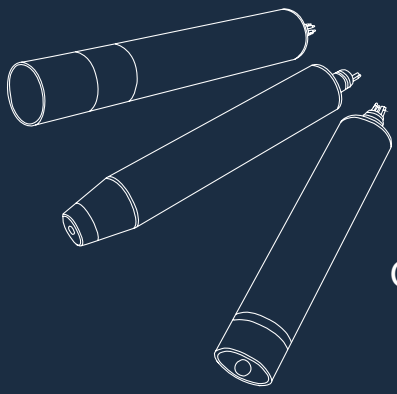
TriOS
Optical Sensors



RAMSES
OPERATING INSTRUCTIONS

Table of Contents

1 General Information

1.1 Introduction

Welcome to TriOS.

We are glad that you have chosen to purchase the RAMSES Radiometer. This manual describes both the first generation RAMSES and the RAMSES G2. Where information applies to both variants, “RAMSES” is used.

RAMSES radiometers are spectral high-resolution radiometers for measuring radiance, irradiance or scalar irradiance in the UV, VIS or UV/VIS range. Due to low weight and size, as well as very low power consumption, they are especially suitable for portable or autonomous use. The group of RAMSES radiometers combines spectral high resolution light measurement with a maximum of flexibility.

In this manual you will find all the information on the RAMSES that you need for commissioning. Technical specifications as well as detection limits and dimensions can be found in chapter 7.

Please note that the user is responsible for compliance with regional and state regulations for the installation of electronic equipment. Any damage caused by incorrect use or unprofessional installation is not covered by the warranty. All sensors and accessories supplied by TriOS Mess- und Datentechnik GmbH must be installed and operated in accordance with TriOS Mess- und Datentechnik GmbH specifications. All parts have been designed and tested according to international standards for electronic instruments. The instrument complies with international standards for electromagnetic compatibility. Please use only original TriOS accessories and cables for a smooth and professional use of the equipment.

Read this manual carefully before using the instrument and keep this manual for future reference. Before operating the sensor, make sure that you have read and understood the safety precautions described below. Always make sure that the sensor is operated properly. The safety precautions described on the following pages are intended to enable trouble-free and correct operation of the device and the associated additional equipment and to prevent you, other persons or equipment from coming to harm.

NOTICE	**Should translations differ from the original German text, then the German version is binding.**

Software Updates

The figures and texts for RAMSES G2 used in this manual refer to firmware version 1.0.9.

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 emit strong electromagnetic waves may affect the measurement data or cause the sensor to malfunction. Avoid operating the following devices with the TriOS sensor in the same room: cellular phones, cordless phones, transceivers, or other electrical devices that generate electromagnetic waves.

1.3 Warnings

- This sensor is developed for use in industry and science. It can be used in air and in water. When using in water, make sure that the connecting cable to the sensor is leak-proof.

NOTICE **Sensors made of stainless steel are not made for use in seawater or high chloride concentrations (corrosion). Only sensors made of titanium can be used here.**

- Sensors made of stainless steel must be cleaned immediately after contact with salt water or other substances that cause corrosion (e.g. acids, alkalis, chlorine-based compounds).
- Material resistance should be tested for each application.
- The sensor has seals made of NBR (acrylonitrile butadiene rubber). On individual request, sealing rings made of other materials may be used. Before operation, make sure that the measured medium does not damage the seals.
- Do not cut, damage or modify the cable. Make sure that there are no heavy objects on the cable and that the cable does not buckle. Make sure that the cable does not run near hot surfaces.
- If the sensor cable is damaged, it must be replaced by an original part by the technical support of TriOS Mess- und Datentechnik GmbH.
- Stop operation of the sensor if excessive heat is generated (i.e. more than hand-warm). Switch off the sensor immediately and remove the cable from the power supply. Please contact your dealer or TriOS customer service.
- The spectrometer may age more rapidly if it is exposed to direct UV light continuously and for a long period of time.
- Never attempt to disassemble or modify any part of the sensor unless specifically described in this manual. Inspections, modifications and repairs may only be carried out by the device dealer or by TriOS authorized and qualified specialists.
- Devices from TriOS Mess- und Datentechnik GmbH comply with the highest safety standards. Repairs to the devices (which include replacement of the connecting cable) must be carried out by TriOS Mess- und Datentechnik GmbH or an authorized TriOS workshop. Incorrect, improper repairs can lead to accidents and injuries.

NOTICE **TriOS does not guarantee the plausibility of the measured values. The user is always responsible for monitoring and interpreting the measured values.**

1.4 User and operating requirements

The RAMSES was developed for use in industry and science. The target group for the operation of the RAMSES is technically experienced personnel in enterprises, universities and institutes. Cleaning the sensor often requires the handling of hazardous substances. We assume that the operating personnel are familiar with the handling of hazardous substances due to their professional training and experience. In particular, the operating personnel must be able to correctly understand and implement the safety labeling and safety instructions on the packaging and in the package inserts of the test kits.

1.5 Intended Use

The intended use of the RAMSES is exclusively to perform measurements of radiance, irradiance or scalar irradiance in the UV, VIS or UV/VIS range in water or in air as described in this manual. Please observe the technical data of the accessories. Any other use is considered improper.

