 100/500 data logger using an SDI-12 or RS-485 interface

Variant A: Connecting the OTT PLS 500 using an SDI-12 interface (protocol and physical interface: SDI-12). The maximum cable length is 200m!

- Connect the OTT PLS 500 to the Sutron XLINK 100/500 data logger as shown in Fig. 7 (right). Also follow the operating instructions of the Sutron XLINK 100/500.

Variant B: Connect the OTT PLS 500 using a physical RS-485 interface (SDI-12 or Modbus protocol via physical RS-485 interface). The maximum cable length is 1000 m! Required wire cross section, see Chapter 5.4.

- Connect the OTT PLS 500 to the Sutron XLINK 100/500 data logger as shown in Fig. 7 (left). Also follow the operating instructions of the Sutron XLINK 100/500.

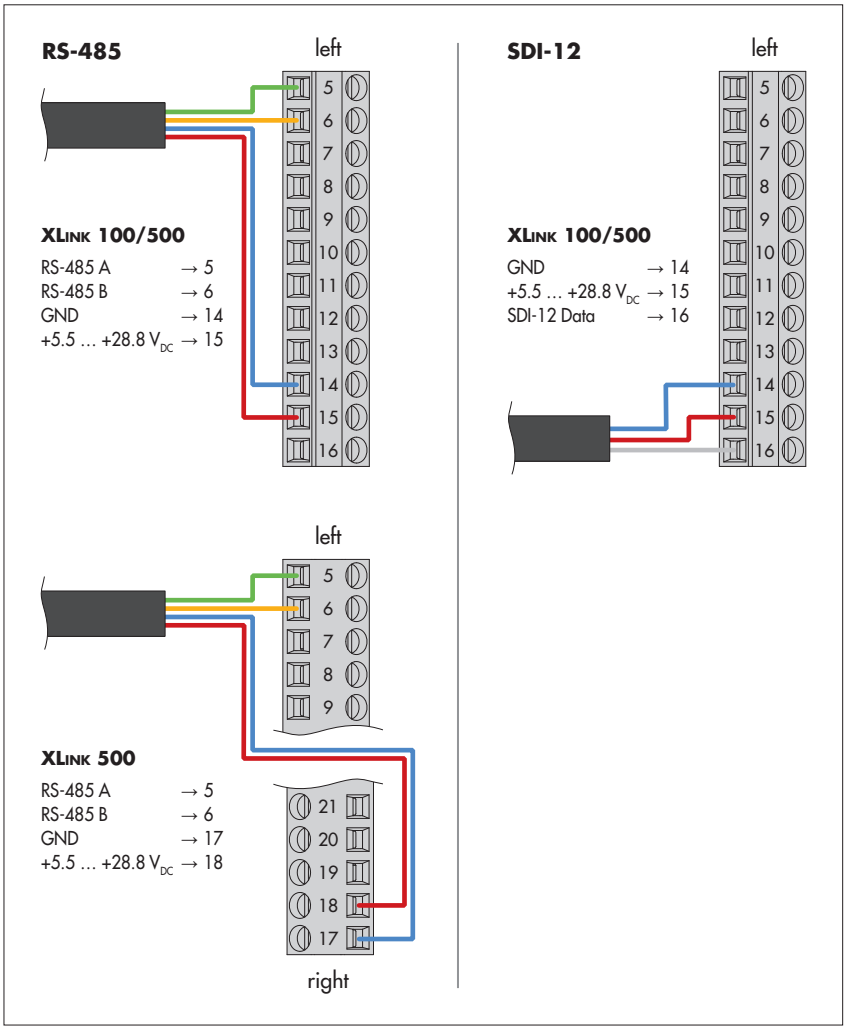


Fig. 7: Connecting the OTT PLS 500 to a Sutron XLINK 100/500 via RS-485 interface (SDI-12- or Modbus protocol; left) or via SDI-12 interface (right). The connection of the power supply of the RS-485 interface to a Sutron XLINK 500 can be made in two ways.

The other (not used) wires of the pressure probe cable are not shown.

- Configure the Sutron XLINK 100/500 data logger as described in the operating instructions of the device.

5.9 Connecting the OTT PLS to the Sutron SatLink 3 data logger using the SDI-12 or RS-485 interface

Variant A: Connecting the OTT PLS 500 using an SDI-12interface (protocol and physical interface: SDI-12). The maximum cable length is 200 m!

- Connect the OTT PLS 500 to the Sutron SatLink 3 satellite transmitter as shown in Fig. 8 (right). Also follow the operating instructions of the Sutron SatLink 3.

Variant B: Connecting the OTT PLS 500 using a physical RS-485 interface (SDI-12 or Modbus protocol via physical RS-485 interface). The maximum cable length is 1000 m! Required wire cross section, see Chapter 5.4.

- Connect the OTT PLS 500 to the Sutron SatLink 3 satellite transmitter as shown in Fig. 8 (left). Also follow the operating instructions of the Sutron SatLink 3.

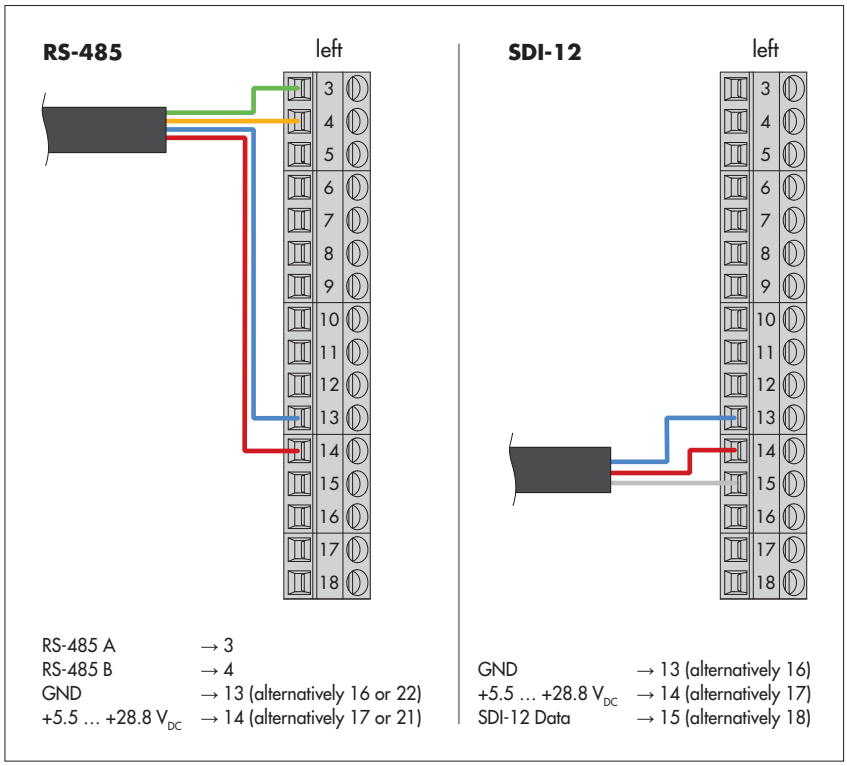


Fig. 8: Connectig the OTT PLS 500 to the Sutron SatLink 3 via RS-485 interface (SDI-12 or Modbus protocol, left) or via SDI-12 interface (right).

The other (not used) wires of the pressure probe cable are not shown.

- Configure the Sutron SatLink 3 satellite transmitter as described in the operating instructions of the device.

6 Configuring/testing the OTT PLS 500

The OTT PLS 500 is immediately ready for operation with the standard configuration provided by factory settings. In this case, the pressure probe operates – depending on the variant code ordered (see Chapter 2) with the factory settings (see Chapter 7).

If required, you can make various settings and enter operating parameters after the installation:

- Units
- Local gravitational acceleration
- Salinity
- Medium water density
- Sensor orientation during installation
- Measurement mode "level" or "depth"
- Averaging time
- Measurement type (single measurement or continuous measurement)
- Offset value for level/depth measurement
- Reference value for level/depth measurement
- Presetting metric or imperial
- Reset pressure probe
- Calculation method discharge measurement
- Rating table and exponential formula for discharge measurement

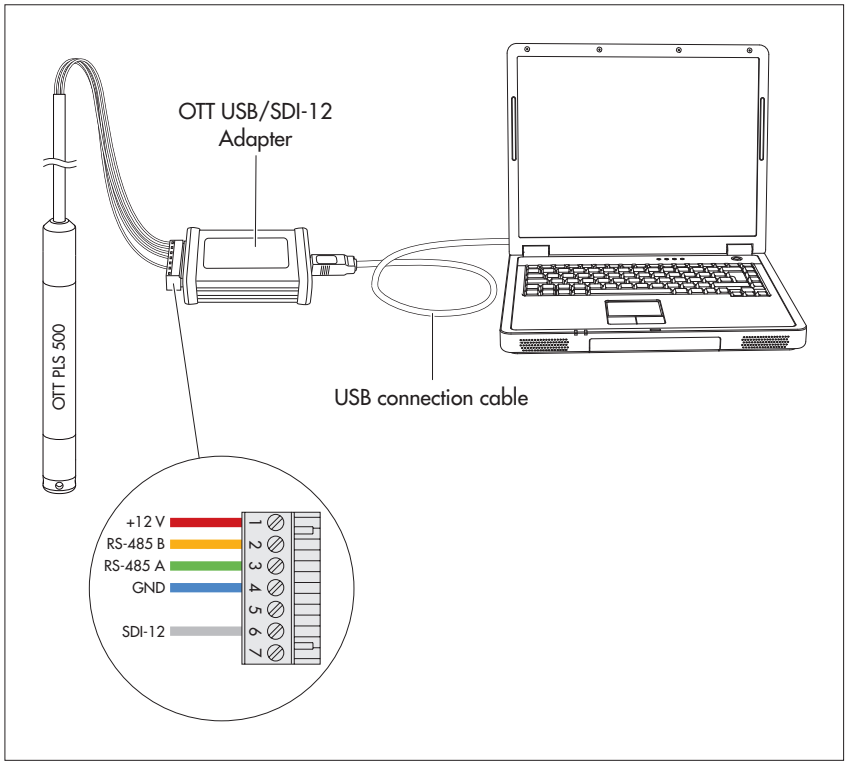
This configuration is carried out via the "OTT USB/SDI-12 Adapter" interface converter toghether with the "OTT SDI-12 Interface" PC software; optionally via the SDI-12 or RS-485 interface. In addition, it is possible to store the sensor orientation, to carry out a control measurement or a system test. In the event of an error, various meta data can be queried for closer analysis.

For this purpose, the pressure probe must be temporarily connected to a PC via the interface converter.

The PC software automatically detects the connected OTT PLS 500 and conveniently provides the SDI-12 commands available for the configuration as buttons.
In Chapter 7.1 you find an overview of these SDI-12 commands.
Alternatively, the configuration can be changed via the "SDI-12 transparent mode" of a data logger (please observe operating instructions of the data logger).

