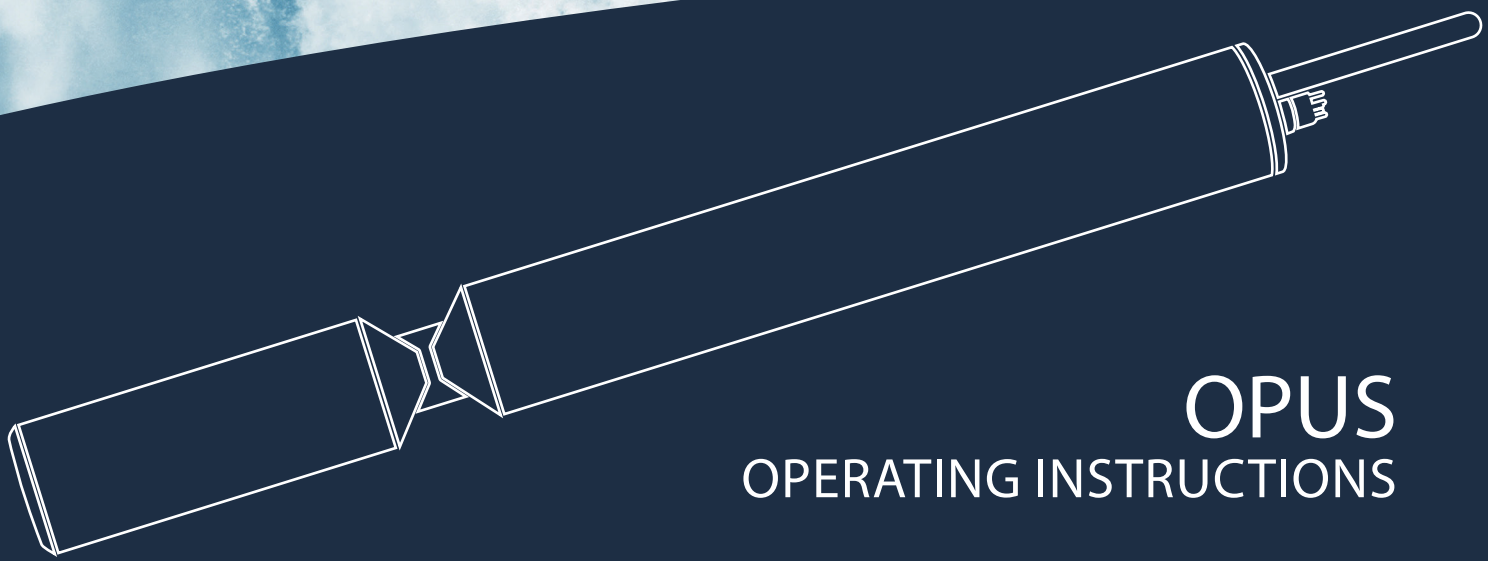
TriOS
Optical Sensors



OPUS

OPERATING INSTRUCTIONS

Table of Contents

1 General Information

1.1 Introduction

Welcome to TriOS.

We are glad that you have chosen to purchase our OPUS immersion sensor.

OPUS is a spectral sensor for the online measurement of nitrogen and carbon compounds. By analyzing a full spectrum, OPUS is able to deliver reliable readings for $N\text{-}NO_3$, $N\text{-}NO_2$, organic ingredients (CODeq, BODeq, DOCeq, TOCeq) and a number of other parameters.

The OPUS features the new TriOS G2 interface, which allows fast and easy configuration of sensors with a web browser. Integration into existing process control systems and external data loggers has never been easier. With the optional battery pack, mobile applications are also feasible. Wi-Fi connectivity allows laptops, tablets or smartphones to be easily used for control without any special application software or app installation.

In this manual, you will find all of the information you will need to commission the OPUS. Technical specifications as well as detection limits and the dimensions can be found in chapter 7.

Please note that the user is responsible for complying with local and national regulations on the installation of electronic devices. Any damage caused by incorrect use or unprofessional installation will not be covered by the warranty. All sensors and accessories supplied by TriOS Mess- und Datentechnik GmbH must be installed and operated in accordance with the specifications provided by TriOS Mess- und Datentechnik GmbH. All parts were designed and tested in accordance with international rules on electronic instruments. The device meets the requirements of the international regulations on electromagnetic compatibility. Please use only original TriOS accessories and cables to ensure smooth and professional operation of the devices.

Before using the device, read the manual carefully, and keep this manual on hand so it can be used later. Before commissioning the sensor, please make sure that you have read and understood the following safety precautions. Always make sure that the sensor is operated correctly. Following the safety precautions described on the following pages should ensure the smooth and correct operation of the device and any additional associated devices, and should prevent injuries to yourself or other persons and damage to other equipment.

NOTICE **If this translation is at all different from the original German text, the German version is binding.**

Copyright Notice

1.2 Health and Safety Information

This manual contains important information about health and safety rules. This information is labelled according to the international specifications of ANSI Z535.6 ("Product safety information in product manuals, instructions and other collateral materials") and must be strictly followed. The distinction is made between the following categories:

⚠ **DANGER**	**Danger warning / will lead to serious injury or death**
⚠ **WARNING**	**Warning / may lead to serious injury or death**
⚠ **CAUTION**	**Caution / may cause moderate injury**
NOTICE	**Can result in damage to property**

Tip / Useful Information

Electromagnetic waves

Devices that radiate strong electromagnetic waves can influence the measurement data or result in a malfunction of the sensor. Avoid using the following devices in the same room as the TriOS sensor: mobile phones, cordless phones, transmitters/receivers and other electrical devices that produce electromagnetic waves.

⚠ **CAUTION**	**Never look directly at the light source. The radiation emitted (UV light) can cause serious damage to the eyes.**

Reagents

Follow the safety and operating instructions of the manufacturer when using reagents. Observe the valid Hazardous Materials Ordinance for reagents (German GefStoffV)!

Biological safety

Liquid waste may be biologically dangerous. Therefore, you should always wear gloves when working with such materials. Please observe the currently valid biological material ordinance!

Waste

When handling liquid waste, the regulations on water pollution, drainage and waste disposal must be observed.

1.3 Warnings

- This sensor has been developed for use in industry and science. It should only be used for the measurement of aqueous solutions, e.g., process waste water, river water or sea water.

NOTICE **Stainless steel sensors are not intended for use in sea water or in high chloride concentrations (corrosion). Only sensors made of titanium can be used in these solutions.**

- Sensors made from stainless steel must be cleaned immediately after coming into contact with salt water or other corrosive substances (e.g., acids, alkalis and chlorine-based solutions).
- The material resistance should be checked after every use.
- The sensor has seals made from NBR (nitrile butadiene rubber). Sealing rings made from other materials may be used upon individual request. Before operation, please ensure that the measured medium does not damage the seals.
- Do not cut, damage or change the cord. Make sure that no heavy objects are placed on the cord and that the cord is not folded. Make sure that the cord is not near hot surfaces.
- If the sensor cord is damaged, it must be replaced by the customer service of TriOS Mess- und Datentechnik GmbH or by an authorized TriOS workshop with an original part.
- Do not place unsuitable items in the optical path when the measurement process is in operation because this can cause damage to the sensor or incorrect measurement results.
- Stop operation of the sensor if excessive heat develops (i.e., if it is hot to the touch). Switch off the sensor immediately and unplug the power cord from the power supply. Please contact your dealer or TriOS customer service.
- Never try to disassemble or modify a part of the sensor if such a procedure is not explicitly described in this manual. Inspections, modifications and repairs may only be done by the dealer or qualified experts authorized by TriOS.
- Devices from TriOS Mess- und Datentechnik GmbH meet the highest safety standards. Repairs to the device (that involve the replacement of the connecting cable) must be carried out by TriOS Mess- und Datentechnik GmbH or a workshop authorized by TriOS. Faulty, improper repairs can result in accidents and injuries.

1.4 Users and Operating Requirements

The OPUS spectral resolution photometer was developed for use in industry and science. The target group for the operation of the OPUS is technically skilled staff in plants, sewage treatment plants, water plants and institutes. The use of this device often requires the handling of hazardous substances. We assume that the operating personnel are familiar with dealing with dangerous substances based on their professional training and experience. The operating personnel must be able to correctly understand and implement the safety labels and information on the packaging and in the package inserts of the test kits.

1.5 Intended Use

The purpose of the OPUS is exclusively the implementation of photometric measurements as described in this manual. For this purpose, the photometer is an immersion sensor that is used underwater or with flow cells. Please note the technical data of the accessory parts. Any other use is not considered to be in compliance with the intended use.

The sensor may only be used to measure the absorption and transmission of aqueous fluids, such as process wastewater, municipal wastewater and surface/groundwater. The use of other media can damage the sensor. For the use of the OPUS in other media than those specified this manual, please contact the customer service of TriOS Mess- und Datentechnik GmbH (support@trios.de).

NOTICE **Avoid touching the glass parts of the optical window, because they can become scratched or dirty. The functionality of the device can no longer be guaranteed if this occurs.**

According to current scientific knowledge, the device is safe to use when it is handled according to the instructions in this user manual.

Damage caused by improper use is not excluded from the guarantee.

1.6 Disposal Information

At the end of the device's life or use, the device and its accessories can be returned to the manufacturer for environmentally friendly disposal for a fee. (See the address below.) The preceding professional decontamination of the device must be proven with a certificate. Please contact us before you send the device back to get more details.

Address of the manufacturer:

TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
D-26180 Rastede
Germany

Telephone: +49 (0) 4402 69670 - 0

Fax: +49 (0) 4402 69670 – 20

1.7 Certificates and Approvals

This product meets all of the requirements of the harmonized European standards. It therefore meets the legal requirements of the EU guidelines. TriOS Mess- und Datentechnik GmbH confirms the successful testing of the product by affixing the CE marking. (See annex.)

2 Introduction

OPUS is an intelligent measuring instrument, which can be operated without additional hardware. In the following chapters, we shall explain the correct operation of the OPUS sensor with all its functions and setting options.

2.1 Product Identification

All TriOS Mess- und Datentechnik GmbH products have a label, which clearly shows the product designation.

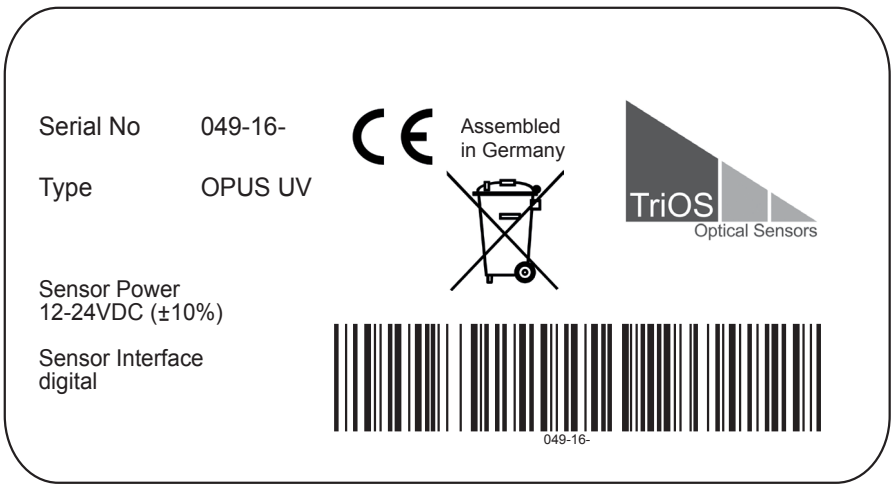
There is also a rating plate on the sensor with the following information that you can use to uniquely identify the product:

Serial number

Product type

Power supply

Interface



In addition to the product bar code, the rating plate includes the TriOS Mess- und Datentechnik GmbH logo and the CE quality label.

Please note that the specifications given here are for illustration purposes only and may deviate depending on the version of the product.

2.2 Scope of Delivery

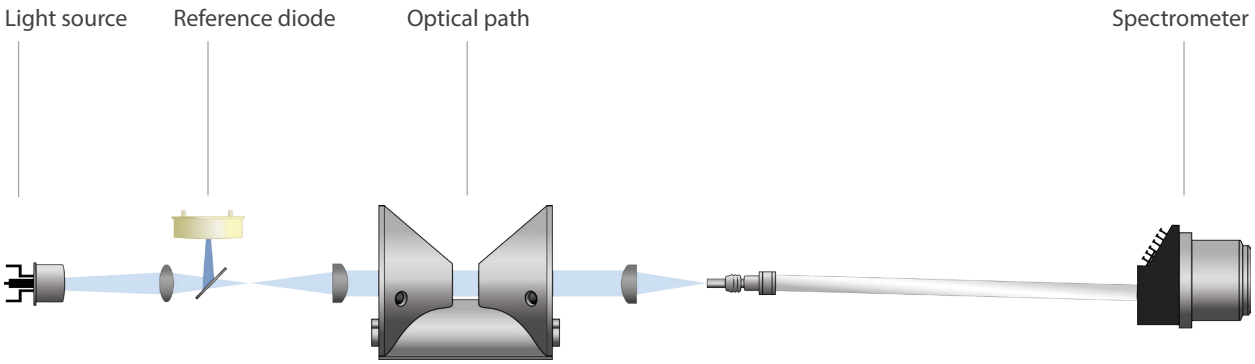
The shipment contains the following components:

- Sensor
- Operating Instructions
- Accessories (if applicable)

Keep the original device packaging in case the device needs to be returned for maintenance or repairs.

2.3 Measurement Principle and Design

For optimal use of the sensor, you must know and understand the idea and theory that the sensor is based on. The following is an overview of the measurement principle, the optical arrangement and the subsequent calculation.



Essentially, the OPUS has four parts: a defined light source, a lens system, the optical path through the medium and a spectrometer. The arrangement of these parts is represented schematically in the illustration above.

A xenon flash lamp is used as a broadband light source. The light passes through the optical path in the medium and is partially absorbed by it. The spectrometer detects the remaining, spectrally resolved light and determines its intensity (*I*)at different wavelengths over a defined wavelength range.