Use in other media may result in damage to the sensor. For the use of the RAMSES in other media than those specified here, please contact the customer support of TriOS Mess- und Datentechnik GmbH (support@trios.de).

According to current scientific knowledge, the device is safe to use if it is handled in accordance with the instructions in this operating manual.

NOTICE	**Avoid any contact with the optical window or the collector, as they may become scratched or dirty. This means that the functionality and accuracy of the device is no longer guaranteed.**

According to current scientific knowledge, the device is safe to use if it is handled in accordance with the instructions in this operating manual.

1.6 Disposal Instructions

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 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
26180 Rastede
Germany
Tel: +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

This manual describes the use and measurement principles in the application with hyperspectral RAMSES radiometers for the measurement of radiance, irradiance and scalar irradiance in air or in water.

All RAMSES sensors are equipped with serial interfaces for data communication. While the first generation RAMSES are always equipped with a RS-232 interface, the advanced version (RAMSES G2) is equipped with a RS-485 interface, because it is more insensitive to interferences. The sensors can be used alone or as part of a complete sensor system. RAMSES and RAMSES G2 can be easily integrated into an existing system of other TriOS sensors, such as photometers, fluorometers and many others.

The modular system increases cost-effectiveness, while the wide range of accessories and customized special solutions allow a wide range of applications, such as installations on ships, as handheld devices or in autonomous measurement stations and in remote locations such as the Arctic or Antarctica.

A fixed microcontroller allows the setting of different integration times, either manually or automatically by the sensor itself. This ensures optimal measurement in all situations.

The respective built-in spectrometer module is called SAM (Spectral Acquistion Module).

2.1 Variants

RAMSES is available in three different variants, which are characterized by different measuring head features:

ACC

(Advanced Cosine Collector)

Irradiance measurement

ARC

(Advanced Radiance Collector)

Radiance measurement

ASC

(Advanced Scalar Collector)

Scalar irradiance measurement

In addition, further features can be selected, resulting in numerous device variants:

Wavelength range

The wavelength range in which measurements are made depends on the spectrometer. The following wavelength ranges are possible: VIS with 320-950 nm, UV with 280-500 nm and UV/VIS with 280-720 nm.

Additional sensors for inclination and pressure

With a longer housing tube it is possible to integrate additional sensors for pressure and/or inclination. A RAMSES thus becomes a SAMIP (I = Inclination; P = Pressure). With RAMSES G2 the inclination sensor is included at the factory, only the pressure sensor is optional here.

Housing material and immersion depth (pressure range)

For all versions, the housing material (stainless steel or titanium) as well as the pressure range (30 bar standard or 100 bar deep sea version) can also be selected. The sensor in the deep sea version always has a titanium housing.

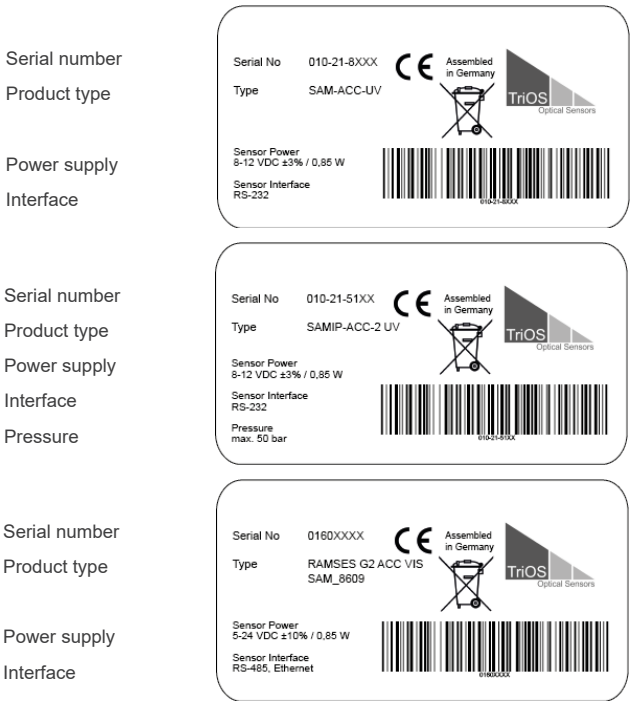
Data logger

Only RAMSES G2 has an internal data logger with a memory capacity of 2 GB.

2.2 Product Identification

All TriOS Mess- und Datentechnik GmbH products are provided with a product label that clearly shows the product designation.

In addition, there is a type plate on the sensor with the following information, which you can use to clearly identify the product:



The type plate also contains the product barcode, the TriOS Mess- und Datentechnik GmbH logo and the CE quality mark.

Please note that the specifications given here are for illustrative purposes only and may vary depending on the design of the product.