Note: For more information on the OTT USB/SDI-12 Adapter, please refer to the "Operating instructions OTT USB/SDI-12 Adapter" and "Online help OTT SDI-12 Interface Software"!

Fig. 9: Changing the factory configuration of an OTT PLS 500 via SDI-12 commands using the "OTT USB/SDI-12 Adapter".



7 SDI-12 Commands and Responses

The OTT PLS 500 communicates either using the physical SDI-12 interface or the RS-485 interface via the SDI-12 transfer protocol. In this technical documentation, you will find a detailed description of the SDI-12 commands implemented in the SDI-12 transfer protocol.

Further information on the SDI-12 standard can be found in the document "SDI-12; A Serial-Digital Interface Standard for Microprocessor-Based Sensors; Version 1.4" (see website "www.sdi-12.org").

All advanced, manufacturer-specific SDI-12 commands on the OTT PLS 500 begin with "**X**". With these commands it is possible to configure the OTT PLS 500, for example using the "SDI-12 transparent mode" on a data logger or with the OTT USB/SDI-12 adapter (accessory).

Conventions for measured value formats

p – sign (+,–; if it is omitted from entries, the OTT PLS 500 automatically adds a "+")
b – numbers (before the decimal point)
e – numbers after the decimal point

7.1 Overview of SDI-12 commands

Standard commands

a!	Confirmation active
aI!	Send identification
aAb!	Change sensor address
?!	Query sensor address; factory setting: **0**
aV!	Carrying out a system test
aM!	Start the measurement
aM1!	Start measurement including statistical values
aMC!	Start the measurement and request CRC [1]
aMC1!	Start measurement including statistical values and request CRC [1]
aC!	Start concurrent measurement [2]
aC1!	Start concurrent measurement [2] including statistical values
aCC!	Start concurrent measurement [2] and request CRC [1]
aCC1!	Start concurrent measurement [2] including statistical values and request CRC [1]
aM2!	Query meta data of last measurement
aMC2!	Query meta data of last measurement including CRC [1]
aC2!	Query meta data of last measurement in concurrent mode
aCC2!	Query meta data of last measurement including CRC [1] in concurrent mode
aR0!	Query data of continuous measurements
aR1!	Query data of continuous measurements including statistical values
aRC0!	Query data of continuous measurements including CRC [1]
aRC1!	Query data of continuous measurements including statistical values and CRC [1]
aR2!	Query meta data of last measurement for continuous measurements
aRC2!	Query meta data of last measurement for continuous measurements including CRC [1]
aHA!	Start "High Volume ASCII" measurement including statistical values and request CRC [1]
aHB!	Start "High Volume Binary" measurement including statistical values and request CRC [1]
aD0!	Send data after **aM!**; **aM1!**; **aM2!**; **aMC!**; **aMC1!**; **aMC2!**; **aC!**; **aC1!**; **aC2!**; **aCC!**; **aCC1!**; **aCC2!**; **aHA!**; **aV!**
aD1!	Send data after **aM1!**; **aM2!**; **aMC1!**; **aMC2!**; **aC1!**; **aC2!**; **aCC1!**; **aCC2!**; **aHA!**; **aV!**
aD2!	Send data after **aM1!**; **aM2!**; **aMC1!**; **aMC2!**; **aC1!**; **aC2!**; **aCC1!**; **aCC2!**; **aV!**
aDB0!	Send data after **aHB!**
aDB1!	Send data after **aHB!**

[1] Cyclic Redundancy Check
[2] simultaneous measurement with multiple sensors on one single bus line

Measured value overview standard commands [1]

	metric units		imperial units	
▶ Send data (D0) after **aM!** command				
<value1> level/pressure	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value2> water temperature	**pbb.ee**	[°C]	**pbbb.ee**	[°F]
<value3> device status	see below			
<value4> discharge [2]	**pbbb.eee**	[m³/s]	**pbbbbb.eee**	[ft³/s]
▶ Send data (D0, D1, D2) after **aM1!** command				
<value1> last single measured value "level/pressure" within the averaging time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value2> water temperature	**pbb.ee**	[°C]	**pbbb.ee**	[°F]
<value3> mean of measured values "level/pressure" within the averaging time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value4> minimum of measured values "level/pressure" within the averaging time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value5> maximum of measured values"level/pressure" within the averaging time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value6> median of measured values "level/pressure" within the averaging time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value7> standard deviation of measured values "level/pressure" within the averaging time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value8> device status; see below				
▶ Send data (D0, D1, D2) after **aM2!** command				
<value1> – relative humidity in the probe housing	**pbb.ee**	[% rH]	**pbb.ee**	[% rH]
<value2> – dew point in the probe housing	**pbb.ee**	[°C]	**pbb.ee**	[°C]
<value3> – current sensor orientation	**pbbb**	[°]	**pbbb**	[°]
<value4> – stored sensor orientation during installation	**pbbb**	[°]	**pbbb**	[°]
<value5> – temperature value of pressure sensor	**pbb.ee**	[°C]	**pbb.ee**	[°C]
<value6> – temperature of internal humidity sensor	**pbb.ee**	[°C]	**pbb.ee**	[°C]
<value7> – pressure value of pressure sensor	**pbbbb.ee**	[mbar]	**pbbbb.ee**	[mbar]
<value8> – standard deviation of pressure value of pressure sensor	**pbbbb.ee**	[mbar]	**pbbbb.ee**	[mbar]
<value9> – device status; see below				

▶ Device status [3]

+0 → no error occured
+1 → system reset – status flag is set when connecting the operating voltage/upon unexpected reset; deletion after status read out
+2 → raw value "pressure" outside the calibrated range (1 % tolerance of full scale is considered)
+4 → raw value "temperature" outside the calibrated range
+8 → sensor orientation change (deviation since installation ↔ currently ≥ 5°) [4]
+16 → overload pressure sensor (≥ +20 % of measuring range + offset)
+32 → pressure probe was reset to factory settings due to internal system error (including potential flow settings)
+64 → internal relative humidity was/is above limit (≥ 25 % rH)[5]

[1] with factory setting
[2] optional with activated discharge measurement; extended command **aXDC<value>!**
[3] if several errors/events occur at the same time, the OTT PLS 500 adds up the status values. Example: **+20** → overload pressure sensor (**+16**) + raw value "temperature" outside the calibrated range (**+4**); values ≥ **+128**: exclusively for internal service purposes
[4] change sensor orientation intended (e.g. new installation): → first reset pressure probe to factory setting with command **aXSF!**
[5] see also "Please note: …" in Chapter 9

Meta data commands

▶ **aIM!**	Determine response to associated	**aM!** command (does not start measurement)
aIM1!		… **aM1!**
aIM2!		… **aM2!**
aIMC!		… **aMC!**
aIMC1!		… **aMC1!**
aIMC2!		… **aMC2!**
aIC!		… **aC!**
aIC1!		… **aC1!**
aIC2!		… **aC2!**
aICC!		… **aCC!**
aICC1!		… **aCC1!**
aICC2!		… **aCC2!**
aIHA!		… **aHA!**
aIHB!		… **aHB!**
aIV!		… **aV!**

▶ **aIM_001!**	… **aIM_003!**[1)]	Query meta data for measured value 1 to 3[1)]; measured value in **aD0!** after	**aM!**
aIM1_001!	… **aIM1_008!**	Query meta data for measured value 1 to 8; measured value in **aD0!** … **aD2!** after	**aM1!**
aIM2_001!	… **aIM2_009!**	Query meta data for measured value 1 to 9; measured value in **aD0!** … **aD2!** after	**aM2!**
aIMC_001!	… **aIMC_003!**[1)]		… **aMC!**
aIMC1_001!	… **aIMC1_008!**		… **aMC1!**
aIMC2_001!	… **aIMC2_009!**		… **aMC2!**
aIC_001!	… **aIC_003!**[1)]		… **aC!**
aIC1_001!	… **aIC1_008!**		… **aC1!**
aIC2_001!	… **aIC2_009!**		… **aC2!**
aICC_001!	… **aICC_003!**[1)]		… **aCC!**
aICC1_001!	… **aICC1_008!**		… **aCC1!**
aICC2_001!	… **aICC2_009!**		… **aCC2!**
aIHA_001!	… **aIHA_018!**	Query meta data for measured value 1 to18; measured value in **aD0!**, **aD1!** after	… **aHA!**
aIHB_001!	… **aIHB_017!**	Query meta data for meas. value 1 to17; meas. value in **aDB0!**, **aDB1!** after	… **aHB!**
aIV_001!	… **aIV_009!**	Query meta data for measured value 1 to 9; value in **aD0!** … **aD2!** after	… **aV!**

[1)] 4 discharge measurement activated

Advanced commands (manufacturer-specific)

- **aXSU<value>!** Set the unit for level/depth measurements
  aXSU! Read the unit for level/depth measurements
  Factory setting: +0 → m (presetting metric); +2 → ft (presetting imperial)

- **aXST<value>!** Set the unit for temperature values
  aXST! Read the unit for temperature values
  Factory setting: +0 → °C (presetting metric); +1 → °F (presetting imperial)

- **aXSD<value>!** Set the unit for discharge values
  aXSD! Read the unit for discharge values
  Factory setting: +0 → m^3/s (presetting metric); +2 → ft^3/s (presetting imperial)

- **aXXG<value>!** Set local gravitational acceleration
  aXXG! Read local gravitational acceleration
  Factory setting: +9.806650 m/s^2

- **aXXS<value>!** Set salinity
  aXXS! Read salinity
  Factory setting: +0.000000 mg/l

- **aXXR<value>!** Set average water density
  aXXR! Read average water density
  Factory setting: +0.999975 kg/dm^3

- **aXXO!** Store sensor orientation during installation

- **aXAA<value>!** Set measuring mode "level" or "depth"
  aXAA! Read measuring mode
  Factory setting: +0 → Measuring mode "level measurement"

- **aXXM<value>!** Set averaging time
  aXXM! Read averaging time
  Factory setting: +1.5 s

- **aXXC<value>!** Set measuring mode
  aXXC! Read measuring mode
  Factory setting: +0 → Measuring mode "single measurement"

- **aXAB<value>!** Set offset value for level/depth measurements
  aXAB! Read offset value
  Factory setting: +0.000 m

- **aXAC<value>!** Set reference value for level/depth measurements
  aXAC! Read reference value
  Factory setting: +0.000 m

- **aXSR<value>!** Reset factory settings for units (metric or imperial)
  aXSR! Read factory settings for units
  Factoring setting: depending on the ordered variant code

- **aXSF!** Reset pressure probe to factory settings without communication settings
  aXSF+1! Reset pressure probe to factory settings including communication settings

- **aXDC<value>!** Set calculation method for discharge measurement
  aXDC! Read calculation method for discharge measurement
  Factory setting: +0 → discharge measurement "deactivated"

- **aXDA<value1><value2>!** Create table entry rating table (calculation method rating table)
- **aXDA<value1><value2><value3>!** Enter coefficients for discharge measurement (exponential formula)

