OSCAR G2

Online hyperspectral integrating cavity absorption meter

Manual preliminary

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Content

1 General notes

OSCAR is an innovative sensor applying the principle of the integrating sphere providing absorption measurements literally free of scattering influence. Please read this manual carefully and follow its recommendations to make the maximum use of it. Please notice that it is in the user responsibility to follow the local governmental rules for the installation of electronic devices. Any damages caused due to misuse or unprofessional installations are not covered by warranty. While operation requires opening the cavity, it is not foreseen to open the main housing of the sensor. Please note that warranty is lost due to open the main housing. **OSCAR** and any accessories, delivered from **TriOS Mess- und Datentechnik GmbH**, should only be installed and operated following the instructions of the manufacturer. Please use only original accessories and cables of **TriOS Mess- und Datentechnik GmbH** for a professional use of the sensor.

This device is designed for use in science. The intended use of the **OSCAR** is to measure the absorption of water or aqueous fluids e.g. river water, sea water, ground water in a temperature range from 2 °C to 40 °C. It has to be operated and powered according to the specifications. All parts have been designed and are tested to fulfil the international rules for electronic instrumentations. The unit is complying with the international EMC rules.

Make sure that you have read and understood the safety precautions described below before using the sensor. Always make sure that the sensor is operated correctly.

This manual is made on basis of OSCAR software version V.1.1.6.

The safety precautions noted on the following pages are intended to provide a simple and correct operation of the instrument and all its accessories to prevent you, other people or devices from harm.

Copyright Notice

1.1 Health and environment

This manual contains important information about health and safety rules. This information will be marked as follows and must be followed.

⚠	**Important hint for safe and professional approach to the measurement system.**

Electromagnetic waves

Electromagnetic waves in the UV range can affect the skin or eyes.

⚠	**Never look directly into the light source.** **The emitted radiation can cause injury to the eyes.**

Reagents

In use of reagents follow the safety and operating instructions of the manufacturer. Observe the valid Ordinance on Hazardous Substances used for any reagents!

Biological Safety

Possibly liquid waste can be biologically hazardous. You should therefore always wear gloves when handling such materials. Observe the currently valid biological agents regulation!

Waste

When dealing with liquid waste, the regulations concerning water pollution, drainage and waste disposal must be observed.

1.2 Warning notices

- This sensor is designed for use in science. It should only be used for measuring aqueous solutions, e.g. river water or sea water.

⚠ **Sensors made of stainless steel are not made for use in sea water (corrosion). Only sensors of titanium can be used in sea water.**

- Sensors which are made of stainless steel have to be cleaned immediately after exposure to salt water or other corrosion-causing substances (e.g. acids, alkalis, chlorine-based compounds).
- Even Titanium will be affected for example by bromine, hydrofluoric acid and hot acids. Do not use sensors of titanium in these media.
- The sensor **OSCAR** has seals of NBR (nitrile butadiene rubber). On custom request sealing rings of other materials can possibly be used. Before operation take care that the assay medium does not damage the seals.
- Before operating check the power supply. **OSCAR** has to be operated with voltages between 12 and 24 VDC.
- Don't use alcohol, benzene, dilutor or other flammable substances to clean or maintain the equipment. The use of these substances may lead to fire. **Exception:** cleaning of the optical windows with a few drops of acetone and optical paper from **TriOS Mess- und Datentechnik GmbH** or a lint-free tissue and cleaning of the cavity with ethanol.
- Do not cut, damage nor modify any of the cables. Make sure that no heavy objects are located on the cable or that the cables are kinked.
- Make sure that the cable does not run near hot surfaces.
- If the power cable is damaged, it must be replaced only by **TriOS Mess- und Datentechnik GmbH** or an authorized **TriOS** workshop with an original replacement.

- Do not cover any other items not provided for this purpose in the optical path, as long as the instrument measures, as this may cause damage to the sensor or incorrect measurement results.

- The optical windows should be cleaned with special optical paper to avoid the risk of false results. Make sure that there is no dirt around the optical path. It is recommended to wear gloves during cleaning.

- Stop the usage of the sensor immediately if it emits smoke, noxious fumes or excessive heat production (i.e. more than lukewarm). Turn off the sensor immediately, remove the cable from the power supply and unplug the power cord from the outlet. Make sure that smoke or fume emissions have ceased. Please contact your dealer or **TriOS Mess- und Datentechnik GmbH** customer service.

- Never attempt to disassemble or alter any part of it to make changes that are not expressly described in this guide. Internal inspections, alterations and repairs should be performed by the equipment dealer or the **TriOS Mess- und Datentechnik GmbH** authorized and qualified professionals.

- Devices from **TriOS Mess- und Datentechnik GmbH** meet the highest safety standards. Repairs of equipment (which includes the replacement of the connecting cable) must be conducted by **TriOS Mess- und Datentechnik GmbH** or an authorized **TriOS** workshop. Defective, improper repairs can lead to accidents and injuries.

1.3 Target group and user skills

The absorption meter **OSCAR** was developed for use in science. The implementation of photometric determinations with test sets often requires the handling of hazardous substances.

We assume that the operator is familiar due to the professional training and experience in dealing with hazardous materials. The operator must in particular be able to understand safety signs and safety instructions on the packaging and the package inserts of the test sets and to apply them.

1.4 Intended use

The intended use of the absorption meter consists exclusively in the implementation of photometric measurements in accordance with these instructions. The sensor is a submersible absorption meter, which can be used immersed in water or in laboratory use. Any other use is improper. Use this appliance only for measuring the absorbance of aqueous fluids. Other media can lead to accidents. For the use of the sensor **OSCAR** in media other than the specified please contact support of **TriOS Mess- und Datentechnik GmbH** (support@trios.de).

CAUTION

- Avoid every contact with the glass and plastic components in the cavity, because they can be scratched or get dirty. This will change the functionality of the sensor; correctness of the measured values is no longer ensured.
- Only touch the sensor on the housing. Do not lift the sensor on the cord.
- Install the sensor and it cables away from hot surfaces.

According to the current scientific knowledge, the appliance is safe to use, if it is handled properly and according to the instructions in this manual.

1.5 Purchased parts package

- Sensor
- Manual
- Accessory (if applicable)(e.g. **G2 Interface Box**)

Preserve the original packing material for a possible return of the unit for maintenance or repair purposes.

1.6 Proper disposal

At the end of lifetime, the device and its accessories may be returned for environmentally friendly disposal. The previous professional decontamination must be proven by a certificate. Please contact us before you send the device to the manufacturer. This will tell you more details.

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2 Introduction

OSCAR is an independent measuring instrument. For the operation nothing more than a power supply of 12 - 24 VDC is required. The sensor is equipped with a configurable digital serial interface. It supports EIA-232 and EIA-485 as well as various protocols, such as Modbus RTU.

The sensor can be configured via the web interface. This is a graphical user interface that can be opened by a web browser.

Like all **TriOS Mess- und Datentechnik GmbH** sensors, **OSCAR** is shipped pre-calibrated so that **OSCAR** is ready for immediate use.

This manual provides information about the specifications, the installation and the operation of **OSCAR.**

2.1 Measuring principle

The measurements of particulate light absorption in natural waters, i.e. that of suspended phytoplankton algae, sediment, detritus etc., remains a difficult issue because with most measurement technique the light scattering of those particles deteriorates the signal and the absorption is strongly overestimated. The observed light attenuation has often to be corrected to receive the correct absorption by subtracting the scattering signal. Furthermore the generally low concentration of particles in natural water makes it necessary for most common techniques to concentrate the particles before their absorption can be measured. A typical technique is to concentrate particles on a glass fibre filter and measure the filter in a spectrophotometer (QFT, quantitative filter technique). However, this requires comprehensive sample handling, like filtration, preservation, storage etc. One possibility to overcome these problems is to measure the original sample inside an integrating sphere, that would reduce/avoid scattering problems and sample handling, and increase sensitivity by a rather long optical path length (up to several meters). To reduce scattering effects to an insignificant level the light distribution inside the sphere has to be homogeneous and isotropic, such that any additional scattering inside the sphere does not change the light field. A simple way to do this is to use a central isotropic light source, as proposed and theoretically described by Kirk (1995, 1997), a point-source integrating-cavity absorption meter (PSICAM). Another, more complex set-up was e.g. used to determine pure water absorption (Pope & Fry 1997, Pope et al. 2000). The PSICAM concept was further investigated by Leathers et al. (2002) and Lerebourg et al. (2002) and successfully tested by Röttgers et al. (2005). First results with natural sample are shown in Röttgers et al. (2007) and Röttgers & Doerffer (2007). First results from a flow-through system are shown in Wollschlaeger et al. (2013).

2.1.1 Measurement setup

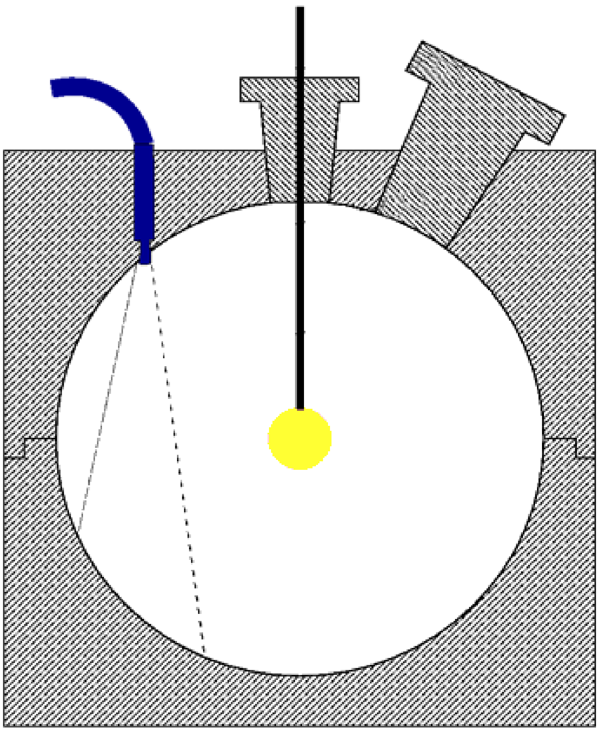

Fig. 1. Schematic cross section of the OSCAR showing the central light source (yellow), the light detector (blue) and the inner cavity (white). The light detector is a tip of a fiber optic which other end is connected to a spectrometer. The central light source is a sphere made from a diffuse quartz-glass sitting on the tip of a fiber optic connected to the light source.

The integrating cavity of the OSCAR (Fig. 1) has an inner diameter of 8.0 cm or 5.0 cm (depending on the ordered version) and is made out of a diffuse reflective plastic material (PTFE). The reflectivity of this material is depending on the material thickness, and between ~ 94 and 97 % for a thickness of 10 mm. The surface is water-repellent to avoid/mitigate problems with contamination. Particulate matter is easily washed out of the cavity. The central light source consists of a small scattering sphere made out of a diffuse quartz-glass with an outer diameter of approx. 10 mm. The light beam from the lamp is guided to the central diffuse emission sphere by a quartz-glass rod. Similarly the light from the cavity to the detector is guided by a second quartz-glass rod. The rod has only a narrow field of view and, thus, does not collect any light coming from the central light source directly. It measures the light reflected at the cavity wall opposite to the collector as well as the path radiance, i.e. the light scattered into the receiving cone of the collector.

2.1.2 Theoretical considerations

According to Kirk (1997) and Leathers et al. (2000), the “transmission”, T_{AB}, measured in a PSICAM is the ratio of the diffuse reflected irradiance F_0 at the inner wall when the cavity is filled with either the sample A or B (Eq. 1). Each irradiance is proportional to the number of times a photon is reflected by the wall N_C, before it is absorbed either by the wall or by the sample fluid. Hence,

$$T_{AB} = \frac{F_0^A}{F_0^B} = \frac{N_C^A}{N_C^B} \qquad (1)$$

N_C is the fraction of photons reaching the wall directly and indirectly by reflection on the wall for one, or more times (Eq. 2). It depends (1) on the probability P_0 that a photon, coming from the central light source, reaches the wall directly, (2) on the reflectivity of the wall ρ, and (3) on the probability P_s that a photon, which is reflected, will return to the wall. In the PSICAM set-up used here the detector does not collect light that comes directly from the light source, thus, for N_C this gives

$$N_C = P_0 \rho P_S + P_0 \rho^2 P_S^2 + ... = P_0 \sum_{n-1}^{\infty} (\rho P_S)^n = \frac{\rho P_0 P_S}{1 - \rho P_S} \qquad (2)$$

Therefore,

$$T_{AB} = \frac{P_0^A P_S^A (1-\rho P_S^B)}{P_0^B P_S^B (1-\rho P_S^A)} \quad (3)$$

P_0 and P_s are related to the radii of the PSICAM $r_0 = r - r_s$ and r, respectively, where r is the inner radius of the cavity and r_s the radius of the central light source and to the absorption coefficient a in the following way (see Kirk 1997 for details):

$$P_0(a, r_0) = \exp(-ar_0) \quad (4)$$

$$P_S(a, r) = \frac{1}{2a^2r^2}\left[1-\exp(-2ar)(2ar+1)\right]. \quad (5)$$

Finally the transmission in the PSICAM is related to the absorption coefficients a_A and a_B of the two solutions as

$$T_{AB} = \exp(-r_0(a_A - a_B))\left[\frac{1-\rho P_S(a_B, r)}{1-\rho P_S(a_A, r)}\frac{P_S(a_A, r)}{P_S(a_B, r)}\right]. \quad (6)$$

When using Eq. (5) and (6), T_{AB} is a function of the light absorption of the samples a_A and a_B, the radii r and r_0, and the reflectivity ρ. Solving Eq. (6) for the reflectivity gives

$$\rho = \frac{T_{AB}\exp(-a_B r_0)P_S(a_B, r) - \exp(-a_A r_0)P_S(a_A, r)}{T_{AB}\exp(-a_B r_0)P_S(a_A, r)P_S(a_B, r) - \exp(-a_A r_0)P_S(a_B, r)P_S(a_A, r)} \quad (7)$$

Hence, if ρ is not known, it can be determined by measuring the “transmission” induces by two solutions with known absorption coefficients using Eq. (7) and (5).