The weakening of the light caused by passing through the measurement medium is compared to the weakening of the light caused by passing through ultra-pure water. The measurement in ultra-pure water provides the so-called basic intensity (I_0). Using Equation 1 and Equation 2, the OPUS determines the transmission (*T)* and the absorbance (*A)* for individual wavelengths within the defined wavelength range.

$$T = \frac{I}{I_0}$$

Equation 1: Calculation of transmission

$$A = -log_{10} T$$

Equation 2: Calculation of absorbance

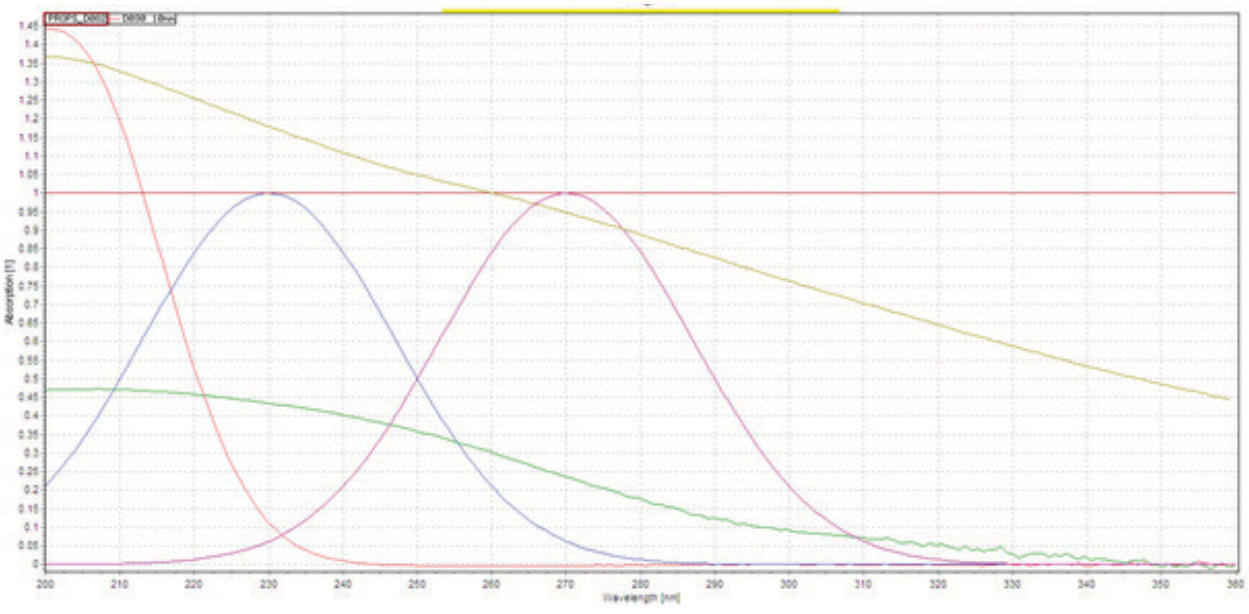
where:

T	Transmission in %
I	current light intensity
I_0	basic light intensity in ultra-pure water
A	absorption in AUs (AU = absorbance unit)

The integrated analysis software can calculate the concentration equivalents using the absorption with the corresponding concentrations.

2.3.1 Spectral Analysis

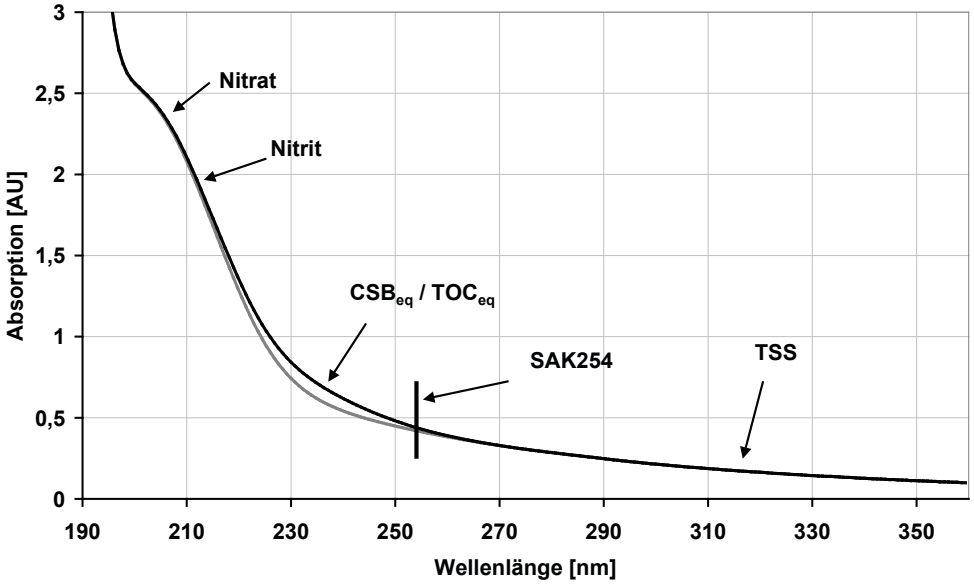
The spectral analysis (LSA) on the OPUS works with the full absorption spectra from 200 to 360 nm. The absorption spectra of the known and expected substances for the respective application are saved on the sensor as an analysis group (LSA group / parameter set) for calibration.



The LSA calculates a combination from the stored absorption spectra of the LSA group whose result fits best with the respective measured absorption spectrum of the medium. The analysis then simultaneously calculates the necessary substance concentrations to reproduce the measured absorption spectrum of the medium.

The sum of all spectral deviations between the absorption spectrum of the medium and the reconstructed absorption spectrum of the LSA produces the fit error in the stored data.

Absorption spectrum of wastewater with/without CODeq



In the displayed spectra, the significant ranges of the parameters are named.

2.3.2 Parameters

Substances with a specific absorption spectrum, such as nitrate and nitrite, can be used directly as elements of the LSA group.

For sum parameters, such COD, BOD, TOC and DOC, theoretical absorption spectra that TriOS has been able to determine over the course of its many years of experience have been stored. Using these parameters, a spectral analysis based on UV absorption can use only the portion that absorbs UV light. Therefore, the OPUS uses only equivalents, and the parameters have the "eq" suffix appended to them, (i.e., CODeq, BODeq, TOCeq and DOCeq).

The LSA group also contains correction spectra that take into account, for example, the effects of turbidity.

Because the entire absorption spectrum is detected, parameters such as SAC_{254} (spectral absorption coefficient at 254 nm) can also be calculated.

2.4 Browser

Every version of the OPUS is equipped with a web interface, which can be used to configure and calibrate the sensor. To access the web interface, you will need the G2 interface box and an Ethernet-capable device with a web browser (e.g., a notebook / laptop).

Open one of the following URLs (depending on the network structure) in your web browser:

http://opus/ or

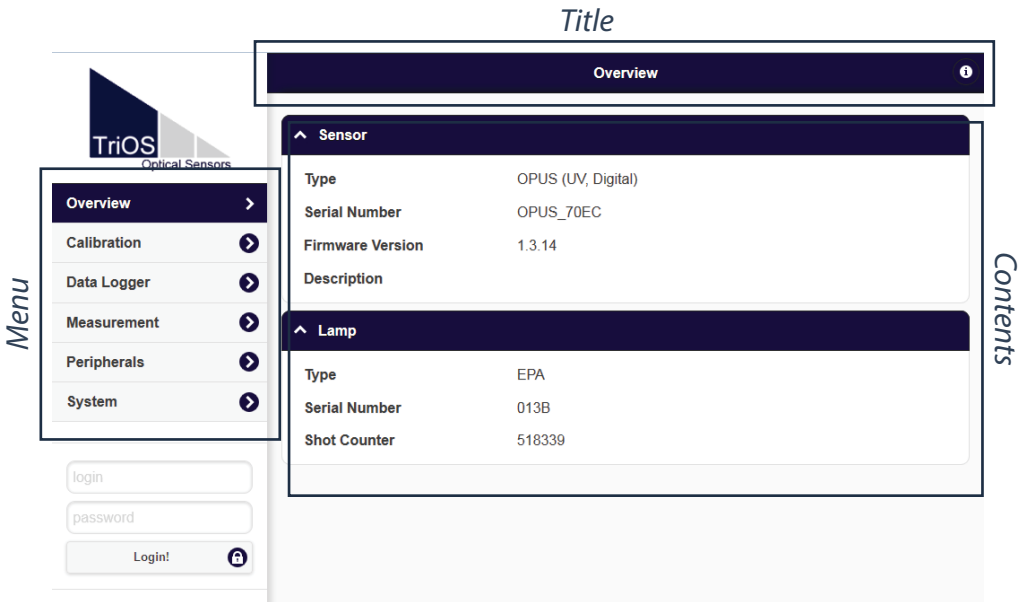
http://opus_7XXX/ (7XXX is the serial number) or

http://192.168.77.1/

Up to version 1.3.x, automatic measurements are stopped when an Ethernet-capable device is connected. As soon as the sensor is disconnected from the Ethernet-capable device, the measurements will continue at the set interval if the timer is activated for automatic measurements.

The web interface is divided into three areas (see figure):

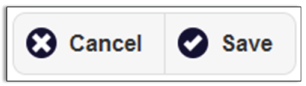
Title, menu and contents.



In the title, the name of the current page is displayed. To the right of that is the "Info" button . This shows the contact data of the corresponding TriOS dealer and of the TriOS Mess- und Datentechnik GmbH.

In the menu on the left, the individual pages are listed. The name of the current page is highlighted in blue.

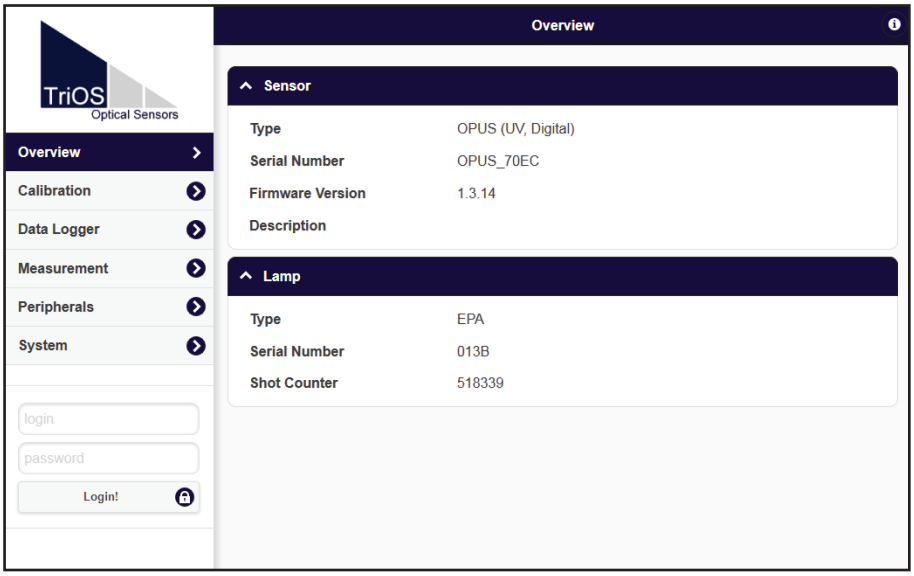
In the menu, you will find the login form used by certified TriOS service technicians to authenticate themselves. In most cases, problems can be solved onsite using this option.



Completed settings must be saved with the "Save" button. Otherwise, all settings are lost.

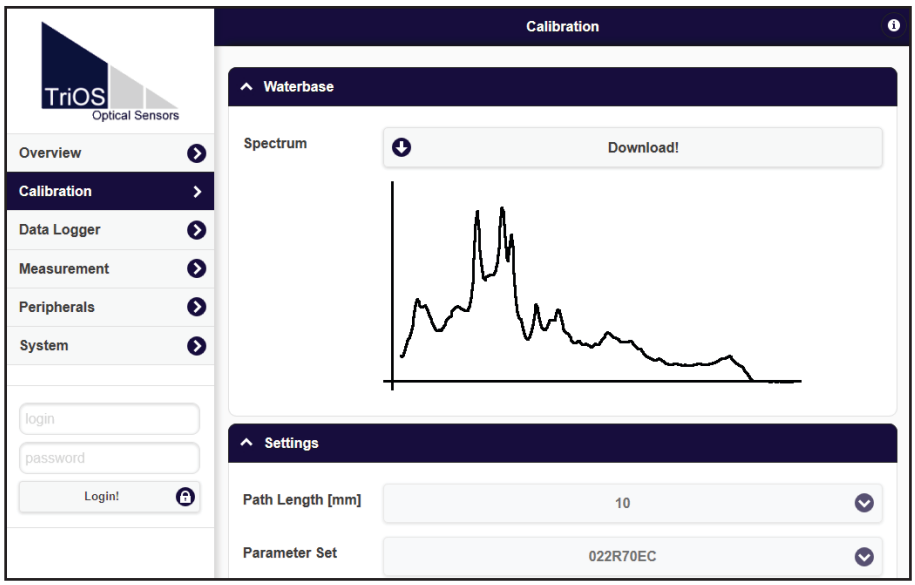
Overview

As shown in the following illustration, basic information about the sensor is summarized on the "Overview" page. This includes the device type and the serial number of the sensor as well as the version number of the firmware installed. The type of lamp module and the serial number of the lamp are listed as well as the number of measurements that have been carried out by this lamp module.



Calibration

Lamp spectrum (I_0) is displayed on the "Calibration" page under "Waterbase". The setting of the optical path in millimetres and the selected parameter set (LSA group) are displayed in "Settings".

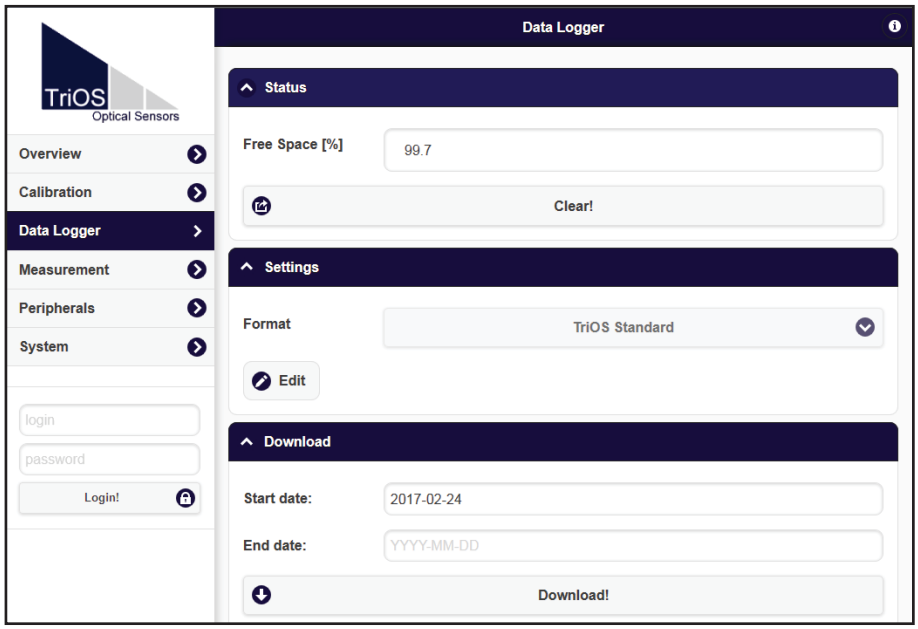


Data logger

The OPUS is equipped with a data logger function that allows it to save approximately 42,000 measurements. This allows the OPUS sensor an almost completely self-sufficient operation over a very long period. A sufficient power supply must be provided.

The data logger function is controlled on the "Data Logger" page, which is shown in the following figure.

The factory-set measurement interval is 2 minutes, which means that the data logger will record measurements for approximately 1400 hours (58 days). When the memory is full, only the most recently recorded measurement data is stored and the old data will be overwritten.



Status

The "Status" area displays the percentage of memory that is still available.

The memory can be formatted and all of the data can be deleted by clicking on the "Clear" button. For safety, users will be prompted for confirmation before deletion.

After confirmation, the OPUS memory is formatted and all of the data is permanently deleted.

Settings

Here you can choose the format that the data will be saved in. There are two options available: "TriOS Standard" and "CSV" (comma separated values).

"TriOS Standard" is set as the default. Parameters such as substance concentrations, sum parameters and absorption values are saved in CSV format, and spectra are saved in TriOS DAT format. This is the only option that allows TriOS service to provide support for more wide-ranging problems.