- **aXDR<value>!** Read table entry rating table (calculation method rating table)
  aXDR! Read number of entries in rating table (calculation method rating table)
  aXDR! Read coefficients for discharge measurement (calculation method exponential formula)

- **aXDD<value>!** Delete table entry rating table
  aXDD+9999! Delete rating table completely

7.2 Standard commands

Command	Response	Description
a!	**a<CR><LF>**	Acknowledgement active **a** – sensor address; factory setting: **0**
aI!	**allccccccccmmmmmmvvv**… …**xxxxxxxxxxxxx<CR><LF>**	Send identification **a** – sensor address **ll** – SDI-12 protocol version **cccccccc** – manufacturer's identification (company name) **mmmmmm** – sensor identification **vvv** – sensor version (in this case firmware) **xxxxxxxxxxxxx** – additional identification (in this case serial number; max. 13 characters) OTT PLS 500 response **014OTTHYDROPLS500100**… …**xxxxxxxxxx**
aAb!	**b<CR><LF>**	Change sensor address **a** – old sensor address **b** – new sensor address
?!	**a<CR><LF>**	Query sensor address **a** – sensor address
aV!	**atttn<CR><LF>**	Perform system test **a** – sensor address **ttt** – time in seconds until the sensor provides the result of the system test response OTT PLS 500: **000** **n** – number of measured values response OTT PLS 500: **9**
aD0!	**a<value1><value2><value3>**… …**<CR><LF>**	Send data (after **aV!**) **a** – sensor address **<value1>** – relative humidity in the probe housing measured value format: **pbb** [% rH] **<value2>** – dew point in the probe housing measured value format: **pbb.ee** [°C] **<value3>** – current sensor orientation measured value format: **pbbb** [°]
aD1!	**a<value4><value5><value6>**… …**<CR><LF>**	Send data (after **aV!**) **a** – sensor address **<value4>** – sensor orientation during installation measured value format: **pbbb** [°] **<value5>** – corrected temperature value of pressure sensor measured value format: **pbb.ee** [°C] **<value6>** – temperature of internal humidity sensor measured value format: **pbb.ee** [°C]
aD2!	**a<value7><value8><value9>**… …**<CR><LF>**	Send data (after **aV!**) **a** – sensor address **<value7>** – corrected pressure value of pressure sensor measured value format: **pbbbb.ee** [mbar] **<value8>** – standard deviation of corrected pressure value of pressure sensor within the averaging time [1)] measured value format: **pbbbb.ee** [mbar] **<value9>** – device status +0 → no error occured +1 → system reset – status flag is set when connecting the operating voltage/upon unexpected reset; deletion after status read out

(Continuation of device status see next page)

[1)] determined from 2 … 238 single measurements of a measurement interval, (see command **aXXC!**)

Command	Response	Description
		(Continuation of device status from previous page) +4 → raw value "temperature" outside the calibrated range +8 → sensor orientation change (deviation since installation ↔ currently ≥ 5°) [1] +16 → overload pressure sensor (≥ +20 % of measuring range + offset) +32 → pressure probe was reset to factory settings due to internal system error (including potential flow settings) +64 → internal relative humidity was/is above limit (≥ 25 % rH) [2] **Note** If several errors/events occur at the same time, the OTT PLS 500 adds up the status values. Example: +20 → overload pressure sensor (+16) + raw value "temperature" outside the calibrated range (+4); values ≥ +128: exclusively for internal service purposes
aM!	**atttn<CR><LF>** and after 0/1 … 60 seconds **a<CR><LF>**	Start measurement – including device status **a** – sensor address **ttt** – time in seconds until the sensor has determined the measurement result response OTT PLS 500: 0/1 … 60 seconds [3] **n** – number of measured values response OTT PLS 500: 3 (level measurement) or 4 (discharge measurement)

[1] intended change of sensor orientation (e.g. new installation): first reset pressure probe to factory setting with command **aXSF!**
[2] see also "Please note: …" in Chapter 9
[3] depending on the set averaging time; advanced command **aXXM<value>!**
In the measurement type "continuous measurement" the time is always 0 seconds (with the exception of the first interval after the start)!

Command	Response	Description
aD0!	**a<value1><value2><value3>**… …**<value4><CR><LF>**	Send data (after **aM!**) **a** – sensor address **<value1>** – mean of measured values "level/pressure" within the averaging time measured value formats[1]: **pbbb.eee** [m] **pbbbbb.e** [cm] **pbbbbb** [mm] **pbbb.eee** [ft] **pbbbb.eee** [inch] **pbb.eeeee** [bar] **pbbbb.ee** [mbar] **pbbbb.eee** [kPa] **pbbb.eeee** [psi] **<value2>** – water temperature measured value formats [2]: **pbb.ee** [°C] **pbbb.ee** [°K] **pbbb.ee** [°F] **<value3>** – device status see **aD2!** after **aV!** **<value4>** – discharge[4] measured value formats [3]: **pbbb.eee** [m^3/s] **pbbbbbb** [l/s] **pbbbbb.eee** [ft^3/s] **Note** Measured value = **–9999** → calculation error occurred or rating table missing; = **–9998** → entries in the rating table are not sufficient for the calculation
aMC!	**atttn<CR><LF>** and after 0/1 … 60 seconds **a<CR><LF>**	Start measurement and request CRC (Cyclic Redundancy Check); for details, see command **aM!**. The response to the following **aD0!** command is extended by a CRC value: **a<value1><value2><value3>**… …**<value4><CRC><CR><LF>**
aC!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line); for details, see-command **aM!**. The number of measured values in the response to this command has two digits: **nn = 03** or **04** [4].
aCC!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line) and request CRC (Cyclic Redundancy Check); for details, see command **aM!**. The number of measured values in the response to this command has two digits: **nn = 03** or **04** [4]. The response to the following **aD0!** command is extended by a CRC value: **a<value1><value2><value3>**… …**<value4><CRC><CR><LF>**
aR0!	**a<value1><value2><value3>**… …**<value4><CR><LF>**	The OTT PLS 500 continuously measures level/pressure, temperature and optionally calculates the discharge. This command permits to retrieve measurement results even without the combination of commands **aM!**/**aD0!**; for details, see command **aD0!** after **aM!**. Requires measurement type "continuous measurement"; extended command **aXXC<value>!**

[1 … 3] depending on the set unit; extended command **aXSU<value>!**[1] ; **aXST<value>!**[2] ; **aXSD<value>!**[3]
[4] optional with activated discharge measurement; exteded command **aXDC<value>!**

Command	Response	Description
aRC0!	**a<value1><value2><value3>…** **…<value4><CRC><CR><LF>**	The OTT PLS 500 continuously measures level/pressure and temperature, optionally calculates the discharge and requests a CRC value (Cyclic Redundancy Check). This command permits to retrieve measurement results, even without the combination of commands **aM!**/**aD0!**; for details, see command **aD0!** after **aM!**. Requires measurement type "continuous measurement"; extended command **aXXC<value>!**
aM1!	**atttn<CR><LF>** and after 0/1 … 60 seconds **a<CR><LF>**	Start measurement – including statistical values **a** – sensor address **ttt** – time in seconds until the sensor has determined the measurement result response OTT PLS 500: 0/1 … 60 seconds [1] **n** – number of measured values response OTT PLS 500: **8**
aD0!	**a<value1><value2><value3>…** **…<CR><LF>**	Send data (after **aM1!**) **a** – sensor address **<value1>** – last single measured value "level/pressure" within the averaging time [2] **<value2>** – water temperature [2] **<value3>** – mean of measured values "level/pressure" within the averaging time [2] [3]
aD1!	**a<value4><value5><value6>…** **…<CR><LF>**	Send data (after **aM1!**) **a** – sensor address **<value4>** – minimum of measured values "level/pressure" within the averaging time [2] [3] **<value5>** – maximum of measured values "level/pressure" within the averaging time [2].[3] **<value6>** – median of measured values "level/pressure" within the averaging time [2] [3]
aD2!	**a<value7><value8><CR><LF>**	Send data (after **aM1!**) **a** – sensor address **<value7>** – standard deviation of measured values "level/pressure" within the averaging time [2].[3] **<value8>** – device status; see **aD2!** after **aV!**
aMC1!	**atttn<CR><LF>** and after 0/1 … 60 seconds **a<CR><LF>**	Start measurement and request CRC (Cyclic Redundancy Check); for details, see command **aM1!**. The response to the following **aD0!** … **aD2!**command is extended by a CRC value: **a<valueX><valueX><valueX><CRC><CR><LF>**
aC1!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line); for details, see-command **aM1!**. The number of measured values in the response to this command has two digits: **nn = 08**.
aCC1!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line) and request CRC (Cyclic Redundancy Check); for details, see command **aM1!**. The number of measured values in the response to this command has two digits: **nn = 08**. The response to the following **aD0!** … **aD2!** command is extended by a CRC value: **a<valueX><valueX><valueX>**… **…<CRC><CR><LF>**

[1] depending on the set averaging time; extended command **aXXM<value>!**
In the measurement type "continuous measurement" the time is always 0 seconds (with the exception of the first interval after the start)!
[2] for measured value formats, see **aD0!** after **aM!** (depending on the set unit)
[3] determined from 2 … 238 single measurements of a measurement interval (see command **aXXC!**)

Command	Response	Description
aR1!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**<value7><value8><CR><LF>**	The OTT PLS 500 continuously measures level/pressure and temperature and determines statistical values. This command permits to retrieve measurement results even without the combination of commands **aM1!/aD0!** … **aD2!**; for details, see command **aD0!** … **aD2!** after **aM1!**. Requires measurement type "continuous measurement"; extended command **aXXC<value>!**
aRC1!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**value7><value8><CRC><CR><LF>**	The OTT PLS 500 continuously measures level/pressure, temperature, determines statistical values and requests a CRC value (Cyclic Redundancy Check). This command permits to retrieve measurement results even without the combination of commands **aM1!/aD0!** … **aD2!**; for details, see command **aD0!** … **aD2!** after **aM1!**. Requires measurement type "continuous measurement"; extended command **aXXC<value>!**
aM2!	**atttn<CR><LF>** and after 0/1 … 60 seconds **a<CR><LF>**	Start measurement – including meta data **a** – sensor address **ttt** – time in seconds until the sensor has determined the measurement result response OTT PLS 500: 0/1 … 60 seconds [1] **n** – number of measured values response OTT PLS 500: **9**
aD0!	**a<value1><value2><value3>**… …**<CR><LF>**	Send data (after **aM2!**) **a** – sensor address **<value1>** – relative humidity in the probe housing measured value format: **pbb.ee** [% rH] **<value2>** – dew point in the probe housing measured value format: **pbb.ee** [°C] **<value3>** – current sensor orientation measured value format: **pbbb** [°]
aD1!	**a<value4><value5><value6>**… …**<CR><LF>**	Send data (after **aM2!**) **a** – sensor address **<value4>** – stored sensor orientation during installation measured value format: **pbbb** [°] **<value5>** – temperature value of pressure sensor measured value format: **pbb.ee** [°C] **<value6>** – temperature of internal humidity sensor measured value format: **pbb.ee** [°C]
aD2!	**a<value7><value8><value9>**… …**<CR><LF>**	Send data (after **aM2!**) **a** – sensor address **<value7>** – pressure value of pressure sensor measured value format: **pbbbb.ee** [mbar] **<value8>** – standard deviation of pressure value of pressure sensor [2] measured value format: **pbbbb.ee** [mbar] **<value9>** – device status; see **aD2!** after **aV!**
aMC2!	**atttn<CR><LF>** and after 0/1 … 60 seconds **a<CR><LF>**	Start measurement and request CRC (Cyclic Redundancy Check); for details, see command **aM2!**. The response to the following **aD0!** … **aD2!** command is extended by a CRC value: **a<valueX><valueX><valueX><CRC><CR><LF>**