2.1.3 Calibration

The error for absorption determination in a PSICAM is related mainly to the error in determining the inner radius *r*, the reflectivity of the PSICAM ρ, and to the “transmission” determination in the PSICAM. The “transmission” measurement is further influenced by the stability of the light source and the spectroradiometer response. From these errors the error related to ρ has the strongest influence: a 1 % error in ρ leads to >10 % error in the absorption determination. Hence, ρ has to be known with a high accuracy. It is determined using Eq. (7), by measuring the “transmission” induced by two solutions with known absorption coefficients.

Determining ρ in this way has the advantage that it will eliminate errors associated with the true ρ of the wall material, and with r_0, a_A, a_B, and the known water absorption. However, the error of the necessary determination of the absorption coefficient with a photometer directly influences the error of the absorption determination with the PSICAM.

Practically ρ is determined following the suggestion by and description in Leathers et al. (2000). Therefore the transmission T_{AB} is determined from a sample solution *A* with an absorption coefficient a_A measured against a reference solution *B* with an absorption coefficient a_B in the PSICAM. The reference solution *B* consists simply of purified water. The assumed absorption coefficient spectrum of this purified water a_w, is taken from published pure water absorption coefficients, whose were adjusted and smoothed to have a complete spectrum for the considered wavelengths range. As discussed above any error in this pure water absorption is compensated by the calibration procedure described here, the exact pure water absorption is of less significance.

The sample solution *A* is prepared from the coloured stain Nigrosine (see www.sigmaaldrich.com product nr. 198285 or Certistain, Merck, Germany), following suggestions of Kirk (1997). Compared to other dye solutions Nigrosine has the advantage of having a considerably high absorption coefficient at all required wavelengths.

A Nigrosine stock solution is prepared by dissolving a few crystals of Nigrosine in 100 ml purified water. The optical density of this solution is roughly determined photometrically in a 1 cm cuvette at 578 nm, to be able to calculate the necessary volume of this stock solution when later preparing the calibration solutions. Calibration solutions with an absorption coefficient (a_{578nm}) between 0.5 and 2 m^{-1} (on the ***log_n*** scale) are prepared by diluting a few milliliters of the stock solution in ca. 2000 ml purified water. The exact spectral absorption coefficients of this Nigrosine in solution is determined photometrically in the range of ca. 350 to 800 nm using a 10 cm cuvette and purified water as the reference.

The transmission measurements in the PSICAM are conducted by determining the light intensity inside the cavity when the cavity is first filled with purified water F_w, and second with the calibration solution F_{nig}. In each case the temperature of the fluid (t_w and t_{nig}) inside the cavity should be recorded for a later temperature correction of the pure water absorption. For field applications the parallel application of a CTD probe is recommended.

After the calibration solution has been measured, the PSICAM has to be cleaned as the stain adsorbs considerably fast on the cavity wall of the PSICAM. Therefore the PSICAM is bleached for 15 min with a 0.1 % sodium hypochlorite solution (NaOCl). Afterward the bleach is removed from the PSICAM by washing the cavity several times with purified water.

The reflectivity is calculated for the pair of pure water/calibration solution using the pure water absorption as a_B, and the sum of absorptions of pure water and Nigrosine as a_A. The pure water absorption is calculated beforehand for each fluid using the specific fluid temperature.

2.1.4 Calibration procedure in short

1) preparation of approx. 100 ml Nigrosine stock solution (a_{580nm}^{1cm} ca. 3 OD)

2) preparation of 2000 ml Nigrosine calibration solution a_{580nm} = 0.5 – 2 m^{-1}

3) determination of Nigrosine absorption, a_{nig}, of the calibration solution (10 cm cuvette in spectrophotometer or using a LWCC system (liquid waveguide capillary cell), 3x)

4) determination of “transmission” (nigrosine solution vs. purified water) in the PSICAM,

5) cleaning and bleaching of the cavity after the measurement of the nigrosine solution

6) calculation of reflectivity (after temperature correction of pure water absorption), where

$a_A = a_w\,(t_{nig}°C) + a_{nig}$

$a_B = a_w\,(t_w°C)$

$T_{AB} = \frac{F_{nig}}{F_w}$

r = inner radius of the cavity

r_s = radius of the central light source

$r_0 = r - r_s$

a = Absorption coefficient on the ***log***

a = *Absorption coefficient on the* $\boldsymbol{\log_n}$ *scale*

F_w = light intensity inside the cavity when the cavity is filled with purified water

F_{nig} = light intensity inside the cavity when the cavity is filled with the calibration solution nigrosine

2.1.5 Measurement of the absorption coefficient of a sample

A regular measurement is done by measuring the light intensity inside the cavity when it is filled with either purified water or the sample. For each measurement the fluid temperature and the sample salinity need to be recorded for a later temperature and salinity correction of the pure water absorption (see below). For each sample measurement, T_{AB} can be calculated by using the reference measurement taken before the sample measurement.

There is no analytical solution for the absorption coefficient $a(\lambda)$ in Eq. (6). When ρ is known, $a(\lambda)$ is determined by solving this equation numerically. This is done by minimizing the least square function $G(a(\lambda))$ for the measured transmission, $T_{exp}(\lambda)$ using a numerically calculated transmission $T_{num}(\lambda)$:

$$G(a(y)) = \sqrt{(T_{num}(\lambda) - T_{\exp}(\lambda))^2} \quad (8)$$

2.1.6 Temperature and salinity correction for pure water absorption

The absorption of pure water, a_w, is dependent on temperature and salinity. Any difference in temperature and salinity of the sample or the reference to that of the theoretical pure water absorption reference (i.e. 20°C and 0 PSU) has to be corrected using instrument-specific temperature and salinity correction coefficients, Ψ_T and Ψ_S as

$$a_w(T,\lambda) = a_w(T_0,\lambda) + (T - T_0)\Psi_T(\lambda) \quad (9)$$

and

$$a_w(S,\lambda) = a_w(S_0,\lambda) + (S - S_0)\Psi_S(\lambda) \qquad (10)$$

where T is the specific temperature, S the specific salinity, and T_0 and S_0 the values at which the pure water absorption had been measured, i.e. 20 °C and 0 PSU.

As a simplified approach the sample and reference can be tempered at 20 °C e.g. with a water bath.

2.1.7 References

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J. Wollschläger, M. Grunwald, R. Röttgers, and W. Petersen, Flow-through-PSICAM: A new approach for determining water constituents absorption continuously, (2013), Ocean Dynamics 63: 761-775.

2.2 Basic measuring arrangement of the OSCAR

The **OSCAR** sensor consists of a multi-LED light source that emits a defined radiation in the visible range, a lens system, the cavity and a miniature spectrometer. The cavity contains the liquid sample to be measured. The **TriOS Mess- und Datentechnik GmbH** absorption meter can be purchased in two different cavity diameters (50 mm and 80 mm).

Fig. 2. Illustration of the OSCAR sensor with 80 mm cavity

2.3 Technical specifications

Technical Specifications

Measurement technology	light source	12 LED
	detector	High-end miniature spectrometer
		256 channels
		360 to 750 nm
		3.3 nm/pixel
Measurement principle		Absorption
Diameter		80 mm or 50 mm
Parameter		Absorption
Turbidity compensation		Yes
Data logger		2 GB
T100 response time		≤ 2 min.
Measurement interval		≥ 1 min.
Housing material		Stainless steel (1.4571/1.4404) or titanium (3.7035)
Dimensions (L x Ø)		450 mm x 135 mm (without hose connection)
Weight	stainless steel	~ 6.2 kg
	titanium	~ 5.5 kg
Interface	digital	Ethernet (TCP/IP)
		RS-232 or RS-485 (Modbus RTU)
Power consumption		≤ 4 W
Power supply		12...24 VDC (± 10 %)
Maintenance effort		Typically ≤ 0.5 h/month
Calibration/maintenance interval		24 months
System compatibility		Modbus RTU
Guarantee		1 year (EU: 2 years)
INSTALLATION		
Max. pressure	with SubConn	30 bar
	in cavity	1 bar more than ambient pressure, 2...4 L/min
Protection type		IP68
Sample temperature		+2...+40 °C
Ambient temperature		+2...+40 °C
Storage temperature		-20...+80 °C

3 Installation

This chapter discusses the proper installation and mounting of the **OSCAR** sensor. Pay special attention to this section and follow the safety precautions to protect the sensor and yourselves from harm and injury.

Before the **OSCAR** sensor is put into operation, it should be ensured that it is securely fastened and that all connections are wired correctly.

3.1 Electrical installation

3.1.1 Power supply

The **OSCAR** sensor is designed for 12 - 24 VDC. With the **G2 Interface Box** a standard 12 or 24 VDC power supply can be used with a minimum output current of 200 mA.

Connect the 8 pin underwater connector to the **OSCAR**. Be careful aligning the pins to the corresponding sockets (Fig. 3). Use the locking sleeve to fix the connector. Turn the sleeve clockwise onto the bulkhead connector like shown in Fig. 4.

Fig. 3. Carefully aligning the pins onto the connector

Fig. 4. Locking sleeve for fixation of the underwater connector

Connect the M12 industrial connector to the device you are using. Take care, that the pins are aligned to the corresponding sockets and turn the locking screw clockwise into the connector.

The **OSCAR** can also be equipped with a fixed cable with M12 industrial plug.

3.1.2 EIA 232 / 485

The **OSCAR** sensor provides two lines for digital, serial communication with a control device. It will thereby support the EIA 232 (RS-232) and EIA 485 (RS-485) standards. Via the web interface (see Fig. 20) it is possible to switch these standards.

Both EIA 232 and EIA 485 are voltage interfaces (as opposed to a current interface like the analog type). With EIA 232 voltages are in the range from -15 V to +15 V, with EIA 485 from -5 V to +5 V, towards GND.

The data is transmitted on a line in EIA 232 for each direction, wherein the RX line for the communication from controller to sensor and for TX line the communication from sensor to controller is used.

The EIA 485 system uses differential balanced lines, whereby the 'B' line transmits the inverted signal of the 'A' line. The differential value between lines A and B is the decisive factor for the transmission robustness against conducted noise signals.

3.1.3 Ethernet

The Ethernet interface is used as an universal interface on the new **TriOS Mess- und Datentechnik GmbH G2** sensors. Thus, there is almost no difference, whether a connection to a single sensor or a complex sensor network should be established (Fig. 5).

Single sensor network

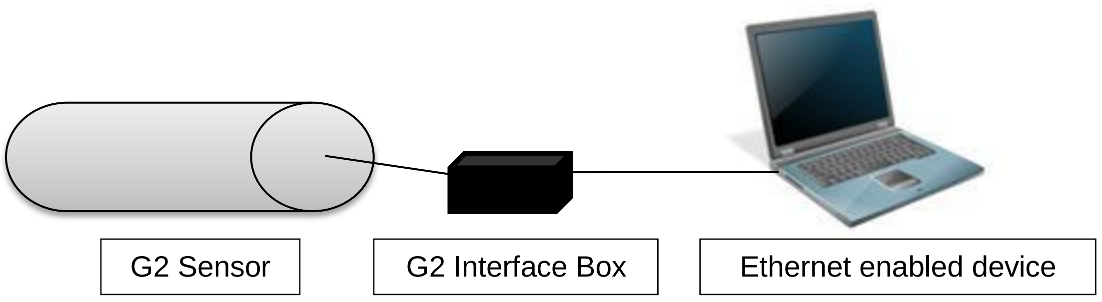

Fig. 5. Single sensor network

The easiest way to connect to the sensor is to use the **G2 Interface Box** (see Fig. 6). This serves the connection as well as the power supply for the sensor and is universal for all **TriOS Mess- und Datentechnik GmbH G2** sensors.

Fig. 6. **G2 Interface Box**

There are three connectors at the **G2 Interface Box**:

1. Power Supply: 12 VDC or 24 VDC, 2.1 mm connector
2. Sensor-connector: 8 Pin M12.
3. Ethernet-connector: RJ-45.

In order to connect to an Ethernet enabled device using the **OSCAR** sensor interface of the **G2 Interface Box**, proceed as follows:

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 in the M12 connector on the cable end of the **OSCAR** sensor to the M12 socket (2) of the G2 interface box and close the screw cap.

Step 3) Connect the 12 or 24 VDC power supply of the **G2 Interface Box** to connect the sensor with voltage.

Step 4) Wait at least 3 seconds before you finally connect the Ethernet LAN cable to your Ethernet enabled device and the **G2 Interface Box**.

The web interface can be used with any web browser via the URL http://oscar/ or http://oscar_B0XX/ (B0XX is the serial number) or http://192.168.77.1/

NOTE: If the web interface is not accessible, make sure that the LAN cable is connected after the sensor has been powered on and try all three URL options.

3.2 Mechanical installation

3.2.1 Submerged use

For submerged use, the **OSCAR** can be completely or partially immersed in the measurement medium. The cavity has to be submerged completely. Use the mounting bolt together with a shackle and a stainless steel chain or wire to hang the sensor in the fluid. Do not carry or pull the sensor with the cable. It is also possible to use special clamps similar to the ones shown in Fig. 7 to install the sensor.