Alternatively, all data can be saved in CSV format. This data can be read and processed by common spreadsheet programs.

Download

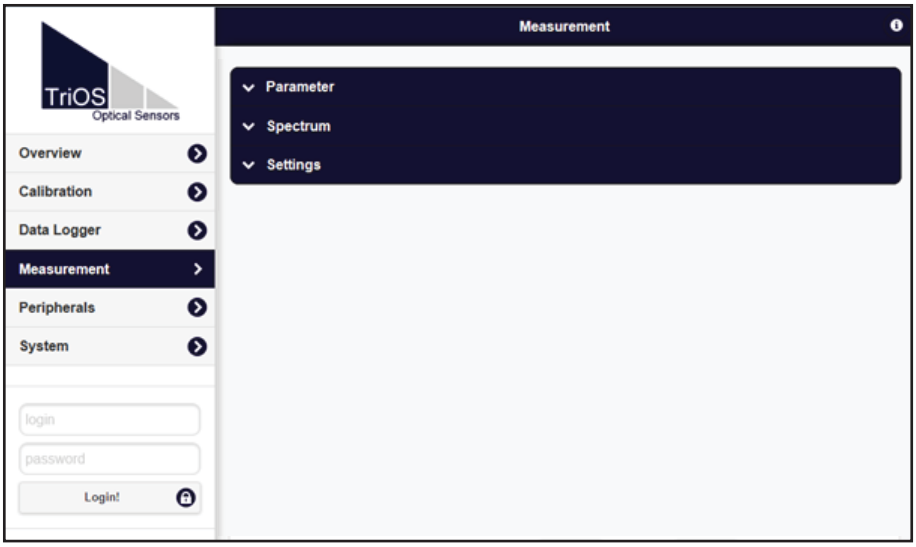
Previously stored data can be retrieved by clicking on the "Download" button.

Because the memory may contain a lot of data, a download can take a long time. Therefore, it is always advisable to determine a time period for the download and to download the data in several data packages.

Measurement

The "Measurement" page shows the results of the last measurements performed and allows the interval to be set for automatic measurements.

A new measurement can be triggered at any time. To do this, click on the "Measure Now!" button. A new measurement will then be done with the saved settings.



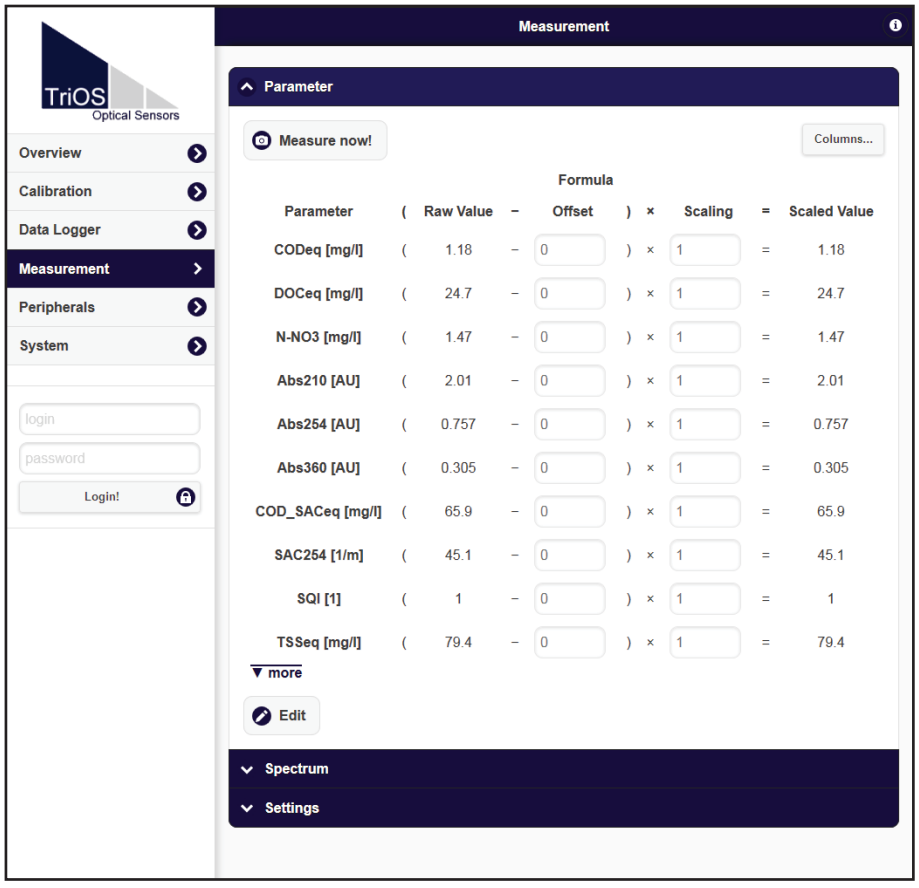
Parameters

The results calculated at the last measurement are displayed in "Parameters". On this page, it is also possible to scale the measured values to the desired parameters with the help of settings for "Offset" and "Scaling".

The sample view shows the values of the following parameters:

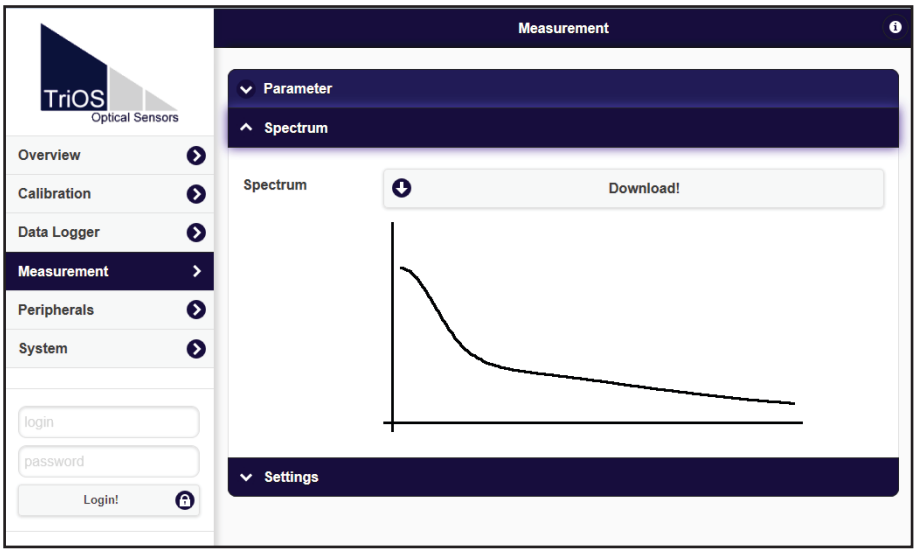
- CODeq* – calculated using spectral analysis (LSA) in mg/L
- DOCeq* – calculated with spectral analysis (LSA) in mg/L
- N-NO3eq* – calculated with spectral analysis (LSA) in mg/L
- Abs210 – test parameter in absorption units AU
- Abs254 – test parameter in absorption units AU
- Abs360 – test parameter in absorption units AU
- COD-SACeq* – COD derived from SAC_{254} in mg/L
- SAC254* – in 1/m
- SQI – sensor quality index
- TSSeq – derived from Abs360 in mg/L

* In the browser, the sum parameters are in English. COD = CSB, BOD = BSB, SAC = SAK.



Spectrum

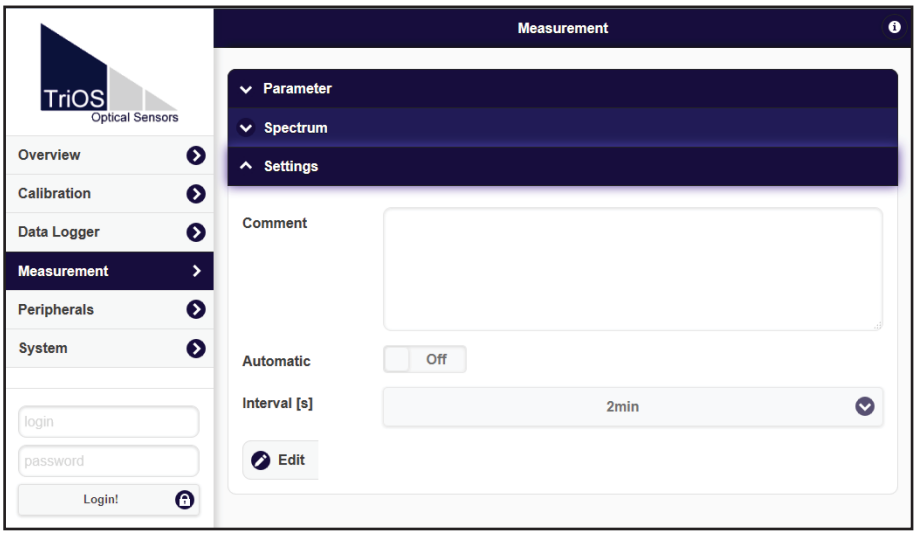
The "Spectrum" item shows the current measured absorption spectrum. Press the "Download" button to download/copy this spectrum to the computer as a CSV file.



Settings

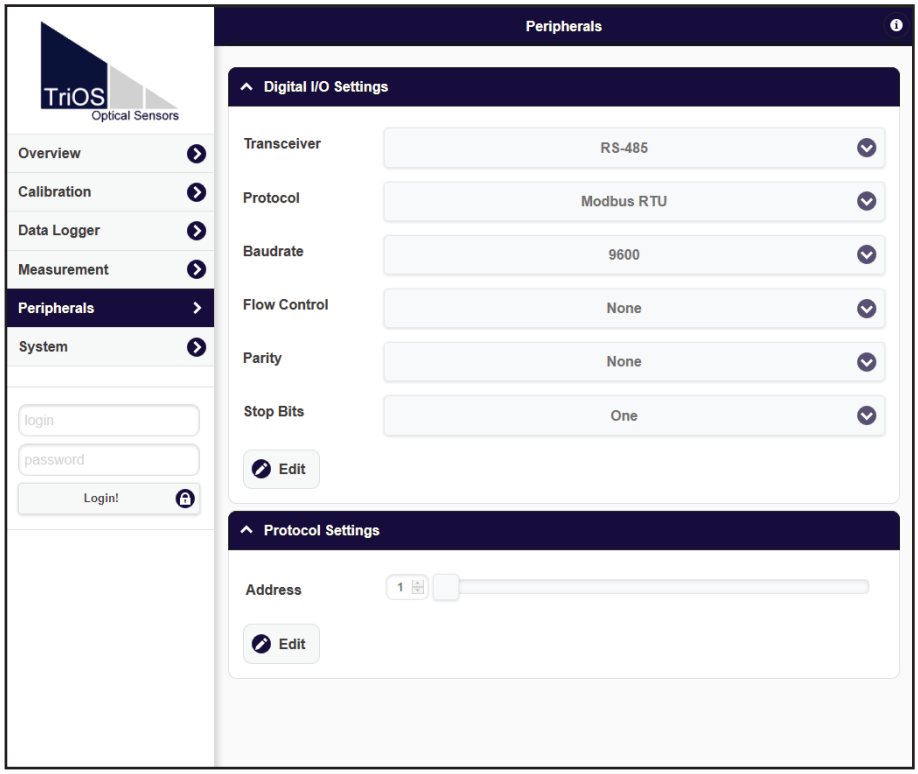
In "Settings" item, you can enter settings for automatic measurement by clicking on the "Edit" button.

- Comments entered in the "Comments" field can be linked to measured values and spectra.
- Automatic measurements can be activated.
- An interval for the automatic measurements can be specified.



Peripherals

The "Peripherals" page is used to configure the interface, select a protocol, and change the Modbus address. To do so, click the “Edit” button at the page bottom.



The factory settings are:

Hardware mode: RS-485

Protocol: Modbus RTU

Baud rate: 9600

Flow control: None

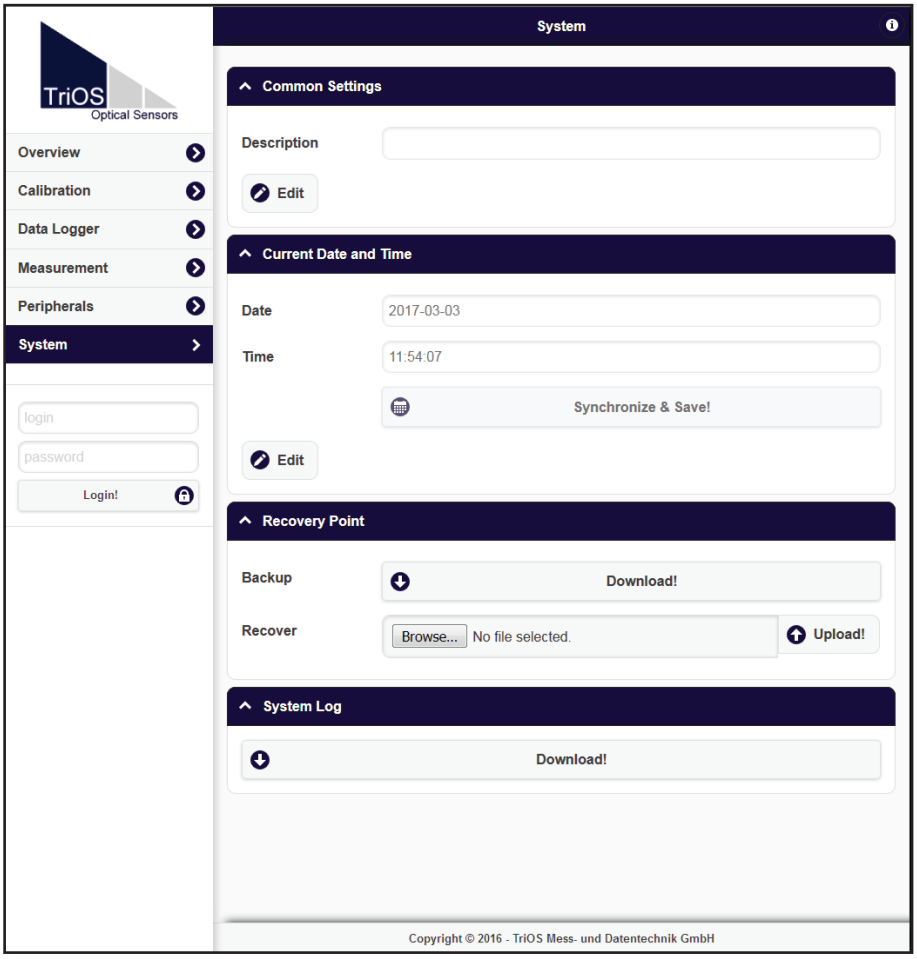
Parity: None

Data bits: 8

Stop bits: 1

System

The “System” page is used to manage the sensor. On this page, the user can load a calibration file and download the current calibration as a recovery point.



Common Settings

After pressing the "Edit" button, a comment such as a name or the location of the sensor can be entered here.

Current Date and Time

You can set the date and time here or synchronize the data time with your computer.

Recovery Point

Click on the "Download" button to download the latest sensor calibration to a PC or other support. This calibration file (config.ini) must be stored and kept safe.

Use the "Upload" function to restore a previously downloaded calibration file or to upload a calibration file generated by the customer support of TriOS Mess- und Datentechnik GmbH to the OPUS. See also chapter 6.3.1.

System Log

If the device is being serviced, system information can be downloaded here.