[1] depending on the set averaging time; extended command **aXXM<value>!**
In the measurement type "continuous measurement" the time is always 0 seconds (with the exception of the first interval after the start)!
[2] determined from 2 … 238 single measurements of a measurement interval (see command **aXXC!**)

Command	Response	Description
aC2!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line); for deteails, see command **aM2!**. The number of measured values in the response to this command has two digits: **nn = 09**.
aCC2!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line) and request CRC (Cyclic Redundancy Check); for details, see command **aM2!**. The number of measured values in the response to this command has two digits: **nn = 09**. The response to the following **aD0!** … **aD2!** command is extended by a CRC value: **a<valueX><valueX><valueX>**… …**<CRC><CR><LF>**
aR2!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**<value7><value8><CR><LF>**	The OTT PLS 500 continuously measures level/pressure and temperature and determines meta data. This command permits to retrieve measurement results even without the combination of commands **aM2!/aD0!** … **aD2!**; for details, see command **aD0!** … **aD2!** after **aM2!**. Requires measurement type "continuous measurement"; extended command **aXXC<value>!**
aRC2!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**<value7><value8>**… **<CRC><CR><LF>**	The OTT PLS 500 continuously measures level/pressure and temperature, determines meta data and requests a CRC value (Cyclic Redundancy Check). This command permits to retrieve measurement results even without the combination of commands **aM2!/aD0!** … **aD2!**; for details, see command **aD0!** … **aD2!** after **aM2!**. Requires measurement type "continuous measurement"; extended command **aXXC<value>!**
aHA!	**atttnnn<CR><LF>**	Start "High volume" measurement in ASCII format and request CRC (Cyclic Redundancy Check) **a** – sensor address **ttt** – time in seconds until the sensor has determined the measurement result response OTT PLS 500: 0/1 … 60 seconds [1] **nnn** – number of measured values response OTT PLS 500: **18**
aD0!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**<value7><value8><value9>**… …**<CRC><CR><LF>**	Send data (after **aHA!**) **a** – sensor address **<value1>** – last single measured value "level/pressure" within the averaging time [2] [3] **<value2>** – temperature value of pressure sensor [2] **<value3>** – temperature value of the precision temperature sensor [2] **<value4>** – mean of measured values "level/pressure" within the averaging time [2] [3]) **<value5>** – minimum of measured values "level/pressure" within the averaging time [2] [3] **<value6>** – maximum of measured values "level/pressure" within the averaging time [2] [3] **<value7>** – median of measured values "level/pressure" within the averaging time [2] [3]) **<value8>** – standard deviation of measured values "level/pressure" within the averaging time [2] [3]) **<value9>** – relative humidity in the probe housing measured value format: **pbb.ee** [% rH] **<CRC>** – CRC value

[1] depending on the set averaging time; extended command **aXXM<value>!**
In the measurement type "continuous measurement" the time is always 0 seconds (with the exception of the first interval after the start)!
[2] for measured value formats see **aD0!** after **aM!** (depending on the set unit)
[3] determinded from 2 … 238 single measurements of a measurement interval (see command **aXXC!**)

Command	Response	Description
aD1!	**a<value10><value11><value12>…** **…<value13><value14><value15>…** **…<value16><value17><value18>…** **…<CRC><CR><LF>**	Send data (after **aHA!**) **a** – sensor address **<value10>** – dew point in the probe housing [2)] **<value11>** – temperature in the probe housing [2)] **<value12>** – current sensor orientation measured value format: **pbbb** [°] [2)] **<value13>** – sensor orientation during installation measured value format: **pbbb** [°] [2)] **<value14>** – corrected pressure value of pressure sensor measured value format: **pbbbb.ee** [mbar] [2)] **<value15>** – corrected pressure value of pressure sensor including potential offset measured value format: **pbbbb.ee** [mbar] **<value16>** – uncorrected pressure value of pressure sensor measured value format: **pbbbb.ee** [mbar] **<value17>** – discharge [2)] **<value18>** – device status; see **aD2!** after **aV!** **<CRC>** – CRC value **Note** Measured value discharge = **-9999** → calculation error occured or rating table missing; = **-9998** → entries in the rating table are not sufficient for calculation
aHB!	**atttnnn<CR><LF>**	Start "High volume" measurement in binary format and request CRC (Cyclic Redundancy Check) **a** – sensor address **ttt** – time in seconds until the sensor has determined the measurement result response OTT PLS 500: 0/1 … 60 seconds [1)] **nnn** – number of measured values response OTT PLS 500: **17**
aDB0!	Binary data header SDI-12 sensor address "0"; packet size 64 bytes; 9 IEEE 32-bit floating point numbers with single precision Binary data	Send data (after **aHB!**) IEEE 32-bit floating point numbers with single precision **<value1>…<value17>** The measured values correspond to the description of **aD0!** and **aD1!** after **aHA!**
aDB1!	Binary data header SDI-12 sensor address "0"; packet size 2 bytes; 4 unsigned 16-bit integer values Binary data	Send data (after **aHB!**) unsigned 16-bit integer values **<value1>** device status; see **aD2!** after **aV!**

[1)] depending on the set averaging time; advanced command **aXXM<value>!**
In the measurement type "continuous measurement" the time is always 0 seconds (with the exception of the first interval after the start)!

7.3 Meta data commands

Command	Response	Description
aIM!	**atttn<CR><LF>**	The response is identical to the corresponding measurement command (**aM!**, **aM1!**, **aM2!**, **aMC!**, **aMC1!**, …). These commands did not start a measurement! For a description of the responses, see commands **aM!**, **aM1!**, **aM2!**, **aMC!**, **aMC1!**, … .
aIM1!	**atttn<CR><LF>**	
aIM2!	**atttn<CR><LF**	
aIMC!	**atttn<CR><LF>**	
aIMC1!	**atttn<CR><LF>**	
aIMC2!	**atttn<CR><LF>**	
aIC!	**atttnn<CR><LF>**	
aIC1!	**atttnn<CR><LF>**	
aIC2!	**atttnn<CR><LF>**	
aICC!	**atttnn<CR><LF>**	
aICC1!	**atttnn<CR><LF>**	
aICC2!	**atttnn<CR><LF>**	
aIHA!	**atttnnn<CR><LF>**	
aIHB!	**atttnnn<CR><LF>**	
aIV!	**atttn<CR><LF>**	The response is identical to the corresponding command "Start system test" (**aV!**). This command does not start a system test! For a description of the response, see command **aV!**
aIM_00X![1]	**a,<field1>,<field2>,…**	The OTT PLS 500 sends meta data for the related measured value **<valueX>**[5] in the form of three data fields. These commands do not start a measurement! The measured value code (**<field1>**) and the unit designations (**<field2>**) correspond to the "SHEF" standard (see "Standard Hydrometeorological Exchange Format (SHEF) – Code Manual" of the "National Weather Service".
aIM1_00X![2]	**…<field3>;<CRC><CR><LF>**	
aIM2_00X![3]		
aIMC_00X![1]		
aIM1C_00X![2]		
aIM2C_00X![3]		
aIC_00X![1]		
aIC1_00X![2]		
aIC2_00X![3]		
aICC_00X![1]		
aICC1_00X![2]		
aICC2_00X![3]		
aIHA_00X![4]		
aIHB_00X![4]		
aIV_00X!![3]		

a – sensor address

<field1> – measured value code
- · water level: **HA** · **HB**
- · temperature: **TW** · **TA** · **TD**
- · humidity: **XR**
- · pressure: **PE**
- · device status: **OS**

<field2> – unit
- · length: **M** · **CM** · **MM** · **INCH** · **FT**
- · pressure: **BAR** · **MBAR** · **KPA** · **PSI**
- · temperature: **DC** · **DF** · **DK**
- · humidity: **%**
- · discharge: **CMS** · **LS** · **CFS**
- · acceleration: **mg**
- · angle: **DEG**

(Continuation of description see next page)

[1] Variable ...X: from 1 to 3 or 4
[2] Variable ...X: from 1 to 8
[3] Variable ...X: from 1 to 9
[4] Variable ...X: from 1 to 17
[5] Part of the response to the command **aD0!**, **aD1!**, **aD2!** (after **aM!**, **aM1!**, **aMC!**, ...)
[6] https://vlab.noaa.gov/web/mdl/shef-information (**BAR** · **KPA** · **MM** → no official SHEF Code)

Command	Response	Description
		(Continuation of the description from previous page)
		<field3>– textual description **Last ring buffer pressure/level**[1)] **Mean pressure/level**[1)] **Min. pressure/level**[1)] **Max. pressure/level**[1)] **Median pressure/level**[1)] **Standard deviation pressure/level**[1)] **High accuracy temperature** **Inside humidity** **Inside dew point** **Inside temperature** **Current orientation** **Stored orientation** **Device status** **Mean temperature pressure sensor** **Standard deviation pressure** **Mean pressure** **Corrected mean pressure** **Discharge**
		<CRC> – CRC value [2)]

[1)] depending on the set unit; extended command **aXSU<value>!** (level or pressure measurement)
[2)] only for **aIMC_00X!**, **aICC_00X!**, **aIMC1_00X!**, **aICC1_00X!**, **aIMC2_00X!**, **aICC2_00X!**

Examples for meta data commands

```
0IM!    → 011003<CR><LF>
5IV!    → 511009<CR><LF>

0IM_002!      → 0,PE,MBAR,Mean pressure;<CR><LF>
0IM2_007!     → 0,TW,DK,High accuracy temperature;<CR><LF>
```

7.4 Advanced SDI-12 commands

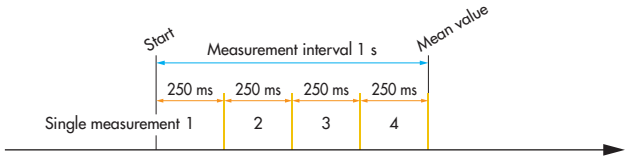
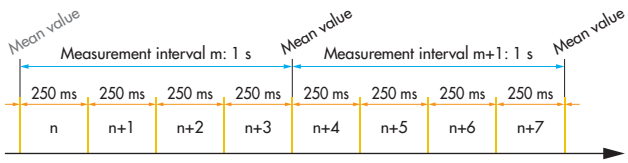
Command	Response	Description
▶ Set/read the unit of level/pressure measured values		
aXSU<value>!	**a<value><CR><LF>**	Set unit Read unit **a** – sensor address **<value>** – **Units for water level measurement** +0: m +1: cm +7: mm +2: ft +5: inch The level measurement is carried out with compensation of water density/salinity, water temperature and local gravitational acceleration! **Units for pressure measurement** +3: mbar +4: psi +6: bar +8: kPa Pressure measurement is done w/o compensation! Factory setting: m or ft[1)] **Note** An "Offset" or "Reference" value can only be used if units are set to meter or feet!
aXSU!	**a<value><CR><LF>**	
▶ Set/read the unit of measured temperature values		
aXST<value>!	**a<value><CR><LF>**	Set unit Read unit **a** – sensor address **<value>** – +0: °C +1: °F +2: K Factory setting: °C or °F[1)]
aXST!	**a<value><CR><LF>**	
▶ Set/read the unit of measured discharge values		
aXSD<value>!	**a<value><CR><LF>**	Set unit Read unit **a** – sensor address **<value>** – +0: m^3/s +1: l^3/s +2: ft^3/s Factory setting: m^3/s or ft^3/s[1)]
aXSD!	**a<value><CR><LF>**	
▶ Store sensor orientation during installation [2)]		
aXXO! [3)]	**atttn<CR><LF>**	Store sensor orientation Description of response: see command **aM!** With this command you can determine and store the sensor orientation during installation. In case of an error, the stored value can be checked against the current sensor orientation. (command **aV!**) **Note** This command starts a subsequent measurement with the set averaging time.

