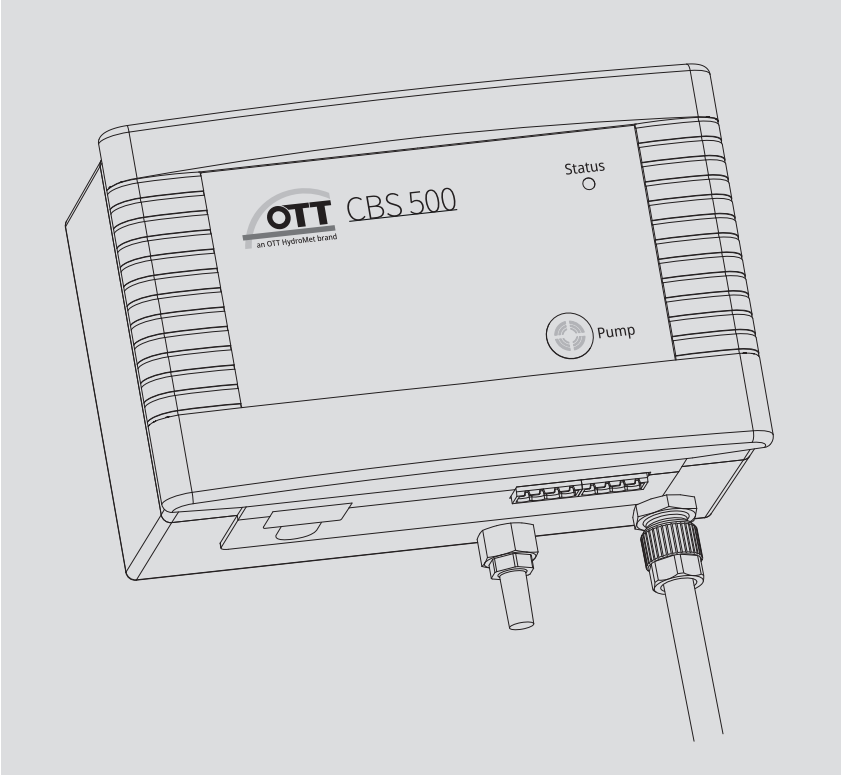
Operating instructions

Bubble Sensor
OTT CBS 500



English

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

Table of contents

1 Scope of supply

▶ OTT CBS 500

– 1 Bubble Sensor OTT CBS 500 with connection for measuring tubes with
  · 4/2 mm and 6/4 mm external/internal diameter
  · ⅜/⅛" external/internal diameter
– 1 Installation kit (top hat rail with fastening parts, screw terminal blocks)
– 1 Information Sheet Compliance – OTT CBS 500
– 1 Factory acceptance test (FAT)

2 Order numbers

▶ OTT CBS 500

Bubble Sensor			6320200190
Variant code (supplementary to order number)			–□–□–□
– Measuring range · Ø Measuring tube [1]	15 m · 4/2 mm and 6/4 mm	1	
	15 m · ⅜/⅛"	2	
	30 m · 4/2 mm and 6/4 mm	3	
	30 m · ⅜/⅛"	4	
– preset measurement units	metric		M
	imperial		I
– System integration	no		0
	yes [2]		Z

[1] external/internal diameter
[2] the OTT CBS 500 is part of a measuring system and is mounted in a control cabinet in the factory; this eliminates the need for device packaging

▶ Accessories

Measuring tube 4/2
– 4/2 mm external/internal diameter
– transparent PE
– length: 50 m 9942005095
– length: 100 m 9942010095

Combined measuring tube/ bubble chamber suspension cable
– 4/2 mm external/internal diameter
– transparent PE
– with kevlar core for length stabilization
– black
– length: 50 m 9942000995
– length: 100 m 9942000895

Measuring tube 6/4 with sheathing 2050013355
– 6/4 mm external/internal diameter
– with sheathing
– length in whole meters according to customer requirements

Measuring tube 6/4 without sheathing 2050030255
– 6/4 mm external/internal diameter
– without sheathing
– length in whole meters according to customer requirements

Bubble chamber suspension cable
– with kevlar core for length stabilization
– black
– length: 50 m 9900005095
– length: 100 m 9900010095

Bubble chamber for groundwater – for observation wells beginning at 2" diameter – 670 grams	5551005142
Bubble chamber for surface water EPS 50	
– for measuring tube 4/2 mm	5551004832
– for measuring tube 6/4 mm	5551004932
Pipe fitting	
– for connecting a measuring tube with ⅜/⅛" external/internal diameter	6320002592

Examples

OTT CBS 500
– measuring range 15 m · measuring tube: 4/2 mm and 6/4 mm external/internal diameter
– measurement unit metric
– no system integration
→ Order number + variant code: 6320200190–1–M–0

OTT CBS 500
– measuring range 30 m · measuring tube: ⅜/⅛" external/internal diameter
– measurement unit imperial
– with system integration
→ Order number + variant code: 6320200190–4–I–Z

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.

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

Please note : …
Information that prevents potential damage or malfunction on the OTT CBS 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 corresponding pictograms **orange/yellow triangle** in these operating instructions:

WARNING **Warnung of a hazardous situation with a medium level 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 injury**.

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

CAUTION **Warning of a hazardous situation with a low level or 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 of the OTT CBS 500

- These operating instructions are intended for professional specialist personnel. The target group includes people who are familiar with working on hydrological bubble sensors.
- Read these operating instructions before using the OTT CBS 500 for the first time! Make yourself completely familiar with the installation and operation of the OTT CBS 500! Retain these operating instructions for later reference.

Inteded use

- Only use the OTT CBS 500 as described in these operating instructions. The intended use of the OTT CBS 500 is the indirect measurement of groundwater and water levels in natural or artificial bodies of water (hydrometry). Any other use is not permitted! For further information → see Chapter 4, *Introduction*.
- Never operate the OTT CBS 500 in potentially explosive environments! For further information → see Chapter 5, *Installing the OTT CBS 500*.
- Only install the OTT CBS 500 if you have the appropriate qualification. If required, obtain training by OTT HydroMet. For further information → see Chapter 5, *Installing the OTT CBS 500*.
- Note all the detailed safety and warning information given within the individual work steps during installation and maintenance! Further information on the structure and design of warning information → see Chapter 3.2, *Explanation of safety information used*.
- If the OTT CBS 500 is powered directly by a battery/rechargeable battery: Protect the supply line of the OTT CBS 500 with a fuse (fine fuse). Recommended: Nominal current: 2.5 A, reaction time: slow. For further information → see Chapter 5, *Installing the OTT CBS 500*.
- It is essential that you comply with the electrical, mechanical, and climatic specifications listed in the technical data! For further information → see Chapter 16, *Technical Data*.
- Do not make any changes or retrofits to the OTT CBS 500! If changes or retrofits are made, all guarantee claims are voided.
- Check the OTT CBS 500, including the measuring tube and the bubble chamber, at regular intervals for secure fastening, mechanical damage, and heavy contamination. Activate the purge function at least once per quarter to remove deposits and maintain measurement accuracy. For further information → see Chapter 11, *Carrying out maintenance work*.
- Have a faulty OTT CBS 500 inspected and repaired by our repair center! Never make any repairs yourself under any circumstances. For further information → see Chapter 14, *Repairs*.
- Dispose of the OTT CBS 500 properly after decommissioning! Never dispose of the OTT CBS 500 in normal household waste. For further information → see Chapter 15, *Notes about the disposal of old units*.

4 Introduction

The bubble sensor OTT CBS 500 working on the air bubble principle can be used – depending on which bubble chamber is used – for measuring water levels in groundwater or in natural or artificial bodies of water.

To meet the different requirements of measurement stations, the OTT CBS 500 is available with two measuring ranges.

Measuring range 15 m

- Measuring range 0 … 15 m (0 … 1500 mbar)
- Resolution 1 mm (0.1 mbar)
- Accuracy ±5 mm
- Measuring tube 4/2 mm and 6/4 mm or ⅜/⅛" external/internal diameter

Measuring range 30 m

- Measuring range 0 … 30 m (0 … 3000 mbar)
- Resolution 1 mm (0.1 mbar)
- Accuracy ±5 mm
- Measuring tube 4/2 mm and 6/4 mm or ⅜/⅛" external/internal diameter

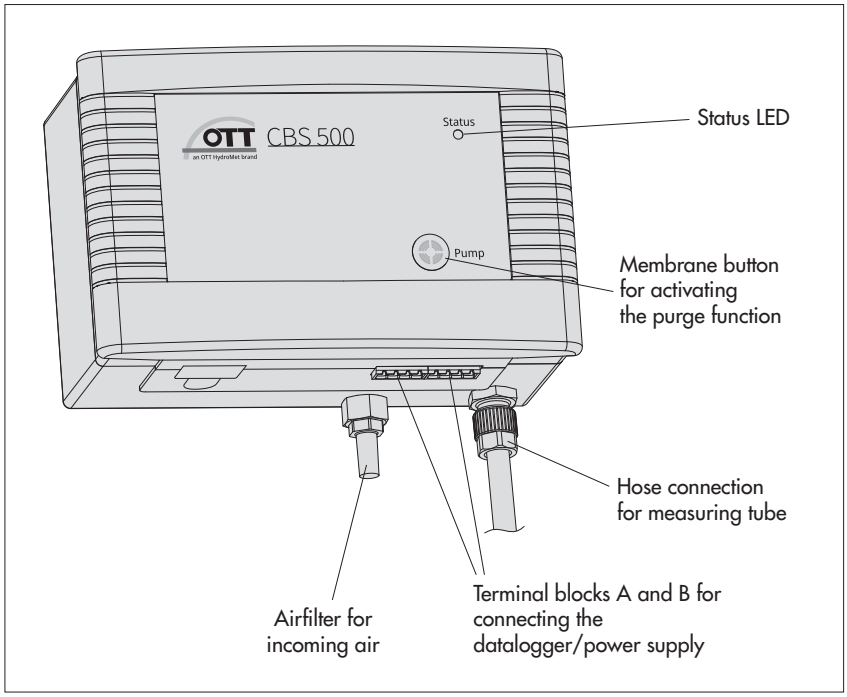
The measurement units are preset at the factory to metric or imperial, depending on the device variant ordered.

The compressed air produced by a piston pump flows via a measuring tube and the bubble chamber into the water to be measured. The pressure created in the measuring tube is directly proportional to the water column above the bubble chamber. The OTT CBS 500 determines the barometric air and bubble pressure one after the other. By taking the difference between the two signals, the OTT CBS 500 calculates the height of the water level above the bubble chamber.

The power supply can be provided from a mains adapter, battery or solar power.

The OTT CBS 500 contains a purge function. This clears the measuring tube and the bubble chamber of any minor contamination by pumping a large volume of air into the measuring tube.

Fig 1: Overview of bubble sensor OTT CBS 500.



By using an intelligent pump strategy, no air drying unit is necessary for the measuring range of 0 … 15 m.

For the display of any error states, the OTT CBS 500 has a "Status" LED (see Fig. 1).

Connection to a datalogger can be established via a choice of interfaces:

- SDI-12 or
- RS-485- (2-wire; SDI-12- / Modbus protocol).