2.3 Scope of Delivery

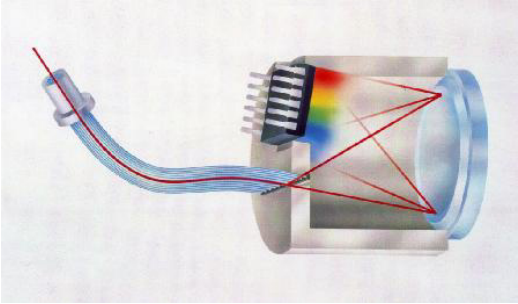
The delivery contains the following components:

- Sensor
- Operating instructions
- CD with calibration data
- Calibration certificates
- Accessories (if applicable)

Keep the original packaging of the unit for possible return for maintenance or repair.

2.4 Measurement Principle and Design

The RAMSES hyperspectroradiometers are based on a highly miniaturised monolithic spectrometer module from ZEISS (MMS or MMS1 series). The basic optical design is shown in the following figure.



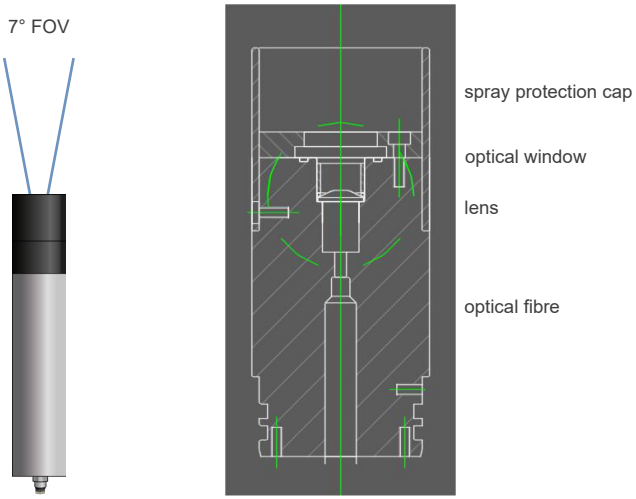
The light is detected by an optical fibre bundle with 30 single fibres giving a total diameter of 0.5mm. These fibres are linear on the entrance side of the polychromator. The entered light is separated into its single colours by a holographic grid mounted on the bottom of the module and detected by a 256 channel photodiode array.

All required signals for controlling the photodiode array and data read-out are generated and controlled within highly miniaturised electronic boards, developed by TriOS. Special emphasis was put on an ultra-low power consumption, to allow long-term operations powered by batteries. A low-power microcontroller builds the digital interface and the central controlling unit.

All RAMSES sensors can be used in air as well as in water. When used in water, the immersion effect must be taken into account. Therefore, during manufacturer calibration, the sensitivity of the spectrometer is measured against a NIST* lamp in both air and ultrapure water (irradiance sensors). For the radiance sensors, the wavelength-dependent immersion effect is constant and is determined by calculation.

RAMSES ARC

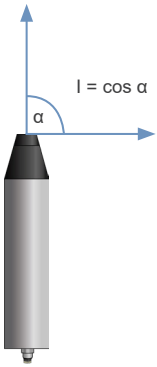
The optical system of the RAMSES-ARC sensor is built by the optical fibre and a lens (fused silica). The field of view (FOV) is defined by the position of the fibre in relation to the focal point of lens. In a standard setup the fibre is fixed in a position minimally closer to the lens then the focal length, in a way giving 7° FOV (full angle) in air.



* NIST = National Institute of Standards and Technology

RAMSES ACC

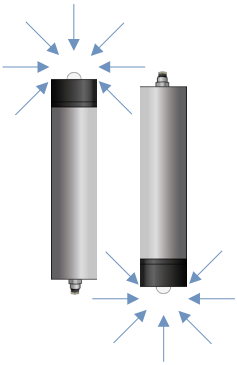
The light is collected by a planar diffuser, the so-called cosine collector, and detected by the fiber. The optical setup is designed so that the angle detection characteristic follows a cosine function. This means that only light from above (α ≤ 90°) is detected. Lateral light (α > 90°) is not measured.



RAMSES ASC

The RAMSES-ASC uses a spherical diffuser instead of the planar one of the RAMSES-ACC. Therefore the detection characteristic is not a function of the incident angle of the light. The simultaneous use of 2 RAMSES-ASC sensors, one in upward and one in downward orientation results in a precise 4Pi scalar irradiance detection.

4 π



Effective area for light from upper half space:

$\Phi_d = ½\pi s^2(1+\cos(\Psi))$

from lower half space:
$\varphi_u = ½\pi s^2(1-\cos(\Psi))$

Scalar irradiance:

$E_0 = \varphi_{ob} + \varphi_{un}$

$E_d - E_u = \varphi_{ob} - \varphi_{un}$

2.5 Browser

RAMSES G2 is equipped with a web interface for sensor configuration and calibration. To access the web interface, you need a G2 InterfaceBox, an Ethernet cable and an Ethernet-enabled 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:

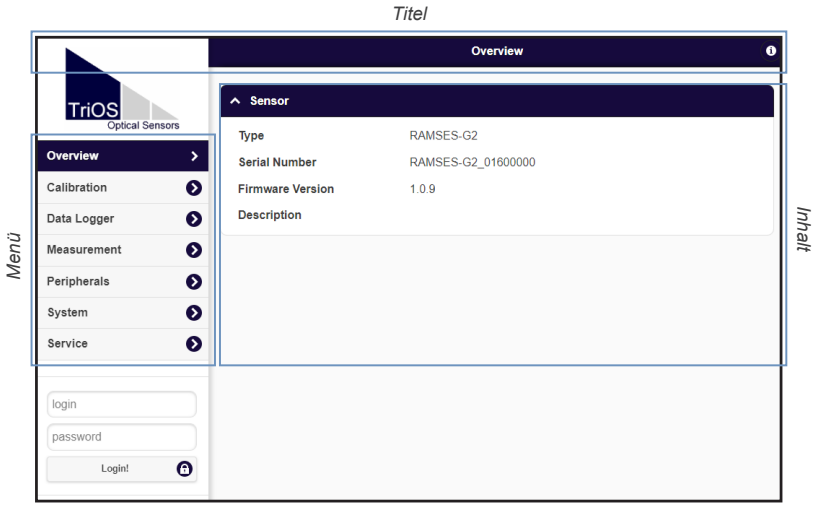
http://ramses/ or

http://ramses_0160XXXX/ (0160XXXX is the serial number) or

http://192.168.77.1/

The web interface is divided into three areas:

Title (above), menu (to the left under the TriOS logo) and content (right).

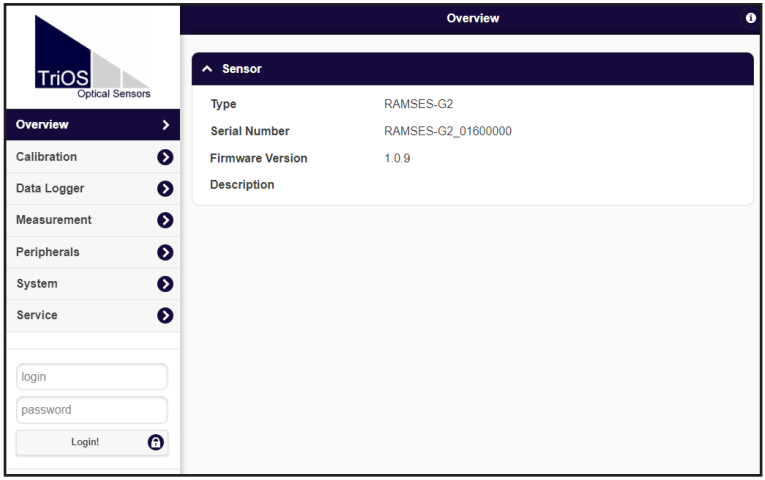


Under the menu, there is a login section that is only available for advanced users who joined a product training at TriOS Mess- und Datentechnik GmbH.

In the menu on the left, the subpoints are listed. There is a “Help” link on the right side that will take you to the TriOS Mess- und Datentechnik GmbH website. An active internet connection is required to access the website.

Overview

The “Overview” page summarises basic information about the sensor. This includes device type, serial number and firmware of the sensor, as well as a description, which can be entered under “System”.

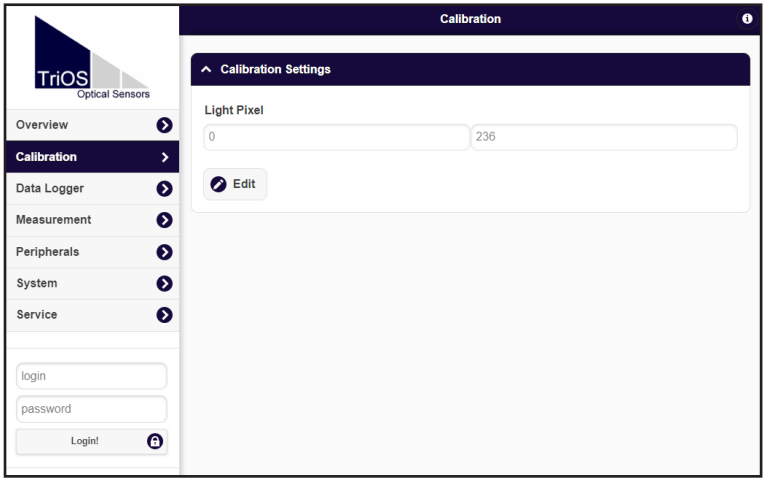


Calibration

On the “Calibration” page, a defined pixel range can be set for third-party systems. Thus, depending on the bandwidth of the required data, it can be decided which pixel range is to be transmitted. In practice, this considerably minimizes the data size, for example when transmitting via telemetry.