2.5 Login

To use the Service function, you need a login and a password. You will receive this when you participate in a TriOS training session.

3 Commissioning

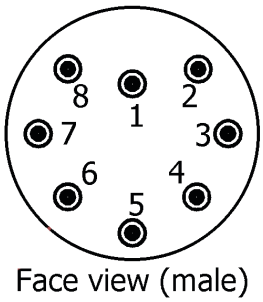
This chapter deals with the commissioning of the sensor. Please pay particular attention to this section and follow the safety precautions to protect the sensor from damage and yourself from injury.

Before the sensor is put into operation, it is important to ensure that it is securely attached and all connections are connected correctly.

3.1 Electrical Installation

The OPUS comes with either a fixed power cable or an underwater plug.

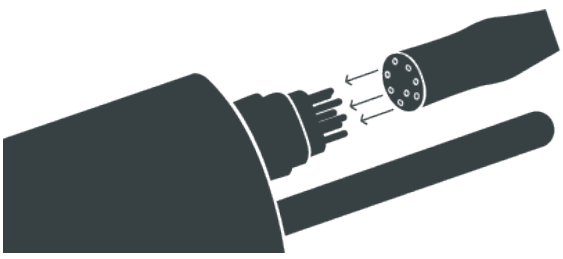
3.1.1 SubConn 8-pin Connector



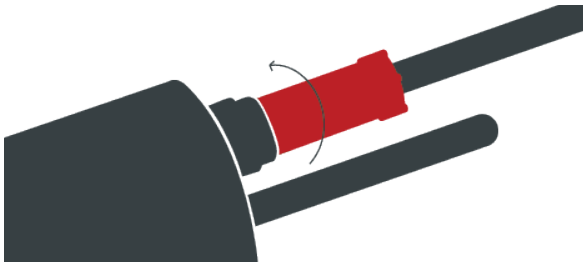
Face view (male)

1. Ground (Power + Ser. Interface)
2. RS232 RX / RS485 A (commands)
3. RS232 TX / RS485 B (data)
4. Power (12...24 VDC)
5. ETH_RX-
6. ETH_TX-
7. ETH_RX+
8. ETH_TX+

Connect the male end of the connecting cable into the connector by aligning the pins with the slots of the cable.

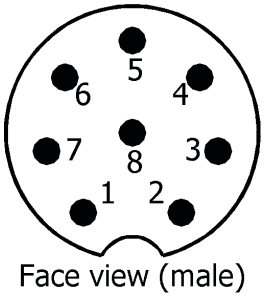


The next step is to rotate the locking sleeve in a clockwise direction to lock the end of the connector into the bulkhead connection.



NOTICE **Do not twist or bend the connector when plugging or unplugging it. Insert the connector straight in and use the locking sleeve to attach the male contact pin.**

3.1.2. Fixed Cable with M12 Industrial Plug



1. RS232 RX / RS485 A (commands)
2. RS232 TX / RS485 B (data)
3. ETH_RX-
4. ETH_RX+
5. ETH_TX-
6. ETH_TX+
7. Ground (Power + Ser. Interface)
8. Power (12...24 VDC)

NOTICE **Ensure correct polarity of the operating voltage or the sensor may be damaged.**

3.2 Interfaces

3.2.1 Serial Interfaces

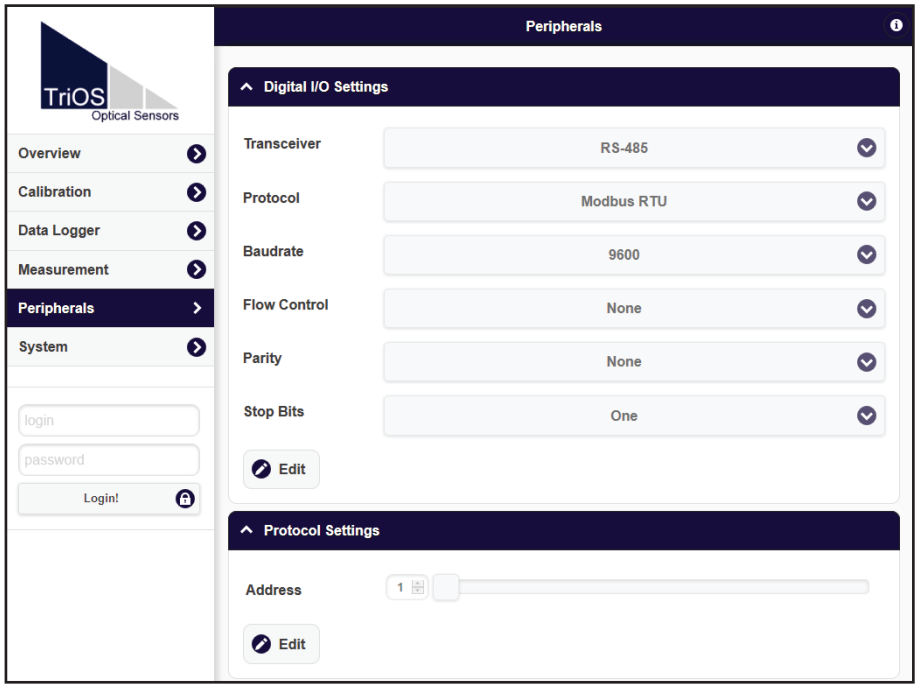
The OPUS provides two lines for digital, serial communication with a control device. It has a configurable digital serial interface. The RS-232 (and EIA 232) and RS-485 (and EIA 485) standards are supported, and the web interface allows switching between the two standards.

The digital RS-232 and RS-485 interfaces are voltage interfaces. For the RS-232, voltages of –15 V to +15 V with respect to the ground are possible. For the RS-485, voltages of –5 V to +5 V with respect to the ground are possible.

For the RS-232, data transmission takes place on one line per direction. The RX cable is used for the communication from the control device to the sensor. The TX cable is used from the sensor to the control device.

RS-485 uses a differential signal where the sign-negative potential of the A line is put on the B line. The A-B difference is decisive where the transmission is most resistant to interactive interference signals.

For the OPUS, the "Peripherals" page of the web interface allows configuration of the digital interface. The setting options are shown in the following figure:



Transceiver: Here you can select the electrical connection standard. The available choices are:

- EIA-232 (and RS-232)
- EIA-485 (and RS-485)

Protocol: Specifies the data protocol to be used. The following are supported:

- Modbus RTU
- IEEE 488.2 (SCPI)
- ASCII Output

A detailed description of the Modbus RTU protocol for the OPUS can be found in the annex.

Baud rate: Specifies the transmission speed. The following options are available:

- 1200
- 2400
- 4800
- **9600** **Standard setting for all TriOS controllers**
- 19200
- 38400
- 57600

Note: If communication problems occur, try to reduce the baud rate.

Flow control: Activates flow control on the software level (XON/XOFF).

Note: If the Modbus RTU protocol is being used, "None" must be selected.

Parity: Activates the parity check for data transmission. The possible options are:

- None (deactivated)
- Even
- Odd

Stop bits: Specifies the number of stop bits. The following options are available:

- One
- Two

Note: In various Modbus devices, it may be necessary to set this to "Two" if a parity check does not need to be done.

The factory settings are:

- Hardware mode: RS-485
- Protocol: Modbus RTU
- Baud rate: 9600
- Flow control: None
- Parity: None
- Data bits: 8
- Stop bits: 1

In the "Protocol settings" section, you can input settings for the active protocol.

- In the Modbus RTU protocol, the following properties are also available:
  - Address: This is the slave address for the Modbus communication. It identifies the sensor in the bus system and must be unique.

3.2.2 Network

For the new TriOS G2 sensors, the IEEE 802.3 10BASE-T-compliant Ethernet interface is used as a universal interface. This makes it possible to connect a single sensor or to build a complex sensor network.

Network with a single G2 sensor

The easiest way to connect to the OPUS is with the G2 interface box. The G2 interface box serves as both the connection and the power supply for the sensor and can be used with all TriOS G2 sensors.

The following figure shows a connection to a single sensor:

The TriOS G2 interface box translates the 8-pin M12 sensor plug to the conventional power supply connections (2.1 mm barrel connector) and to the network access (RJ45 socket).

G2 interface box

There are three connectors on the housing of the G2 interface box:

1. Power supply, 12 or 24 VDC, 2.1 mm barrel connector
2. Sensor connector, 8-pin M12
3. Ethernet connection, RJ45 socket

Proceed as follows to connect the sensor to an Ethernet-capable device via the G2 interface box:

Step 1) Make sure that the Ethernet adapter of your device is configured to automatically obtain the network settings (IP address and DNS server).

Step 2) Plug the M12 plug of the sensor cable into the M12 socket (2) of the G2 interface box and tighten the screw plug.

Step 3) Connect the 12 or 24 VDC power supply to the G2 interface box to supply the sensor with power.

Step 4) Wait at least 3 seconds before you connect the LAN cable using your Ethernet-capable device and the G2 interface box.

The web interface can now be accessed with any browser using the following URLs:

http://opus/

http://opus_7XXX/ (7XXX is the serial number)

http://192.168.77.1/

If the web interface cannot be accessed, make sure that the LAN cable was connected after the sensor was connected to the power supply and try all three URL options.

Automatic measurement by the OPUS is stopped when an Ethernet-capable device is connected. When the LAN connection between the sensor and the Internet capable device is disconnected, the measurements will continue at the set interval if the timer is activated.

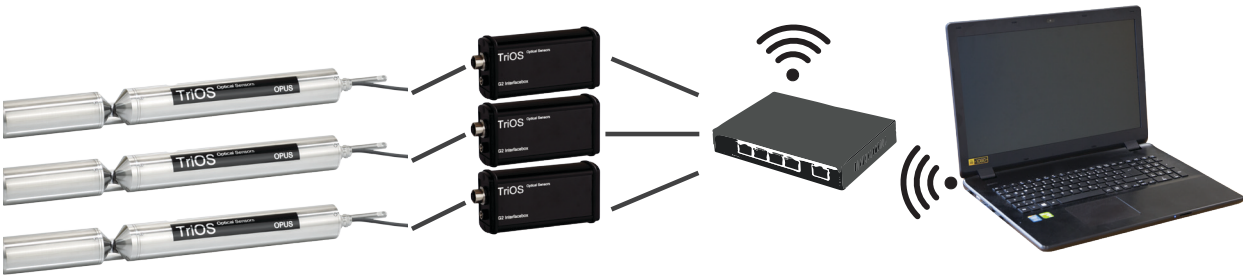
Network with multiple G2 sensors

By using an Ethernet switch / hub or a conventional router, it is possible to connect multiple sensors into a complex network and use them simultaneously. In the sensor network, each sensor must have its own G2 interface box for a power supply.

Like any G2 sensor, the OPUS delivers a simple DHCP server as well as a simple DNS server, which is configured exclusively for a direct connection as described in the previous section. For a complex sensor network, the servers must be supplied by the user. The OPUS recognizes these servers automatically and then turns off the internal servers. Ask your network administrator how a sensor network is best implemented in your case.

The following illustrations show examples of different ways to set up a sensor network.

G2 sensors	G2 interface box	a) Ethernet switch / hub b) Router with DHCP server	a) Ethernet-capable device with DHCP server b) Ethernet-capable device



G2 sensors	G2 interface box	a) Access point b) Wireless router with DHCP server	a) Wi-Fi-capable device with DHCP server b) Wi-Fi-capable device

The OPUS can only be used with one Ethernet-capable device at a time.

If multiple sensors are used in a network, the web interface can be accessed via the host name http://opus_7XXX/ (7XXX is the serial number) or via the IP address. Ask your network administrator for advice.

NOTICE **Damage caused by improper use is not covered by the warranty!**

4 Use

The OPUS can be operated with any of the TriOS controllers. Instructions for correct installation can be found in the controller manual.

NOTICE **Never transport the sensor by holding the cable.**

4.1 Normal Operation

4.1.1 Immersion Operation

For immersion operation, the OPUS can be completely or partially immersed in the water/measuring medium. To get a correct measurement, the measuring window must be completely immersed and free of air bubbles. Use the mounting rod with a shackle and a stainless steel chain or a steel wire to hang the device in the medium. Do not add weight to or pull on the sensor cable. The OPUS can also be attached with suitable hydraulic clamps, as shown in the following illustration. Make sure to use suitable brackets with an inner diameter of 48 mm (not for the deepsea version). To protect the housing pipe against excess concentrated pressure, install the brackets close to the device covers. Fitting brackets can be obtained from TriOS.

The sensor should be installed perpendicular to the direction of flow. This minimizes deposits on the windows and optimally supports the nano-coating function.

The sensor must not touch the ground, because it may cause damage.

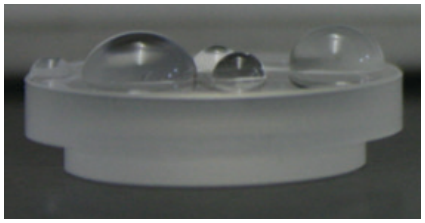
When immersing the sensor, make sure there are no air bubbles in front of the sensor discs. If there are air bubbles in front of the window, carefully shake the sensor until the bubbles have been removed.

4.1.2 Cleaning System

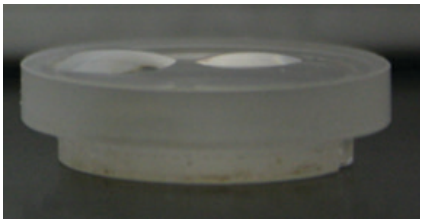
The OPUS and the other sensors from TriOS Mess- und Datentechnik GmbH have innovative antifouling technology that prevents pollution and dirt from attaching to the optical window: nano-coated window in combination with compressed-air cleaning.

Nano-coating

All optical windows from TriOS are treated with a nano-coating.



Window with nano-coating



Window without nano-coating

Wetting of the surface of the coated glass is significantly lower. This effect creates a nano-coated surface on the glass. Dirt cannot adhere to the nano-coated surface on the glass. In combination with the compressed-air cleaning, the windows are kept clean for long periods of time and so the amount of cleaning necessary is reduced..

Compressed air cleaning

The OPUS can be modified with the optional compressed-air cleaning head. The head is equipped with an air outlet directly on the window plate of the device and a hose fitting for the compressed-air connection. TriOS controllers have valves that are controlled by software, which allows fixed cleaning intervals to be set. Compressed air of between 3 and 6 bars must be provided.

NOTICE

The optimum pressure for compressed-air cleaning is 3 to 6 bars. The total length of the hose should not exceed 25 meters. Suitable hoses are available from TriOS (polyurethane, 6 mm outer diameter, 4 mm inner diameter).

To connect the hose, push the hose into the matching connection port. To remove the hose, press the blue locking ring in the direction of the connection and pull the hose out. Secure the hose to the device and the cable with cable ties if necessary to avoid uncontrolled hits and movement of the compressed-air hose.

NOTICE

The pressure should not exceed 7 bars because this may damage the valve!

During compressed air flushing, measurements can be adversely affected. Therefore, flushing intervals should be meaningfully controlled.