Fig. 7. Clamps for installation of the OSCAR

Take care to use matching clamps with an inner diameter of 68 mm. Use two clamps at the sensor housing, one next to the cavity and one at the bottom. Take care, that the clamps are mounted near the screws and the caps of the sensor to avoid damages by squeezing the sensor tube. The clamps can be purchased from **TriOS Mess- und Datentechnik GmbH.**

The operating pressure inside the cavity should not exceed 1 bar difference compared to its surrounding medium. Make sure that the sensor is installed in the correct position to ensure free water flow.

3.2.2 Operation on-site

The **OSCAR** can also be filled in an on-site operation. There is a specific holder supplied with the **OSCAR** applicable as a stand in the laboratory (see Fig. 8).

In such an installation the inlet should be positioned at the bottom, the outlet on the top of the cavity to reduce air bubbles.

Fig. 8. Specific holder for the OSCAR

4 Operation

As mentioned above **OSCAR** is an independent measuring device, which can be operated without additional hardware. In the following subsections, we explain the correct operation of the **OSCAR** sensor with all its functions and setting options.

For now the **OSCAR** sensor is in a development state. You can measure and collect data with the sensor but further calculation of the absorption under the consideration of the reflectivity of the cavity has to be done with the software **MSDA_XE** made of **TriOS Mess- und Datentechnik GmbH.**

4.1 Web Interface – configuration of the sensor

All **OSCAR** sensors are equipped with a **web interface** for sensor configuration and calibration. To access the **web interface,** you need a **G2 interface box,** an Ethernet cable and an Ethernet-enabled device with a web browser, e.g. a notebook.

Open one of the following URLs (depending on the structure of the network) with your web browser: http://oscar/ or http://oscar_B0XX/ (B0XX represents the serial number) or http://192.168.77.1/

Details and information on how to connect the **OSCAR** sensor to your Ethernet enabled device can be found in chapter 3.1.3. Please note all warning and safety instructions therein to avoid any damage to the **OSCAR** sensor and your Ethernet-enabled device.

Depending on your browser and terminal being used, certain representations and possibly controls may differ from the figures shown in this manual.

⚠ **Damage caused by misuse is not covered by the warranty!**

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

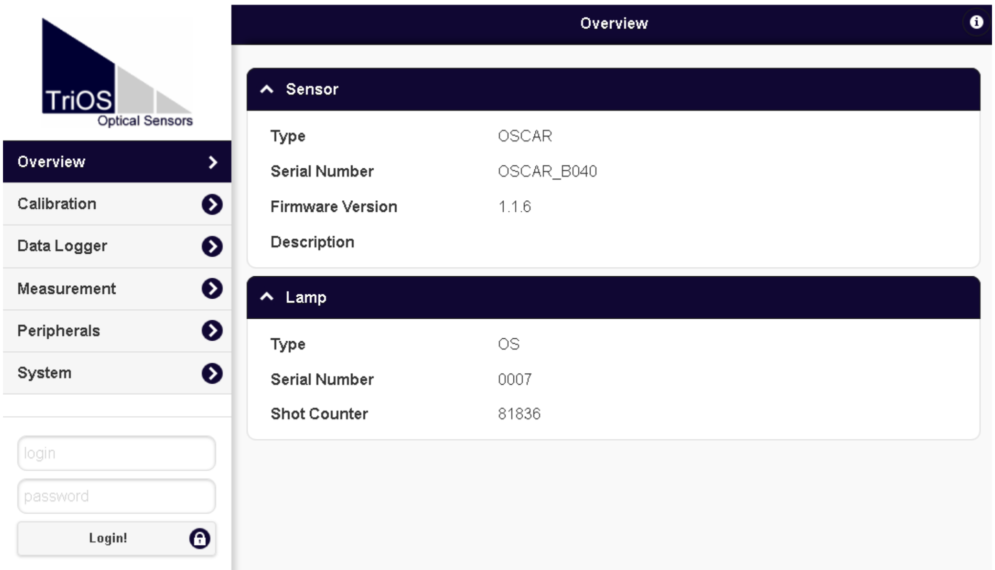

Fig. 9. Web interface: Setting areas

The **web interface** as shown in Fig. 9 is divided into three areas: Title (above), menu (to the left under the TriOS logo) and content (right). Under the menu, there is a login section only accessible to certified TriOS service technicians.

In the menu, the name of the current page is highlighted in blue, so that the open menu is clearly identified at all times. On the top right, there is a ⓘ button, which shows the contact details of the corresponding TriOS dealer or **TriOS Mess- und Datentechnik GmbH**.

The menu is used to navigate in the **web interface.** Each line is a link to another page with correspondingly different setting options. The link that points to the currently displayed page is highlighted in the menu. Special, selected contents and features are reserved to **TriOS Mess- und Datentechnik GmbH** customer service staff**.** These contents require authentication and thus are not available to everyone.

The content page displays the relevant information and setting options. Content that requires authentication will be disabled ("greyed out") if authentication fails or would prove unfeasible for lack of appropriate information.

4.1.1 Overview

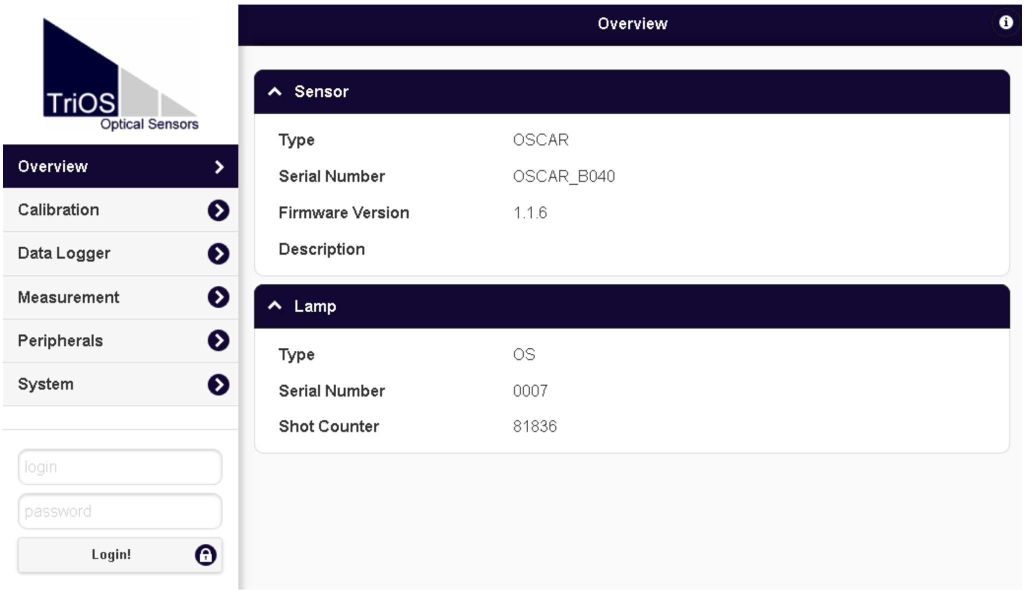

Fig. 10. Web interface: Overview

The “Overview” page (Fig. 10) summarizes basic information about the **OSCAR** sensor. This includes device type, serial number and firmware of the sensor at the top, and lamp type, lamp serial number and shot counter (number of measurements) at the bottom.

4.1.2 Data logger

The **OSCAR** sensor is equipped with an internal data logger with a data memory of 2 GB. This allows the **OSCAR** sensor an almost completely self-sufficient operation over a very long period. The only accessory required is an appropriately dimensioned power supply. Each measurement is stored until the memory is full. The top line of the data logger submenu indicates the memory percentage which is still available.

Previously stored data can be retrieved by means of the "Download" button (Fig. 11). It is possible to set a start and an end date for the data download. We recommend choosing a window of time for the download / export, because 2 GB can take a long time.

With the "Download Service" button the measurement data as well as the configuration file and the log file can be saved external as a backup or for support reasons.

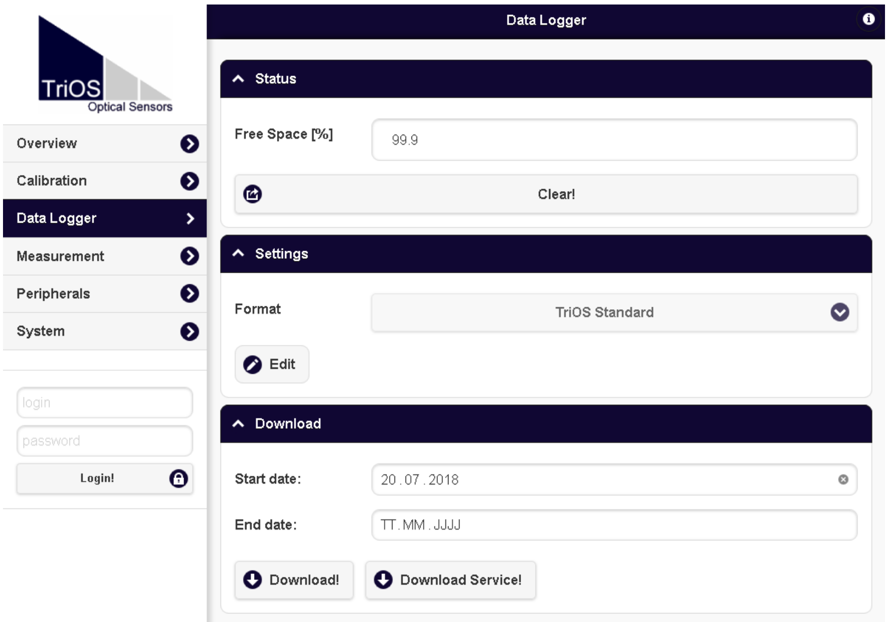

Fig. 11. Web interface: Data logger

The **OSCAR** sensor stores and presents data as CSV (Comma Separated Values) and **MSDA_XE** files. CSV files can be read by the most popular spreadsheet programs. **MSDA_XE** files can be opened with the freeware **MSDA_XE** developed by **TriOS Mess- und Datentechnik GmbH.**

The default configuration is set to Trios Standard. In this case, numerical values are stored in CSV format and spectra in **MSDA_XE** format. However, you may change this setting and store everything only in CSV format.

⚠ **If you like to post-process you data with MSDA_XE, the "Format" setting has to be "TriOS Standard"!**

The memory can be formatted and all data deleted by means of the “Clear” button. For safety, users will be prompted for confirmation before deletion (Fig. 12).

Fig. 12. Web Interface: Data logger delete data confirmation window

⚠ **After confirmation, the OSCAR memory and thus all data is permanently deleted.**

4.1.3 Measurement

The "Measurement" page (Fig. 13) shows the results of the last performed measurement and allows configuring the settings for automatic measurements.

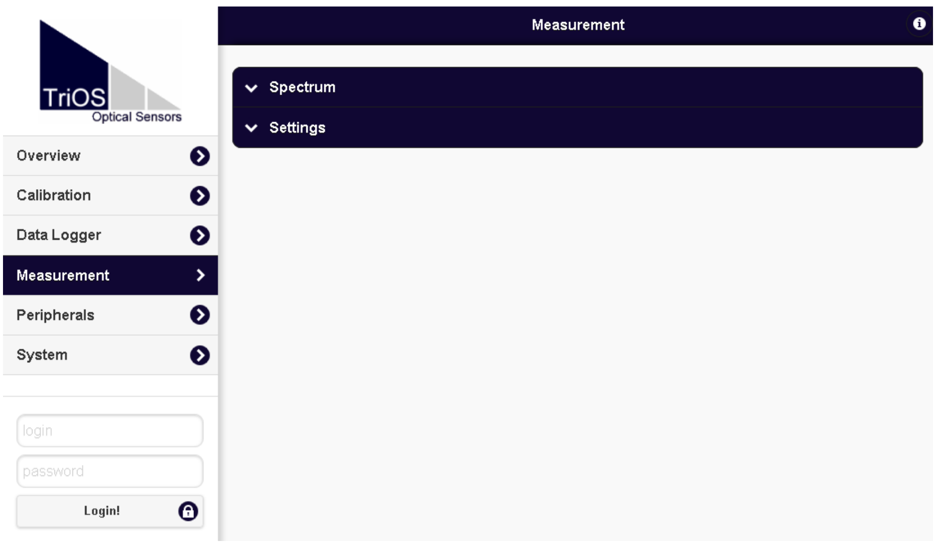

Fig. 13. Web interface: Measurement

The "Spectrum" item shows the current spectrum. You can press the "Download" button to download this spectrum to the computer. Fig. 14 shows the example of an attenuation spectrum.