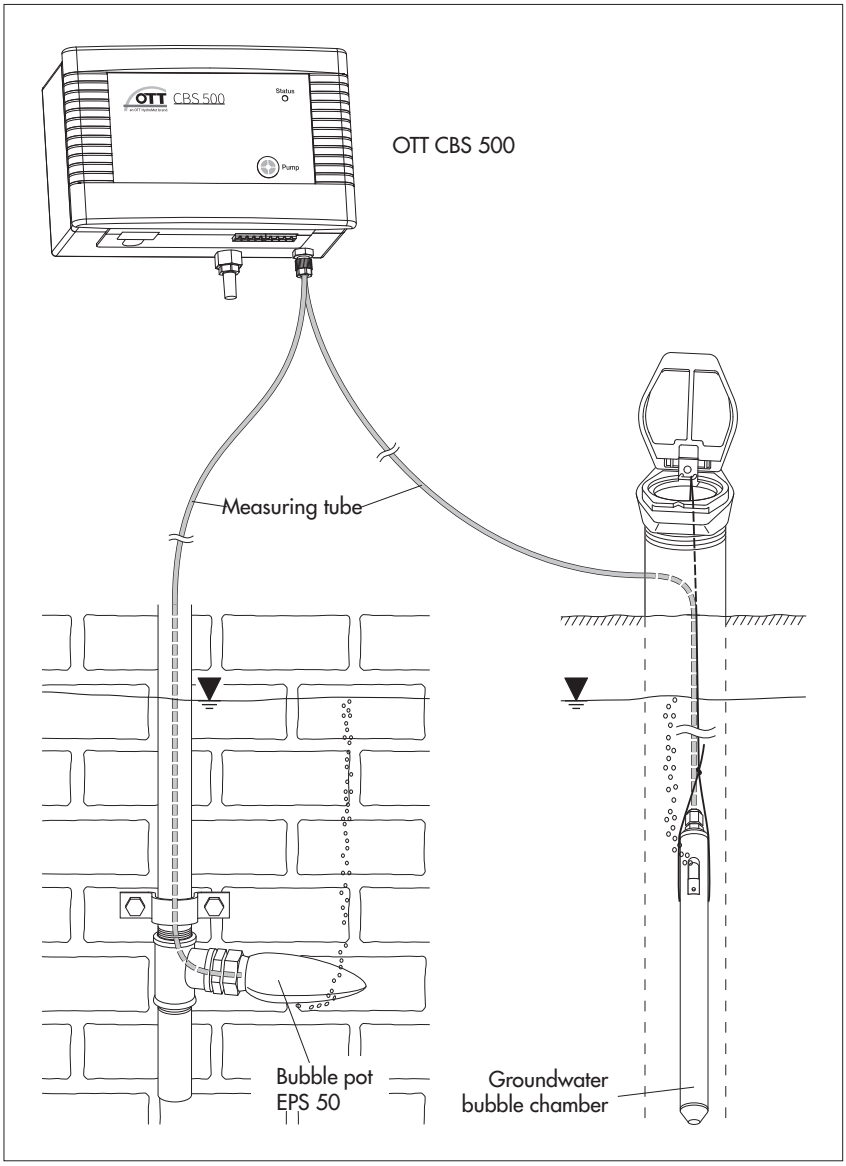


Fig. 2: Main layout of a level-/groundwater measurement site with the bubble sensor OTT CBS 500.

5 Installing the OTT CBS 500

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

If the OTT CBS 500 is operated in an explosive atmosphere, there is a risk of the atmosphere igniting. An explosion caused by this involves the risk of serious damage to property and personal injury. (The risk of explosion relates exclusively to the device itself. The bubble chamber does not pose a hazard in this context.)

▶ **Never** operate the OTT CBS 500 in potentially explosive environments (e.g. in waste water channels)! The OTT CBS 500 does not have EX protection (explosion protection).

5.1 Mounting the OTT CBS 500 on top hat rail

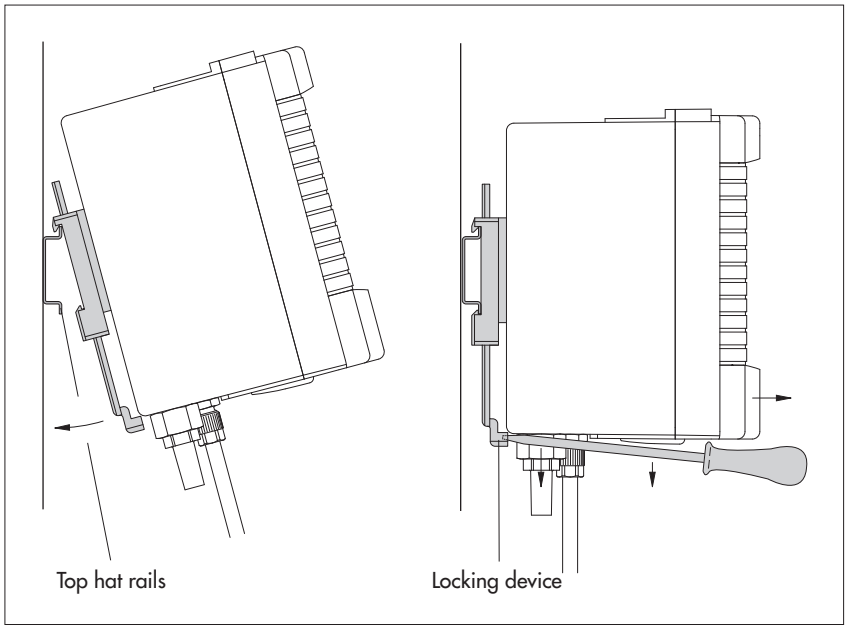
The OTT CBS 500 is designed only to be installed on top hat rails (a section of top hat rail is supplied with the OTT CBS 500). Choose a dry and dust free location for the installation such as a gauge station or control cabinet.

■ First attach the OTT CBS on the upper edge of the top hat rail and then press the underside against the top hat rail until it clicks into place.

Demounting the OTT CBS 500 from top hat rail

■ First press one locking device downwards and pull the OTT CBS slightly forwards at this point. Press the second locking device downwards and remove the OTT CBS upwards from the top hat rail.

Fig. 3: Mounting the OTT CBS 500 on the top hat rail (left)/demounting (right).



5.2 Connecting the measuring tube to OTT CBS 500

CAUTION **Risk of injury to fingers during cutting work**

When installing the measuring tube, there is a risk of injury to fingers from cutting work.

▶ Wear protective gloves when installing the measuring tube!

To install the measuring tube on the OTT CBS 500, proceed as follows:

Measuring tube with 2 mm internal diameter

- Cut off the end of the measuring tube square with a sharp knife and push onto the factory fitted connection nipple.

Maximum length of measuring tube: 100 m

Measuring tube with 4 mm internal diameter

- Cut off the end of the measuring tube square with a sharp knife.
- Remove cap nut (width across flats: 10) and pull off the short factory mounted measuring tube from the connection nozzle.
- Push cap nut over the measuring tube (Ø 4 mm).
- Push measuring tube onto the connection nozzle.
- Push the cap nut back onto the connection nozzle and tighten by hand.

Maximum length of measuring tube: 75 m

Measuring tube with ⅛" internal diameter

For the measuring tube with ⅛" internal diameter a special pipe fitting is available (accessories). Please follow the instructions supplied with the pipe fitting for installation.

Maximum length of measuring tube: 100 m

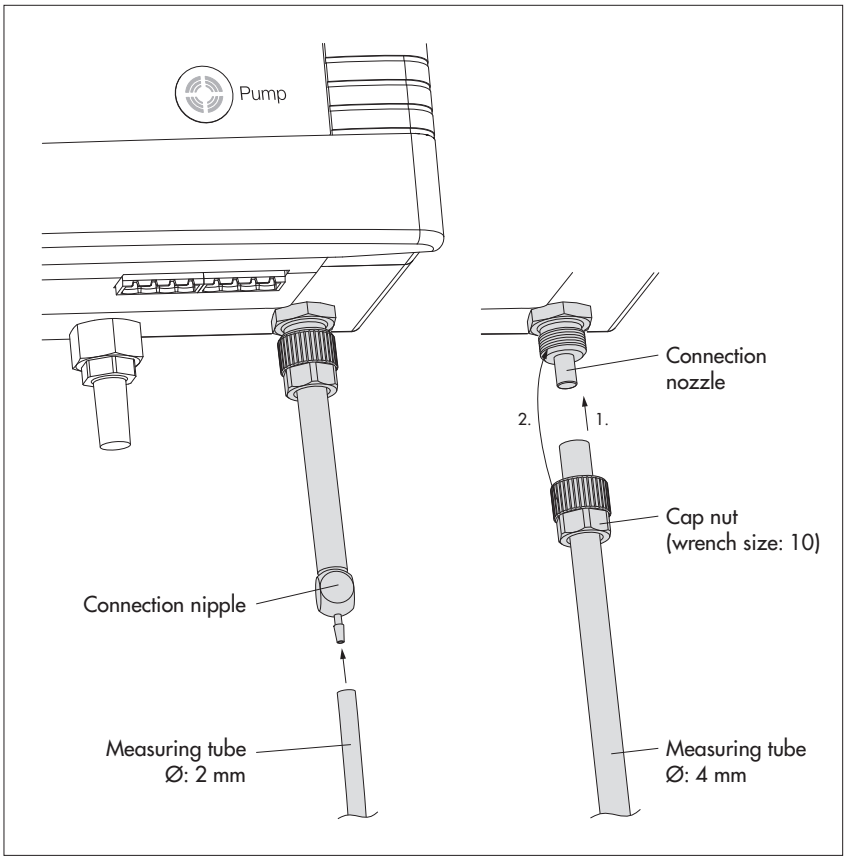


Fig. 4: Connecting the measuring tube to the OTT CBS 500.

6 Installing the bubble chamber

WARNING **Risk of drowning**

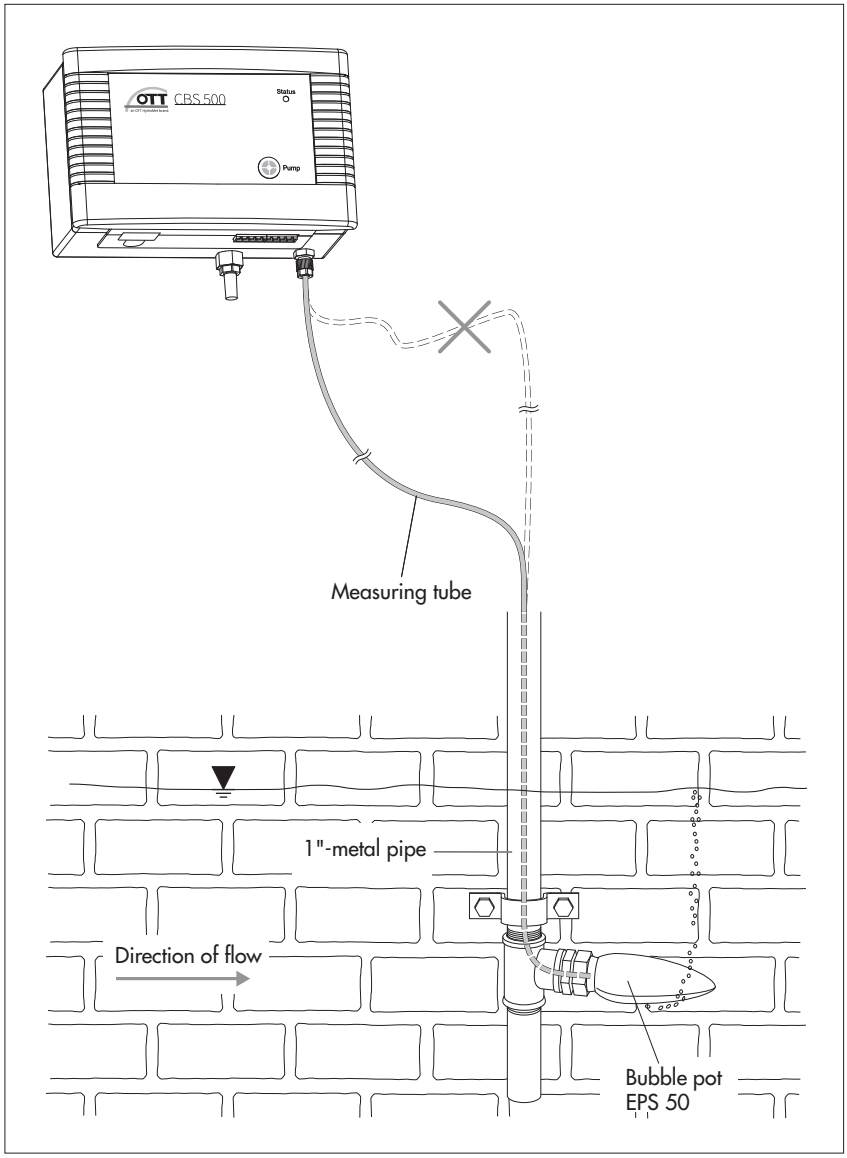
The bubble chamber is often installed in deep or fast flowing waters – posing a risk of drowning!