4.1.3 Floater

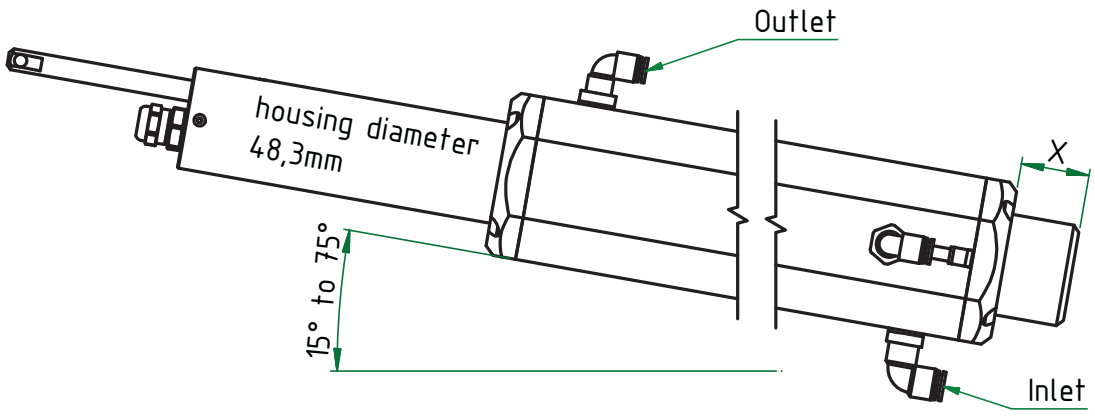
The float is the ideal solution for fluctuating water levels.

4.2 Bypass Installation

With the optional flow cell, the OPUS can be installed as a bypass. A panel is available on which the OPUS and the flow cell can easily be mounted.

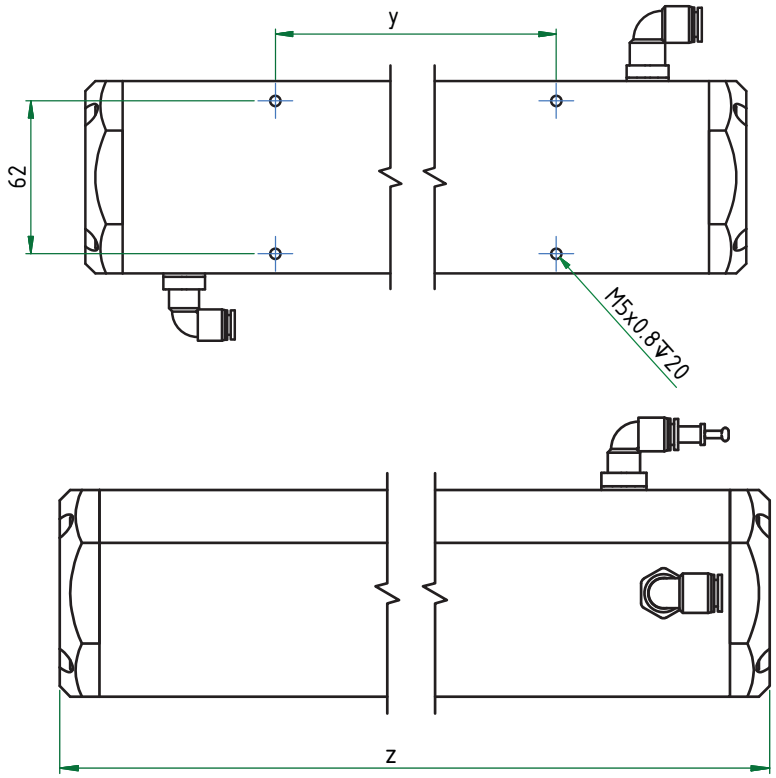
NOTICE **The maximum pressure in the flow cell must not exceed 1 bar. Make sure that the sensor is installed in the correct position to ensure the free flow of water.**

The OPUS flow cell has three hose connections. The inflow has an 8-mm hose connection and is located on the right side of the flow cell. There is a 6-mm outlet hose connection on the left side of the cell. Finally, there is a third hose connection on the top of the cell for cleaning with fluids. If the third hose connection is not being used, it should be sealed with a plug.



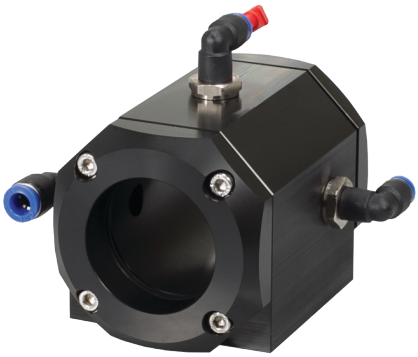
Because the OPUS is available in different path lengths, the dimensions of the associated flow cells vary accordingly, as described in the following table:

Path length [mm]	x [mm]	y [mm]	z [mm]
up to 10	99.5	62	108
50	98.5	96	150



The hoses are installed by putting light pressure on the hose connectors. To remove the hoses, press on the locking ring on the hose connector and carefully pull the hose away.

NOTICE **The flow cell cannot be combined with the compressed-air cleaning.**



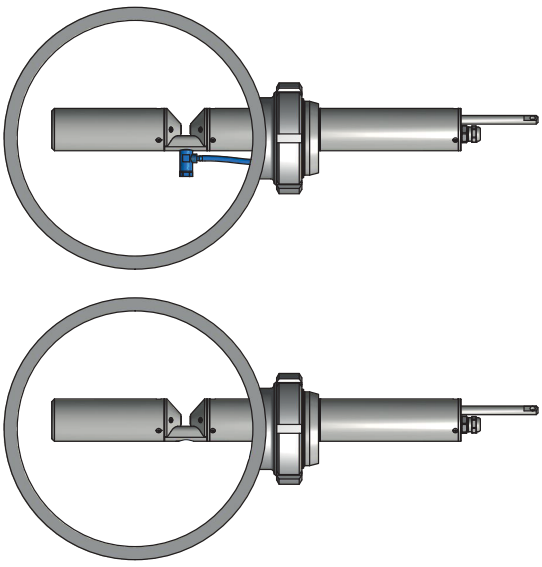
Follow the steps below to install the OPUS sensor in the flow cell cuvette.

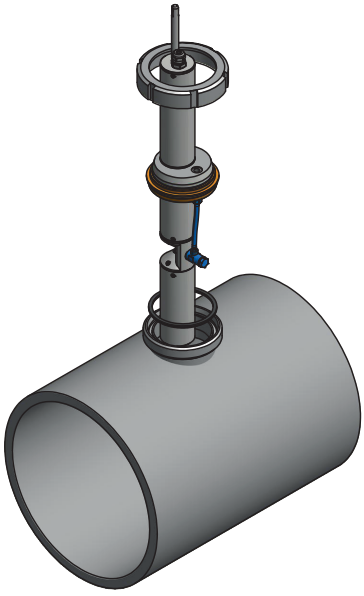
1. Remove both end caps of the flow cell and the two O-rings by loosening the eight screws.
2. Slide the OPUS into the flow cell and secure it in the correct position. All openings must be clear so that the fluid can flow directly through the optical path. The back side of the OPUS should point towards the bottom of the flow cell. The screw heads on the housing should disappear completely into the flow cell so that the OPUS sits centrally in the flow cell.
3. Slide a seal over the OPUS in the slots provided in the flow cell. Before final assembly, please check the seals for damage and use new seals when necessary. O-rings (48 x 5 mm NBR) are available as spare parts and can be purchased from TriOS Mess- und Datentechnik GmbH.
4. With the sensor in the correct position, install both end caps and secure them with the eight screws.

The flow cell and the OPUS should be installed at an angle of 15° to 75° to the horizontal so bubbles and sinking dirt particles do not affect the measurement. After installation, check for leaks and the free flow of water.

4.3 Pipe Installation

The OPUS can be mounted directly in the pipe (either with the special flanged version of the sensor or by the customer on-site). In the case of a grounded tube, no additional grounding of the sensor housing is required if there is no insulation between the tube and the sensor. One of the flange solutions available from TriOS is shown in the figures below (possible with and without compressed air cleaning).





5 Calibration

5.1 Manufacturer Calibration

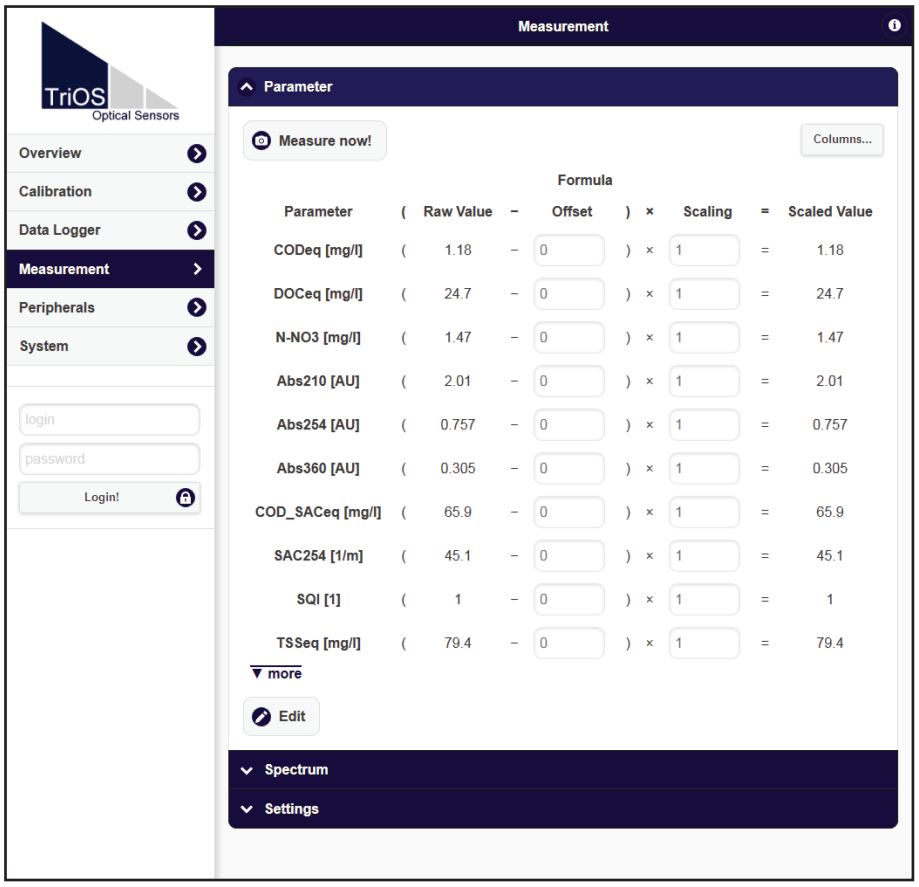
All TriOS sensors are delivered calibrated. The calibration of the OPUS is stored in the sensor, meaning that all values that are output are calibrated values. See also chapter 2.3.

The calibration (LSA group) must match the application of the OPUS. The composition of the UV-light-absorbing substances in the different water sources must match the calibration and be represented by the LSA group. For example, an application in seawater requires an LSA group that includes the absorption spectrum of sea salt. Drinking water contains different substances than wastewater.

5.2 Customer Calibration

The sensor can be adapted to laboratory analyses and local conditions with other scaling factors. This is set in the controller or directly in the browser for the sensor. To do this, open the "Measurement" submenu in the browser. The customer calibration or local calibration supplements the manufacturer calibration. The manufacturer calibration values are not changed by the customer calibration.

For sum parameters, such as CODeq, BODeq, TOCeq and DOCeq, theoretical absorption spectra have been stored. Using these parameters, a spectral analysis based on UV absorption can use only the portion that absorbs UV light, which can be represented to a greater or lesser extent in the medium depending on the local conditions. Therefore, these sum parameters typically require customer-specific calibration.



In the "Parameters" subitem under "Measurement", individual measurements can be triggered by pressing the "Measure now!" button. All of the available parameters can be scaled by pressing the "Edit" button.

The formula used to calculate the scaled measured value with scaling factor and offset is shown in the top row.

(Raw Value – Offset) x Scaling = Scaled Value

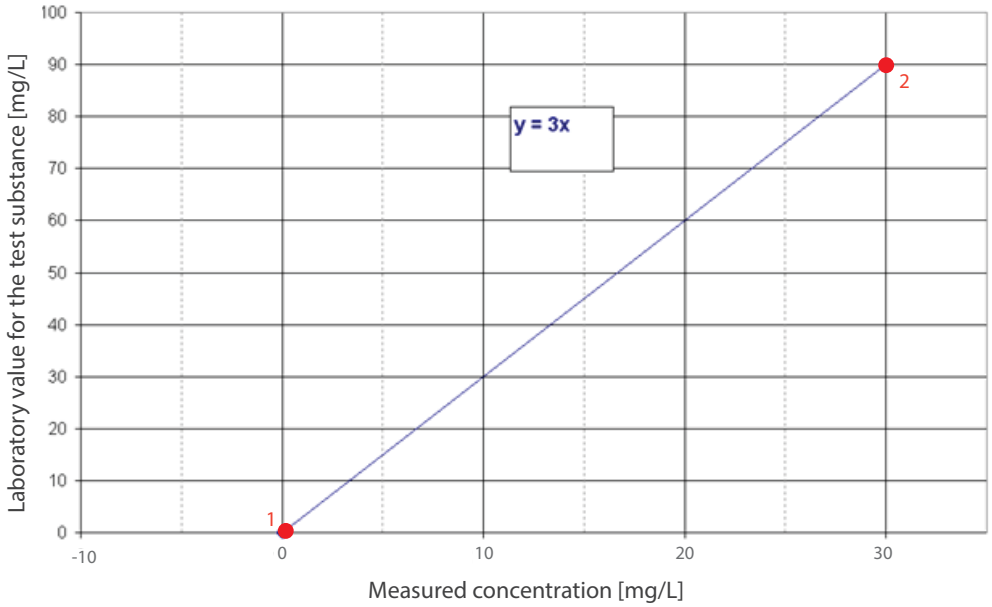
(Measured value – Axis Offset) x Scaling factor = Scaled measured value

The customer calibration can be used as a fine adjustment of the sensor for special media and supplements the manufacturer calibration.

The local calibration is adjusted using a linear equation. Normally, only the scaling factor is needed to adjust the local calibration.

For local calibration, at least one data point consisting of a laboratory value and a sensor value is required.

1. *Offset = 0* is given
2. Make a diagram like the one shown below and connect the two data points with a straight line. The slope of the straight line is the scaling factor.