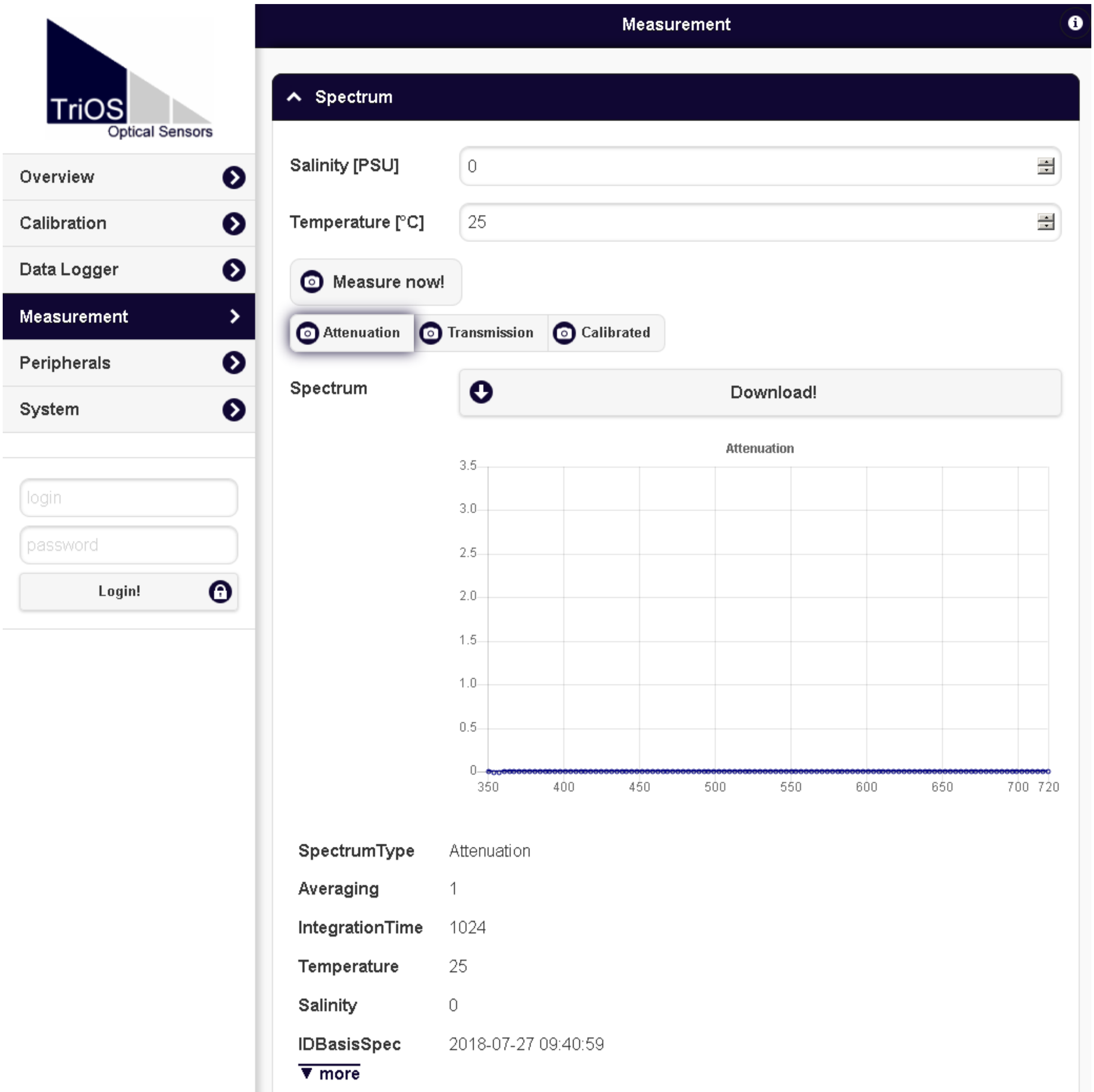

Fig. 14. Web interface: Measurement sub-item Spectrum, spectrum type attenuation

It is mandatory to enter the values for salinity and temperature before each measurement, when you now press the “measure now” button or the button of the spectrum type you want to record, the values of salinity and temperature are saved and written into spectrum attributes.

In case of any temperature or salinity change the new values always have to be entered manually.

With the button “measure now” the spectrum type, that is set chosen under “settings” (see Fig. 18), will be recorded.

Examples of a transmission and a calibrated spectrum are pictured in Fig. 16 and Fig. 17.

With the button “more” further information is visible, like listed below.

Length	111
lampLEDs	255
tempLampModule	32.25
tempSpectrometer	35.188
tempMainCPU	36.188
Deviation	12.468
Maximum	0.0004

▲ less

Fig. 15. Web interface: Measurement sub-item Spectrum, further information

Please note: The values above are just examples, they might be different in your application!

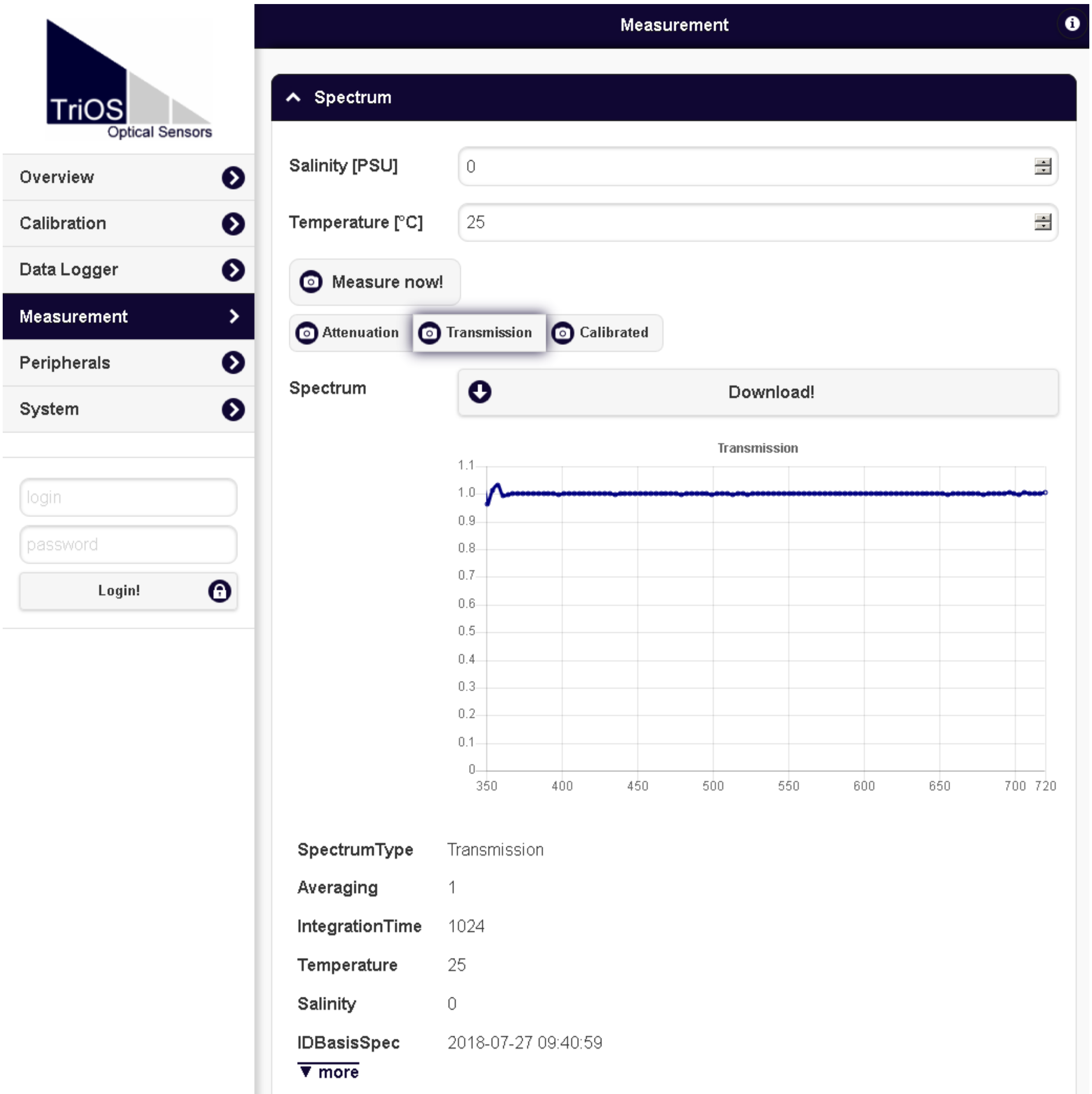

Fig. 16. Web interface: Measurement sub-item Spectrum, spectrum type transmission

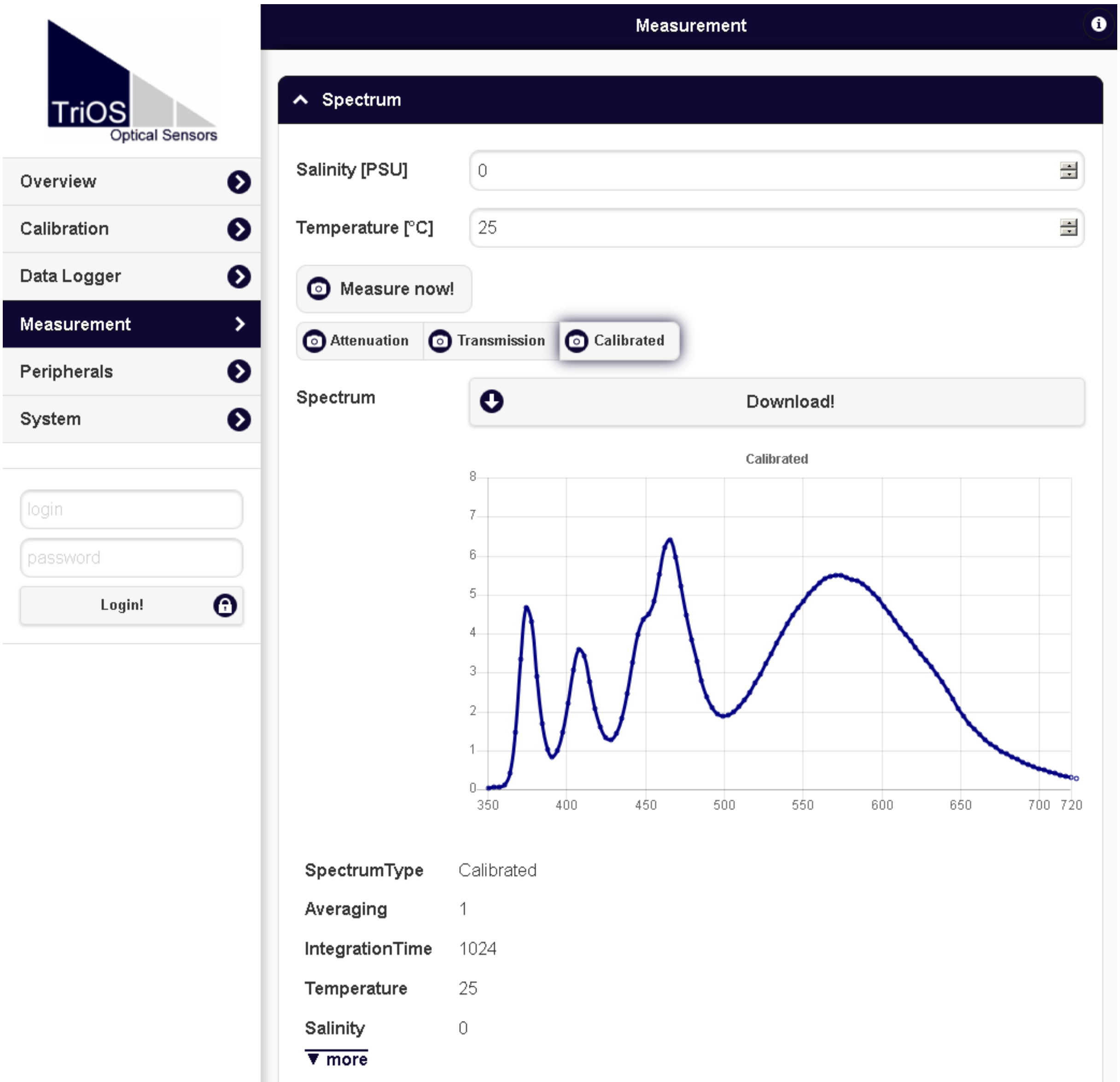

Fig. 17. Web interface: Measurement sub-item Spectrum, spectrum type calibrated

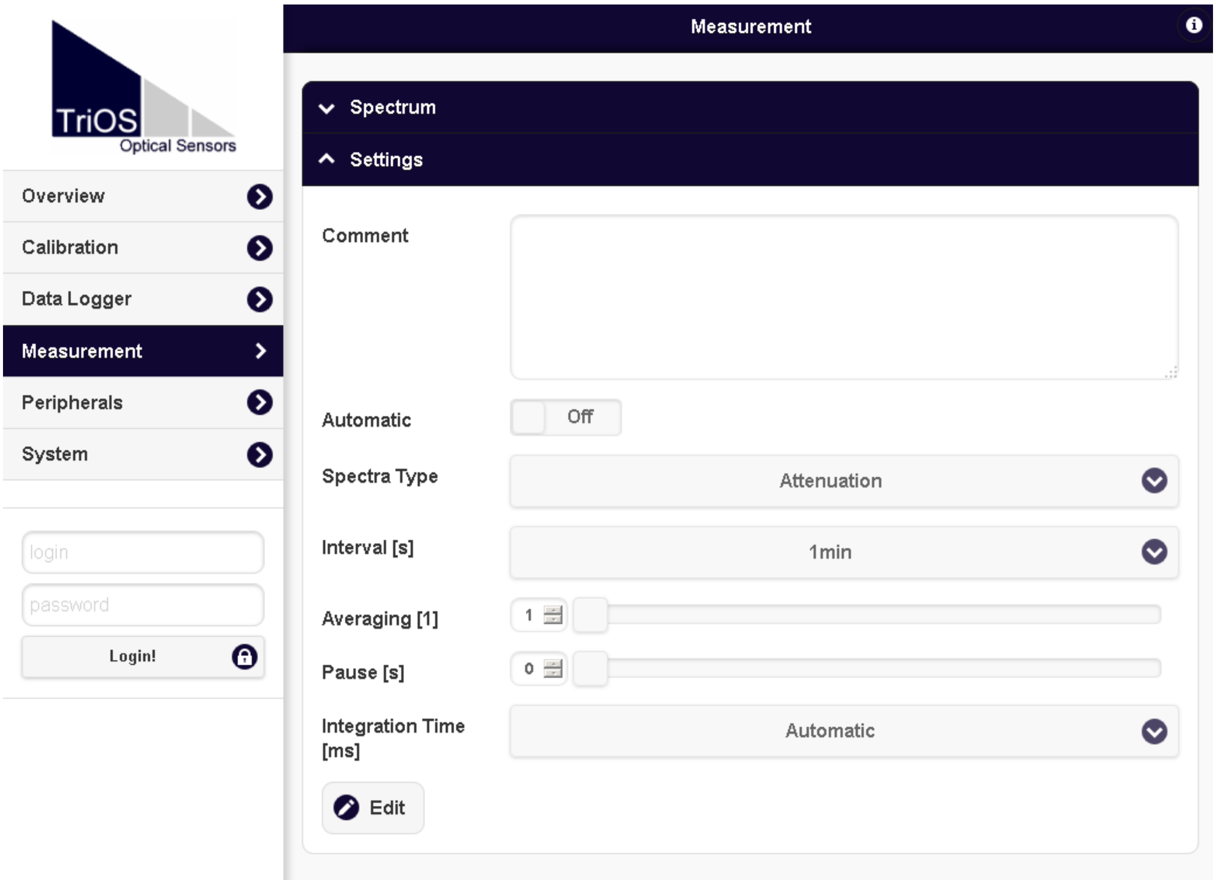

Fig. 18. Web interface: Measurement sub-item Settings

In the sub-item settings page (Fig. 18), you can enter adjustments by clicking on the "Edit" button. Comments entered in the comments field are combined with measured values and spectra. You may also enable automatic measurements and specify the corresponding measurement interval.