[1)] depending on the ordered variant code

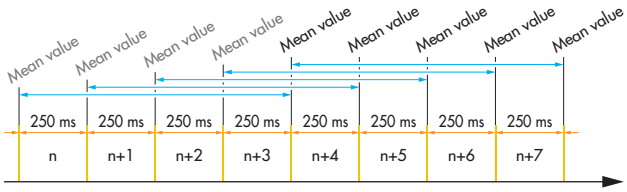
[2)] intended change of sensor orientation (e.g. new installation): → first reset pressure probe to factory setting with command **aXSF!**

[3)] **aXXO!** → Character "O"

Command	Response	Description
▶ Set/read local gravitational acceleration		
aXXG<value>!	**a<value><CR><LF>**	Set local gravitational acceleration
aXXG!	**a<value><CR><LF>**	Read local gravitational acceleration **a** – sensor address **<value>** – **b.eeeeee** Value range: 9.780360 … 9.832080 m/s² Factory setting = 9.806650 m/s² The gravitational acceleration at the earth's surface varies between 9.78036 m/s² at the equator and 9.83208 m/s² at the poles. Also, it decreases by 0.003086 m/s² for each kilometer of elevation above sea level. Formula for the local gravitational acceleration "g" in m/s²: $g = 9.780356\,(1 + 0.0052885\,\sin^2\alpha - 0.0000059\,\sin^2 2\alpha) - 0.003086\,h$ α latitude; h height above sea level in km (Reference: Jursa, A.S., Ed., Handbook of Geophysics and the Space Environment, 4th ed., Air Force Geophysics Laboratory, 1985, pp. 14-17). **Example** Local gravitational acceleration in Kempten (Germany): At a height above sea level of 669 m and a latitude of 47.71° , a local gravitational acceleration of 9.80659 m/s² results. **Note** The OTT PLS 500 is preset to an average value for Germany (Kassel). The measured value deviation caused by gravitational acceleration is ±3 mm in Germany (Flensburg – Oberstdorf). This measurement error is compensated by inputting the local gravitational acceleration.
▶ Set/read salinity		
aXXS<value>!	**a<value><CR><LF>**	Set salinity
aXXS!	**a<value><CR><LF>**	Read salinity **a** – sensor address **<value>** – **bbbb.eee** Value range: 0 … 500000 g/l Factory setting = 0 g/l Using this command, you can set the salinity at your station during the level/depth measurement. This is useful, for example, for stations with increased salinity. Alternatively, it is also possible to set the average water density.
▶ Set/read average water density		
aXXR<value>!	**a<value><CR><LF>**	Set average water density
aXXR!	**a<value><CR><LF>**	Read average water density **a** – sensor address **<value>** – **b.eeeeee** Value range: 0.500000 … 2.000000 kg/dm³ Factory setting = 0.999975 kg/dm³ (at 0 °C) Using this command, you can set the actual water density at your station during level/depth measurement. This is useful, for example, at stations with brackish water. Alternatively, it is also possible to set the salinity.

Command	Response	Description
▶ Set/read depth measurement measuring mode		
aXAA<value>!	**a<value><CR><LF>**	Set measuring mode depth measurement Read measuring mode **a** – sensor address **<value>** – +0 = measuring mode depth deactivated +1 = measuring mode depth activated Factory setting: **+0** → depth measurement deactivated
aXAA!	**a<value><CR><LF>**	
▶ Set/read averaging time		
aXXM<value>!	**a<value><CR><LF>**	Set averaging time Read averaging time **a** – sensor address **<value>** – **bb.e** Input/output without leading zero! Value range: 0.5 … 59.5 s Factory setting: 1.5 s **Note** This command starts a subsequent measurement with the set averaging time.
aXXM!	**a<value><CR><LF>**	
▶ Set/read measurement type		
aXXC<value>!	**a<value><CR><LF>**	Set measurement type Read measurement type **a** – sensor address **<value>** – +0: single measurement +1: continuous measurement, interval mode +2: continuous measurement, floating mode Factory setting: **+0** → measurement type "single measurement" An OTT PLS 500 measurement interval is defined as arithmetic mean of single measurements over an adjustable averaging time. A single measurement takes 250 milliseconds. The averaging time is 0.5 … 59.5 seconds. Single measurement: The OTT PLS 500 is in the idle state by default. An SDI-12 measurement command starts a single measurement interval over the set averaging time. This measurement type is available in parallel on the SDI-12- and RS-485 interfaces.  Continuous measurement, interval mode: In interval mode, single measurements take place continuously one after the other. The OTT PLS 500 immediately responds to an **aRx!** command with a measured value (with the exception of the first interval after the start). This value is always updated after the averaging time has expired. The response to an **aMx!** command indicates the time until the averaging time has expired and an updated value is available. 

Command	Response	Description
		Continuous measurement, floating mode: in the floating mode, individual measurements are also taken continuously one after the other, and starting from the most recent value, the calculation of the mean value is carried out backwards. The OTT PLS 500 also immediately responds to an **aRx!** command with a measured value. However it is updated with each individual measurement.



▶ Set/read offset for level measurement

aXAB<value>!	**attt1<CR><LF>**	Set offset value
aXAB!		Read offset value
		a – sensor address
		<value> – **pbbbb.eee** [1]

Input/output without leading zeros!
Value range: –9999.999 … +9999.999
Factory setting= +0.000

With this command, you can apply a linear offset (positive/negative) to a level measurement value. After setting the offset, the OTT PLS 500 automatically starts a measurement. Then check the measured value with the **aD0!** command.

Caution
This command overwrites a possibly set reference value!

Example
Measured value = +10.040 m
Offset = –0.200 m
Output = +9.840 m

Notes
– A subsequent change of the unit (**aXSU<value>!**) may result in rounding errors of ±0.001.
– If the unit of level measurement is set to pressure values (**aXSU<value>!**), a measurement is already active or an error has occured, the OTT PLS 500 responds with a service request (**a<CR><LF>**).

[1] depending on the set unit; extended command **aXSU<value>!**

Command	Response	Description
▶ Set/read reference value for level/depth measurement		
aXAC<value>!	**attt1<CR><LF>**	Set reference value
aXAC!	**a<value><CR><LF>**	Read reference value **a** – sensor address **<value>** – **pbbbb.eee** [1)] Input/output without leading zeros! Value range: –9999.999 … +9999.999 Factory setting = +0.000 With this command, you can establish, for example, a reference to a level zero point during level measurement by entering a reference value. After setting the reference value, the OTT PLS 500 automatically starts a measurement. Then check the measured value with the **aD0!** command. **Caution** This command overwrites a possibly set offset value! **Example** Measured value= +2.100 m Reference value = +1.500 m Output = +1.500 m (Offset calculated by the OTT PLS 500 and applied to all other measured values = +0.600 m) **Notes** – A subsequent change of the unit (**aXSU<value>!**) may result in rounding errors of ±0.001. – If the unit of level measurement is set to pressure values (**aXSU<value>!**), a measurement is already active or an error has occured, the OTT PLS 500 does not respond.
▶ Reset/read all units to default (metric or imperial)		
aXSR<value>!	**a<value><CR><LF>**	Reset units to default
aXSR!	**a<value><CR><LF>**	Read default units **a** – sensor address **<value>** – +0: metric +1: imperial +2: individual customer setting (only for reading) This command resets all – potentially individually changed – units to metric or imperial values (according to the delivery state). The factory setting depends on the ordered variant code.
▶ Reset pressure probe to factory settings without communication settings		
aXSF!	**a<CR><LF>**	Reset pressure probe **a** – sensor address Resets all settings to factory values (delivery state according to the ordered variant code). Individually changed communication settings on the RS-485 interface (Modbus, SDI-12) remain unchanged. RS-485 protocol → unchanged Units → default metric or imperial

[1)] depending on the set unit; extended command **aXSU<value>!**

Command	Response	Description
▶ Reset pressure probe to factory settings including communication settings		
aXSF+1!	**a<CR><LF>**	Reset pressure probe **a** – sensor address Resets all settings – including potentially changed communication settings on the RS-485 interface (Modbus, SDI-12) to factory values (delivery state according to the ordered variant code). RS-485 protocol – Modbus; measurement type continuous measurement, interval mode – SDI-12; measurement type single measurement Units default metric or imperial
▶ Set calculation method discharge measurement		
aXDC<value>! **aXDC!**	**a<value><CR><LF>** **a<value><CR><LF>**	Set calculation method Read calculation method **a** – sensor address **<value>** – +0: deactivated; factory setting +1: activated, calculation method rating table +2: activated, calculation method according to Standard ISO 1100-2, exponential formula $Q = p(h-e)^{\beta}$ h = level at water surface e = effective level at discharge = 0 β = gradient of the rating curve p = constant which numerically corresponds to discharge at (h-e) = 1
▶ Create table entry in rating table (calculation method rating table)		
aXDA<value1>… **…<value2>!**	**a<value1><value2><CR><LF>**	Create table entry **a** – sensor address **<value1>** – water level at related discharge **<value2>** – discharge at related water level **Notes** – precondition: calculation method rating table is activated – maximum 50 table entries – entries are sorted automatically – unit water level: as specified by **aXSU!** (if a pressure unit is set, "m" is used alternatively) – unit discharge: as specified by **aXSD!** **Example** **aXDA<+5.750><+63.000>!**
▶ Enter coefficient for discharge measurement (calculation method exponential formula)		
aXDA<value1>… **…<value2>…** **…<value3>!**	**a<value1><value2><value3>…** **…<CR><LF>**	Set coefficient **a** – sensor address **<value1>** – factor "e" of exponential formula; offset; factory setting = +0.000 **<value2>** – factor "p" of exponential formula; scaling; factory setting = +1.000 **<value3>** – factor "β" of exponential formula; exponent; factory setting = +1.000 **Note** – precondition: calculation method exponential formula is activated **Example** **aXDA<+1.260><+21.800><+2.540>!**