- When working in areas where there is a risk of drowning, wear suitable personal protective equipment (PPE) to protect yourself from drowning!

Please ensure the following is noted during installation:

- No contamination or moisture may be allowed into the measuring tube.
- When immersing the bubble chamber (only EPS 50), the OTT CBS 500 must be activated, so that the piston pump is operating during this process.
- Do not damage or kink the measuring tube during installation.
- Lay the measuring tube such that there is a continuous drop from the OTT CBS 500 towards the bubble chamber. Otherwise moisture could collect in a "hollow" and potentially block the tube with the formation of drops (see Fig. 5).

Fig. 5: Routing requirements for measuring tube.



6.1 Installing the bubble chamber for surface water

We recommend using the Bubble Pot EPS 50 for measurements in surface waters. See "Bubble Pot EPS 50" installation instructions for information on its installation.

6.2 Installing the bubble chamber for groundwater

CAUTION **Risk of injury to fingers/hands due to suspension cable**

When lowering the bubble chamber quickly into the observation well, there is a risk of injury due to burns and cuts to fingers and hands.

▶ Wear protective gloves when installing the bubble chamber.

To install the bubble chamber for ground water, proceed as follows:

- Determine depth of the bubble chamber (e.g. using a contact gauge). The bubble chamber must be positioned under the lowest expected water level;
  Depth = Distance from bubble opening to upper edge of the top cap
- Push the measuring tube into the cable gland of the bubble chamber as far as it goes.
- Tighten the cable gland firmly by hand.
- Cut suspension cable to length;
  Suspension cable length = Depth + 125 cm
  (to protect the suspension cable from being twisted off, it can be melted, with a cigarette lighter for example).
- Feed the suspension cable through the hole in the bubble chamber as shown in Fig. 6 and tie firmly.
- Slide cover into position B (upwards), see Fig. 6.

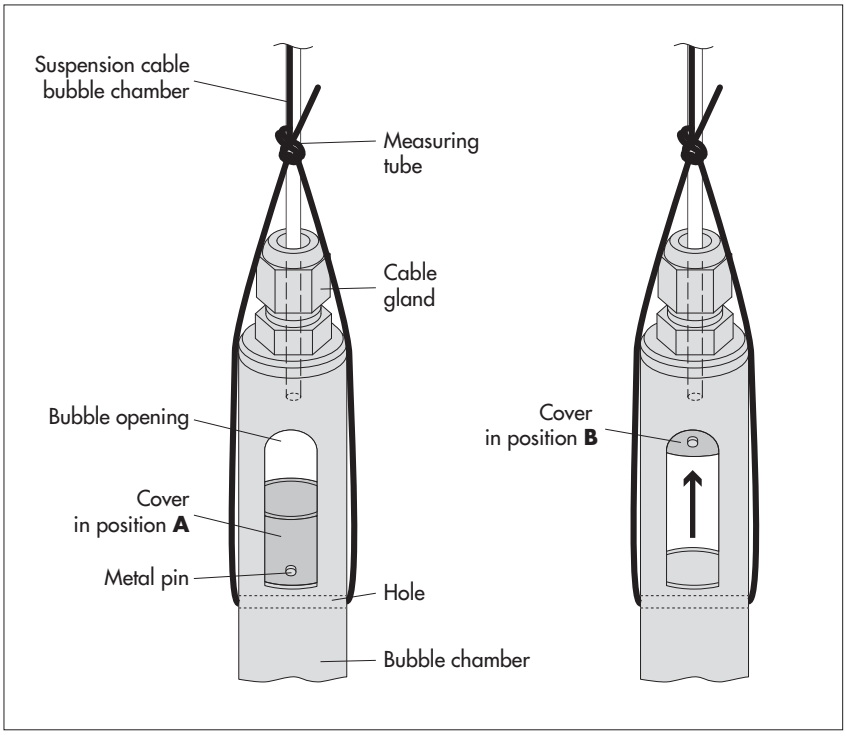


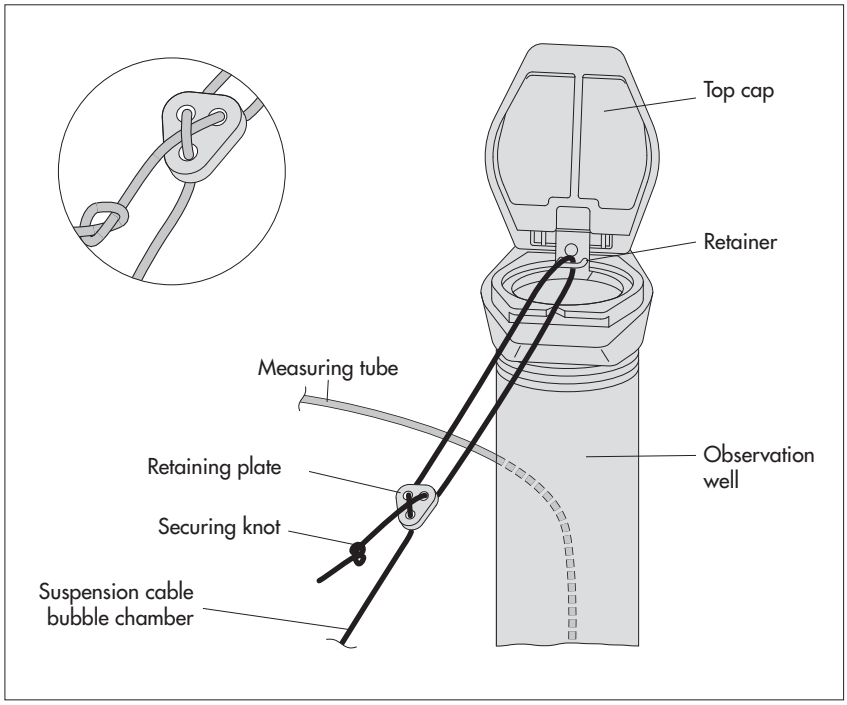
Fig. 6: Installing bubble chamber for groundwater.

When lowering the bubble chamber, the cover must be in position B. The cover prevents water entering the measuring tube during installation.

During initial startup, over pressure builds up in the measuring tube. As a result, the cover falls back to position A and opens the measuring tube in process.

- As shown in Fig. 7, attach the suspension cable of the bubble chamber to the retainer on an OTT top cap already mounted. The retaining plate allows a fine height adjustment afterwards.
- Secure the suspension cable against slipping with a knot.
- If top caps without retainers are used, ensure the suspension cable is attached securely.
- Check all knots and attachments for correct position and firmness.
- Lower the bubble chamber slowly into the observation well with the suspension cable.
- Feed the measuring tube out of the observation well through a hole.

Fig. 7: Installing the bubble chamber for groundwater – attaching the suspension cable.



7 Connecting OTT CBS 500

The OTT CBS 500 has the following interfaces

- SDI-12
- RS-485 (2-wire; SDI-12 / Modbus-protocol)

as well as a

- connection for the power supply (U_{Bat} + GND).

The two interfaces make it possible to connect the OTT CBS 500 both to an OTT datalogger and to any datalogger by another manufacturer that has the correct interfaces. Note that only one of the interfaces can be used (no parallel operation of interfaces)!
The SDI-12 interface meets SDI-12 Standard 1.4.

All electrical connections are made using two screw terminal strips (supplied) at terminal blocks A and B on the underside of the OTT CBS 500.

Please note: The electrical installation of the OTT CBS 500 may only be carried out by a qualified electrician with the appropriate qualifications and experience.

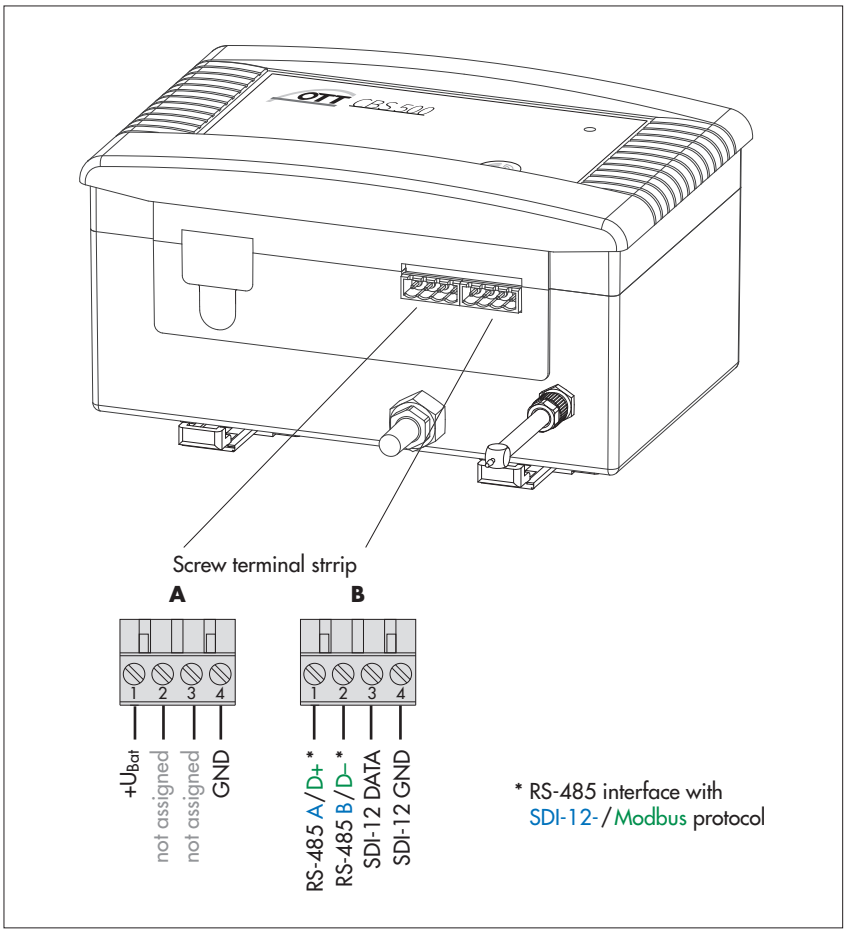


Fig. 8: Assignments for the screw terminal strips of the OTT CBS 500.

- **Note on measurement mode (continuous vs. command-controlled):**
  After applying the operating voltage, the OTT CBS 500 automatically enters continuous measurement mode. In this mode, the device performs measurements continuously at regular intervals. The time interval between two measurements (cycle time) can be set using an SDI-12 command (**aXXC<value>!**).

  Continuous measurement mode is required for using the Modbus protocol and for SDI-12 commands of type "**aR**...**!**".

  If an SDI-12 command of type "**aM**...**!**" or "**aC**...**!**" is sent to the OTT CBS 500, the continuous measurement mode is terminated. In this state, the device only performs measurements in response to explicit "**aM**...**!**"- or "**aC**...**!**" commands.

  To reactivate continuous measurement mode, the device must be restarted by interrupting the power supply. Alternatively, an SDI-12 command of type "**aR**...**!**" can be sent to the device.