Under “Spectra Type” you can select the spectrum type that will be sent for example to a **TriOS** controller or Modbus communication device. You can choose between attenuation, transmission and calibrated. If you select calibrated, the other spectra types will not be calculated. If you choose transmission, you get calibrated spectra, too, but no attenuation spectra.

Only if you activate attenuation, all 3 spectra types will be saved to the internal data logger.

For measurements with **OSCAR** the interval should set ≥ 60s, otherwise the temperature correction of the LED intensities does not work properly.

⚠ **If you want to use the averaging function, set the pause to 60s to avoid strong warming effects of the LED's.**

⚠ **The integration time (= IT) should always be in automatic mode or readings can become unreliable.**

The maximum values are 12 h for the interval, 24 for the averaging and 60 s for pause.

If the entered values do not make sense or the spectra cannot be calculated within the given time, an error message appears like shown in Fig. 19 when activating the automatic mode.

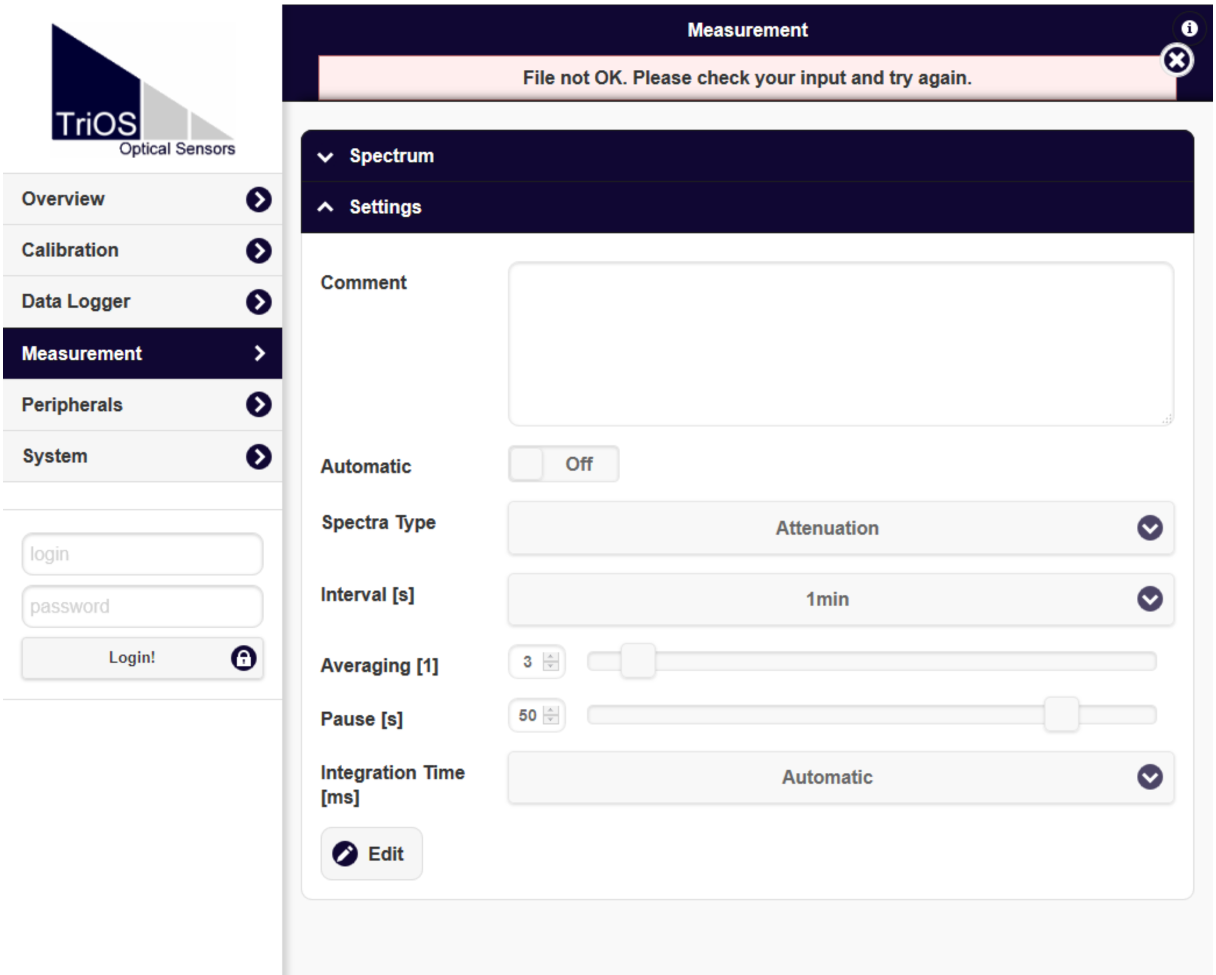

Fig. 19. Web interface: Measurement sub-item Settings, error message

4.1.4 Peripherals

The "Peripherals" page is used to configure the interface, select a protocol, and change the Modbus address (see Fig. 20). To do so, just click on the “Edit” button at the page bottom.

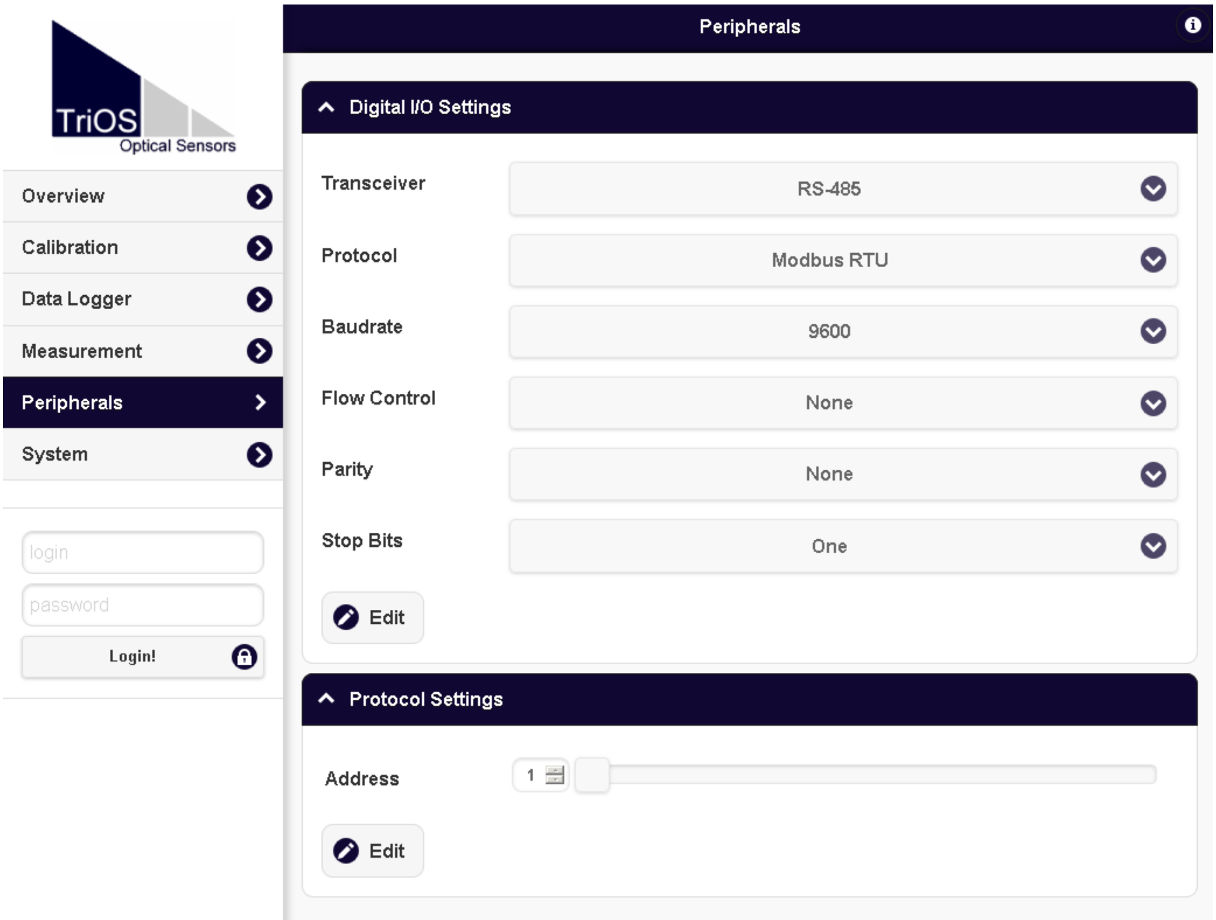

Fig. 20. Web interface: Peripherals

The factory settings are:

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

The following setting options are available under "Peripherals":

- **Transceiver:** Specifies the standard electrical connection.

  Possible options are:

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

- **Protocol:** Specifies the protocol to be used for data.
  - **Modbus RTU**
  - **TriOS data protocol**
  - IEEE 488.2 (SCPI)
  - ASCII Output

- **Baud rate.** Specifies the selectable baud rate, i.e. transmission speed. **Note:** Reduce the baud rate should there be communication difficulties.

- **Flow control.** Enables flow control on the software level (XON / XOFF). **Note:** This is only supported with the **TriOS data protocol** and must be disabled when using Modbus RTU.

- **Parity.** Activates the parity check during data transfer. Possible options are:
  - None (disabled)
  - Even
  - Odd

- **Stop bits.** Specifies the number of stop bits. **Note:** For various Modbus devices, it may be necessary to set it to "Two" if parity check is to be avoided.

4.1.5 System

The "System" page (Fig. 21) is used to configure general **OSCAR** sensor parameters such as date and time. Furthermore, it allows downloading the current calibration as a backup.

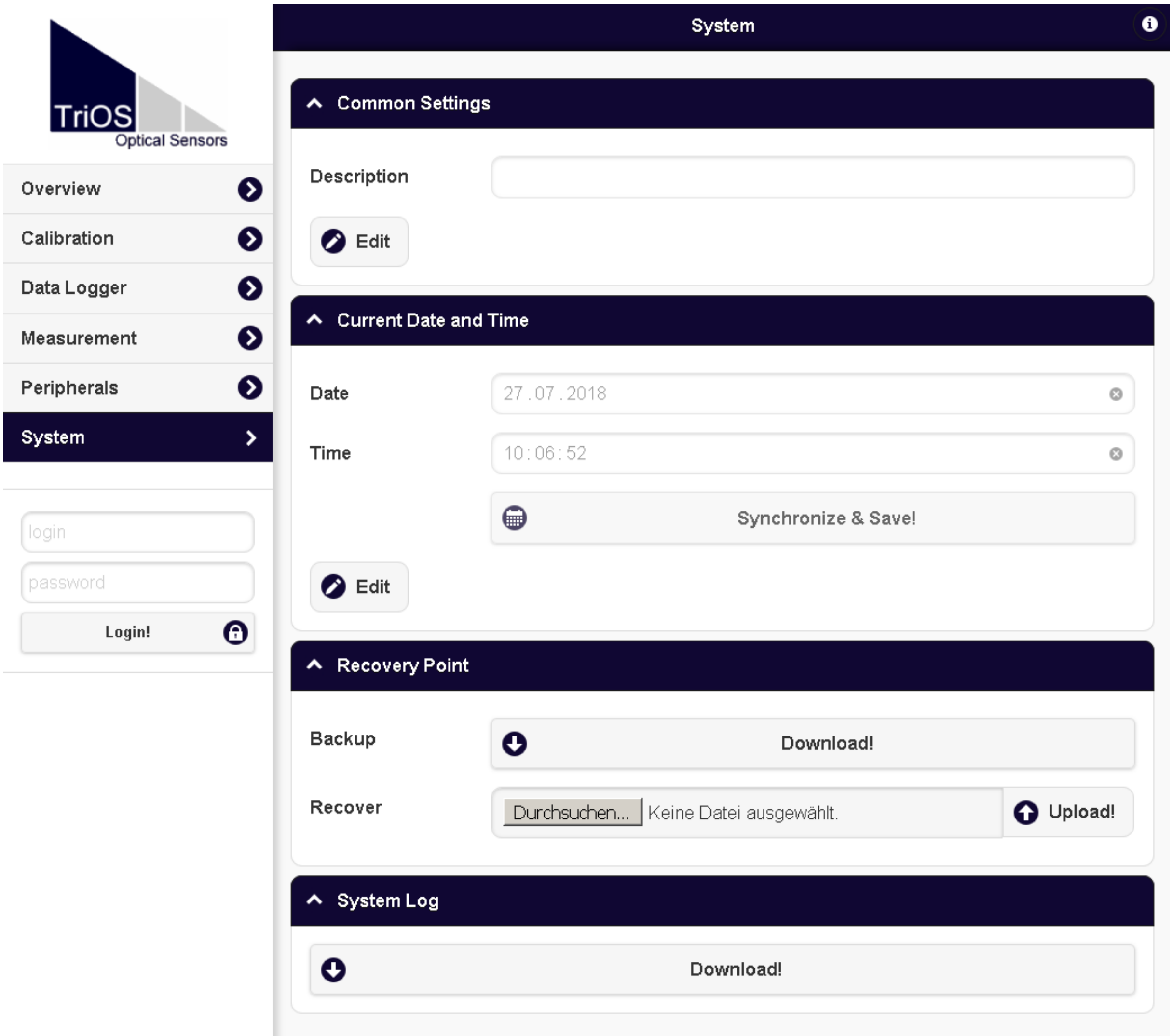

Fig. 21. Web interface: System

Click on the "Download" button to download the latest sensor calibration to a PC or other support.