Command	Response	Description
▶ Read table entry in rating table (calculation method rating table)		
aXDR<value1>!	**a<value2><value3><CR><LF>**	Read table entry **a** – sensor address **<value1>** – entry (index) in the table to read out **<value2>** – water level at related discharge **<value3>** – discharge at related water level **Notes** – precondition: calculation method rating table activated – entries are sorted automatically – unit water level: as specified by **aXSU!** (if a pressure unit is set, "m" is used alternatively) – unit discharge: as specified by **aXSD!**
▶ Read number of entries in rating table (calculation method rating table)		
aXDR!	**a<value><LF>**	Read number of table entries **a** – sensor address **<value>** – number of table entries **Note** – precondition: calculation method rating table activated
▶ Read coefficient exponential formula (calculation method according to Standard ISO 1100-2)		
aXDR!	**a<value1><value2><value3>…** **…<CR><LF>**	Read coefficient **a** – sensor address **<value1>** – factor "e" of exponential formula; offset **<value2>** – factor "p" of exponential formula; scaling **<value3>** – factor "β" of exponential formula; exponent **Note** – precondition: calculation method exponential formula activated
▶ Delete table entry in rating table (calculation method rating table)		
aXDD<value>!	**a<CR><LF>**	Delete table entry **a** – sensor address **<value>** – entry (index) in the table to be deleted **Note** – precondition: calculation method rating table activated
▶ Delete rating table completely (calculation method rating table)		
aXDD+9999!	**a<CR><LF>**	Delete rating table completely **a** – sensor address This command deletes a rating table completely. **Note** – precondition: calculation method rating table activated and at least one table entry is available

8 RS-485 Interface with Modbus protocol (RTU)

8.1 Preconditions

▶ OTT PLS 500 variant code: → Protocol RS-485 interface	M Modbus
▶ Measurement type	continuous measurement (interval mode or floating mode)
▶ Interface	EIA-485 (RS-485)
▶ Transmission parameter	8 Data bit, 1 Stop bit, Even parity
▶ Transmission speed	9600 (factory setting), 19200
▶ Bus address	1 … 247

8.2 Value ranges

16-bit Integer values

Modbus Register	1															
Byte	0								1							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

int range: –32767 … 32767
uint range: 0 … 65534
bitfield16 range: 0 … 0x7FFF

32-bit Integer values

Modbus Register	1		2	
Byte	0	1	3	4
Bit	31 … 24	23 … 16	15… 08	07 … 00

int range: –214483647 … 214483647
uint range: 0 … 4294967294

Floating point values

Modbus Register	1															
Byte	0								1							
Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
IEEE 754	sign	Exponent							Fraction							

Modbus Register	2															
Byte	2								3							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IEEE 754	Fraction least															

float32 range: see IEEE 754

String values

Modbus Register	1		2		3		4		5		6		7		8	
Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bit	E	X	A	M	P	L	E	spc	S	T	R	I	N	G	!	NULL

- **Note:** The OTT PLS 500 has only one "Holding Register" Block.

8.3 Function "Read Holding Registers" – Sensor description

Register name	Register-number [1]	Data type	Length	Access mode	min. / max.	Description
▶ Protocol ID	1 (0)	uint 32	2	R		OTT Hydromet device assignment starting with register number 40001 and beginning with the 32-bit OTTP identifier
▶ ID protocol-description	3 (2)	uint 16	1	R		0x0001 "Common Block"
▶ Length of protocol-description	4 (3)	uint 16	1	R		16-bit register
▶ Product ID	5 (4)	Integer 32 bit	2	R		Product ID 63039 (0x0000F63F)
▶ Device ID	7 (6)	Integer 32 bit	2	R		Device ID 001 (0x00000001)
▶ Firmware version	9 (8)	Integer 32 bit	2	R		V1.23.4 = 123400 (0x0001E208)
▶ Bootloader version	11 (10)	Integer 32 bit	1	R		V1.23.4 = 123400 (0x0001E208)
▶ Reference system physical elements	13 (12)	uint 16	1	R		0x001 = SHEF 0x002 = OTT
▶ Reference system units	14 (13)	uint 16	1	R		0x001 = SHEF 0x002 = OTT
▶ Number of channels	15 (14)	uint 16	1	R	1 … 40	Number of sensor channels: 13
▶ Channel 1 – definition of physical element	16 (15)	uint 16	1	R		Mean value level or pressure HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 1 – unit	17 (16)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR 0x0009: MM 0x000A: KPA
▶ Channel 1 – unit string	18 (17)	uint 16	3	R		e.g. MBAR
▶ Channel 2 – definition of physical element	21 (20)	uint 16	1	R		last single measured value Level or pressure value HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 2 – unit	22 (21)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR 0x0009: MM 0x000A: KPA
▶ Channel 2 – unit string	23 (22)	uint 16	3	R		compare "Channel1: unit string"

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)

Register name	Register-number [1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 3 – definition of physical element	26 (25)	uint 16	1	R		water temperature TW, Temperature Water (0x5457)
▶ Channel 3 – unit	27 (26)	uint 16	1	R		0x0010: °C 0x0011: °F 0x0012: Kelvin
▶ Channel 3 – unit string	28 (27)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 4 – definition of physical element	31 (30)	uint 16	1	R		Minimum level or pressure value HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 4 – unit	32 (31)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR 0x0009: MM 0x000A: KPA
▶ Channel 4 – unit string	33 (32)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 5 – definition of physical element	36 (35)	uint 16	1	R		Maximum level or pressure value HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 5 – unit	37 (36)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR 0x0009: MM 0x000A: KPA
▶ Channel 5 – unit string	38 (37)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 6 – definition of physical element	41 (40)	uint 16	1	R		Median level or pressure value HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 6 – unit	42 (41)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR 0x0009: MM 0x000A: KPA

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)

Register name	Register-number [1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 6 – unit string	43 (42)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 7 – definition of physical element	46 (45)	uint 16	1	R		Standard deviation of level or pressure value HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 7 – unit	47 (46)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR 0x0009: MM 0x000A: KPA
▶ Channel 7 – unit string	48 (47)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 8 – definition of physical element	51 (50)	uint 16	1	R		Device status OS, Status of device (0x4f53)
▶ Channel 8 – unit	52 (51)	uint 16	1	R		0x0001: none
▶ Channel 8 – unit string	53 (52)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 9 – definition of physical element	56 (55)	uint 16	1	R		relative humidity in the probe housing XR, Humidity, relative (0x5852)
▶ Channel 9 – unit	57 (56)	uint 16	1	R		0x0010: %
▶ Channel 9 – unit string	58 (57)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 10 – definition of physical element	61 (60)	uint 16	1	R		dew point in the probe housing TD, Dew point (0x5444)
▶ Channel 10 – unit	62 (61)	uint 16	1	R		0x0010: DEGREE C 0x0011: DEGREE F 0x0012: Kelvin
▶ Channel 10 – unit string	63 (62)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 11 – definition of physical element	66 (65)	uint 16	1	R		temperature of internal humidity sensor TA, Temperature of air (0x5441)
▶ Channel 11 – unit	67 (66)	uint 16	1	R		0x0010: DEGREE C 0x0011: DEGREE F 0x0012: Kelvin
▶ Channel 11 – unit string	68 (67)	uint 16	3	R		compare "Channel1: unit string"

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)

Register name	Register-number [1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel12 – definition of physical element	71 (70)	uint 16	1	R		current sensor orientation 0x0001: not defined
▶ Channel 12 – unit	72 (71)	uint 16	1	R		0x0010: degree
▶ Channel 12 unit string	73 (72)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 13 – definition of physical element	76 (75)	uint 16	1	R		sensor orientation during installation 0x0001: not defined
▶ Channel 13 – unit	77 (76)	uint 16	1	R		0x0010: degree
▶ Channel 13 – unit string	78 (77)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 14 – definition of physical element	81 (80)	uint 16	1	R		Discharge QR, Discharge river (0x5152)
▶ Channel 14 – unit	82 (81)	uint 16	1	R		0x0002: Cubic meters per second [m^3/s] 0x0003: Liter per second [l^3/s] 0x0004: Cubic feet per second [ft^3/s]
▶ Channel 14 – unit string	83 (82)	uint 16	3	R		compare "Channel1: unit string"

8.4 Function "Read Holding Registers" – Sensor values

Register name	Register-number [1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 1	101 (100)	float 32	2	R		Mean value of measured values "level/pressure" within the averaging period
▶ Channel 2	103 (102)	float 32	2	R		Last single measured value "level/pressure" within the averaging period
▶ Channel 3	105 (104)	float 32	2	R		Temperature value
▶ Channel 4	107 (106)	float 32	2	R		Minimum measured value "level/pressure" within the averaging period
▶ Channel 5	109 (108)	float 32	2	R		Maximum measured value "level/pressure" within the averaging period
▶ Channel 6	111 (110)	float 32	2	R		Median of measured values "level/pressure" within the averaging period
▶ Channel 7	113 (112)	float 32	2	R		Standard deviation of measured values "level/pressure" within the averaging period
▶ Channel 8	115 (114)	uint 32	2	R		device status

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)

Register name	Register-number [1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 9	117 (116)	float 32	2	R		relative humidity in the probe housing
▶ Channel 10	119 (118)	float 32	2	R		dew point in the probe housing
▶ Channel 11	121 (120)	float 32	2	R		temperature of internal humidity sensor
▶ Channel 12	123 (122)	float 32	2	R		current sensor orientation
▶ Channel 13	125 (124)	float 32	2	R		sensor orientation during installation
▶ Channel 14	127 (126)	float 32	2	R		discharge

8.5 Configuration register

Register values/factory settings are described in Chapter 7 "SDI-12 commands and responses".

Changes to the Modbus communication settings will cause a Modbus timeout because the internal communication is restarted and the stack cannot respond. Successful changes are answered with a regular Modbus response, invalid data with "illegal data value" and unsupported register addresses with "illegal data address".

Please note: Changes to the SD-I12 address will reset the entire system and cause a Modbus timeout.