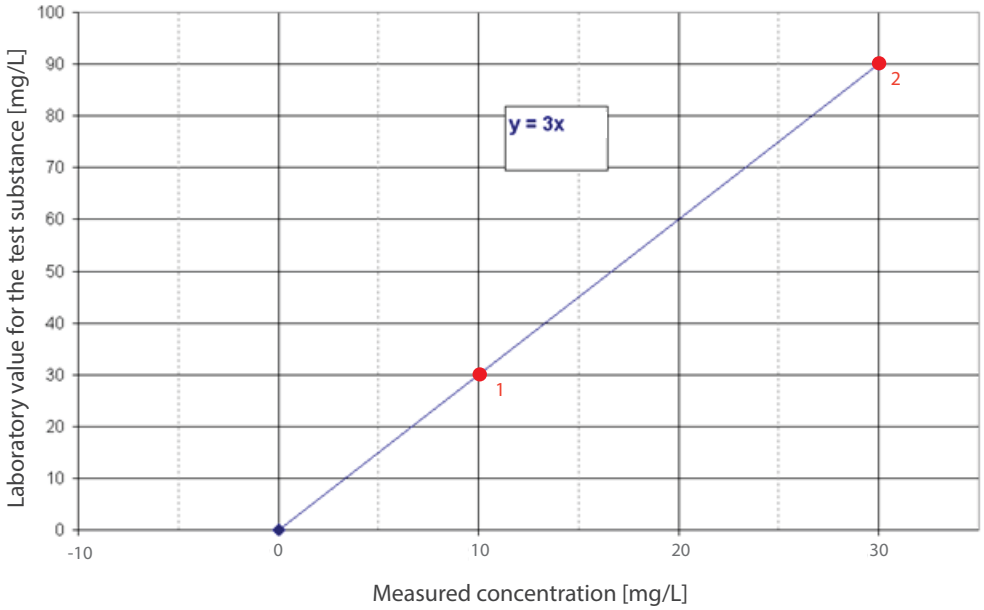
3. The scaling factor can be calculated using the following equation:

$$\textit{scaling factor} = \frac{\textit{Laboratory value}}{\textit{Measured value}}$$

For the previous example in the figure, this means:

$$\textit{scaling factor} = \frac{90\ \text{mg/L}}{30\ \text{mg/L}} = 3$$

4. If there are several laboratory values available, all of the laboratory values should be entered in the graph. Offset = 0 should still be given. As shown in the diagram, the slope of the line is equal to the scaling factor.



All of the TriOS controllers have the ability to set scaling factors and offset values for the measurement parameters. Please refer to the appropriate manual. Make sure not to do double scaling with the sensor: once in the G2 sensor menu directly and once more with the TriOS controller!

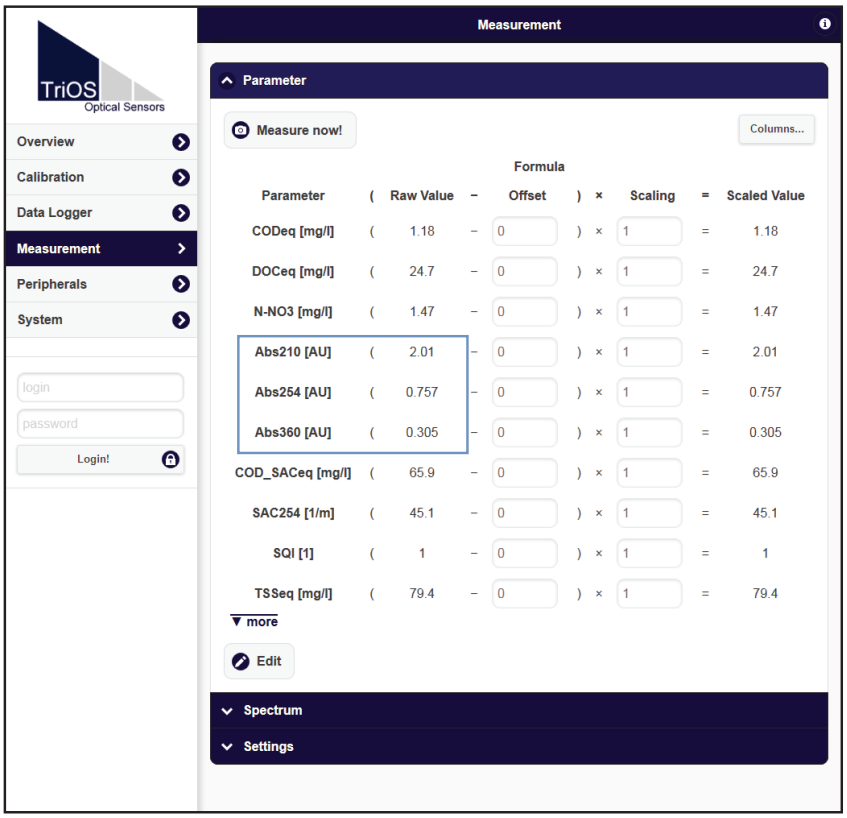
Customer calibration can be used as a fine adjustment of the sensor for special media and is not intended to replace the manufacturer calibration.

NOTICE **Measurement ranges and detection limits of the scaled parameters are dependent on the scaling factor!**

5.3 Measurement Properties

Ideally, the optical path of the OPUS is chosen so that the absorption at 210 nm (abs210) is not greater than 2.5 AU and the absorption at 360 nm (abs360) is not greater than 0.5 AU. If absorption at 210 nm is over 3 AU or if absorption at 360 nm is over 0.8 AU, the measured values can vary greatly or may not be able to be calculated (output: NAN)

The path length must be chosen according to the absorption level of the medium.



Limit values for absorption at 210 nm and 360 nm

Abs210	0.2...2.5	2.5...3	≥ 3
Abs360	≤ 0.5	0.5...0.8	≥ 0.8

5.3.1 Nitrate and Nitrite

The absorption spectra of nitrate and nitrite are very similar. To make sure nitrite is measured in addition to nitrate, absorption at 210 and 360 nm must stay within the specified limits. This can also be ensured if the concentrations of nitrate and turbidity (see chapter 5.3.2) stay within the specified limits.

Path (mm)	Parameters	N-NO3 N-NO2	NO3 NO2
0.3	Nitrate	2.4...120	11...530
	Nitrite	4.4...220	14.4...730
1	Nitrate	0.7...36	3.2...160
	Nitrite	1.3...67	4.3...220
2	Nitrate	0.35...18	1.6...80
	Nitrite	0.65...33.5	2.15...110
5	Nitrate	0.14...7.2	0.64...32
	Nitrite	0.26...13.4	0.86...44
10	Nitrate	0.07...3.6	0.32...16
	Nitrite	0.13...6.7	0.43...22
50	Nitrate	0.014...0.72	0.064...3.2
	Nitrite	0.026...1.34	0.086...4.4

Abs210	0.2...2.5	2.5...3	≥ 3

5.3.2 Seawater, Brackish Water

At up to 1 g/l sea salt (1 PSU) in natural waters at a path length of 10 mm, the interference is still negligible.

Limit values for sea salt

Path [mm]	Sea salt [g/L]
0.3	33
1	10
2	5
5	2
10	1
50	0.2

5.3.3 Turbidity

There are correlations between turbidity and absorption, however these depend greatly on the size and type of the particles.

At turbidity of up to 200 NTU at a path length of 10 mm, the interference should still be negligible.

Absorption at 360 nm should therefore be below 0.5 AU. If it is over 0.8 AU at 360 nm, the measured values can vary greatly or may not be able to be calculated (NAN).

Path (mm)	Parameters	Limit value
0.3	Turbidity	6600 NTU
	DOCeq	3000 mg/L
	TSSeq	5000 mg/L
1	Turbidity	2000 NTU
	DOCeq	900 mg/L
	TSSeq	1500 mg/L
2	Turbidity	1000 NTU
	DOCeq	450 mg/L
	TSSeq	750 mg/L
5	Turbidity	400 NTU
	DOCeq	180 mg/L
	TSSeq	300 mg/L
10	Turbidity	200 NTU
	DOCeq	90 mg/L
	TSSeq	150 mg/L
50	Turbidity	40 NTU
	DOCeq	18 mg/L
	TSSeq	30 mg/L

The turbidity essentially works as an offset. Therefore, the limit values for Abs360 must be adhered to (see 5.3).

Limit values

Abs360	≤ 0.5	0.5...0.8	≥ 0.8

5.3.4 Unknown Substances

Substances that absorb UV light but are not taken into account in the LSA group can severely interfere with the measurement result. Under certain circumstances, measured values can no longer be calculated (NAN or permanently zero).

If this is the case, please contact TriOS customer service (see also chapter 6.3.2).

6 Malfunction and Maintenance

To ensure an error-free and reliable measurement, the device should be periodically inspected and maintained. The sensor must be cleaned first.

6.1 Cleaning and Upkeep

The deposits (vegetation) and dirt that collects on the sensor depends on the medium and the duration of exposure in the medium. Therefore, the degree of pollution depends on how the sensor is used. For this reason, it is not possible to give a general answer regarding how often the sensor should be cleaned.

Normally, the system is kept clean by the nano-coated window and also by the air cleaning system. If the contamination is too bad, the following instructions should be followed.

NOTICE **Damage caused by improper cleaning is not covered by the warranty!**

6.1.1 Cleaning the Housing

⚠ CAUTION **Please use protective goggles and gloves when cleaning the sensor, especially when using acids, etc.**

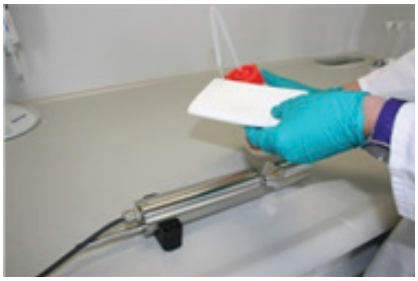
To loosen dirt, we recommend softening the sensor for several hours in a rinsing solution. During cleaning, do not let the exposed connectors come in contact with water. To prevent contact with water, , make sure that the locking cap of the connector is properly locked. Please learn about the risks and the safe handling of the cleaning solution used.

If the sensor is very dirty, additional cleaning with a sponge may be necessary. You should exercise extreme caution to avoid scratching the glass of the optical path.

In the case of calcification, a 10% citric acid or acetic acid solution can be used for cleaning.

Brownish dirt or spots can be contamination due to iron manganese oxides. For this type of contamination, a 5% oxalic acid solution or a 10% ascorbic acid solution can be used to clean the sensor. Please note that the sensor should only briefly come in contact with the acid, and then it should be thoroughly rinsed.

NOTICE **Under no circumstances should the sensor be cleaned with hydrochloric acid. Even very low concentrations can damage the components made of stainless steel. In addition, TriOS Mess- und Datentechnik GmbH cautions against using other strong acids, even if the sensor should have a titanium housing.**


6.1.2 Cleaning the Measuring Window

You can clean the window with a few drops of acetone and a lint-free cloth, a clean paper towel or a special optical paper from TriOS Mess- und Datentechnik GmbH. Make sure that you do not touch the window surface with your fingers!

TriOS Mess- und Datentechnik GmbH sells a cleaning set that contains acetone and special optical cleaning paper to simplify cleaning the optical window.

NOTICE **Do not use any aggressive cleaning solutions, putty, sandpaper or cleaning solutions that contain abrasive substances to remove dirt.**

6.2 Maintenance and Inspection

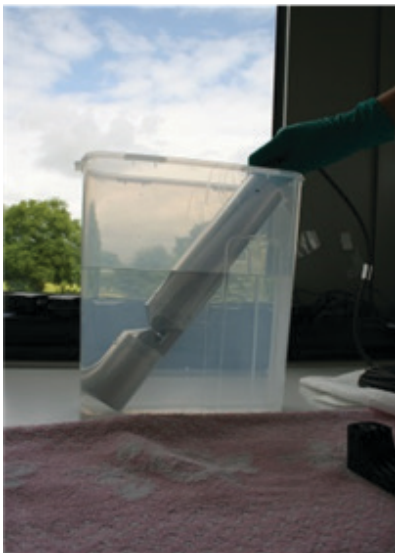
NOTICE **Avoid touching the glass parts of the optical window, since these can become scratched or dirty. This means the functionality of the device can no longer be guaranteed.**

6.2.1 Checking the Zero Value

Prepare the sensor for the zero-value check as described in the previous chapter.

We recommend using the TriOS VALtub to check the zero value, because this seals the optical path optimally and allows for a fast zero-value check. Make sure that the O-rings of the VALtub are positioned exactly over the seals of the sensor.

Alternatively, another container suitable for immersion can be used. When taking a measurement, the optical path must always be completely immersed in the water.



The zero value of the OPUS is checked via the web interface. To access the web interface, you will need the G2 interface box and an Ethernet-capable device with a web browser, such as a notebook/laptop.

Before the zero-value check, prepare the sensor as described below:

Clean the probe as described in chapter 6.1.1 "Cleaning the Housing". At the end of the cleaning process, rinse the probe carefully with deionized water. Dry the sensor with a paper towel. Wipe the sensor off with a little acetone on a kitchen towel to remove any greasy residues.

⚠ CAUTION **For your own safety, you must wear the appropriate gloves and protective goggles!**

Clean the sensor window with special optical paper or a soft, lint-free cloth and a few drops of acetone according to the previous instructions on cleaning the measuring window.

Important: Next polish the window with a soft, dry cloth or special optical paper to remove the thin film that may have appeared while cleaning the window.

Have a suitable measurement container filled with ultra-pure water ready nearby. Before this step, the measurement container should have already been carefully cleaned with a detergent solution and rinsed with ultra-pure water.

Immerse the sensor in the container of ultra-pure water. Make sure that the measuring windows are completely covered by water. Wait 10 to 15 minutes. During this time, hidden dirt can come loose from the sensor.

Remove the probe from the water and rinse it with ultra-pure water. Empty and then refill the container with fresh ultra-pure water and immerse the sensor again. Lift the probe and move it around in the water to remove any air bubbles. You can now check the zero value using the web interface.

The sensors should be positioned diagonally in the measurement container or vertically in the VALtub, if possible, to prevent very small, almost invisible air bubbles from collecting at the top of the measuring window. When using an upright measuring cylinder, which requires the sensor to be positioned vertically, make sure to check for air bubbles in the optical path.

Ensure a stable ground for the container!

Complete the zero-value check at an ambient temperature of 20°C, if possible. The temperature of the ultra-pure water should also be 20°C.

General Information:

- Do not touch the part of the sensor that has been submerged in the ultra-pure water with your hands during the sensor check unless you are wearing gloves.
- Be sure to use highly pure water (ultra pure, resistance of 18.2 MΩcm) or distilled water.
- If impurities in the water show up during the check, the process must be started over!
- Make sure there are no air bubbles in front of the measuring windows.

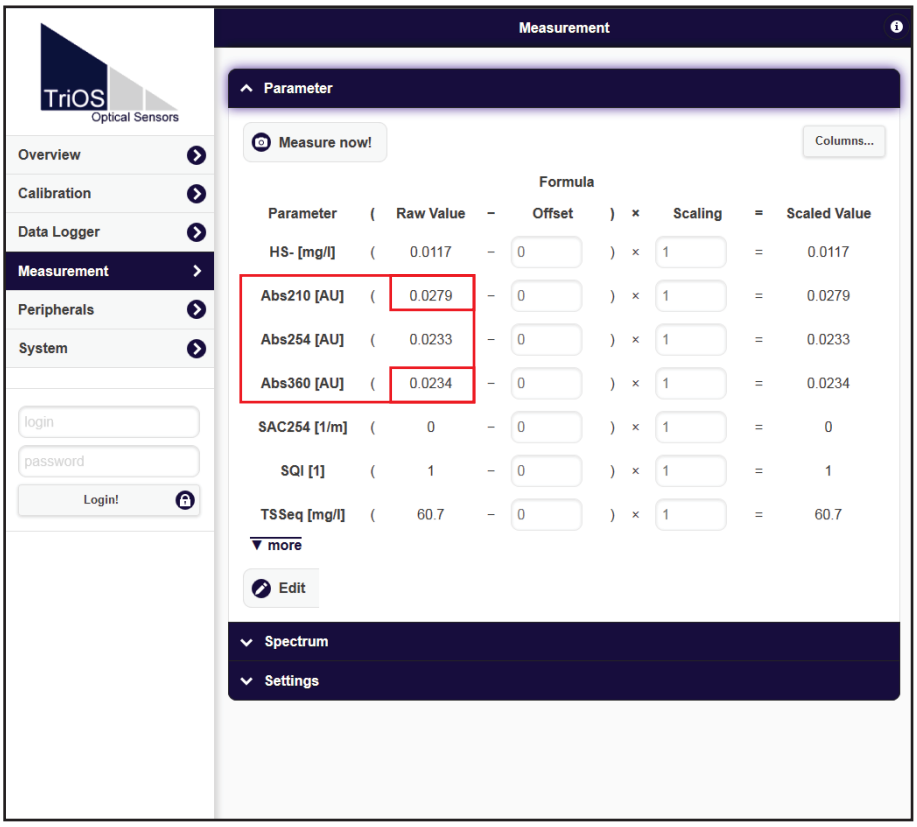
We recommend carrying out at least five individual measurements in "Measurement" prior to the check, to bring the sensor up to operating temperature.