7.1 Connecting power supply

The OTT CBS 500 requires a power supply of 9.6 … 30 V_{DC},
typ. 12/24 V_{DC} (e.g. using batteries or mains connection with galvanically seprated low safety voltage).

Please note the following when dimensioning the power supply:

- Maximum permissible supply voltage: 30 V_{DC}!
- Maximum power consumption/day: 3700 mAh (typ. 320 mAh/day) (with1 min measurement interval and 100 m measuring tube)
- Peak current consumption: temporary up to 2 A!
- If the OTT CBS 500 is powered directly by a battery/rechargeable battery: Protect the supply line* with a fuse (fine fuse).
  Recommended: Nominal current: 2.5 A, reaction time: slow.
  * screw terminal strip A, terminal 1
- When using solar panels, we recommend the use of an overvoltage protection device.

To supply the OTT CBS 500 with power proceed as follows:

- Connect the power supply to screw terminal strip A of the OTT CBS 500 as shown in Fig. 8.
  Used terminals: 1 (+U_{Bat}) and 4 (GND).

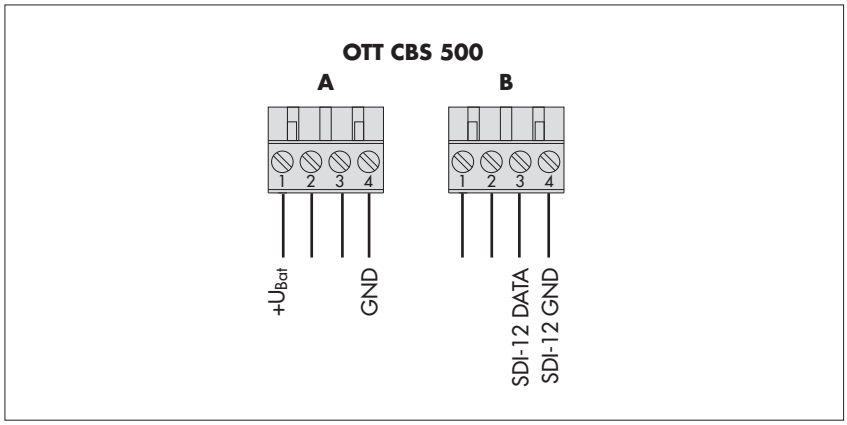
Remarks:

- The OTT CBS 500 does not have a switch to turn the device on or off.
  The OTT CBS 500 is ready for operation as soon as the supply voltage is applied.
- The supply voltage should be continuously applied to the OTT CBS 500 instead of being switched on and off at each polling interval via a datalogger.
  (This ensures smooth operation, shortens the initialisation phase and prevents potential communication errors at the start of measurment.)
- Each time the supply voltage is connected, the piston pump is activated once for approx. 400 strokes (approx. 5 minutes running time).

7.2 Connecting the OTT CBS 500 to any datalogger using the SDI-12 interface

- Connect the OTT CBS 500 to an SDI-12 input on the datalogger. Please refer to the datalogger manual. Fig. 10 shows the pin assignment. The maximum cable length is 100 m for a point-to-point connection and 70 m for SDI-12 bus operation.

Fig. 9: Required terminals on the screw terminal strip when using the SDI-12 interface.



Please note: The OTT CBS 500 cannot be powered via the SDI-12 interface (12 volt line)! The peak current consumption of the bubble sensor is up to 2 A for a short time!

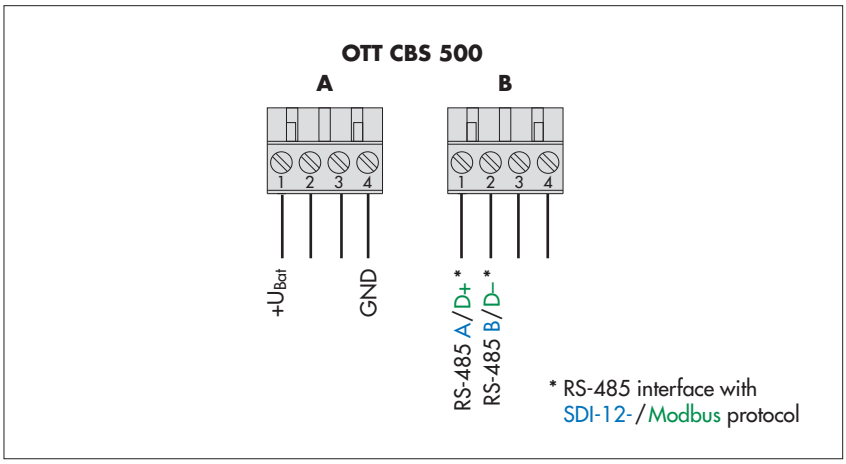
Find detailed information on connection to OTT/Sutron dataloggers in Chapters 7.4 to 7.6.

Find the SDI-12 commands and responses that can be used with the OTT CBS 500 in Chapter 9, *SDI-12 commands and responses*.

7.3 Connecting OTT CBS 500 to any datalogger/electronic control using the RS-485 interface

- Connect the OTT CBS 500 to an RS-485 input of a datalogger/electronic control (SDI-12 or Modbus protocol). Follow the datalogger's /electronic control's operating instructions.
  See Fig. 10 for the assignments.
  This is the maximum cable length for
  – SDI-12 protocol: 100 m
  – Modbus protocol: 1000 m.

Fig. 10: Required terminals on the screw terminal strip when using the RS-485 interface.



Note on using the physical RS-485 interface:
Depending on the device variant, the SDI-12 or Modbus (RTU) transmission protocol is available on the RS-485 interface. The RS-485 interface in combination with the SDI-12 protocol is intended and tested for use with OTT and Sutron dataloggers! OTT HydroMet cannot guarantee functionality if you connect the OTT CBS 500 to a third-party data collector via the RS-485 interface (SDI-12 protocol).

Find detailed information on connecting to OTT/Sutron dataloggers in Chapters 7.4 to 7.6.

Find the SDI-12 commands and respones that can be used with the OTT CBS 500 in Chapter 9, *SDI-12 commands and responses;* find information on the Modbus (RTU) transmission protocol in Chapter 10, *RS-485 interface with Modbus protocoll (RTU).*

7.4 Connecting OTT CBS 500 to IP datalogger OTT netDL using the SDI-12 or RS-485 interface

Variant A: Connect OTT CBS 500 using the SDI-12 interface (protocol and physical interface: SDI-12). The maximum cable length is 100 m for a point-to-point connection and 70 m for SDI-12 bus operation.

- Connect OTT CBS 500 to IP-datalogger OTT netDL as shown in Fig. 11 (right). Follow the operating instructions of OTT netDL.

Variant B: Connect OTT CBS 500 using the physical RS-485 interface (SDI-12 protocol via RS-485 interface).
The maximum cable length is 1000 m.

- Connect OTT CBS 500 to IP-datalogger OTT netDL as shown in Fig. 11 (left). Follow the operating instructions of OTT netDL.

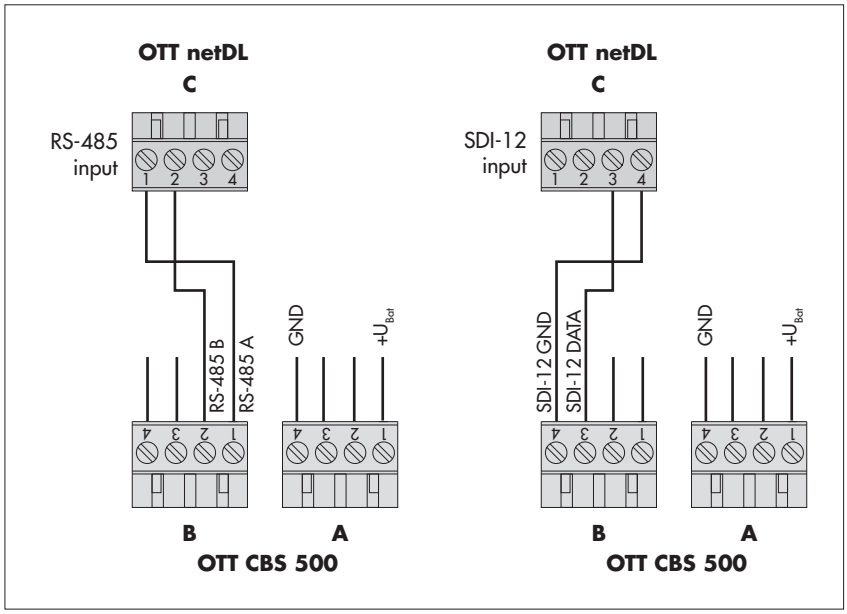


Fig. 11: Connecting OTT CBS 500 to an OTT netDL using the RS-485 interface (SDI-12 protocol; left) or using the SDI-12 interface (right).

The letters above the screw terminal strips indicate possible connections on the OTT netDL.

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

7.5 Connecting OTT CBS 500 to Sutron XLink 100/500 datalogger using SDI-12 or RS-485 interface

Variant A: Connect OTT CBS 500 using the SDI-12 interface (protocol and physical interface: SDI-12). The maximum cable length is 100 m for a point-to-point connection and 70 m for SDI-12 bus operation.

- Connect OTT CBS 500 to the Sutron XLink 100/500 datalogger as shown in Fig. 12 (bottom). Follow the operating instructions of Sutron XLink 100/500.

Variant B: Connect OTT CBS 500 using the physical RS-485 interface (SDI-12-or Modbus protocol via physical RS-485 interface).
The maximum cable length is 1000 m.

- Connect OTT CBS 500 to the Sutron XLink 100/500 datalogger as shown in Fig. 12 (top). Follow the operating instructions of Sutron XLink 100/500.

! **Please note:** The OTT CBS 500 cannot be powered via the Sutron XLink 100/500! The peak current consumption of the bubble sensor is up to 2 A for a short time!

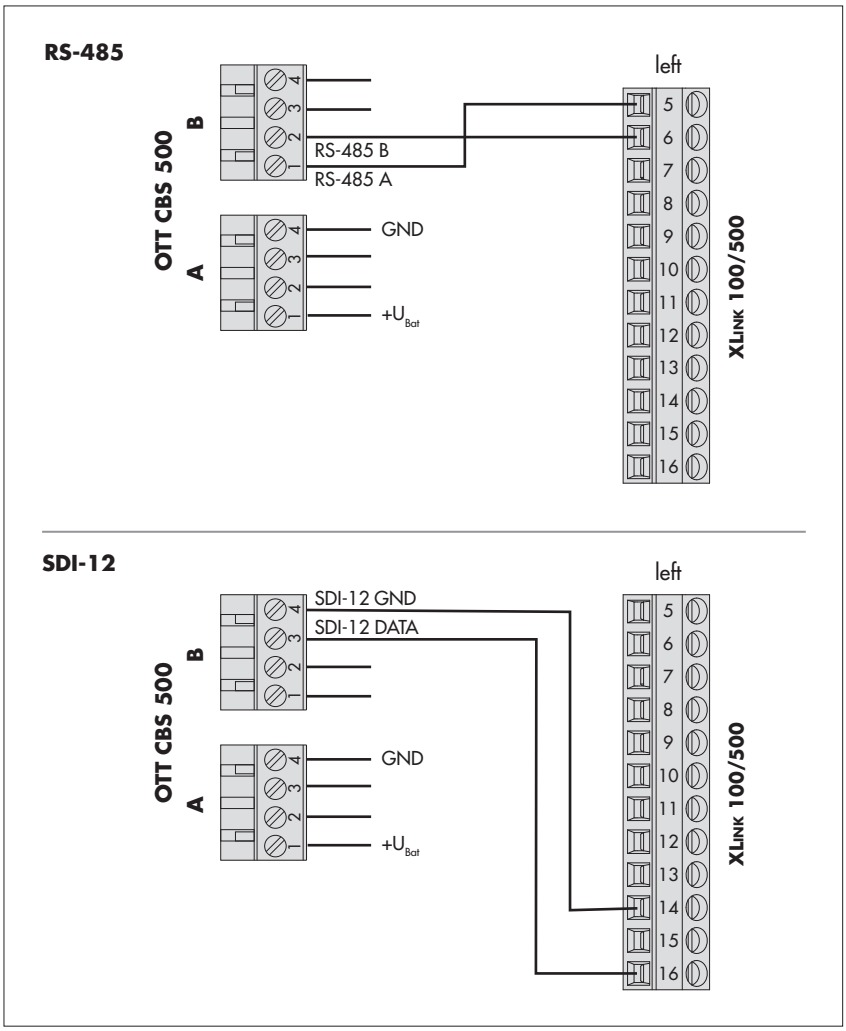


Fig. 12: Connecting OTT CBS 500 to Sutron XLink 100/500 using the RS-485-interface (SDI-12 or Modbus-prol; top) or the SDI-12 interface (bottom).