The **OSCAR** sensor opens a window presenting all data held in the calibration file. This file must be stored and kept safe. For the normal user this file is keyed and unreadable.

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 **OSCAR** sensor.

Select the path to the appropriate calibration file in the “File” field by clicking on the “Browse” button. Then, click on the "Upload" button to start the transfer. If the operation is successful, this will be indicated by a green box that reads "Success". Otherwise, you should see a box with an error message at the top of the screen.

The following error messages and warnings are possible:

- **File not OK.** The calibration file could not be read correctly. Check the path and select the correct file. If the error persists, contact **TriOS Mess- und Datentechnik GmbH customer service.**
- **Device type or serial number does not match.** The calibration file is not suitable for the currently connected sensor.

4.1.6 Calibration

This chapter is only an overview of G2 Interface. A detailed step by step description is located in chapter 6.

On the page "Calibration" **OSCAR** can be calibrated. That means a new waterbase (zero line) can be recorded and Nigrosin for the reflectivity calculation can be measured (Fig. 22).

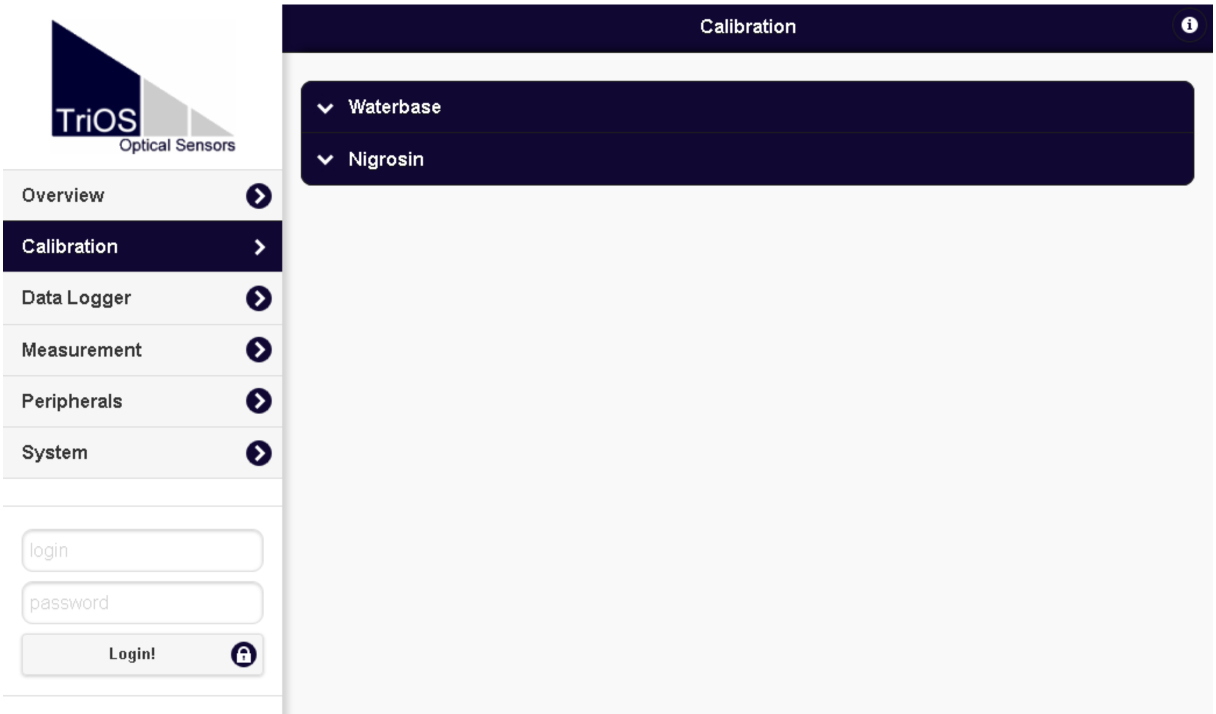

Fig. 22. Web-Interface: Calibration

On the page "Calibration" sub-item “Waterbase” the calibrated spectrum of the water basis (= zero line in ultra pure water) is visible (see Fig. 23).

With “Edit” a new zero line can be recorded.

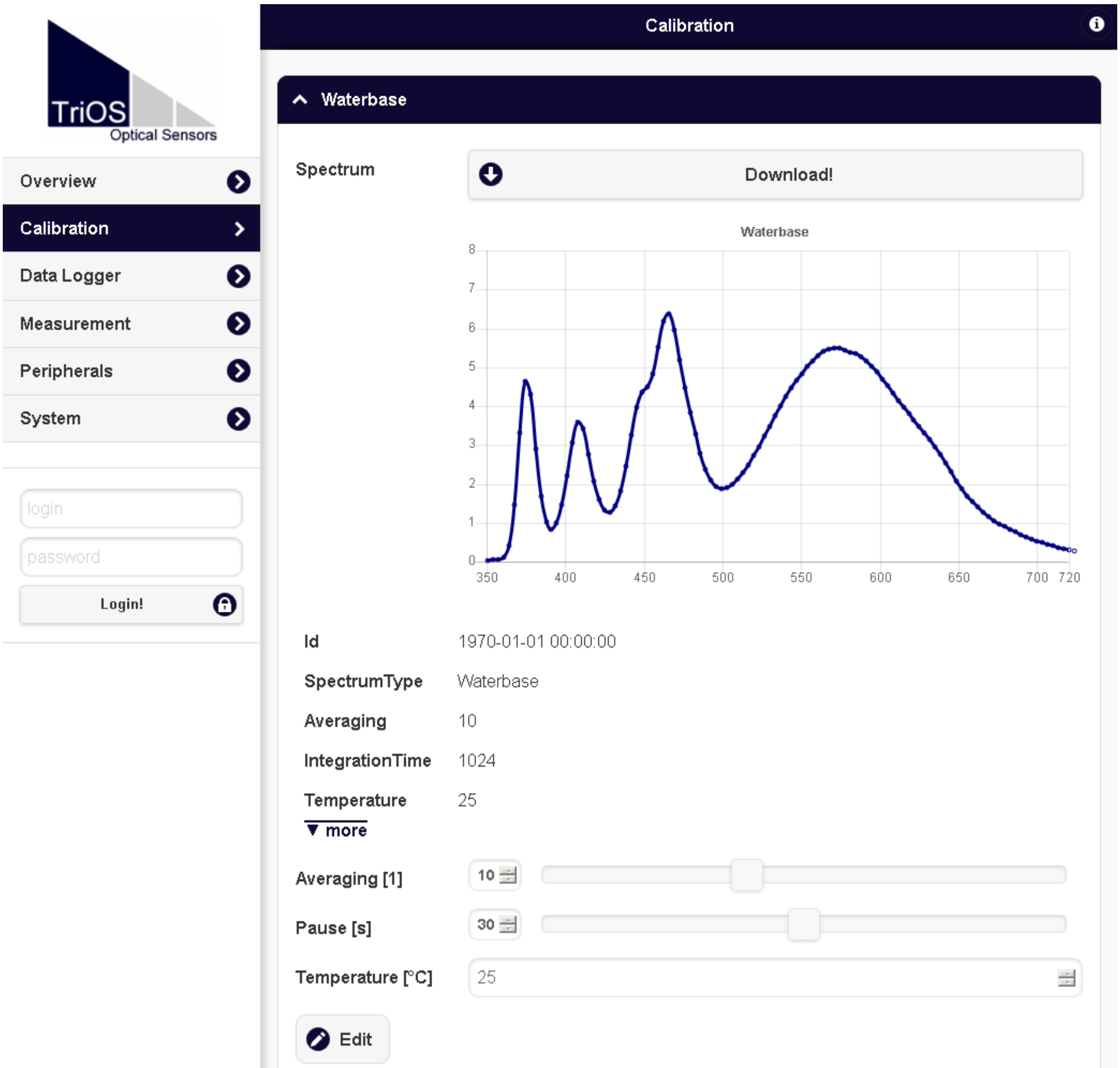

Fig. 23. Web-Interface: Calibration sub-item Waterbase

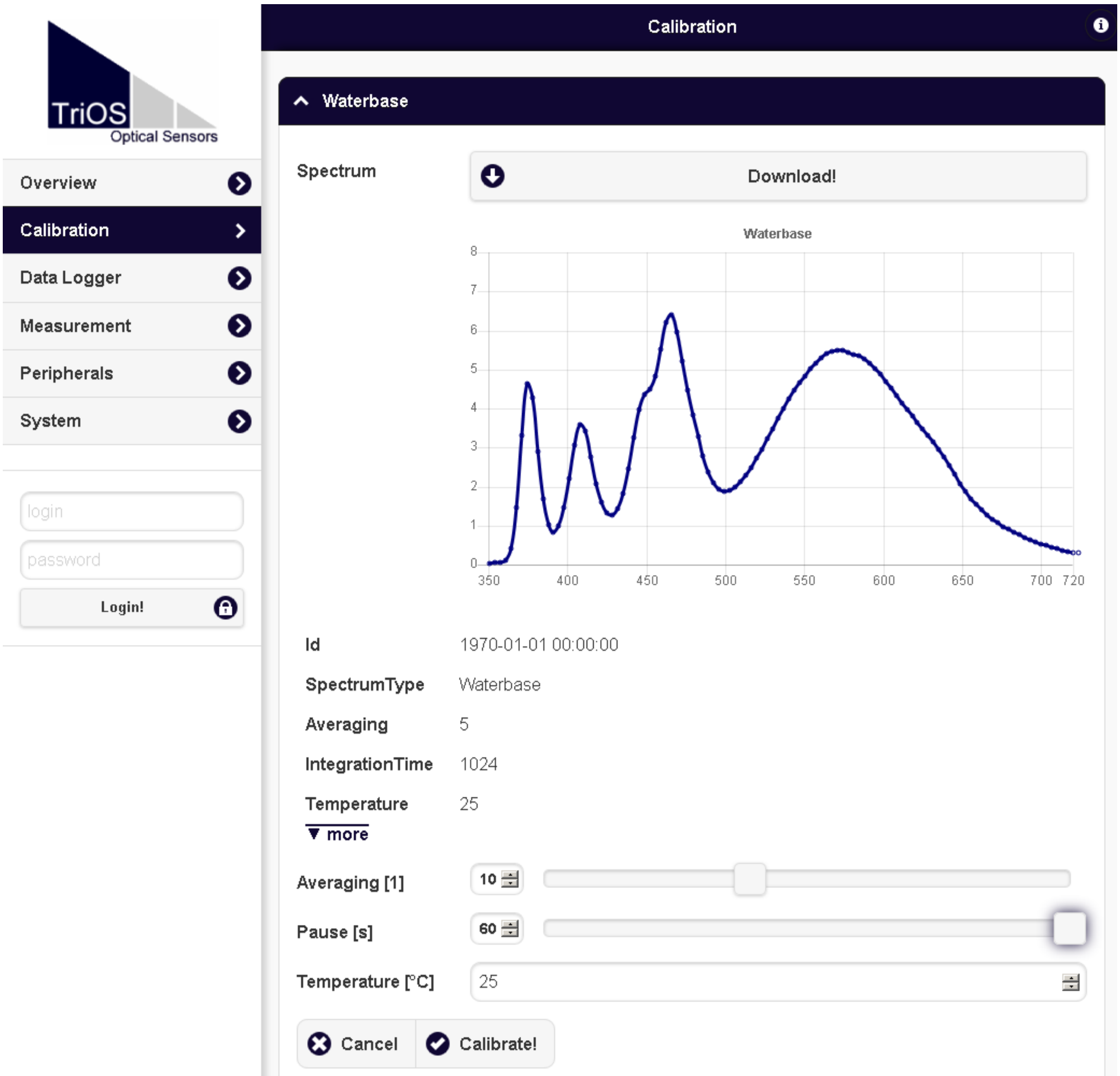

Fig. 24. Web-Interface: Calibration sub-item Waterbase, settings

We recommend to set the averaging from 5 to 10 and the pause to 60 seconds.
Set the temperature for the ultra pure water and then press the “calibrate” button (Fig. 24).