Register name	Register-number [1]	Data type	Length	Access mode	Description
Unit level/pressure	201 (200)	uint 16	1	R/W	Setting unit for level/pressure
Unit temperature	202 (201)	uint 16	1	R/W	Setting unit for temperature
Unit discharge	203 (202)	uint 16	1	R/W	Setting unit for discharge
Calculation method discharge	204 (203)	uint 16	1	R/W	Setting calculation method discharge
Local gravitational acceleration	205 (204)	float 32	2	R/W	Setting local gravitational acceleration
Water density	207 (206)	float 32	2	R/W	Setting water density
Salinity	209 (208)	float 32	2	R/W	Setting salinity
Units imperial/metric	211 (210)	uint 16	1	R/W	Select presetting of units
Depth measurement	212 (211)	uint 16	1	R/W	Activate depth measurement
Averaging time	213 (212)	float 32	2	R/W	Setting averaging time
Continuous measurement	215 (214)	uint 16	1	R/W	Activate measurment mode continuous measurement
SDI-12 address	216 (215)	uint 16	1	R/W	Setting SDI-12 asdress
Modbus bus address	217 (216)	uint 16	1	R/W	Setting Modbus bus address
Transmission speed	218 (217)	uint 16	1	R/W	Setting Modbus transmission speed
Modbus parity	219 (218)	uint 16	1	R/W	Setting Modbus parity

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)

Settings of the exponential formula ($Q = p\ (h - e)^{\beta}$) according to ISO 1100-2:

Register name	Register-number[1)]	Data type	Length	Access mode	Description
Factor "e" of the exponential formula	251 (250)	float 32	2	R/W	Coefficient: offset "e"
Factor "p" of the exponential formula	253 (252)	float 32	2	R/W	Coefficient: scaling "p"
Factor "β" of the exponential formula	255 (254)	float 32	2	R/W	Coefficient: exponent "β"

The entries in the rating table can be set using the following two tabs. The value table is sorted in ascending order, therefore it is not possible to write directly into the value table. With the aid of the two registers, the OTT PLS 500 controls the correct insertion of the values into the rating table. If the maximum table size (50 entries) is reached, a write attempt is answered with "NAK not acknowledge".

To delete a specific entry, enter the water level of the entry to be deleted and a discharge value of "–9999" in the format "float32". To change a specific value, enter the water level of the entry to be changed and a new discharge value.

Please note: To correctly change entries in the rating table, the water level register **must be written first**. When writing a value to the discharge register, the register values of water level and discharge are taken over. If the sequence is not observed, both register values will be discarded!

Register name	Register-number[1)]	Data type	Length	Access mode	Description
Water level	261 (260)	float 32	2	W	write water level to associated discharge
Discharge	263 (262)	float 32	2	W	write discharge to associated water level

Register values with the entries "Water level" and "Discharge" of the rating table (empty entries are marked by the value "–9999" in the format "float32"):

Register name	Register-number[1)]	Data type	Length	Access mode	Description
Water level 1	301 (300)	float 32	2	R	table entry 1: water level
Discharge 1	303 (302)	float 32	2	R	table entry 1: discharge
Water level 2	305 (304)	float 32	2	R	table entry 2: water level
Discharge 2	307 (306)	float 32	2	R	table entry 2: discharge
Water level n	…	float 32	2	R	table entry n: water level
Discharge n	…	float 32	2	R	table entry n: discharge
Water level 50	497 (496)	float 32	2	R	table entry 50: water level
Discharge 50	499 (498)	float 32	2	R	table entry 50: discharge

[1)] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)

9 Carrying out maintenance work

The maintenance interval of the OTT PLS 500 strongly depends on the local ambient conditions. Even a thin build-up of deposits on the measuring cell will not appreciably affect the measurement results. If very heavy contamination occurs at the station due to algae, mud, vegetation or sediment, the pressure probe should be checked from time to time. For example, imprecise or implausible measured values may indicate a "blocked" measuring cell.

Maintenance plan

- recommended interval: every 15 months (adapt to local environmental conditions if necessary)
- work required:
  - check pressure sensitive membrane of the pressure cell; clean if necessary
  - check the desiccant of the humidity absorber; replace if necessary (see seaparate operating instructions for the humidity absorber used)

Check/replace desiccant of the humidity absorber

Required replacement parts

- Dry desiccant cartridge for replacement (color indicator → orange ■)

For procedure, see separate OTT FAD 4 and OTT FAD 6 assembly instructions.

Please note: With a correctly installed and regularly maintained humidity absorber, the relative humidity in the probe housing is always below 25 % (see Chapter 7.2, **<value1>** in the response to **aD0!** after **aV!**).

If the humidity rises above this, the OTT PLS 500 outputs error message **+64** in the device status (**<value9>** in response to **aD2!** after **aV!**). This is usually an indication of an insufficiently maintained moisture absorber. Slightly increased values allow further operation of the pressure probe. In this case, however, error-free measured values can no longer be guaranteed over the entire operating temperature range. When the dew point is reached, drops often form in the pressure compensation capillary, resulting in unusable measured values! If this occurs, the OTT PLS 500 must be replaced.

How to clean the pressure probe

Required equipment

- Brush with hard bristles
- Common household scale remover
- Clear water for rinsing the pressure probe

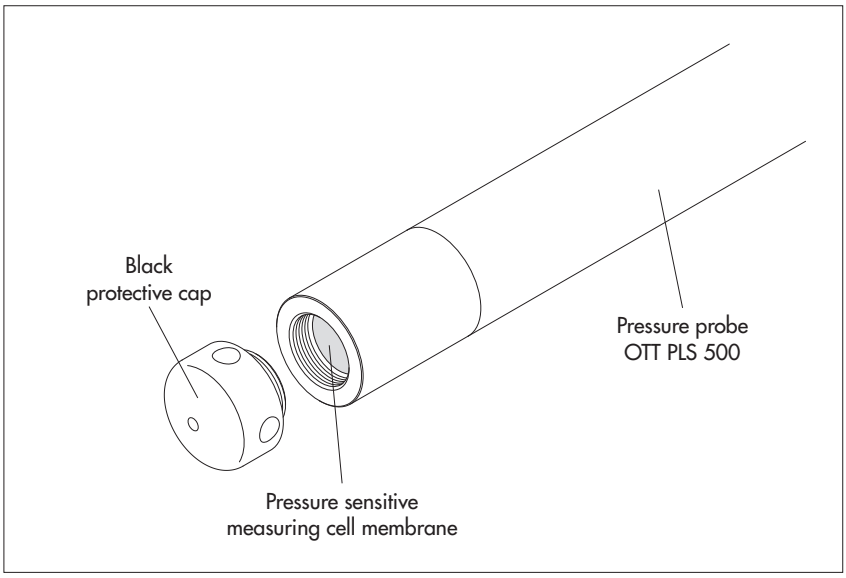
CAUTION **Risk of injury to eyes and skin during maintenance works!**

When cleaning the measuring cell, aggressive dirt particles and acidic scale remover can get into the eyes/on the skin.

- Wear eye protection goggles during maintenance work!
- Wear suitable protective gloves during maintenance work!
- Observe the application and warning instructions of the scale remover used!

- Uninstall OTT PLS 500 (see Chapter 5).
- Remove the black protective cap.
- Clean the measuring cell carefully using a brush (hard bristles). Lime scale deposits can be removed using a common household scale remover.
- Rinse the pressure probe **thoroughly** with clear water!
- Reattach the black protective cap.
- Reinstall OTT PLS 500 (see Chapter 5).
- Determine measured value and compare to reference value (staff gauge, contact gauge) and correct if necessary[1)] (enter reference or offset value or use the scaling function of the connected data logger).

Fig. 10: Cleaning the pressure probe.



[1)] for example, via interface converter "OTT USB/SDI-12 Adapter" in combination with the PC software "OTT SDI-12 Interface"; see Chapter 6

10 Troubleshooting

Sensor does not respond on the RS-485/SDI-12 interface

- For SDI-12 protocol: Sensor correctly connected to a data logger with SDI-12 input?
  → Correct connection assignment.
- Polarity of the supply voltage reversed?
  → Correct connection assignment.
- Supply voltage < 5.5 V or > 28.8 V?
  → Adjust level of voltage supplied (check the length and cross-section of the connection cable).
- Is the supply voltage not direct current?
  → Only operate the sensor with direct current.
- Does the sensor address of the OTT PLS 500 correspond with the sensor address used by the data logger?
  → Correct sensor address.

Sensor does not respond on the RS-485 interface to ...

- SDI-12 commands: is the RS-485 interface of the sensor configured to Modbus-protocol?
  → Test communication via Modbus communication.
- Modbus communication: is the RS-485 interface of the sensor configured to SDI-12 protocol?
  → Test communication via SDI-12 commands.

Sensor does not respond on the RS-485 interface

- "RS-485 A" and "RS-485 B" wires interchanged?
  → Correct the wire assignment.

Measured value varies unexpectedly, jumps or is not present

- Sensor soiled
  → Clean sensor carefully; see Chapter 9, "Carrying out maintenance work".
- Installation of the sensor steady (e.g. movement from swell)?
  Control option: Perform system test of the OTT PLS 500 with **`aV!`** and retrieve result with **`aD0!`** and **`aD1!`** (e.g. as described in Chapter 6). If **`<value3>`** deviates from **`<value4>`** by several degrees, this indicates a change in the orientation of the probe.
  → Optimise installation.
- Condensed water drop in the pressure compensation capillary?
  Control option: Perform system test of the OTT PLS 500 with **`aV!`** and retrieve result with **`aD0!`** (e.g. as described in Chapter 6). The **`<value1>`** shows the relative humidity inside the probe. If this is greatly increased, it indicates that moisture has penetrated the pressure compensation capillary. In most cases this type of error is caused by a missing or insufficiently maintained humidity absorber.
  → Replace the pressure probe.

Various types of error

- Errors that cannot be narrowed down further occur; however, communication on the RS-485-/SDI-12 interface via SDI-12 commands is possible[1]:
  → Perform a system test of the OTT PLS 500 with **`aV!`** and retrieve result with **`aD0!`** … **`aD2!`**. For interpretation of the responses, see Chapter 7.2, **`aD0!`**, **`aD1!`** and **`aD2!`** after **`aV!`**.

[1] for example, via interface converter "OTT USB/SDI-12 Adapter" in combination with the PC software "OTT SDI-12 Interface"; see Chapter 6

11 Repair

- In the event of a problem with the device, refer to Chapter 10, "Troubleshooting", if you can resolve the problem yourself.
- In the event of a device defect, please contact the repair center of OTT HydroMet:

OTT HydroMet GmbH
Repaircenter
Ludwigstrasse 16
87437 Kempten · Germany
Telephone +49 831 5617-433
Fax +49 831 5617-439
repair@ott.com

! **Please note:** Only have a defective OTT PLS 500 checked and repaired by the repair center of OTT Hydromet! Under no circumstances carry out any repairs yourself. Any repairs or attempted repairs carried out by the customer will result in the loss of any guarantee rights.

12 Notes about the disposal of old units

Within the member countries of the European Union
In accordance with the European Union guideline 2012/19/EC, OTT takes back old devices within the member countries of the European Union and disposes of them in an appropriate way. The devices concerned by this are marked with the symbol shown here.

- For further information on the return process, please contact your local sales contact. You will find the addresses of all sales partners in the internet on "www.ott.com". Please take into consideration also the national implementation of the EU guideline 2012/19/EC of your country:

For all other countries
- Dispose of the OTT PLS 500 properly after taking out of service.
- Observe the regulations valid in your country for the disposal of electronic devices!
- Never put the OTT PLS 500 into the normal domestic waste!