- Configure the Sutron XLink 100/500 datalogger as described in the operating instructions of the device.

7.6 Connecting OTT CBS 500 to Sutron SatLink 3 datalogger using the SDI-12 or RS-485 interface

Variant A: Connect OTT CBS 500 using the SDI-12 interface (protocol and physical interface: SDI-12). The maximum cable length is 100 m for a point-to-point connection and 70 m for SDI-12 bus operation.

- Connect OTT CBS 500 to the Sutron SatLink 3 Satellite transmitter as shown in Fig.13. Follow the operating instructions of Sutron SatLink 3.

Variant B: Connect OTT CBS 500 using the physical RS-485 interface (SDI-12-or Modbus protocol via physical RS-485 interface).
The maximum cable length is 1000 m!

- Connect OTT CBS 500 to the Sutron SatLink 3 Satellite transmitter as shown in Fig. 14. Follow the operating instructions of Sutron Sutron SatLink 3.

! **Please note:** The OTT CBS 500 cannot be powered via the Sutron SatLink 3! he peak current consumption of the bubble sensor is up to 2 A for a short time!

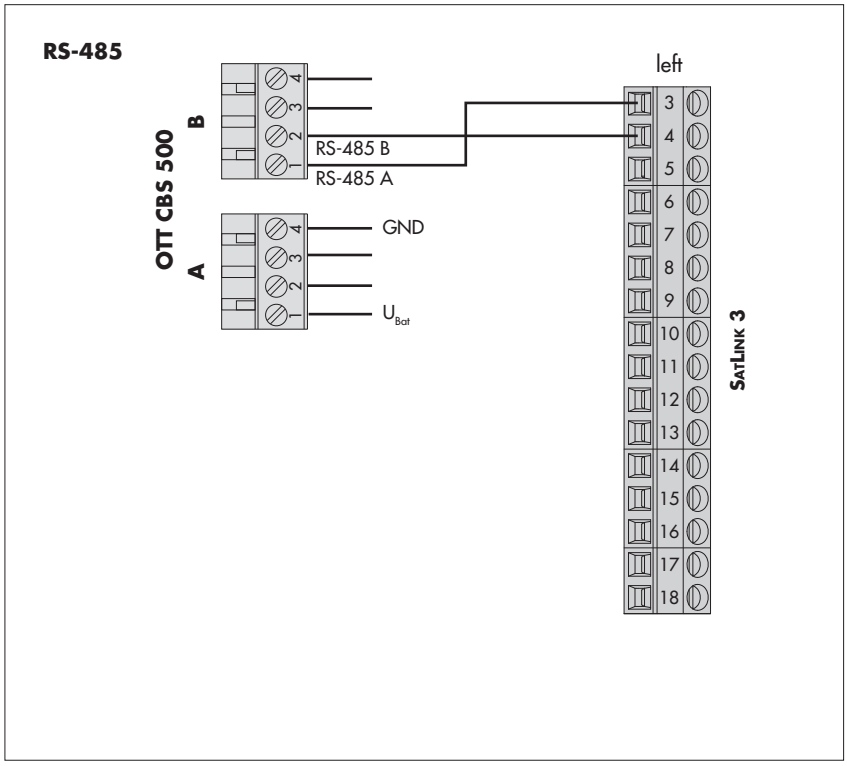


Fig. 13: Connecting OTT CBS 500 to Sutron SatLink 3 using the RS-485 interface (SDI-12 or Modbus-protocol; left) .

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

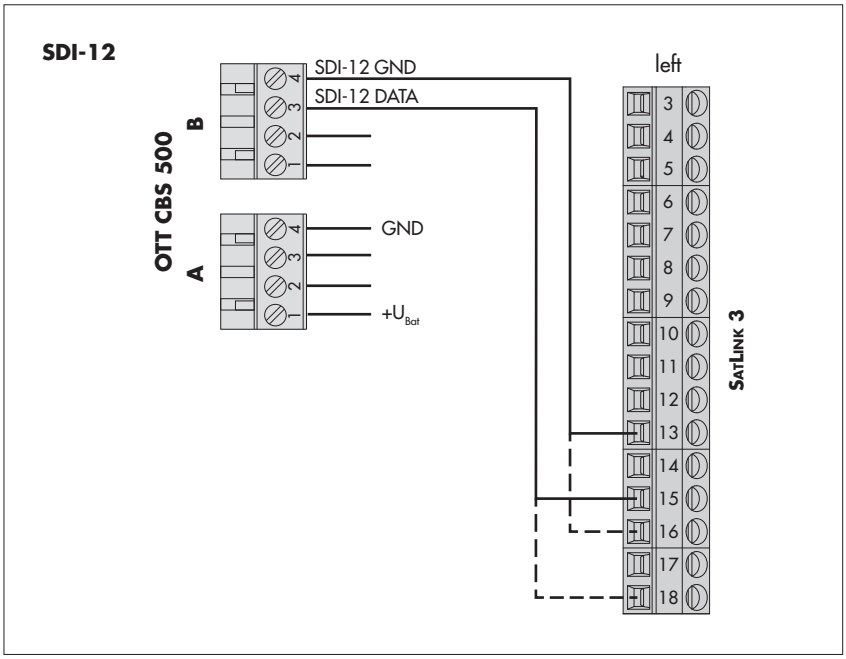


Fig. 14: Connecting OTT CBS 500 to Sutron SatLink 3 using the SDI-12 interface.

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

8 Activating the purge function

On the front of the OTT CBS 500 there is a "Pump" membrane button (see Fig. 15). Pressing the button activates the purge function for as long as it is pressed; the "Status" LED lights for approx. 2 seconds. With an activated purge function, the
CBS pumps a large amount of air through the measuring tube for the required time period (see also Chapter 11). The purge function can also be activated via an SDI-12 command.

Remark: Press the membrane button for at least one second as otherwise the error memory is called and displayed at the "Status" LED.

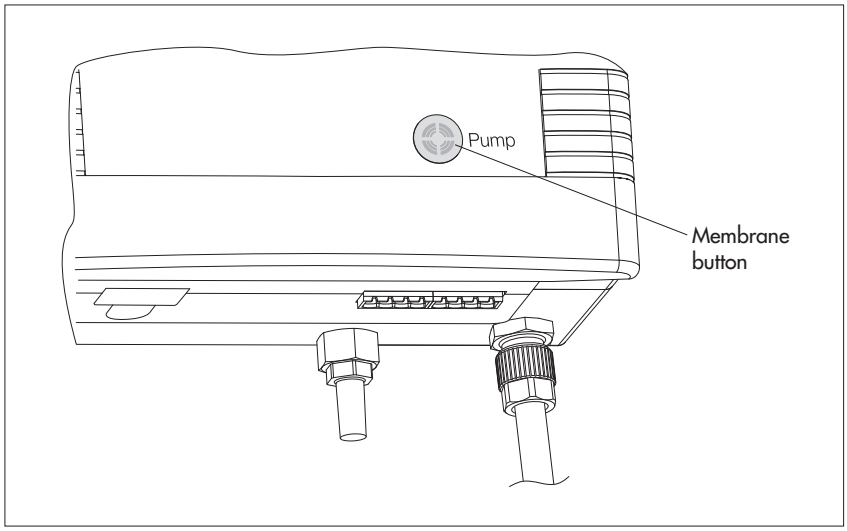


Fig. 15: Activating purge function manually on the OTT CBS 500 with membrane button.

9 SDI-12 Commands and responses

The OTT CBS 500 communicates either using the physical SDI-12 interface or the RS-485 interface via 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 CBS 500 begin with "X". With these commands it is possible to configure the OTT CBS 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 CBS 500 automatically adds a "+")
b – numbers (before the decimal point)
e – numbers after the decimal point

9.1 Overview of SDI-12 commands

Standard commands

- **a!** Confirmation active
- **aI!** Send identification
- **aAb!** Change sensor address
- **?!** Query sensor address; factory setting: **0**
- **aV!** Start system test
- **aM!** Start 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 data of continuous measurements including statistical values and 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> Water level	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value2> Device status, see below	**+bbb**	[1]	**+bbb**	[1]
<value3> Discharge [2]	**pbbb.eee**	[m^3/s]	**pbbbbb.ee**	[ft^3/s]
▶ Send data (D0, D1, D2) after **aM1!** command				
<value1> last single measured value of water level within the measuring time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value2> mean of measured values of water level over the measuring time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value3> minimum water level within the measuring time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value4> maximum water level within the measuring time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value5> median of measured values of water level over the measuring time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value6> standard deviation of measured values of water level over the measuring time	**pbbb.eee**	[m]	**pbbb.eee**	[ft]
<value7> device status; see below				
▶ Send data (D0, D1, D2) after **aM2!** command				
<value1> – relative humidity in the device housing	**pbb.ee**	[% rH]	**pbb.ee**	[% rH]
<value2> – dew point in the device housing	**pbb.ee**	[°C]	**pbb.ee**	[°C]
<value3> – corrected temperature value of the pressure sensor	**pbb.ee**	[°C]	**pbb.ee**	[°C]
<value4> – temperature in the device housing	**pbb.ee**	[°C]	**pbb.ee**	[°C]
<value5> – corrected pressure value of the pressure sensor	**+bbbb.ee**	[mbar]	**+bbbb.ee**	[mbar]
<value6> – standard deviation of corrected pressure value over the measuring time	**+bbbb.ee**	[mbar]	**+bbbb.ee**	[mbar]
<value7> – device status; see below				

▶ Device status [3]

+0	→ no error occured
+1	→ water level/pressure too low
+2	→ overload (measuring range exceeded)
+4	→ supply voltage too low (< 9.6 Volt)
+8	→ current consumption too high
+16	→ watchdog-/software error
+32	→ insufficient power supply to the pump motor
+64	→ insufficient power supply to the switch valve
+128	→ piston pump malfunction – current consumption of the pump motor too high
+256	→ pressure cell error
+512	→ a CRC error has occured in the correction table for pressure values or there is a discrepancy between the serial number of the pressure cell and the table data

[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 CBS 500 adds up the status values. Example: +5 → water level is too low (+1) + supply voltage is too low (+4); values ≥ +1024: for internal service purposes only

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!**
aIM3_001! … **aIM3_009!**	Query meta data for measured value 1 to 9; measured value in **aD0!** … **aD2!** after	**aM3!**
aIMC_001! … **aIMC_003!**[1]		… **aMC!**
aIMC1_001! … **aIMC1_008!**		… **aMC1!**
aIMC2_001! … **aIMC2_009!**		… **aMC3!**
aIC_001! … **aIC_003!**[1]		… **aC!**
aIC1_001! … **aIC1_008!**		… **aC1!**
aIC2_001! … **aIC2_009!**		… **aC3!**
aICC_001! … **aICC_003!**[1]		… **aCC!**
aICC1_001! … **aICC1_008!**		… **aCC1!**
aICC2_001! … **aICC2_009!**		… **aCC3!**
aIHA_001! … **aIHA_017!**	Query meta data for measured value1 to 17; measured value in **aD0!**, **aD1!** after…	**aHA!**
aIHB_001! … **aIHB_017!**	Query meta data for measured value 1 to17; measured value in **aDB0!**, **aDB1!** after…	**aHB!**
aIV_001! … **aIV_009!**	Query meta data for the system test value 1 to 9; value in **aD0!** … **aD2!** after	… **aV!**