On the sub-item “Nigrosin” (Fig. 25) a new measurement of Nigrosin can be taken. You also can perform an average measurement and you have to set the temperature of the solution.

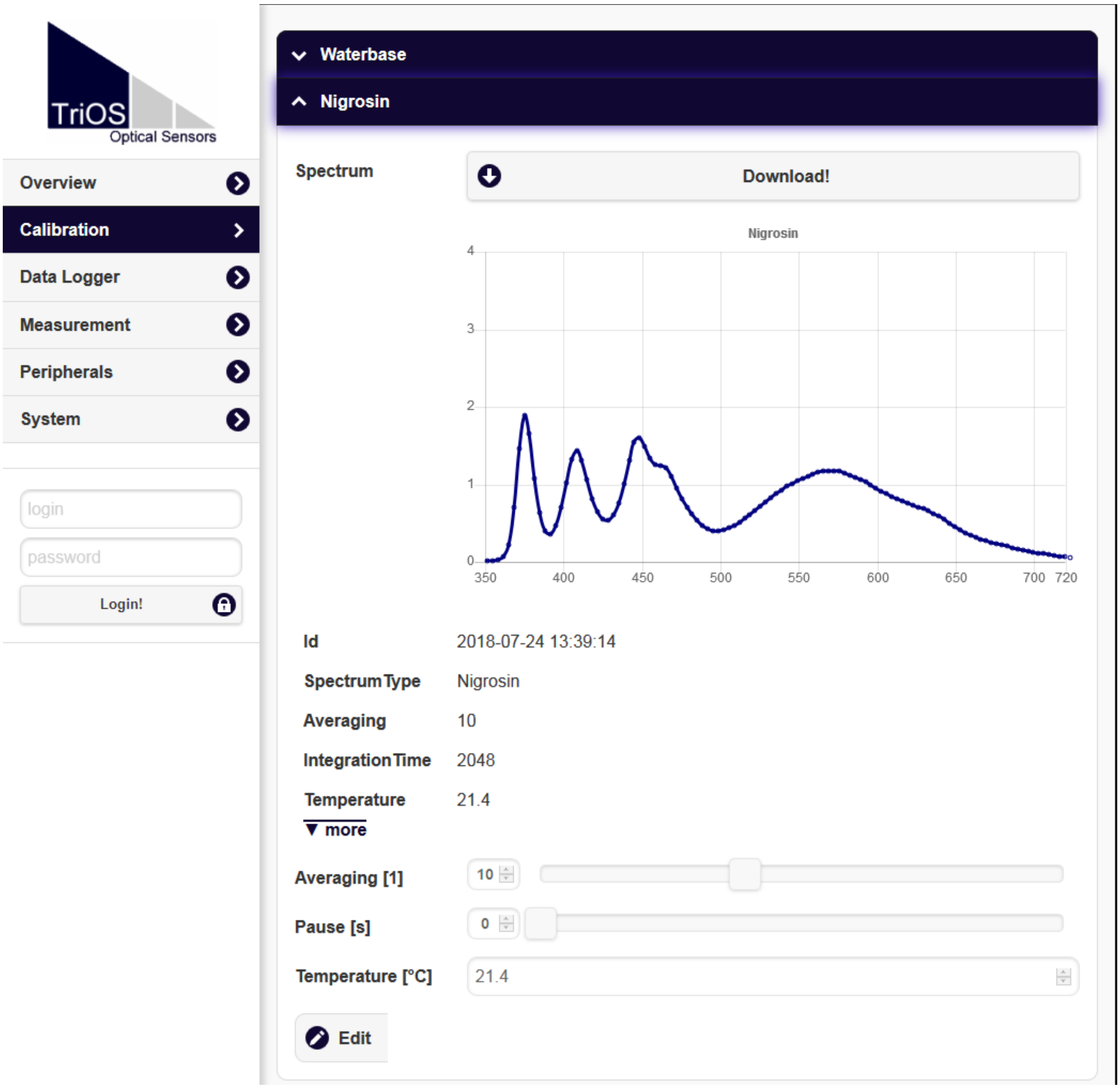

Fig. 25. Web-Interface: Calibration sub-item Nigrosin

4.2 Data calculation with MSDA_XE

The approximation method of the calculation of absorption in 1/m under consideration of the reflectivity of the cavity is not integrated to the **OSCAR** firmware yet. The calculation of absorption has to be done external with the software **MSDA_XE**.

OSCAR calculates the attenuation without the consideration of reflectivity. Attenuation *A* is calculated as

$$A = -\log(T) = -\log(\frac{I}{I_0}) \qquad (9)$$

I_0 = calibrated intensity of the water base (zero line)

I = calibrated intensity of the sample

The absorption calculated with the software **MSDA_XE** from **OSCAR** calibrated spectra has the unit 1/m on the $\mathbf{log_{10}}$ scale. So it is easily possible to compare the absorption spectra measured with **OSCAR** with other common absorption spectrometer

The actual version of the **MSDA_XE** software can be downloaded from the website www.trios.de.

4.2.1 Calculation of the reflectivity

On the **OSCAR** Control page within the **MSDA_XE** software you can calculate the reflectivity for a new pair of a waterbase (zero line) and a Nigrosin measurement.

The sensor will be delivered with a CD-ROM with device files and calibration files for the sensor. Each sensor has a unique device file, which has to be imported into the software, to run the sensor. The device file has the name: **OSCAR**_BXXX.ini, whereas ‘BXXX’ stands for the serial number of the **OSCAR**. Additionally the water base file and the reflectivity file are required.

For data calculation proceed as follows

- Install the **MSDA_XE** software
- Open the **MSDA_XE** software

- Import the ini file of the **OSCAR**

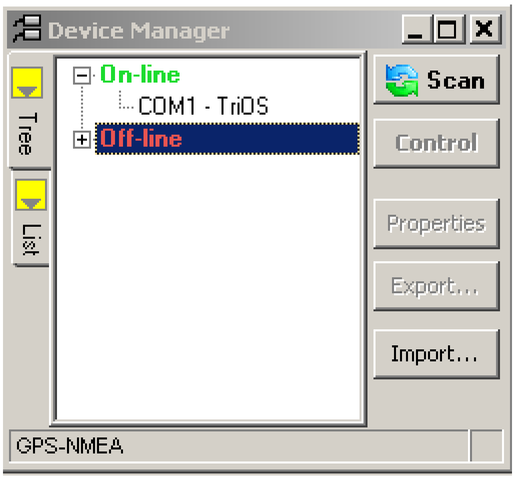

Fig. 26. Device manager of MSDA_XE

- Open the **OSCAR** control window direct from the device manager (Fig. 26 and Fig. 27).
- Mark OSCAR_BXXX
- Press the button "Control" and the control window opens

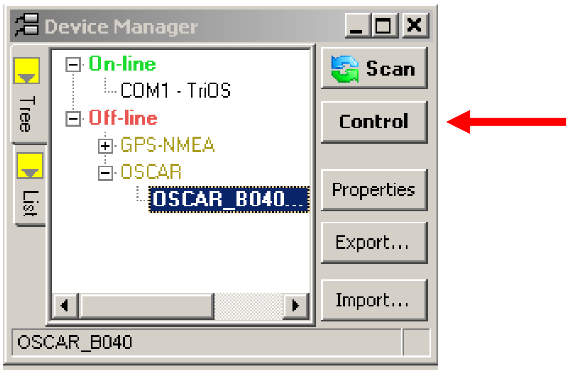

Fig. 27. Device manager of MSDA_XE

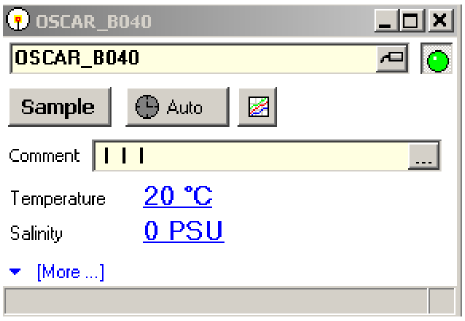

Fig. 28. OSCAR control window

- Press [More ...] in the appearing window to open the advanced settings (Fig. 28).

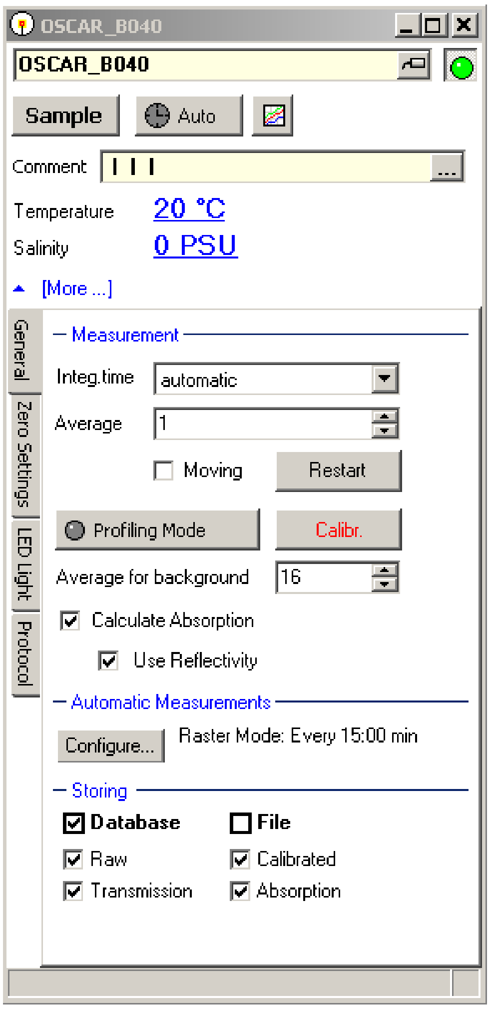

Fig. 29. OSCAR control window with general settings menu

- Press the tab [Zero Settings] (Fig. 29): In this page spectra can be selected from the database for the reflectivity calculation (see Fig. 30).

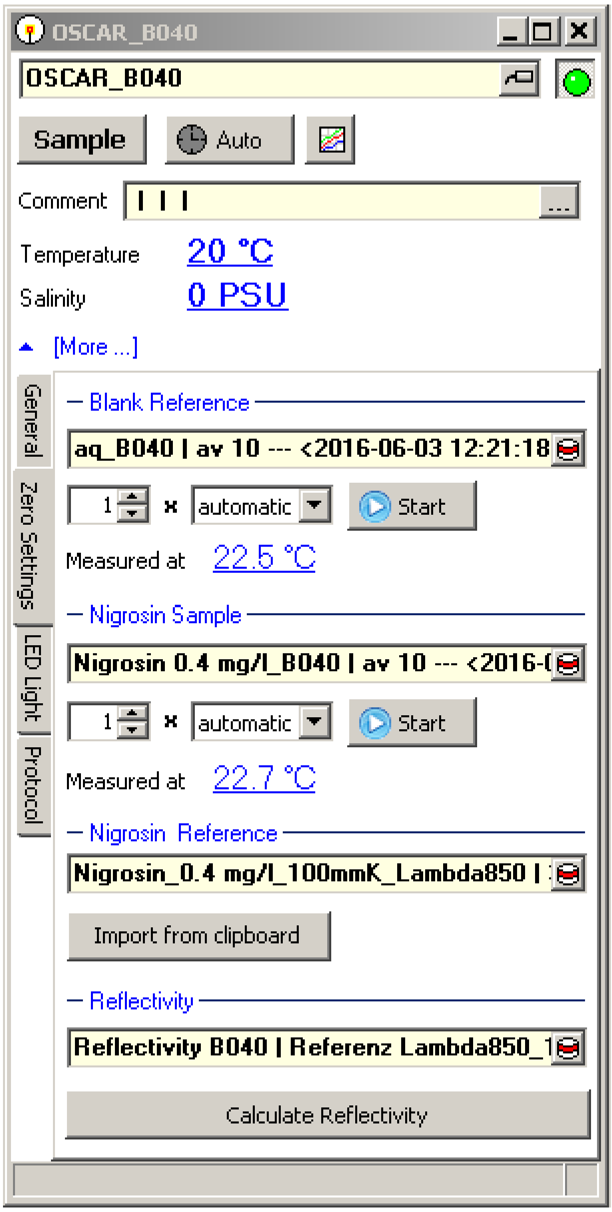

Fig. 30. OSCAR control window for the reflectivity calculation

- Open the database under main menu – Database – Data.
- Import the calibrated water and Nigrosin spectra measured with the **OSCAR G2** device.

- On the page “Zero Settings” you can choose the calibrated spectrum for “Blank Reference” (calibrated spectrum of purified water, waterbase) and the “Nigrosin Sample” (calibrated spectrum of Nigrosin) measured with **OSCAR.**

- The data for the Nigrosin Reference measured with a reference absorption spectrometer can be copied form a textfile or an Excel sheet. For this mark the wavelength and the corresponding absorption value (Important: The absorption value has to be calculated on the $\mathbf{log_{10}}$ scale) in the wavelength range 360 – 750 nm. Then copy it and press the button “Import from clipboard° in the **OSCAR** Control Field page “Zero Settings”. The reference data will now be transformed into a dat.file which is compatible with the **MSDA_XE** software.

- If necessary update the temperature values.

- Press “Calculate reflectivity”.

For more detailed information on the plotting options, database operations and all general **MSDA_XE** features please refer to the **MSDA_XE** manual.

4.2.2 Calculation of absorption spectra with reflectivity

For the calculation of absorption spectra with reflectivity proceed as follows:

- Download the measured data from the **OSCAR.**

- Note: It is not possible to set the temperature and the salinity values of the measured spectra in **MSDA_XE** after the measurement. So you first have to open the dat.file of the **calibrated** spectra and change the value for temperature to your measured temperature value of the medium. If you have measured in seawater, update the value for salinity. After that, import the **calibrated** spectra into the database.