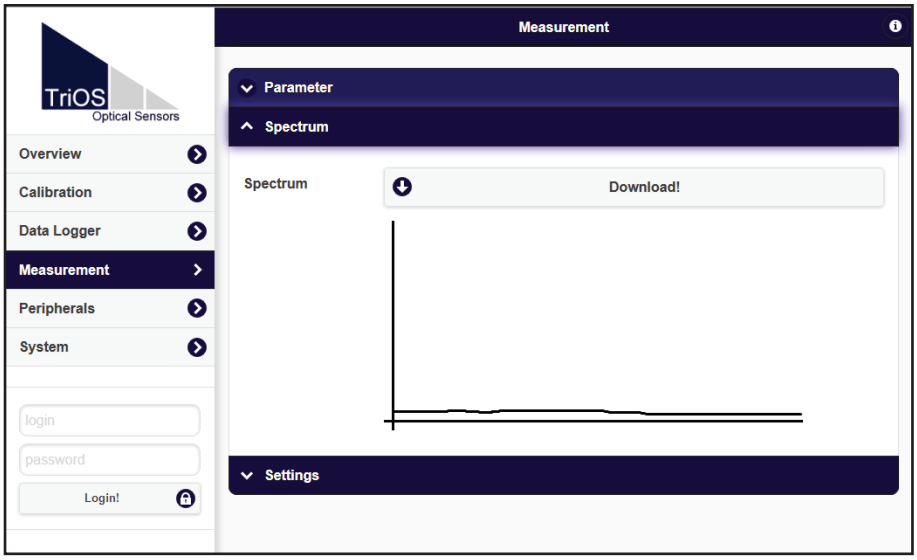
NOTICE **Damage caused by improper cleaning is not covered by the warranty!**

Limit values to decide whether a new zero line must be drawn:

- 0.1 AU for 360nm
- 0.2 AU for 210nm

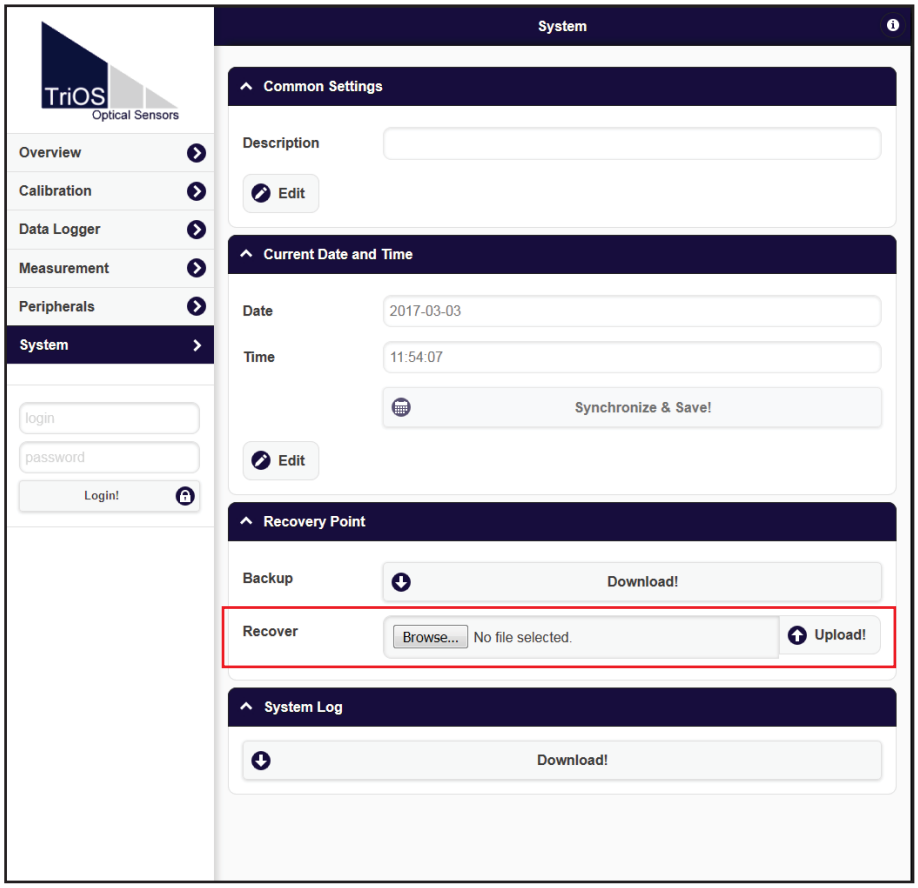
Below these values, you do not need to draw a new zero line, unless there are structures that are clearly interfering with the measurement.





6.3 Troubleshooting

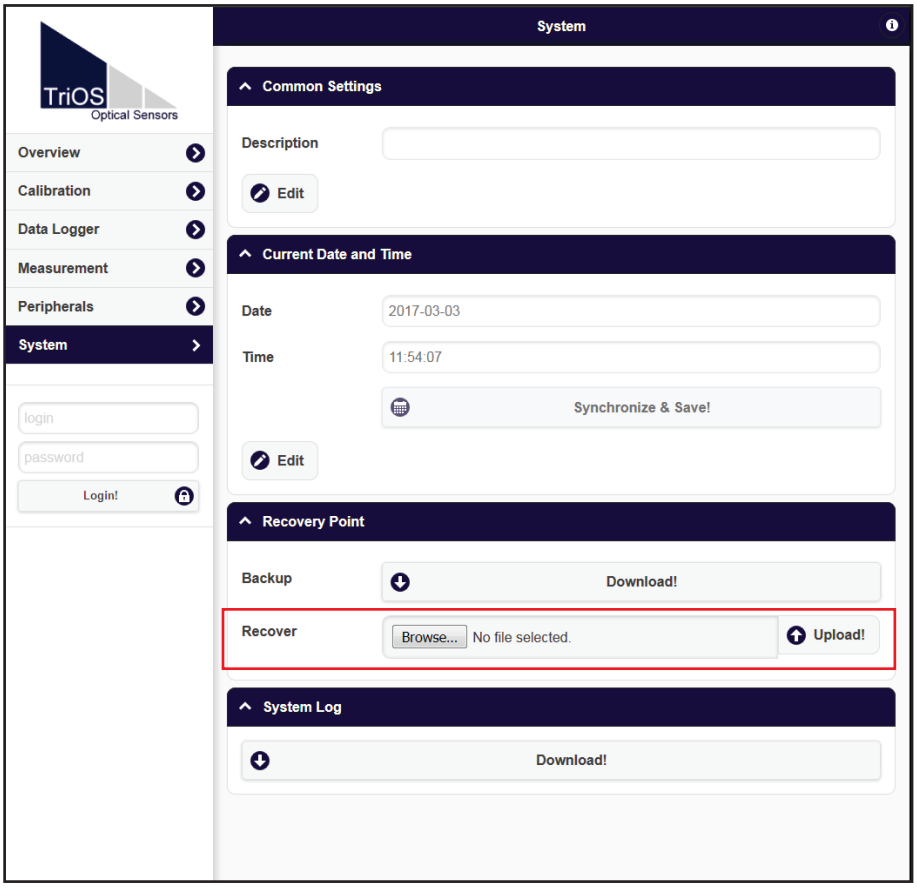
6.3.1 Uploading Recovery Point



If a previously downloaded recovery point needs to be uploaded, this can be done using the "Upload" function.

6.3.2 Uploading a New Calibration

For service, several spectra should be sent to TriOS customer service first (see also chapter 2.4 Data Logger and chapter 5.3.3). Use the "Upload" function to upload a calibration file to the OPUS that was generated by customer support at TriOS Mess- und Datentechnik GmbH.



6.4 Returns

Please observe the following instructions when returning items.

If returning a sensor, please contact customer service first. To ensure a smooth return and to avoid incorrect deliveries, each return package must first be reported to customer service. You will receive an RMA form, which you need to fill out completely and send back to us. Customer service will check your form and then give you an RMA number. Please attach the document with the number so it is clearly visible on the outside of the return package or write it in large numbers on the packaging so that your return package can be correctly allocated and accepted.

Caution! Return shipments without an RMA number can not be accepted and processed!

Please make sure that the sensor is cleaned and disinfected before shipping. In order to prevent damage to the goods during shipping, use the original packaging. If this is not available, make sure that safe transport is guaranteed and the sensor is safely packed using enough packing material.

7 Technical Data

7.1 Technical Specifications

Measurement technology	Light source	Xenon Flash Lamp
	Detector	High-end miniature spectrometer
		256 channels
		200 to 360 nm
		0.8 nm/pixel
Measurement principle		Absorption, spectral analysis
Optical path		0.3 mm, 1 mm, 2 mm, 5 mm, 10 mm, 20 mm, 50 mm
Parameters		see 7.2
Measurement range		see 7.2
Measurement accuracy		see 7.2
Turbidity compensation		Yes
Data logger		~ 2 GB
Reaction time T100		2 mins
Measurement interval		≥ 1 min
Housing material		Stainless steel (1.4571/1.4404) or titanium (3.7035)
Dimensions (L x Ø)		470 mm x 48 mm (with 10 mm path)
Weight	stainless steel	~ 3 kg (for 10-mm path)
	titanium	~ 2 kg (for 10-mm path)
Interface	digital	Ethernet (TCP/IP)
		RS-232 or RS-485 (Modbus RTU)
Power consumption		≤ 8 W
Power supply		12...24 VDC (± 10 %)
Required supervision		typically ≤ 0,5 hours per month
Calibration/maintenance interval		24 months
System compatibility		Modbus RTU
Warranty		1 year (EU: 2 years)

INSTALLATION

Max. pressure	with Subconn	30 bars
	with fixed cable	3 bars
	in FlowCell	1 bar, 2...4 L/min

Protection type	IP68
Sample temperature	+2...+40 °C
Ambient temperature	+2...+40 °C
Storage temperature	-20...+80 °C
Inflow velocity	0.1...10 m/s

7.2 Measurement Ranges and Limits of Detection

The following table provides an overview of the measurement ranges of various parameters as a function of the path length.

These values apply to individual substances in ultra-pure water under laboratory conditions.

Path (mm)	Parameters	Measurement principle	Unit	Measurement range	Detection limit	Limit of determination	Precision	Accuracy*
1	Nitrate N-NO_3	Spectral	mg/L	0...100	0.3	0.5	0.05	± (5% + 0.1)
	Nitrite N-NO_2	Spectral	mg/L	0...150	0.5	1.2	0.12	± (5% + 0.1)
	CODeq	Spectral	mg/L	0...2200***	30	100	10	
	BODeq	Spectral	mg/L	0...2200***	30	100	10	
	DOCeq	Spectral	mg/L	0...1000	5	10	1	
	TOCeq	Spectral	mg/L	0...1000	5	10	1	
	TSSeq	Spectral	mg/L	0...1500	60	200	20	
	KHP	Spectral	mg/L	0...4000	5	10	1	± (5% + 2)
	SAC_{254}	Single wavelength	1/m	0...2200	15	50	5	
	COD-SACeq**	Single wavelength	mg/L	0...3200	22	73	7.3	
	BOD-SACeq**	Single wavelength	mg/L	0...1050	7.2	24	2.4	
10	Nitrate N-NO_3	Spectral	mg/L	0...10	0.03	0.05	0.005	± (5% + 0.01)
	Nitrite N-NO_2	Spectral	mg/L	0...15	0.05	0.12	0.012	± (5% + 0.01)
	CODeq	Spectral	mg/L	0...220***	3	10	1	
	BODeq	Spectral	mg/L	0...220***	3	10	1	
	DOCeq	Spectral	mg/L	0...100	0.5	1	0.1	
	TOCeq	Spectral	mg/L	0...100	0.5	1	0.1	
	TSSeq	Spectral	mg/L	0...150	6	20	2	
	KHP	Spectral	mg/L	0...400	0.5	1	0.1	± (5% + 0.2)
	SAC_{254}	Single wavelength	1/m	0...220	1.5	5	0.5	
	COD-SACeq**	Single wavelength	mg/L	0...320	2.2	7.3	0.73	
	BOD-SACeq**	Single wavelength	mg/L	0...105	0.72	2.4	0.24	

* based on a standard calibration solution

** Based on KHP (100 mg COD standard solution is equivalent to 85 mg/L KHP)

*** depends on the composition of the COD and BOD (sum parameters)

1 mg/L N-NO_3 corresponds to 4.43 mg/L NO_3

1 mg/L N-NO_2 corresponds to 3.29 mg/L NO_2

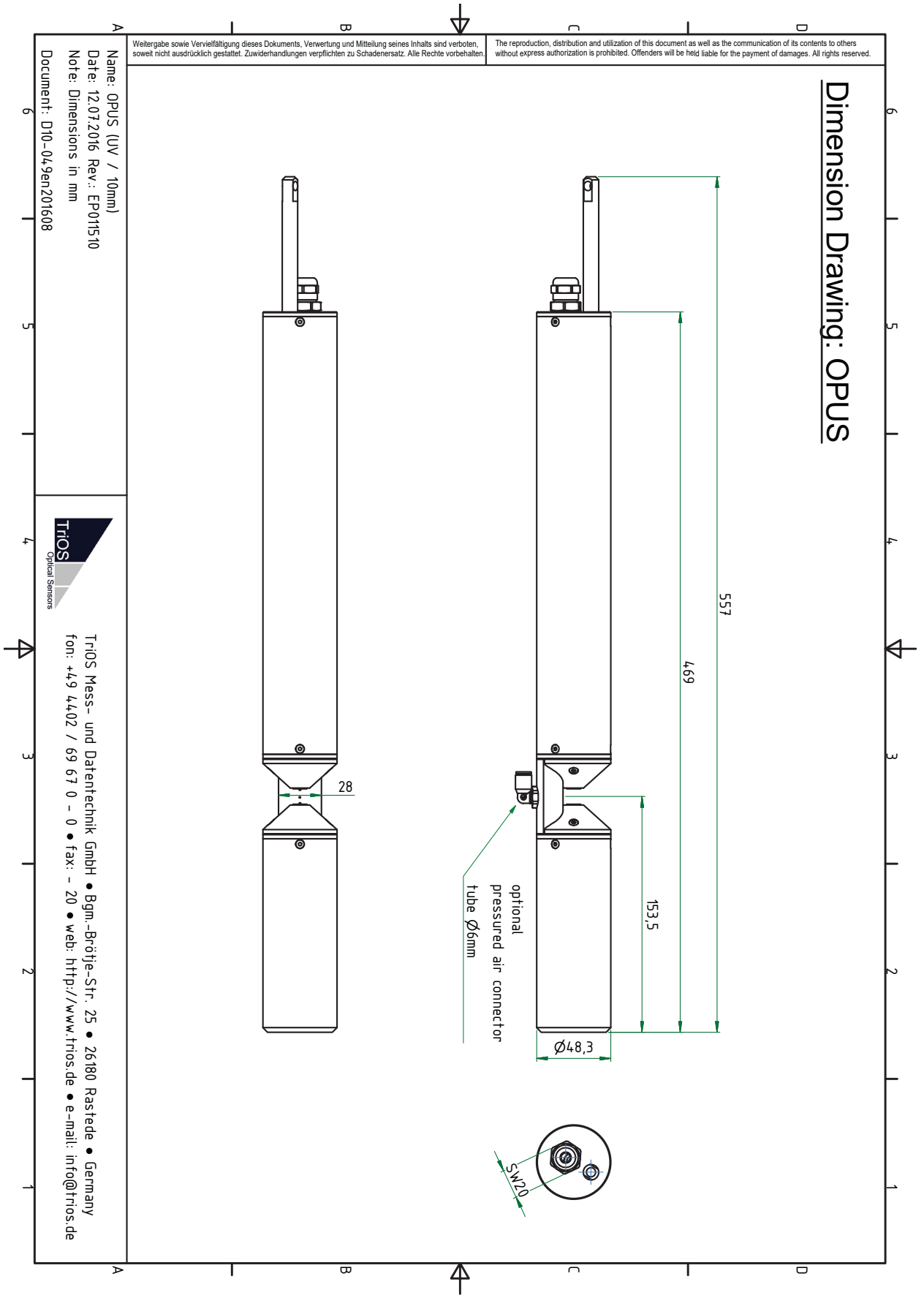
Opus UV: Measurement ranges depending on the path length*