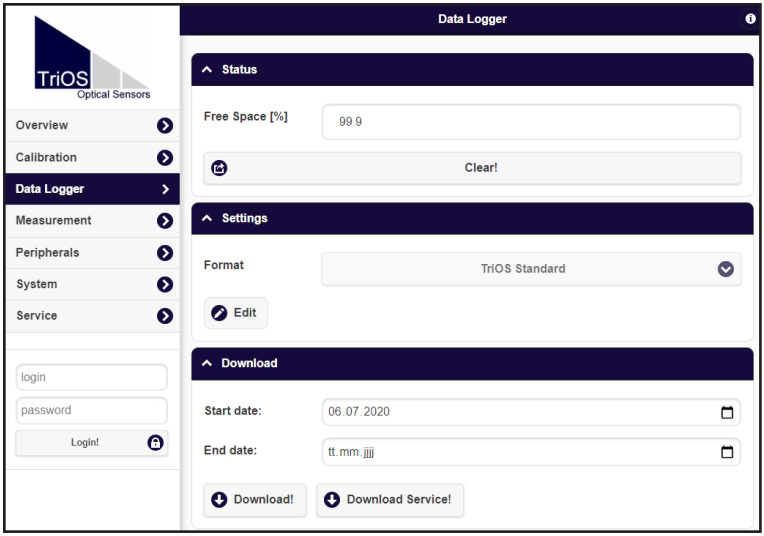
When operating via Modbus RTU, the start and stop pixels can thus be read out first in order to then transmit only those pixel-based intensity values that are actually required.

Despite the set pixel range, however, the sensor always measures the entire spectrum.



Data Logger

RAMSES G2 has an internal data logger with a 2 GB data memory. This enables the sensor to operate almost self-sufficiently over a very long period of time. All you need is an appropriately sized power supply unit. The following figure shows the layout of the “Data Logger” page:



Status

The “Status” area shows how many percent of the memory are still free.

The “Clear” button formats the memory and deletes all data - for safety only after confirming the security prompt.

After confirming the security question, the memory on the RAMSES G2 and thus all data is irrevocably deleted.

Settings

RAMSES G2 saves the spectra both in the TriOS standard format (*.dat) and as a CSV file (*.CSV; Comma Separated Values). CSV files can be opened and read by all common spreadsheet programs.

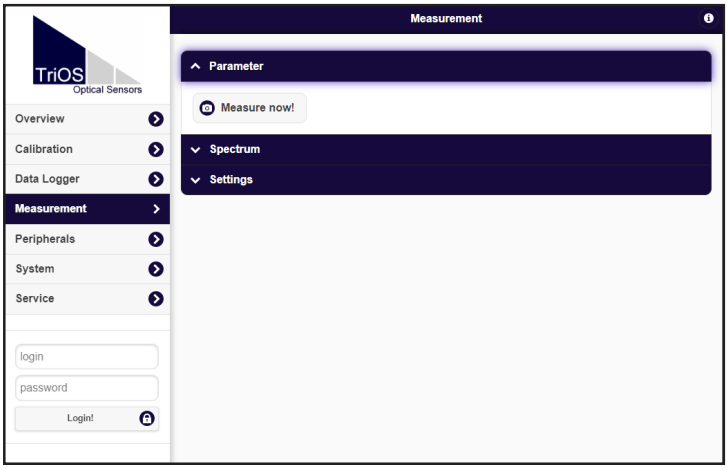
Download

Already saved data can be retrieved via the “Download” button. It is possible to set a start and end date for the data download. We recommend selecting a time window for the download/export, as the approx. 2 GB download can take a long time.

Measurement

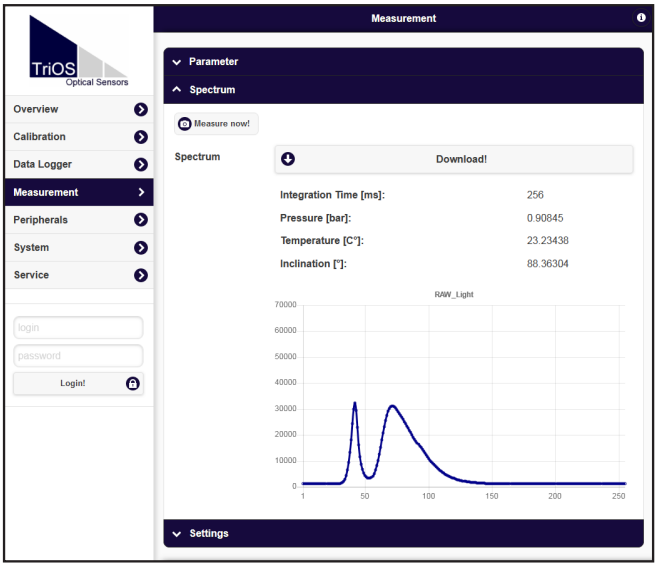
Parameter

A new measurement can be triggered at any time. To do so, click on the button “Measure Now! A new measurement is then carried out with the saved settings.



Spectrum

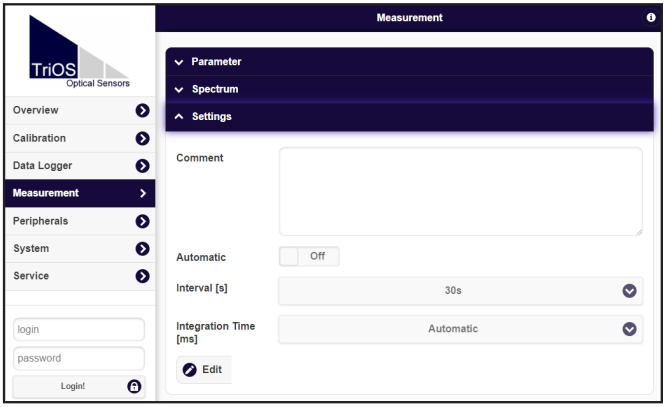
The “Spectrum” item shows the currently measured spectrum. Click on the “Download” button to download this spectrum to the computer (CSV format).