[1] 4 discharge measurement activated

Advanced commands (manufacturer-specific)

▶ **aXSU<value>!** Set unit for water level measurement
aXSU! Read unit for water level measurement
Factory setting: **+0** → m (presetting metric); **+2** → ft (presetting imperial)

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

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

▶ **aXAA<value>!** Set measuring mode "level" or "depth"
aXAA! Read measuring mode
Factory setting: **+1** → measuring mode "level measurement"

▶ **aXXM<value>!** Set measuring time
aXXM! Read measuring time
Factory setting: **+50** → 50 seconds

▶ **aXXC<value>!** Set cycle time
aXXC! Read cycle time
Factory setting: +60 → 60 seconds

▶ **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

▶ **aXXR<value>!** Set medium water density
aXXR! Read medium water density
Factory setting: +0.999972 kg/dm^3

▶ **aXXT<value>!** Set medium water temperature
aXXT Read medium water temperature
Factory setting: +3.980000 °C

▶ **aXXS<value>!** Set salinity
aXXS! Read salinity
Factory setting: +0

▶ **aXXG<value>!** Set local gravitational acceleration
aXXG! Read local gravitational acceleration
Factory setting: +9.80665 m/s^2

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

▶ **aXSF!** Reset bubble sensor to factory settings without communication settings
aXSF+1! Reset bubble sensor 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 rating table entry (calculation method rating table)
▶ **aXDA<value1><value2><value3>!** Enter coefficient for discharge calculation (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

▶ **aXCA<value>!** RS-485 interface: set Modbus (RTU) address
aXCA! RS-485 interface: read Modbus (RTU) address
Factory setting: +1

▶ **aXCB<value>!** RS-485 interface: set Modbus (RTU) transmission speed (baud rate)
aXCB! RS-485 interface: read Modbus (RTU) transmission speed (baud rate)
Factory setting: +0 → 9 600 bit/s

▶ **aXCP<value>!** RS-485 interface: set Modbus (RTU) parity
aXCP! RS-485 interface: read Modbus (RTU) parity
Factory setting: +3 → even, 1 Stoppbit

9.2 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 identification (company name) **mmmmmm** – sensor designation **vvv** – sensor version (in this case firmwareversion) **xxxxxxxxxxxxx** – additional designation (in this case serial number; max. 13 characters) OTT CBS 500 response: **014OTTHYDROCBS500100**… …**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 CBS 500: **31** … 301 sec. [1] **n** – number of measured values response OTT CBS 500: **7**
aD0!	**a<value1><value2><value3>**… …**<CR><LF>**	Send data (after **aV!**) **a** – sensor address **<value1>** – relative humidity in the device housing measured value format: **+bb.ee** [% rH] **<value2>** – dew point in the device housing [1] measured value format: **pbb.ee** [°C] **<value3>** – corrected temperature value of pressure sensor measured value format: **pbb.ee** [°C]
aD1!	**a<value4><value5><value6>**… …**<CR><LF>**	Send data (after **aV!**) **a** – sensor address **<value4>** – temperature of the internal humidity sensor measured value format: **pbb.ee** [°C] **<value5>** – corrected pressure value of the pressure sensor measured value format: **+bbbb.ee** [mbar] **<value6>** – standard deviation of corrected pressure value of pressure sensor within the measuring time measured value format: **+bbbb.ee** [mbar]

[1] depending on the set measuring time; see extended command **aXXM<value>!** The OTT CBS 500 adds 1 second to the set measuring time.
[2] dew point calculation is performed for output values down to a minimum of –15° Celsius; if a calculation is not possible (e.g. Temp. < 0) → output value: +9999

Command	Response	Description
aD2!	**a<value7><CR><LF>**	Send data (after **aV!**) **a** – sensor address **<value9>** – device status **+0** → no error **+1** → level/pressure too low **+2** → overload (measuring range exceeded) **+4** → supply voltage too low (< 9.6 Volt) **+8** → current consumption too high **+16** → watchdog/software error **+32** → insufficient power supply to the pump motor **+64** → insufficient power supply to the switch valve **+128** → piston pump malfunction – current consumption of the pump motor too high **+256** → pressure cell error **+512** → a CRC error has occured in the correction tablefor pressure values or there is a discrepancy between the serial number of the pressure cell and the table data. **Remarks:** – if several errors/events occur at the same time, the OTT CBS 500 adds up the status values. Example: +5 → level is too low (+1) + supply voltage is too low (+4). – values ≥ +1024: for internal service purposes only
aM!	**atttn<CR><LF>** and after 31 … 301 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 CBS 500: 31 … 301 sec. [1] **n** – number of measured values response OTT CBS 500: 2 (level-/pressure measurement only) or 3 (incl. discharge calculation)

[1] depending on the set measuring time; see extended command **aXXM<value>!** The OTT CBS 500 adds 1 second to the set measuring time.

Command	Response	Description
aD0!	**a<value1><value2><value3>…** **…<CR><LF>**	Send data (after **aM!**) **a** – sensor address **<value1>** – mean of measured values level/pressure over the measuring 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>** – device status see **aD2!** after **aV!** **<value3>** – discharge [3] measured value formats [2]: **pbbb.eee** [m^3/s] **pbbbbbb** [l/s] **pbbbbb.ee** [ft^3/s] **Remark:** – measured value discharge = **-9999** → calculation error occurred or rating table missing; = **-9998** → number of entries in the rating table are not sufficient for a calculation. – output without leading zero (s)
aMC!	**atttn<CR><LF>** and after 31 … 301 seconds **a<CR><LF>**	Start measurment 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>…** **…<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 = 02** or **03** [3].
aCC!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measuremen-twith 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 = 02** or **03** [3]. The response to the following **aD0!** command is extended by a CRC value: **a<value1><value2><value3>…** **…<CRC><CR><LF>**
aR0!	**a<value1><value2><value3>…** **…<CR><LF>**	The OTT CBS 500 continuously measures level/pressure 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!**. This requires continuous measurement mode; see note on measurement mode in Chapter 7.

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

Command	Response	Description
aRC0!	**a<value1><value2><value3>… …<CRC><CR><LF>**	The OTT CBS 500 continuously measures level/ pressure, optionally calculates the discharge and requests 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!**. This requires continuous measurement mode; see note on measurement mode in Chapter 7.
aM1!	**atttn<CR><LF>** and after 31 … 301 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 CBS 500: 31 … 301 sec. [1] **n** – number of measured values response OTT CBS 500: 7
aD0!	**a<value1><value2><value3>… …<CR><LF>**	Send data (after **aM1!**) **a** – sensor address **<value1>** – last single measured value level/pressure within the measuring time [2] **<value2>** – mean of measured values level/pressure over the measuring time [2] [3] **<value3>** – minimum of measured values level/pressure within the measuring time [2] [3]
aD1!	**a<value4><value5><value6>… …<CR><LF>**	Send data (after **aM1!**) **a** – sensor address **<value4>** – maximum of measured values level/pressure within the measuring time [2] [3] **<value5>** – median of measured values level/pressure over the measuring time [2] [3] **<value6>** – standard deviation of measured values level/pressure over the measuring time [2] [3]
aD2!	**a<value7><CR><LF>**	Send data (after **aM1!**) **a** – sensor address **<value7>** – device status; see **aD2!** after **aV!**
aMC1!	**atttn<CR><LF>** and after 31 … 301 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 = 07.
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 = 07. 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 measuring time; see extended command **aXXM<value>!** (The OTT CBS 500 adds 1 second to the set measuring time.)
[2] for measured value formats, see **aD0!** after **aM!** (depending on the set measurement unit)
[3] determined from several individual measurements (the number depends on the set measuring time); see extended command **aXXM!**)

Command	Response	Description
aR1!	**a<value1><value2><value3>…** **…<value4><value5><value6>…** **…<value7><CR><LF>**	The OTT CBS 500 continuously measures level/pressure 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!**. This requires continuous measurement mode; see note on measurement mode in Chapter
aRC1!	**a<value1><value2><value3>…** **…<value4><value5><value6>…** **…<value7><CRC><CR><LF>**	The OTT CBS 500 continuously measures level/pressure and 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!**. This requires continuous measurement mode; see note on measurement mode in Chapter
aM2!	**atttn<CR><LF>** and after 31 … 301 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 CBS 500: 31 … 301 sec. [1] **n** – number of measured values resonse OTT CBS 500: **7**
aD0!	**a<value1><value2><value3>…** **…<CR><LF>**	Send data (after **aM2!**) **a** – sensor address **<value1>** – relative humidity in the device housing measured value format: **+bb.ee** [% rH] **<value2>** – dew point in the device housing measured value format: **pbb.ee** [°C] **<value3>** – corrected temperature value of the pressure sensor measured value format: **pbb.ee** [°C]
aD1!	**a<value4><value5><value6>…** **…<CR><LF>**	Send data (after **aM2!**) **a** – sensor address **<value4>** – temperature im in the device housing measured value format: **pbb.ee** [°C] **<value5>** – corrected pressure value of the pressure sensor measured value format: **+bbbb.ee** [mbar] **<value6>** – standard deviation of the corrected pressure value of the pressure sensor within the measuring time [1] measured value format: **+bbbb.ee** [mbar]
aD2!	**a<value7><CR><LF>**	Send data (after **aM2!**) **a** – sensor address **<value7>** – device status; see **aD2!** after **aV!**
aMC2!	**atttn<CR><LF>** and after 31 … 301 seconds **a<CR><LF>**	Start measurement – including meta data – 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 measuring time; see extended command **aXXM<value>!** (The OTT CBS 500 adds 1 second to the set measuring time.)

Command	Response	Description
aC2!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line) – including meta data; for details, see command **aM2!**. The number of measured values in the response to this command has two digits: nn = 07.
aCC2!	**atttnn<CR><LF>**	Start concurrent measurement (simultaneous measurement with multiple sensors on one single bus line) – including meta data– 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 = 07. The response to the following **aD0!** … **aD2!** command is extended by a CRCvalue: **a<valueX>**……**<valueX><valueX><CRC><CR><LF>**
aR2!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**<value7><CR><LF>**	The OTT CBS 500 continuously measures level/pressure 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!**.This requires continuous measurement mode; see note on measurement mode in Chapter 7.
aRC2!	**a<value1><value2><value3>**… …**<value4><value5><value6>**… …**<value7><CRC><CR><LF>**	The OTT CBS 500 continuously measures level/pressure, 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!**. This requires continuous measurement mode; see note on measurement mode in Chapter 7.
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 CBS 500: 31 … 301 sec. [1)] **nnn** – number of measured values response OTT CBS 500: 15
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 measuring time [2)] **<value2>** – corrected temperature value of the pressure sensor **<value3>** – mean of measured values level/pressure over the measuring time [2) 3)] **<value4>** – minimum of measured values level/pressure within the measuring time [2) 3)] **<value5>** – maximum of measured values level/pressure-within the measuring time [2) 3)] **<value6>** – median of measured values level/pressure over the measuring time [2) 3)] **<value7>** – standard deviation of measured values level/pressure over the measuring time [2) 3)] **<value8>** – relative humidity in the device housing [% rH] **<value9>** – dew point in the device housing **<CRC>** – CRC value

[1)] depending on the set measuring time; see extended command **aXXM<value>!** (The OTT CBS 500 adds 1 second to the set measuring time.)
[2)] for measured value formats, see **aD0!** after **aM!** (depending on the set measurement unit)
[3)] determined from several individual measurements (the number depends on the set measuring time); see extended command **aXXM!**)

Command	Response	Description
aD1!	**a<value10><value11><value12>…** **…<value13><value14><value15>…** **…<CRC><CR><LF>**	Send data (after **aHA!**) **a** – sensor address **<value10>** – temperature in the device housing **<value11>** – last single measured value of the pressure sensor [mbar] **<value12>** – last single measured value of the pressure sensor including offset correction [mbar] **<value13>** – uncorrected mean value of the pressure sensor over the measuring time [mbar] **<value14>** – discharge [1] **<value15>** – device status; see **aD2!** after **aV!** **<CRC>** – CRC value **Remark:** Measured value discharge = 0.000 → discharge calculation is deactivated; –9999 → calculation error or rating table missing; –9998 → number of 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 CBS 500: 31 … 301 sec. [2] **nnn** – number of measured values response OTT CBS 500: 15
aDB0!	Binary data header SDI-12 sensor address: "0"; packet size: 64 bytes; data type: 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>**…**<value15>** 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; data type: 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] for measured value format, see **aD0!** after **aM!** (depending on the set unit)
[2] depending on the set measuring time; see extended command **aXXM<value>!** (The OTT CBS 500 adds 1 second to the set measuring time.)