Parameters	Measurement principle	Unit	Factor	Path length [mm]						
				0.3	1	2	5	10	20	50
Absorbance (au)	Spectral	au**	-	0.01...2.2	0.01...2.2	0.01...2.2	0.01...2.2	0.01...2.2	0.01...2.2	0.01...2.2
Absorbance (1/m)	Spectral	1/m	-	50...7300	15...2200	7.5...1100	3...440	1.5...220	0.75...110	0.3...44
Nitrate N-NO_3	Spectral	mg/L	-	1.0...330	0.3...100	0.15...50	0.06...20	0.03...10	0.015...5	0.006...2
Nitrate NO_3	Spectral	mg/L	-	4.43...1460	1.33...440	0.67...220	0.27...88	0.13...44	0.067...22	0.030...9
Nitrite N-NO_2	Spectral	mg/L	-	1.7...500	0.5...150	0.25...75	0.1...30	0.05...15	0.025...7.5	0.01...3
Nitrite NO_2	Spectral	mg/L	-	5.6...1650	1.65...500	0.82...250	0.33...100	0.17...50	0.083...25	0.033...10
DOCeq	Spectral	mg/L	-	17...3300	5.0...1000	2.5...500	1.0...200	0.5...100	0.25...50	0.1...20
TOCeq	Spectral	mg/L	-							
CODeq	Spectral	mg/L	-	100...7300***	30...2200***	15...1100***	6.0...440***	3.0...220***	1.5...110***	0.6...44***
BODeq	Spectral	mg/L	-	100...7300***	30...2200***	15...1100***	6.0...440***	3.0...220***	1.5...110***	0.6...44***
KHP	Spectral	mg/L	-	17...13300	5.0...4000	2.5...2000	1.0...800	0.5...400	0.25...200	0.1...80
SAK254	Single wavelengths	1/m	-	50...7300	15...2200	7.5...1100	3.0...440	1.5...220	0.75...110	0.3...44
COD-SACeq****	Single wavelengths	mg/L	1.46	75...10600	22...3200	11...1600	4.4...640	2.2...320	1.1...160	0.44...64
BOD-SACeq*****	Single wavelengths	mg/L	0.48	24...3500	7.2...1050	3.6...525	1.44...210	0.72...105	0.36...52.5	0.15...21
TSSeq*****	Single wavelengths	mg/L	2.6	130...4300	40...1300	20...650	8.0...260	4...130	2.0...65	0.8...26

* under laboratory conditions
** unit of absorption level
*** depends on the composition of the COD or BOD (sum parameters)
**** based on KHP (note: 100 mg COD standard solution is equivalent to 85 mg/L KHP)
***** based on SiO_2

Note:
1 mg/L N-NO_3 corresponds to 4.43 mg/L NO_3
1 mg/L N-NO_2 corresponds to 3.29 mg/L NO_2

7.3 External Dimensions



8 Accessories

8.1 VALtub

The VALtub is used to test and recalculate the zero values. Because of the adapted shape, only small amounts of water are required to take a measurement.

8.2 Controller

8.2.1 TriBox3

Digital, 4-channel display and control unit with integrated solenoid valve for compressed-air control

TriBox3 is a measurement and control system for all TriOS sensors. The device offers 4 sensor channels with selectable RS-232 or RS-485 function. In addition to the Modbus RTU, various other protocols are available. A built-in valve allows the use of compressed-air cleaning for the sensors. The TriBox3 also offers various interfaces, including an IEEE 802.3 Ethernet interface, an IEEE 802.11 b/g/n interface, a USB connection and 6 analog outputs (4...20 mA). An integrated relay can be used to trigger alarms or to control external devices. Features such as low power consumption, a robust aluminium housing and a range of interfaces make it suitable for all applications associated with environmental monitoring, drinking water, wastewater treatment plants and many other areas.

8.2.2 TriBox Mini

Digital 2-channel controller

Mini controller with two digital sensor inputs and two 4...20mA outputs. All of the measured values and diagnostics data that are stored can be selected using an integrated web browser.

9 Warranty

The warranty period of our devices within the EU is 2 years from the date of the invoice. Outside of the EU, the warranty period is one year. All normal consumables, such as light sources, are not included in the warranty.

The warranty is subject to the following conditions:

- The device and all accessories must be installed as described in the corresponding manual and must be operated according to the specifications.
- Damage due to contact with corrosive and damaging substances, liquids or gases and damage during transport are not covered by the warranty.
- Damage due to improper handling and use of the device is not covered by the warranty.
- Damage resulting from modification or unprofessional attachment of accessories by the customer is not covered by the warranty.

NOTICE **Opening the sensor voids the warranty!**

10 Customer Service

If you are having a problem with the sensor, please contact TriOS customer service.

We recommend sending the sensor in for maintenance and calibration every 2 years. To do this, please request an RMA number from customer service.

Technical support contacts:

support@trios.de

Telephone: +49 (0) 4402 69670 - 0

Fax: +49 (0) 4402 69670 – 20

To help us provide you faster service, please send us the sensor ID number by email (the last four digits of the serial number consisting of letters and numbers, e.g., 28B2)

11 Contact

We are constantly working to improve our devices. Visit our website for news.

If you have found an error or bug in one of our devices or programs, please let us know:

Customer service:	support@trios.de
General questions/ sales:	sales@trios.de
Website:	www.trios.de

TriOS Mess- und Datentechnik GmbH

Bürgermeister-Brötje-Str. 25

D-26180 Rastede

Germany

Telephone	+49 (0) 4402 69670 - 0
Fax	+49 (0) 4402 69670 - 20

12 Keyword Index

Annex

CE Declaration of Conformity

CE

TriOS Optical Sensors

Hersteller/Manufacturer/Fabricant: TriOS Mess- und Datentechnik GmbH
Bürgermeister-Brötje-Str. 25
D- 26180 Rastede

Konformitätserklärung
Declaration of Conformity
Déclaration de Conformité

Die TriOS GmbH bescheinigt die Konformität für das Produkt
The TriOS GmbH herewith declares conformity of the product
TriOS GmbH déclare la conformité du produit

Bezeichnung Product name Designation	**OPUS**
Typ / Type / Type:	**UV, UV/VIS**
Mit den folgenden Bestimmungen With applicable regulations Avec les directives suivantes	2014/30/EU EMV-Richtlinie 2011/65/EU RoHS-Richtlinie
Angewendete harmonisierte Normen Harmonized standards applied Normes harmonisées utilisées	EN 61326-1:2013 EN 55011:2009 + A1:2010 EN 61010-1:2010 EN 50581:2012
Datum / Date / Date 27.01.2017	Unterschrift / Signature / Signatur R. Heuermann

D05-049yy201701

Modbus RTU

Serial Interface

Upon delivery, the OPUS sensor is configured to RS485 with the following settings:

- Baud rate: 9600 bps
- Data bits: 8
- Stop bits: 1
- Parity: none

Data types

Name	Register	Format
Bool	1	false: 0x0000, true: 0xFF00
Uint8	1	8-bit positive integer. Values: 0x0000 - 0x00FF
Uint16	1	16-bit positive integer. Values: 0x0000 - 0xFFFF
Uint32	2	32-bit positive integer. Values: 0x00000000 - 0xFFFFFFFF
Float	2	IEEE 754 32-bit floating-point number
Char[n]	$[\frac{n}{2}]$	Null-terminated ASCII character string
Uint16[n]	n	Field of n 16-bit integers (cf. Uint16)
Float[n]	2n	Field of n floating-point numbers (cf. float)

Functions

The OPUS supports the following Modbus functions:

Name	Code	Description / Use
Read multiple registers	0x03	Read the serial number, configuration, calibration and measurement data
Write multiple registers	0x10	Write the configuration and calibration
Write single register	0x06	Triggering of (calibration) measurements
Report slave ID	0x11	Read the serial number

Standard Modbus server address

Upon delivery, the OPUS sensor is set to address 1 (0x01).

Read / Write multiple registers (0x03 / 0x10)

The following values are in the registers:

Note: Before the registers can be read above address 1000, a measurement must be triggered.

Designation	R/W	Address	Data type	Description
Measurement time-out	R	1	Uint16	The time in [10-1 s] that the currently running measurement process will still require (see also “Trigger measurement”)
OPUS serial number	R	10	Char[10]	Serial number of the OPUS sensor
Firmware version	R	15	Char[10]	Version number of the installed firmware
Lamp serial number	R	20	Char[8]	Serial number of the lamp module

Data comment #1	RW	109	Char[64]	First comment line for the measurement data
Data comment #2	RW	141	Char[64]	Second comment line for the measurement data
Data comment #3	RW	173	Char[64]	Third comment line for the measurement data
Data comment #4	RW	205	Char[64]	Fourth comment line for the measurement data
System date and time	RW	237	Uint32	Date and time as seconds since 1 January 1970
Device description	RW	239	Char[64]	An unrestricted description of the sensor e.g.,: "south supply line"
LSA name	R	500	Char[8]	Name of the active substance analysis
Available substances	R	504	Uint16[13]	In this bit field, a set bit describes which substances are available in the active analysis (see order of concentration values as of register 1000 / 1500). First bit N-NO3, second bit N-NO2, third bit bit CODeq, …

Designation	R/W	Address	Data type	Description
N-NO3 concentration / scaled concentration	R	1000 / 1500	Float	
N-NO2 concentration / scaled concentration	R	1002 / 1502	Float	
CODeq concentration / scaled concentration	R	1004 / 1504	Float	
BODeq concentration / scaled concentration	R	1006 / 1506	Float	
DOCeq concentration / scaled concentration	R	1008 / 1508	Float	
HA concentration / scaled concentration	R	1010 / 1510	Float	
Salinity concentration / scaled concentration	R	1012 / 1512	Float	
TOCeq concentration / scaled concentration	R	1014 / 1514	Float	
TSSeq concentration / scaled concentration	R	1016 / 1516	Float	
Phenol concentration / scaled concentration	R	1018 / 1518	Float	
HS concentration / scaled concentration	R	1020 / 1520	Float	
Chloride concentration / scaled concentration	R	1022 / 1522	Float	
Bromide concentration / scaled concentration	R	1024 / 1524	Float	
CO3 concentration / scaled concentration	R	1026 / 1526	Float	
NH2Cl concentration / scaled concentration	R	1028 / 1528	Float	
Fouling concentration / scaled concentration	R	1030 / 1530	Float	
SAC254 concentration / scaled concentration	R	1032 / 1532	Float	
Abs360 concentration / scaled concentration	R	1034 / 1534	Float	
Abs210 concentration / scaled concentration	R	1036 / 1536	Float	
Fit-Error concentration / scaled concentration	R	1038 / 1538	Float	
KHP concentration / scaled concentration	R	1040 / 1540	Float	
Abs254 concentration / scaled concentration	R	1042 / 1542	Float	
Abs720 concentration / scaled concentration	R	1044 / 1544	Float	
NO3 concentration / scaled concentration	R	1046 / 1546	Float	
NO2 concentration / scaled concentration	R	1048 / 1548	Float	
SUVA concentration / scaled concentration	R	1050 / 1550	Float	
COD_SACeq concentration / scaled concentration	R	1052 / 1552	Float	

BOD_SACeq concentration / scaled concentration	R	1054 / 1554	Float	
TOC_SACeq concentration / scaled concentration	R	1056 / 1556	Float	
DOC_SACeq concentration / scaled concentration	R	1058 / 1558	Float	

Designation	R/W	Address	Data type	Description
Spectrum type	R	2000	Uint16	Type of the last recorded spectrum Possible values: 0x0001: Absorption spectrum
Averaging	R	2001	Uint16	Number of individual measurements which were averaged for the last recorded spectrum
CalFactor	R	2002	Float	Normalization factor of the last recorded spectrum
Flash count	R	2004	Uint16	Number of lamp flashes during the last measurement
Path length	R	2006	Uint16	Optical path length in [mm] through the medium during the last measurement
Temperature	R	2007	Float	Sensor temperature in [°C] during the last measurement
Length	R	2009	Uint16	The number of value pairs in the spectrogram. The number will vary from sensor to sensor. For a UV OPUS, the spectrogram is limited to the range [200nm ; 360nm]; for a UV/VIS-OPUS, it is limited to the range [200nm ; 720nm]
Abscissa	R	2100	Float[Length]	The values on the abscissa by which the spectrogram is described (wavelengths)
Ordinate	R	2612	Float[Length]	The values on the ordinate by which the spectrogram is described. In the case of an absorption spectrum, this is the absorbance.
Waterbase path length	R	4006	Uint16	Optical path length in [mm] through the medium of the waterbase

Write single register (0x06)

With the “write single register” function, specific actions are written in the register rather than values. The following section describes how this mechanism works.

Designation	Address	Description
Trigger measurement	1	A single measurement is taken. The type of measurement depends on the written value: 0x0101: Absorption spectrum + substance analysis All other values are reserved for future expansions and can cause uncertain behaviour of the sensor. Note: Up to and including firmware version 1.2.4, it is possible that Modbus requests will not be answered during the measurement.

Report slave ID (0x11)

Provides the sensor designation followed by the serial number followed by the firmware version each as a null-terminated ASCII character string.

Example:

O	P	U	S	0x00	7	0	7	A	0X00	1	.	3	0x00