Settings

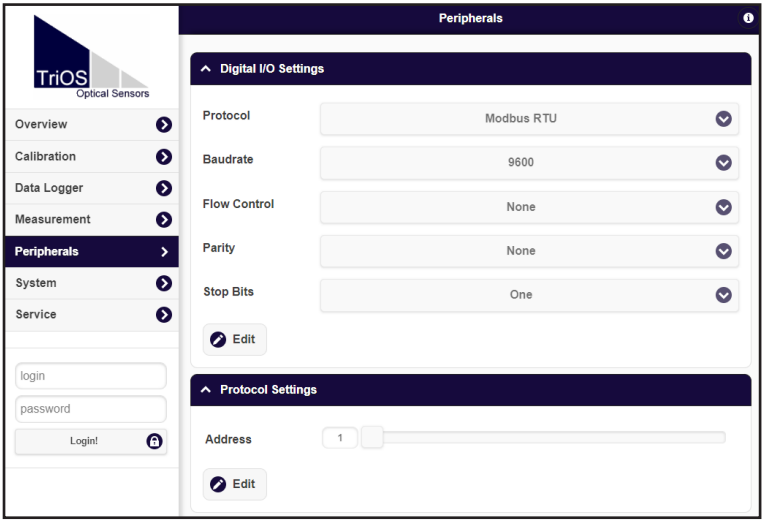
In the subitem “Settings”, settings for the automatic measurement can be made after pressing the “Edit” button:

- Comments can be inserted in the “Comment” field, which are then linked to the measured values and spectra.
- Automatic measurements can be activated.
- An interval for the automatic measurements can be set.
- The integration time can be set.



Peripherals

In the submenu “Peripherals”, after pressing the button “Edit”, the interface can be configured, a protocol can be selected and the Modbus address can be changed.



The factory settings are:

Protocol: Modbus RTU

Baud rate: 9600

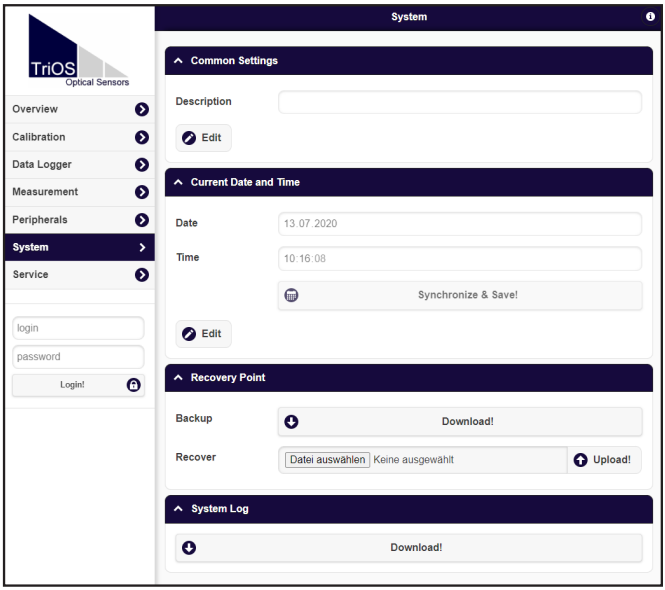
Flow control: None

Parity: None

Stop bits: One

System

The “System” page is used to manage the sensor. You can save and change the current configuration or check the log entries.



Common Settings

After pressing the “Edit” button, a comment such as a name or the location of the sensor can be entered here. This description will be appear on the “Overview” page.

Current Date and Time

Here the date and time of the sensor can be set or synchronised with the PC.

Recovery Point

To download the current recovery point from the sensor and save it on a PC or other medium, press the “Download” button. This file (config.ini) must be saved and stored securely. For the user this file is encrypted and unreadable.

If a previously downloaded recovery point or a file created by the technical support of TriOS Mess- und Datentechnik GmbH is to be uploaded, this can be achieved via the “Upload” function. If the upload is successful, this is confirmed with a pop-up at the top “Success”. Otherwise, an error message will appear at the top.

The following error messages and warnings may occur:

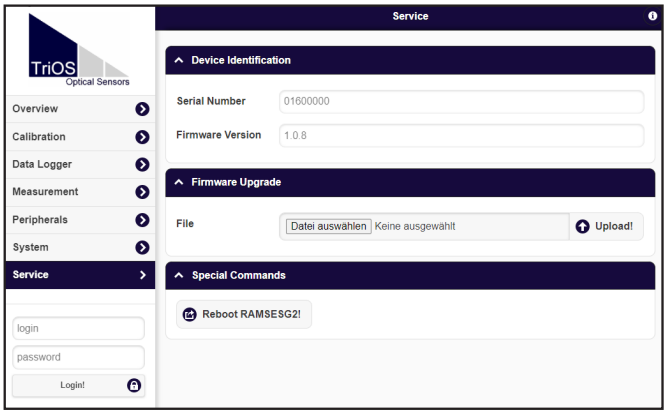
- „File not OK”: The calibration file could not be read correctly. Check the path and select the correct file. If the error persists, contact the technical support of TriOS Mess- und Datentechnik GmbH.
- „Device type or serial number does not match”: The file is not suitable for the currently connected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

System Log

In case of service, a data set with log entries can be downloaded here.