9.3 Meta data commands

Command	Response	Description
aIM!	**atttn<CR><LF>**	The response is identical to the corresponding commands (**aM!**, **aM1!**, **aM2!**, **aMC!**, **aMC1!**, ...). These commands do 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 CBS 500 sends meta data for the related measured value **<valueX>** [4] 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") [5].
aIM1_00X! [2]	...**<field3>;**<CRC>**<CR><LF>**	
aIM2_00X! [2]		
aIMC_00X! [1]		
aIM1C_00X! [2]		
aIM2C_00X! [2]		
aIC_00X! [1]		
aIC1_00X! [2]		
aIC2_00X! [2]		
aICC_00X! [1]		
aICC1_00X! [2]		
aICC2_00X! [2]		
aIHA_0XX! [3]		
aIHB_0XX! [3]		
aIV_00X! [3]		

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

<field2> – unit
- · length: **M** · **CM** · **MM** · **IN** · **FT**
- · pressure: **BAR** · **MBAR** · **PSI** · **KPA**
- · temperature: **DC** · **DF** · **K**
- · humidity: **%**
- · discharge: **CMS** · **LS** · **CFS**

(Continuation of description see next page)

[1] Variable ...X: from 1 to 2 or 3
[2] Variable ...X: from 1 to 7
[3] Variable ...X: from 1 to 15
[4] Part of the response to the command **aD0!**, **aD1!**, **aD2!** (nach **aM!**, **aM1!**, **aMC!**, ...)
[5] https://vlab.noaa.gov/web/mdl/shef-information (**IN**, **BAR**, **MBAR**, **PSI**, **K**, **LS** → no official SHEF Code)

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

[1] only for aIMC_00X!, aICC_00X!, aIMC1_00X!, aICC1_00X!, aIMC2_00X!, aICC2_00X!, aIHA_0XX!

Examples for meta data commands

```
0IM!    → 00512<CR><LF>
5IV!    → 51217<CR><LF>

0IM_001!      → 0, HA, M, Mean level;<CR><LF>
0IM2_004!     → 0, TA, DC, Inside temperature;<CR><LF>
```

9.4 Advanced SDI-12 commands

Command	Response	Description
▶ Set/read the unit of level/pressure measured values		
aXSU<value>!	**a<value><CR><LF>**	Set unit
aXSU!	**a<value><CR><LF>**	Read unit **a** – sensor address **<value>** – **Units for water level measurment** +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)] **Please note** – An "Offset" or "Reference" value can only be used if unitsare set to meter or feet! – If you have already entered values for the "Offset" or "Reference" parameters before changing the measurement mode, you must reset these values! The entered parameters are not converted automatically!
▶ Set/read the unit of measured temperature values		
aXST<value>!	**a<value><CR><LF>**	Set unit
aXST!	**a<value><CR><LF>**	Read unit **a** – sensor address **<value>** – +0: °C +1: °F +2: K Factory setting: °C or °F [1)]
▶ Set/read the unit of measured discharge values		
aXSD<value>!	**a<value><CR><LF>**	Set unit
aXSD!	**a<value><CR><LF>**	Read unit **a** – sensor dadress **<value>** – +0: m^3/s +1: l^3/s +2: ft^3/s Factory setting: m^3/s or ft^3/s [1)]
▶ 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/s^2 Factory setting = 9.806650 m/s^2

[1)] depending on the ordered variant code

Command	Response	Description
		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 hight 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 CBS 500 iis 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 atyour 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 average water temperature		
aXXT<value>!	**a<value><CR><LF>**	Set average water temperature Read average water temperature **a** – sensor address **<value>** – **pbb.eeeeee** Value range: –20.000000 … +55.000000 °C Factory setting: +3.980000 °C With this command, you can set the actual water temperature at your station during level/depth measurement. This is useful, for example, at stations with a very high/low water temperature.
aXXT!	**a<value><CR><LF>**	
▶ Activate/deactivate purge function		
aXXP<value>!	**a<value><CR><LF>**	Activate/deactivate purge function Read status of purge function **a** – sensor address **<value>** – **+0** = purge function deactivated **+1** = purge function activated **+2+ttt** = purge function activated for ttt seconds Value range ttt: 1 … 300 sec. With the purge function activated, the OTT CBS 500 pumps a greater volume of air through the bubble tube over a given period. For further information see Chapter 8 and 11.
aXXP!	**a<value><CR><LF>**	
▶ Set/read measurement mode		
aXAA<value>!	**a<value><CR><LF>**	Set measurement mode "level" or "depth" Read measurement mode **a** – sensor address **<value>** – +0 = measurement mode "depth" (reference point ↔ water surface) +1 = measurement mode "level" (water level relative to zero point) Factory setting: **+1** → "level" **Please note** If you have already entered values for the "Offset" or "Reference value" parameters before changing the measurement mode, you must reset these values! The entered parameters are not converted automatically!
aXAA!	**a<value><CR><LF>**	
▶ Set/read cycle time		
seeaXXC<value>!	**a<value><CR><LF>**	Set cycle time Read cycle time **a** – sensor address **<value>** – cycle time in seconds **+bbbb** Input/output without leading zero! Value range: 31 … 7200 s Factory setting: 60 s Time interval in which the OTT CBS 500 starts measurements one after the other; see note on measurement mode in Chapter 7. **Please note** The cycle time must be greater than or equal to the measuring time. If this is not the case, the OTT CBS 500 automatically adjusts the measuring time to the set cycle time.
aXXC!	**a<value><CR><LF>**	

Command	Response	Description
▶ Set/read measuring time		
aXXM<value>!	**a<value><CR><LF>**	Set measuring time Read measuring time **a** – sensor address **<value>** – measuring time **+bbb** Input/output without leading zeros! Value range: 30 … 300 s Factory setting: 50 s Duration over which the OTT CBS 500 determines an average measured value.
aXXM!	**a<value><CR><LF>**	
▶ Set/read offset for water level measurement		
aXAB<value>!	**attt1<CR><LF>**	Set offset value 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 This command allows you to apply a linear offset (positive/negative) to a water level measurement. After setting the offset, the OTT CBS 500 automatically starts a measurement. Then check the measurement value with the command **aD0!**. **Caution** This command overwrites any reference value that may have been set! **Example** Measured value = +10.040 m Offset = –0.200 m Output = +9.840 m **Notes** – If the unit is subsequently changed (**aXSU<value>!**) rounding errors of ±0.001 are possible. – If the water level measurement unit is set to pressure values (**aXSU<value>!**), a measurement is already active, or an error has occurred, the OTT CBS 500 responds with a service request.(**a<CR><LF>**).
aXAB!		

[1] depending on the set unit; see 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 CBS 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 CB 500 and applied to all other measured values = +0.600 m) **Notes** – If the unit is subsequently changed (**aXSU<value>!**) rounding errors of ±0.001 are possible. – If the water level measurement unit is set to pressure values (**aXSU<value>!**), a measurement is already active, or an error has occurred, the OTT CBS 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; see 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 commu - nication 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 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 is 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 rating table completely **a** – sensor address **<value>** – entry (index) in the table to be deleted **Remark** – 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

Command	Response	Description
▶ RS-485 interface: set/read Modbus (RTU) address		
aXCA<value>!	**a<value><CR><LF>**	Set Modbus (RTU) address Read Modbus (RTU) address **a** – sensor address **<value>** – **+bbb** Input/ouput without leading zeros! Value range: +1 … +247 Factory setting: +1 **Note:** Modbus transmission parameters are changed immediately; any communication already in progress is directly affected by this.
aXCA!	**a<value><CR><LF>**	
▶ RS-485 interface: Set/read Modbus (RTU) transmission speed (baud rate)		
aXCB<value>!	**a<value><CR><LF>**	Set baud rate Read baud rate **a** – sensor address **<value>** – +0: 9 600 bit/s +1: 19 200 bit/s +2: 115 200 bit/s Factory setting: +0 → 9 600 bit/s **Note:** Modbus transmission parameters are changed immediately; any communication already in progress is directly affected by this.
aXCB!	**a<value><CR><LF>**	
▶ RS-485 interface: Set/read Modbus (RTU) parity		
aXCP<value>!	**a<value><CR><LF>**	Set parity Read parity **a** – sensor address **<value>** – +0: none, 1 stoppbit (8N1) +1: none, 2 stoppbits (8N2) +2: odd, 1 stoppbit (8O1) +3: even, 1 stoppbit (8E1) Factory setting: +3 → even, 1 stoppbit **Note:** Modbus transmission parameters are changed immediately; any communication already in progress is directly affected by this.
aXCP!	**a<value><CR><LF>**	

10 RS-485 interface with Modbus protocol (RTU)

10.1 Preconditions

▶ Measurment mode	Continuous measurement (see note on measurement mode in Chapter 7)
▶ Interface	EIA-485 (RS-485)
▶ Transmittion parameter	8 data bit, 1 stoppbit, even parity
▶ Transmission speed	9600 (factory setting), 19200
▶ Bus address	1 … 247

10.2 Value ranges

16-bit integer valus

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	2	3
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 CBS 500 has only one "holding register" block.