Materials used
see Chapter 13, "Technical data"

13 Technical data

Water level

Measuring range	
Variant 1	0 … 10 m ·33 ft water column /0 ...1 bar
Variant 2	0 … 20 m ·66 ft water column /0 ... 2 bar
Variant 3	0 … 40 m ·131 ft water column /0 ... 4 bar
Variant 4	0 …100 m ·328 ft water column /0 ... 10 bar
Resolution	0.001 m · 0.1 cm · 1 mm 0.001 inch · 0.001 ft 0.00001 bar · 0.01 mbar 0.0001 psi
Accuracy (linearity + hysteresis)	
Standard specification	≤ ± 0.05 % full scale
USGS specification (valid for variant code 1)	0 … 500 mbar: ≤ ±0.2 mbar (–5 ... +55°C) 0 … 500 mbar: ≤ ±0.3 mbar (–20 ... –5°C; +55 ... +70°C) 500 ... 1000 mbar: ≤ ±0.5 mbar (–20 ... +70°C)
Long-term stability (linearity + hysteresis)	≤ ±0.1 %/a full scale
Zero drift	≤ ±0.05 % full scale
Units	m · cm · mm inch · ft bar · mbar · kPa psi
Overload protection for the measuring cell (without permanent mechanical damage)	
Variant 1 (0 … 10 m · 33 ft WC / 0 ... 1 bar)	6.7 bar
Variant 2 (0 … 20 m · 66 ft WC / 0 ... 2 bar)	12 bar
Variant 3 (0 … 40 m · 131 WC / 0 ... 4 bar)	16.7 bar
Variant 4 (0 … 100 m · 328 ft WC / 0 ... 10 bar)	26.7 bar
Pressure sensor	ceramic (Al_2O_3 99,9 %), capacitive
Temperature-compensated operating range	–20 (ice free) … +70 °C · –4 (ice free) … +158 °F

Water temperature

Measuring range	–40 … +70 °C · –40 … +158 °F
Resolution	0.01 °C · 0.01 °K
Accuracy	
–20 … +50 °C · – 4 … +122 °F	typ. ±0.05 °C; max. ±0.1 °C · typ. ±0.09 °F; max. ±0.18 °F
–40 … +70 °C · –40 … +158 °F	typ. ±0.05 °C; max. ±0.15 °C · typ. ±0.09 °F; max. ±0.27 °F
Units	°C, °K, °F

Relative humidity in the probe housing

Measuring range	0 … 100 % rH
Resolution	1 % rH
Accuracy	typ. ±2 % rH (20 … 80 % rH) max. ±3 % rH (0 … 100 % rH)
Units	°C, °K, °F

Supply voltage	+5.5 … +28.8 V_{DC}; typ. 12/24 V_{DC}
Current consumption	
idle	< 250 µA; typ. 15 µA
active	< 4 mA; typ. 2.9 µA
Interfaces	SDI-12 version 1.4 EIA-485 (RS-485); SDI-12 protocol or Modbus RTU
Measured physical parameters	– water level/hydrostatic pressure – water temperature – relative humidity in the probe housing – sensor orientation
Measured value processing	– Mean value* within a time interval – Minimum value* within a time interval – Maximum value* within a time interval

	– Median* within a time interval – Standard deviation* within a time interval – Hydrological discharge (Q) * Measured value: water level/hydrostatic pressure
Individually configurable functions	– Selection of units – Water density – Local gravitational acceleration – Salinity – Depth/level – Measurement interval – Offset – Reference value
Measurement interval	0.5 … 59.5 s
Storage temperature	–40 … +85 °C · –40 … +185 °F

Mechanical data

Dimensions of pressure probe L x Ø	194 mm x 22 mm
Cable length	2 … 200 m ±1 % ±5 cm · 6.5 … 656 ft ±1 % ±0.16 ft
Weight of pressure probe	approx. 0.650 kg
Weight of pressure probe cable	approx. 0.055 kg/m
Material	
Pressure probe housing	POM, stainless steel 1.4539 (904 L), resistant to sea water
Cable jacket	PUR
Seals	Viton
Separating membrane	ceramic Al_2O_3
Type of protection	IP 68

Installation

Minimum bending radius pressure probe cable	49 mm · 0.16 ft
Maximum total cable length	
SDI-12	200 m · 656 ft (point-to-point; no bus operation)
EIA-485 (RS-485)	1000 m · 3281 ft
Wire colors	
red	Supply voltage (+5.5 … +28.8 V_{DC})
orange	RS-485 A
green	RS-485 B
blue	GND
grey	SDI-12 data

Performance classification in accordance with DIN EN ISO 4373

Measurement reliability	Performance class1
Temperature range	Temperature class 2
Relative humidity	Class1

Product certifications

CE (EU)	This device complies with the essential requirement of the EMC Direcitve 2014/30/EU.
FCC (US)	FCC Part 15, Class "B" Limits; This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: – the equipment must not cause harmful interference; – the equipment must accept any interference received, including interference that may cause undesired operation.
IC (CN)	Canadian Radio Interference-Causing Equipment. This Class B digital device meets all requirements of the Canadian Regulation, ICES-003, Class B Interference-Causing Equipment Regulations.

Annex A – Shorten pressure probe cable

If required, you can shorten the pressure probe cable of an OTT PLS 500 independently. This is useful in all cases, where the local conditions require a significantly shorter cable length (a slightly too long pressure probe cable can also be looped – taking into account the minimum bending radius).

Please note: Shorten a pressure probe cable only under completely dry ambient conditions! If possible, do this in an interior (e.g. in a workshop). No moisture may penetrate into the pressure compensation capillary!

Tools required

- OTT Stripping tool (order number: 99.000.136.9.5)
- Side cutting pliers
- Crimping pliers for end sleeves (+ end sleeves 0.25 mm²)

CAUTION **Risk of cuts when trimming the pressure probe cable!**

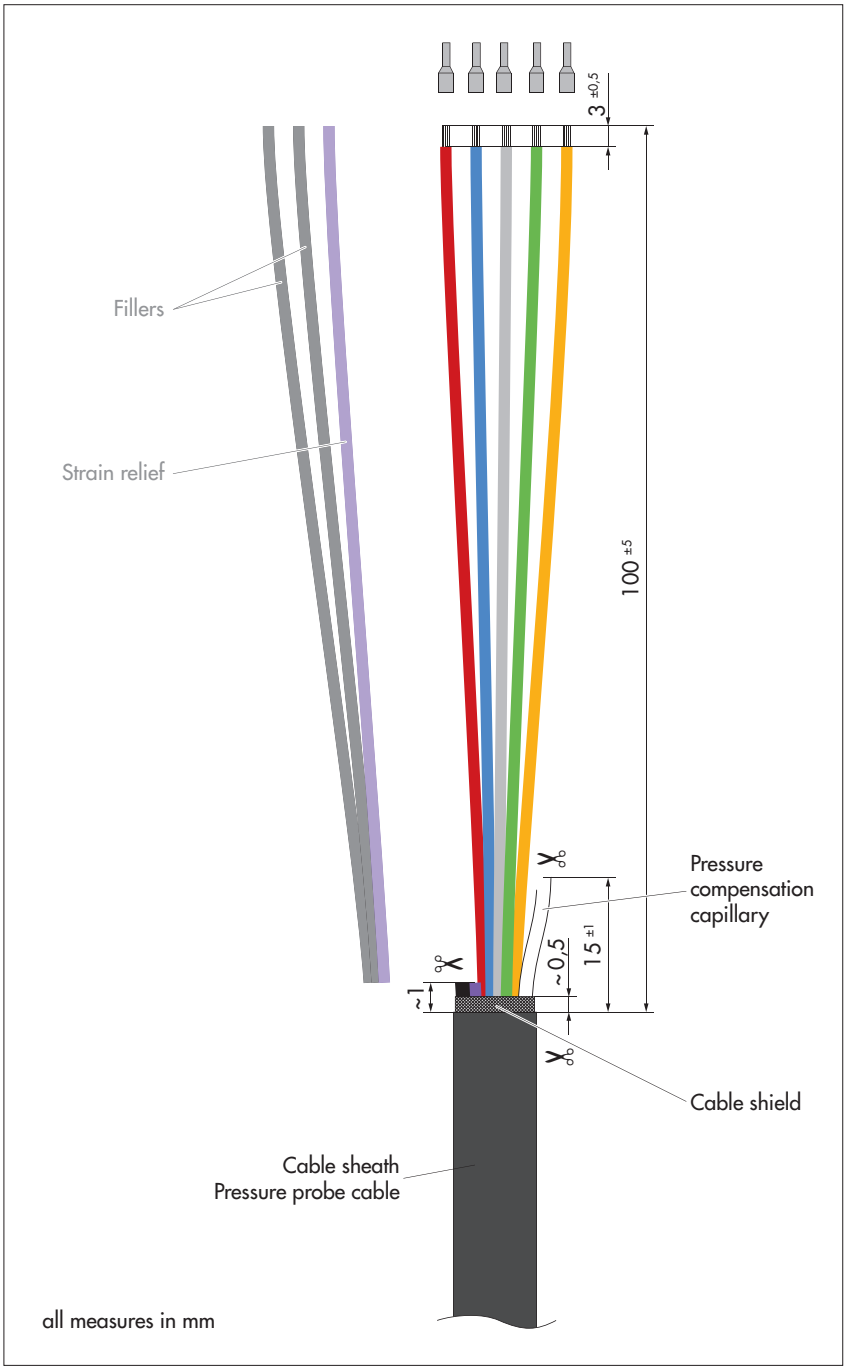
When trimming the pressure probe cable, the stripping tool/side cutting pliers can cause injuries to the fingers or hands.

- Wear protective gloves when trimming the pressure sensor cable.

- Shorten pressure probe cable by desired length.
- Strip pressure probe cable with OTT stripping tool;
  For dimensions, see Fig. A1:
  Tip: first practice stripping on a cable remnant.
  – place the OTT stripping tool on the cable sheath and cut carefully by rotating the tool; remove cable sheath;
  – pinch off the cable shield at the cable sheath and remove it;
  – pinch off and remove two black fillers at the end of the cable sheath;
  – pinch off and remove the violet Kevlar-strain relief at the end of the cable sheath;
  – strip five individual wires with the OTT stripping tool.
- Put end sleeves on the individual wires.
- Shorten pressure compensation capillary to 15 $^{\pm 1}$ mm; do not cut at right angles but at an angle!
- Until final installation, protect the cable end from penetrating moisutre and dirt by using the supplied transport protection box.

Please note: the cable shield must not be connected to earth/ground when installing the OTT PLS 500!

Fig. A1: Dimensions of the OTT PLS 500 pressure probe cable (picture is not to scale).



Annex B – Note on Declaration of Conformity

If necessary, you can download the current version of the Declaration of Conformity for the OTT PLS 500 as pdf file from our website: "www.ott.com/resources"!

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