Service

To use the service function, you need a login and a password. You will receive this when you attend a TriOS training workshop.



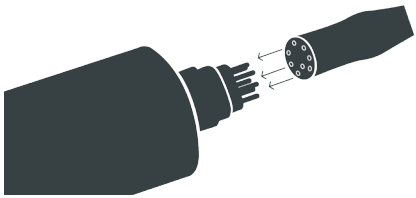
3 Commissioning

This chapter covers the commissioning of the sensor. Pay special attention to this section and follow the safety precautions to protect the sensor from damage and yourself from injury.

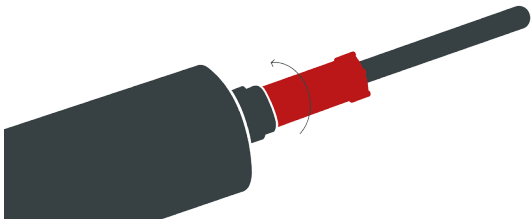
Before putting the sensor into operation, make sure that it is securely fastened and that all connections are properly connected.

3.1 Electrical Installation

All RAMSES radiometer are delivered with a SUBCONN underwater connector. Connect the male end of the connecting cable into the connector by making the pins align with the slots of the cable.

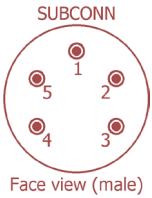


The next step is to hand-tighten the locking sleeve to secure the end of the connector into the bulkhead connection.



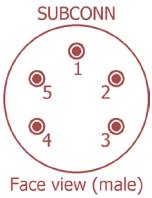
NOTICE **Do not twist or bend the connector when plugging or unplugging it. Insert the connector straight in and use the locking sleeve to attach the male contact pin.**

3.1.1 RAMSES SAM - SubConn-5pin Connector



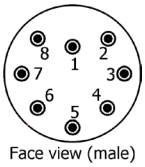
1. Ground
2. RS-232 RX (commands)
3. RS-232 TX (data)
4. Power (8...12 VDC)
5. DO NOT CONNECT

3.1.2 RAMSES SAMIP - SubConn-5pin Connector



1. Ground
2. RS-232 RX (commands)
3. RS-232 TX (data)
4. Power (8...12 VDC)
5. DO NOT CONNECT

3.1.3 RAMSES - G2 SubConn-8pin Connector



1. Ground
2. RS-485 A (commands)
3. RS-485 B (data)
4. Power (12...24 VDC)
5. ETH_RX-
6. ETH_TX-
7. ETH_RX+
8. ETH_TX+

The sensor is ready for commissioning as soon as the mounting of accessories is completed, it is connected to your control unit and the configuration is finished.

3.2 RAMSES (SAM+SAMIP) RS-232

The serial interface of the sensor is RS-232. The protocol used is TriOS data protocol. A detailed description of the TriOS data protocol can be found in the appendix.

3.2.1 Use with power supply and PC (RS-232 connection only)

In the laboratory, for example, the use of the power supply unit PS101+ (85...265VAC / 12VDC) is a reliable solution.

The front panel of the unit includes 3 LEDs. The green one indicates that the system in powered. The other two yellow LEDs are indicating the status of the RS-232 lines. The CMD LED monitors the PC connection and activities, the DATA LED monitors the connected sensor line. Both show the following functionality:

- off: no sensor/PC connected
- half-power: sensor/PC connected, no data transfer
- full-power: data are transmitted

The sensor is connected to the PS101+ unit via the M8 industrial connector mounted on the sensor connection cable. Take care during the mounting that the pins are aligned with the sockets.

PC connection is done via a RS-232 9pin connector (D-Sub9). A matching cable is delivered with the power supply. Connect the other side of the cable to the serial port of your PC.

Use the delivered line connector to supply line voltage to the unit. All PS101+ units have a built-in AC/DC converter. Input voltages between 85..265VAC (50..60Hz) are accepted.

3.2.2 Use with IPS104 and PC

The use with the IPS104 interface and power supply units is very similar to the use with the PS101 single channel unit. IPS units are available as a 4 channel version, for simultaneous operation of several sensors.

The CMD-LEDs are here not indicating the connection of the PC, but indicates the operation of the assembled interfaces for the sensors (e.g. CMD-LED of Ch 4 will not be on if you are operating a 2 or 3 channel version). Flashing CMD-LEDs are indicating that commands are send to the sensors by the controlling unit (e.g. PC).

To increase the number of simultaneously connected sensors, IPS104 units can be ‘stacked’. This means, that on every sensor channel on an IPS104 unit another IPS104 unit can be connected. This could be repeated for up to 4 levels, allowing to connect more than 200 sensors at once.