10.3 Sensor description register

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 63200 (0x0000F6E0)
▶ 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 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 [2] 0x0009: MM [2] 0x000A: KPA [2]
▶ Channel 1 – unit string	18 (17)	uint 16	3	R		e.g. MBAR [3]
▶ Channel 2 – definition of physical element	21 (20)	uint 16	1	R		Last single measured value level or pressure 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 [2] 0x0009: MM [2] 0x000A: KPA [2]
▶ 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)
[2] no official SHEF code
[3] the register is 3 x 16 bits long and contains a char[6] array

Register name	Register number[1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 3 – definition of physical element	31 (30)	uint 16	1	R		Minimum value level or pressure HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 3 – 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 3 – unit string	33 (32)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 4 – definition of physical element	36 (35)	uint 16	1	R		Maximum value level or pressure HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 4 – unit	37 (36)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR [2] 0x0009: MM [2] 0x000A: KPA [2]
▶ Channel 4 – unit string	38 (37)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 5 – definition of physical element	41 (40)	uint 16	1	R		Median value level or pressure HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 5 – unit	42 (41)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR [2] 0x0009: MM [2] 0x000A: KPA [2]
▶ Channel 5 – unit string	43 (42)	uint 16	3	R		compare "Channel1: unit string"

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start addresse)
[2] no official SHEF code

Register name	Register number[1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 6 – definition of physical element	46 (45)	uint 16	1	R		Standard deviation level or pressure HA, Height of reading (0x4841) HB, Depth of reading (0x4842)
▶ Channel 6 – unit	47 (46)	uint 16	1	R		0x0002: M 0x0003: CM 0x0004: FT 0x0005: MBAR 0x0006: PSI 0x0007: INCH 0x0008: BAR [2] 0x0009: MM [2] 0x000A: KPA [2]
▶ Channel 6 – unit string	48 (47)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 7 – definition of physical element	51 (50)	uint 16	1	R		Device status OS, Status of device (0x4f53)
▶ Channel 7 – unit	52 (51)	uint 16	1	R		0x0001: none
▶ Channel 7 – unit string	53 (52)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 8 – definition of physical element	56 (55)	uint 16	1	R		Relative humidity in the device housing XR, Humidity, relative (0x5852)
▶ Channel 8 – unit	57 (56)	uint 16	1	R		0x0010: %
▶ Channel 8 – unit string	58 (57)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 9 – definition of physical element	61 (60)	uint 16	1	R		Dew point in the device housing TD, Dew point (0x5444)
▶ Channel 9 – unit	62 (61)	uint 16	1	R		0x0010: DEGREE C 0x0011: DEGREE F 0x0012: Kelvin
▶ Channel 9 – unit string	63 (62)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 10 – definition of physical element	66 (65)	uint 16	1	R		Temperature in the device housing TA, Temperature of air (0x5441)
▶ Channel 10 – unit	67 (66)	uint 16	1	R		0x0010: DEGREE C 0x0011: DEGREE F 0x0012: Kelvin [2]
▶ Channel 10 – 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)
[2] no official SHEF code

Register name	Register-number[1]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 11 – definition of physical element	71 (70)	uint 16	1	R		Corrected temperature value of the pressure sensor TA, Temperature of air (0x5441)
▶ Channel 11 – unit	72 (71)	uint 16	1	R		0x0010: DEGREE C 0x0011: DEGREE F 0x0012: Kelvin [2]
▶ Channel 11 – unit string	73 (72)	uint 16	3	R		compare "Channel1: unit string"
▶ Channel 12 – definition of physical element	76 (75)	uint 16	1	R		Discharge QR, Discharge river (0x5152)
▶ Channel 12 – unit	77 (76)	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 12 – unit string	78 (77)	uint 16	3	R		compare "Channel1: unit string"

10.4 Sensor values register

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 measuring time
▶ Channel 2	103 (102)	float 32	2	R		Last single measured value "level/pressure" within the measuring time
▶ Channel 3	107 (106)	float 32	2	R		Minimum measured value "level/pressure" within the measuring time
▶ Channel 4	109 (108)	float 32	2	R		Maximum measured value "level/pressure" within the measuring time
▶ Channel 5	111 (110)	float 32	2	R		Median of measured values "level/pressure" within the measuring time
▶ Channel 6	113 (112)	float 32	2	R		Standard deviation of measured values "level/pressure" within the measuring time
▶ Channel 7	115 (114)	float 32	2	R		Device status
▶ Channel 8	117 (116)	uint 32	2	R		Relative humidity in the device housing

[1] the corresponding register start addresses are given in brackets (register number - 1 = register start address)
[2] no official SHEF code

Register name	Register number[1)]	Data type	Length	Access mode	min. / max.	Description
▶ Channel 9	119 (116)	float 32	2	R		Dew point in the device housing
▶ Channel 10	121 (118)	float 32	2	R		Temperature in the device housing
▶ Channel 11	123 (120)	float 32	2	R		Corrected temperature value of the pressure sensor
▶ Channel 12	125 (122)	float 32	2	R		Discharge

10.5 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 restartedand the stack cannot respond. Successful changes are answered with a regular Modbus response, invalid data with "illegaldata 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	Set unit level/pressure
Unit temperature	202 (201)	uint 16	1	R/W	Set unit temperature
Unit Discharge	203 (202)	uint 16	1	R/W	Set unit discharge
Calculation method discharge	204 (203)	uint 16	1	R/W	Set calculation method discharge
Local gravitational acceleration	205 (204)	float 32	2	R/W	Set local gravitational acceleration
Water density	207 (206)	float 32	2	R/W	Set water densitiy
Salinity	209 (208)	float 32	2	R/W	Set 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
Measuring time	213 (212)	float 32	2	R/W	Measuring time
Continuous measurement	215 (214)	uint 16	1	R/W	Activate measurement mode continuous measurement
SDI-12 address	216 (215)	uint 16	1	R/W	Set SDI-12 address
Modbus bus address	217 (216)	uint 16	1	R/W	Set Modbus bus address
Transmission speed	218 (217)	uint 16	1	R/W	Set Modbus transmission speed
Modbus parity	219 (218)	uint 16	1	R/W	Set Modbus parity

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

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 formulal	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 CBS 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 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
Discharge1	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 address)

11 Carrying out maintenance work

The OTT CBS 500 bubble sensor itself is maintenance free. We recommend that the measuring tube and bubble chamber are checked at regular intervals as described below and cleaned as required:

11.1 Activating the purge function

Activate the purge function of the OTT CBS 500 quarterly by pressing the membrane button "Pump" (see also Fig. 10) and checking whether air bubbles rise out of the bubble chamber. If not, check whether the bubble chamber is blocked, and/or whether the measuring tube is leaking or blocked.

11.2 Cleaning the bubble chamber

Check the bubble chamber quarterly for sand buildup and weed infiltration. For light sand buildup, clean the bubble chamber using the purge function, and for heavier buildup or weed infiltration clean the bubble chamber carefully manually (do not change the position of the bubble chamber).

11.3 Testing the measuring tube

After 15 years' operation, test the measuring tube for tightness/pressure resistance roughly every 2 years.

12 "Status" LED

For the display of any error states that may occur, the OTT CBS 500 has a "Status" LED on the front of the device (see Fig. 1).

The following error states can arise:

▶ water level too low (< 5 cm)	1 x flash
▶ overload (measuring range exceeded)	2 x flash
▶ power supply voltage too low	3 x flash
▶ pump motor overloaded	4 x flash
▶ watchdog error	5 x flash
▶ data memory defective	6 x flash
▶ data bus defective	7 x flash
▶ analog converter defective	8 x flash
▶ measuring cell defective	9 x flash

The OTT CBS 500 shows an error state when it arises and for approximately 2 minutes after pressing the "Pump" membrane button.

The "... defective" error states indicate hardware problems that can only be resolved by the OTT Repair Centre (see Chapter 13). The "watchdog error" error state means that the OTT CBS 500 has been restarted. No intervention is necessary.

Any error states arising can be displayed as follows:

■ Press "Pump" membrane button briefly (< 1 second; otherwise the purge function is called) → the LED "Status" lights once for a longer period as confirmation → Pause → 1st error state arising (e.g. flashing once) → Pause → 2nd error state arising (e.g. flashing three times) → Pause → … .
The OTT CBS 500 repeats all error states arising for approx. two minutes.

Notes:

▶ Interrupt displaying error states: press membrane button briefly.
▶ If no error state has arisen: the LED "Status" lights once for a longer period as confirmation.

13 Troubleshooting

Sensor does not respond on the SDI-12 interface

- If installed: Is the fuse in the power supply cable defective?
  → Replace the fuse.
- Is the sensor connected correctly to a data logger with an SDI-12 input?
  → Correct the pin assignment.
- Is the polarity of the supply voltage reversed?
  → Correct the pin assignment.
- Is the supply voltage < 9.6 V or > 30 V?
  → Correct the supply voltage (check the length and cross-section of the connection cable).
- Is the supply voltage not DC?
  → Only operate the sensor with DC voltage.

Sensor does not respond on the RS-485 interface (Modbus)

- Modbus (RTU) communication parameters set incorrectly?
  → Check and correct the communication parameters.
- Is the OTT CBS 500 in command-controlled measurement mode?
  → activate continuous measurement mode; see note on measurement mode in Chapter 7.

Measured value varies or is not present

- Is the bubble chamber or the measuring tube blocked? Is the measuring tube leaking? → see Chapter 11, *Carrying out maintenance work*.

Display of error states on the "Status" LED

→ see Chapter 12, *"Status" LED*.

Status messages/output of the interfaces

Status	Status message/output
+0	no error occured
+1	water level/pressure too low
+2	overload (measuring range exceeded)
+4	supply voltage too low (< 9.6 Volt)
+8	current consumption too high
+16	watchdog-/software error
+32	insufficient power supply to the pump motor
+64	insufficient power supply to the switch valve
+128	piston pump malfunction – current consumption of pump motor too high
+256	pressure sensor error
+512	a CRC error has occured in the correction table for pressure values, or there is a discrepancy between the serial number of the pressure sensor and the table data.

14 Repair

- In the event of a problem with the device, refer to Chapter 13, "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
Phone +49 831 5617-433
Fax +49 831 5617-489
repair@ott.com

Please note: Only have a defective OTT CBS 500 checked and repaired by the repair center of OTT Hydromet! Under no circumstances carry out any repairs yourself. Only a qualified repair followed by a factory final test guarantees the specified measurement accuracy. If you attempt to repair the device yourself, you will also lose all warranty claims.

15 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 salescontact. You will find the addresses of all sales partners in the internet on "www.otthydromet.com". Please take into consideration also the national implementationof the EU guideline 2012/19/EC of your country:

OTT Hydromet GmbH
Abteilung Logistik
Ludwigstrasse 16
87437 Kempten · Germany
Phone +49 831 5617-170
Fax +49 831 5617-179
logistik@ott.com

For all other countries

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

Materials used

Housing: ABS

15 Technical Data

Measuring range	
Device variant "Measuring range 15 m"	0 … 15 m or 0 … 1500 mbar 0 … 50 ft or 0 … 25 psi
Device variant "Measuring range 30 m"	0 … 30 m or 0 … 3000 mbar 0 … 100 ft or 0 … 50 psi
Resolution	0.001 m · 0.1 cm · 1 mm · 0.1 mbar 0.0033 ft · 0.012 inch · 0.00142 psi
Accuracy	
for measuring range 0 … 5 m	±3 mm · ±0,01 ft
for measuring range 5 … 15/30 m	±0.065 % of measured value or ±5 mm · ±0.164 ft, whichever value is lower
Measuring dynamics (max. level change)	1 m/min
Units	m · cm · mm · ft · inch mbar · bar · PSI · kPa
Interfaces	SDI-12, SDI-12 via RS-485 (Version 1.4) Modbus RTU
Power supply	10 … 30 V_{DC}, typ. 12/24 V_{DC}
Current consumption	
Query interval 1 min	typ. 320 mAh / day (max. 3 700 mAh / day)
Query interval 15 min	typ. 25 mAh / day (max. 300 mAh / day)
Operating/display elements	
"Pump" membrane button	Call purge function; display error status using LED
"Status" LED	Display operating state/error status
Dimensions L x W x H	165 mm x 205 mm x 115 mm
Weight	approx. 1500 g
Housing material	ABS
Type of protection	IP 4x
Measuring tube	
internal diameter	2 mm and 4 mm or ⅛" (depending on the device variant)
max. length for 2 mm + ⅛" internal diameter	100 m
max. length for 4 mm internal diameter	75 m
Temperature range	
Operation	–20 … +70 °C
Storage	–40 … +80 °C
Relative humidity	10 … 95 %; non-condensing
Performance classification in accordance with DIN EN ISO 4373	
Measurement reliability	Performance class 1
Temperature range	Performance class 1
Relative humidity	Class 1
Product certifications	
CE (EU)	This device complies with the essential requirement of the EMC Direcitve 2014/30/EU.
FCC (US)	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.

Appendix A – Note on the declaration of conformity

If required, you can download the current version of the declaration of conformity for the OTT CBS 500 from our website as a PDF file: "www.ott.com/resources".

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