- To calculate collected data, open main menu – processing – spectrum – absorption (Fig. 31).

- Choose calibrated input. (Note: You can choose only the calibrated input, because the calibrated spectra of the OSCAR are temperature corrected. It is not possible to choose the raw input, because there exists no data file for the temperature correction of the LEDs in **MSDA_XE** for **OSCAR-G2**).

- Select the database as data source and enter the right parameter files.

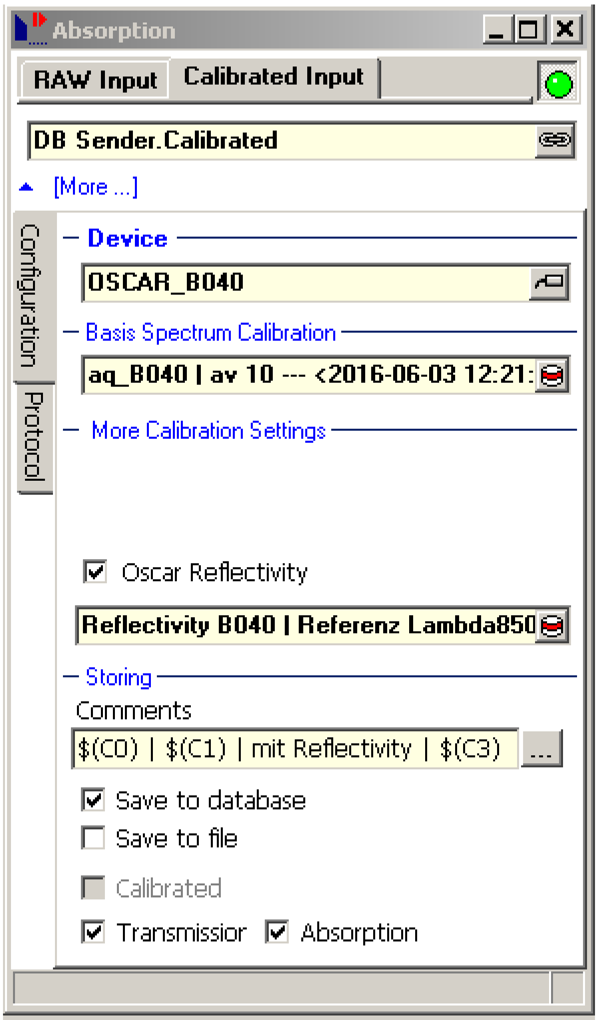

Fig. 31. Absorption window for the calculation of absorption spectra with reflectivity

- Mark the spectra that should be calculated in the database and send them to the “Absorption” window.
- As result you get absorption on the $\mathbf{log_{10}}$ scale. If you need absorption on the $\mathbf{log_{n}}$ scale, the absorption values have to be multiplicated with ln10. This can be calculated with the function “singleSpecCalc. For the use of this feature a special licence is

necessary. Please contact support of **TriOS Mess- und Datentechnik GmbH** (support@trios.de).

4.3 Operation in practice

In the following the practical operation with **OSCAR** is described:

- Connect the **OSCAR** via **G2 Interface Box** with your PC or laptop (see section 3.1.3), open the sensor menu with a web browser and configure the settings (see 4.1.3). Enter a meaningful comment according to your medium and set the measuring interval to a value you need.
- Fill the cavity with the medium; note the temperature and the salinity of the medium.
- If the temperature and salinity of the medium are constant, you can set the values before starting automatic measurements under the page “measurement” “spectrum” (see Fig. 14). Confirm them by executing a single measurement.
- Enable automatic measurements (see Fig. 18).

Fig. 32. Setting for automatic measurement

- After finishing the automatic measurements, open the sensor menu with a web browser and download the measured data.
- If it is necessary to correct the temperature and salinity values of the recorded spectra, open the dat.file with calibrated spectra. Set the temperature of each spectrum to the measured temperature of the medium. Also set the value for salinity.
- Save the file and import it into the database of the **MSDA_XE** software.
- Start the calculation of absorption under consideration of the reflectivity (see chapter 4.2.2).

5 Cleaning and servicing

Deposits (fouling) and dirt on the sensor are depending on the medium and the duration of exposure in the medium. Therefore, the degree of contamination is depending on the application. For this reason it is impossible to give a general answer how often to clean the sensor.

The following rules and hints shall help to service the sensor correctly. Please note that these instructions are referring to the sensor housing, not the cavity. The cleaning and handling of the cavity is described later in this chapter. During the following cleaning procedure, the cavity needs to be properly close and prevented from any liquids or cleaning agents to enter the inner part.

⚠	**Damage caused by improper cleaning is excluded from the warranty!**

5.1 Sensor housing cleaning

In general it is recommended to soak the sensor in a rinsing solution for a few hours to solve hard dirt. To save the connector and be sure, that it is dry at every time, it is recommended to use a dummy plug for the connector. If the sensor is heavily dirty, an additional cleaning with a sponge may be necessary. Please inform yourself about the risks and the safety instructions of the cleaning solution. If the sensor cannot be cleaned, like described above, because calcifications are present, a 10% citric acid or acetic acid solution can be used. In case of brownish dirt points of iron or manganese oxides debris, a 5% oxalic acid or 10% ascorbic acid solution can be used to clean the sensor. Please do not use hydrochloric acid under any circumstances. Even very low concentrations will affect stainless steel parts. Additionally **TriOS Mess- und Datentechnik GmbH** warns against using strong acids, even if the sensor has titanium housing.

For the cleaning of the windows between the cavity and the main housing, polish them with a tissue and a few drops of acetone. Take care, that there are no fingertips on the windows. During the cleaning a thin film can appear, which can be removed with a soft tissue or pure water. Do not use any grinding cleaning solutions or blades to remove persistent dirt. To facilitate the cleaning of the optical windows **TriOS Mess- und Datentechnik GmbH** offers a cleaning set with acetone and special optical cleaning paper.

5.2 Cavity cleaning

The PSICAM cavity wall can be cleaned by using pure HPLC-grade ethanol and a lint-free tissue. Touching the wall with unprotected finger should be avoided. Optical influences by organic material attached to the wall can further be removed by bleaching for about 15 minutes using a ca. 0.1 % sodium hypochlorite solution (NaOCl). The central light source can either be carefully cleaned with ethanol.

How to open the cavity?

Position the device horizontally and make sure it cannot slip away (Fig. 33). Even though the top cap of the cavity fits in any orientation on the main part, we recommend making a small mark with a pencil. The cavity can be opened with the four screws on the top cap.

Fig. 33. OSCAR positioned for cavity opening

Be careful when opening the cavity (see Fig. 34). The inner area may not be scratched and the light source (glass sphere and fibre rod) need to be handled with maximum care since it can break easily. Please note that the glass rods of the light source and the detector are solely stuck and fitted by small O-rings.

Fig. 34. OSCAR with open cavity

6 Calibration

6.1 Factory calibration

All **TriOS Mess- und Datentechnik GmbH** sensors are factory calibrated at time of delivery. Depending on the parameter specific calibration substances are used for this. The calibration data is delivered together with the sensor. For all **OSCAR** devices water base spectra are taken and stored for the cavity. One reflectivity calibration with Nigrosine (see section 2.3) is delivered with the sensor.

6.2 Procedure of the factory calibration

- Preparation of a stocksolution of Nigrosin in ultra pure water with a concentration of about 100 mg/l.
- Preparation of a dilution of Nigrosin in ultra pure water with a concentration of 0.4 mg/l in a 2 L volumetric flask
- The Nigrosin dilution is measured three times with an absorption spectrometer Perkin Elmer Lambda 850 in a 100 mm cuvette. The three measurements are averaged. The temperature of the Nigrosin solution should be about 20 °C.
- The cavity is rinsed and filled with ultra pure water of a known temperature. A water basis (zero line) is taken with an average of 10 and a pause of 60 seconds between the single measurements. Before starting the waterbase calibration the temperature value of the water is entered.
- The cavity is emptied.
- The cavity is rinsed and filled with the Nigrosin dilution. Before filling the cavity the temperature of the Nigrosin solution is recorded. The temperature value of the solution is entered. The Nigrosin calibration is taken with an average of 10 and a pause auf 60 seconds between the single measurements.
- The cavity is emptied.
- Cleaning and bleaching of the cavity.
- The cavity is again rinsed and filled with ultra pure water. The waterbase is checked with some measurements of the pure water.

- After the measurements the data are downloaded and the calibrated waterbase and Nigrosin spectra are imported into the database of **msda_xe**.
- The calculation of the reflectivity is performed with the averaged spectrum of pure water measured before the Nigrosin measurement.
- The reference Nigrosin measurement is imported from clipboard as described in chapter 4.2.1.
- The reflectivity is calculated.

6.3 Reference spectrum of Nigrosin

The following figure shows an example of the nigrosin reference measurement with an absorption spectrometer Perkin Elmer Lambda 850.

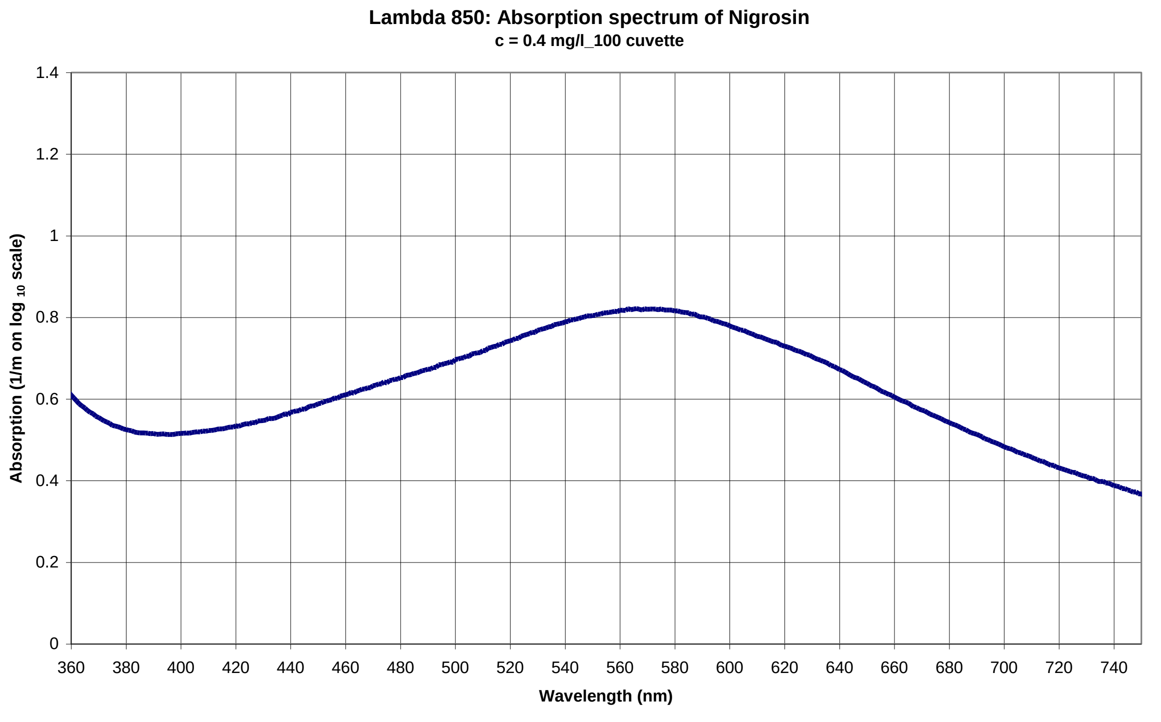

Fig. 35. Reference spectrum of Nigrosin recorded with Perkin Elmer Lambda 850

7 Warranty

Warranty time is 2 years following the date of invoice. Excluded from warranty are all parts of the instruments that are considered consumables, e.g. light sources or O-rings. Warranty is bounded to a proper use of the instrument and accessories.

- The instrument and attachments must be installed, powered and operated in compliance with the directions of this manual.
- Damage resulting from contact with incompatible materials, fluids or gases (e.g. corrosive, acid, solvent materials, fluids or gases) is not covered.
- Damage incurred by shipment is not covered.
- Damage by improper treatment by the customer is not covered.
- Damage by modification of the instrument or mounting improper parts by the customer is not covered.
- Opening of the main housing of the sensor by the customer will cause a total loss of warranty (this does not refer to the cavity).

⚠ **Opening the sensor by the customer will cause a total loss of warranty!**

8 Support

If you have questions concerning the usage of **OSCAR** as well as any other **TriOS Mess- und Datentechnik GmbH** product or software feel free to contact us.

Technical support: support@trios.de

Sales: info@trios.de

fon: +49 (0) 4402 / 69 67 0 - 0

fax: +49 (0) 4402 / 69 67 0 - 20

To arrange a quick help, please send us via email the device number and the file ‘trace.log’ that can be downloaded from the sensor under the page “system”. The file contains information about the device and possible error sources. It is also helpful to send spectra measured by the unit.

8.1 Fast functional test

A quick test of the device function can be performed with a measurement of air in the cavity. Send the spectra to **support@trios.de**. You also can send spectra of the medium or purified water to the support department.

9 Contact information

We are always working to improve our products. Please check our website for updates.

If you identified any problems concerning the sensor device respectively the corresponding software or if you would like to see some additional features enabled in a future version, please feel free to contact us:

Technical support: support@trios.de

General request / sales: info@trios.de

Our website: www.trios.de

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