3.2.3 TriBox3 Connection

TriBox3 is an online display and control system for fixed stations, e.g. environmental monitoring stations, industrial plants, etc.. It allows the connection of four sensors (in the standard configuration), offers data logging functionality and different types of interfaces (e.g. 4..20mA, network, USB).

In combination with RAMSES sensors, the TriBox does not output single parameters but only collects spectra and triggers measurements.

The connection on the TriBox3 side is an M12 industrial connector. The required cable for the RAMSES connection is PUR-SUB-M12 / xx m and for RAMSES G2 PUR-SUB8-M12 / xx m.

Please note that when operating the TriBox3 with RAMSES G2, only RAW spects are output.

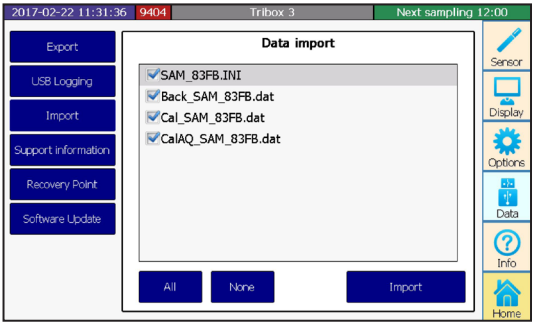
For first generation RAMSES, calibration spectra can be displayed by uploading the calibration files.

Before you connect the RAMSES to the TriBox3, you must first import the files

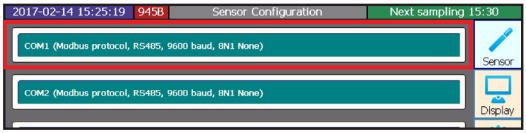
- Cal_SAM_8XXX.dat
- CalAQ_SAM_8XXX.dat
- SAM_8XXX.ini
- Back_SAM_8XXX.dat

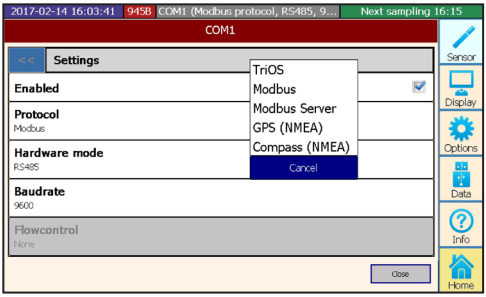
contained on the calibration CD into the TriBox3.

Copy the four files to a USB stick and connect it to the TriBox. Select the menu “Data” in the navigation bar and then the submenu item “Import” (blue button on the left). You will now see the four files, which you first select and then upload to the TriBox by clicking on the Import button (bottom right).

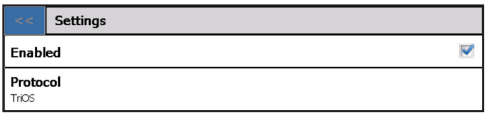


Now go to the “Sensor” menu in the navigation bar and click on a COM port you want to use.



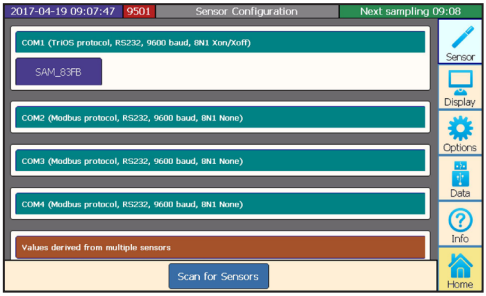


Click on “ Protocol “ and select the TriOS data protocol.

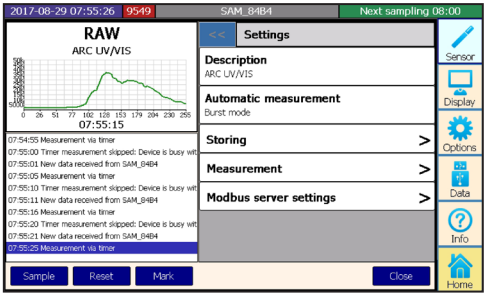


Now return to the sensor menu by clicking on the “Close” button (bottom right).

Now connect your sensor to the TriBox3 and press the “ Scan for Sensors” button (bottom center). All connected sensors are now displayed.



To change the sensor settings, click on the corresponding sensor button.



3.3 RAMSES G2 RS-485

The serial interface of the sensor is RS-485. The protocol used is Modbus RTU. A detailed description of the Modbus RTU protocol for RAMSES G2 can be found in the appendix.

3.3.1 Network

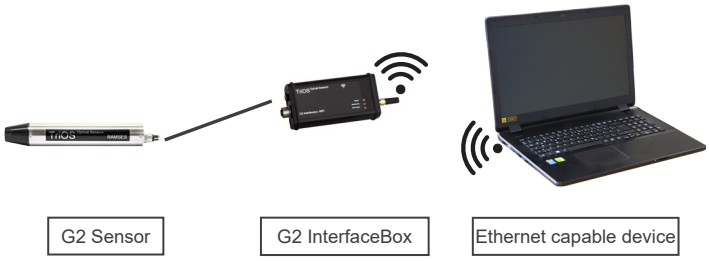
The IEEE 802.3 10BASE-T compliant Ethernet interface is used as the universal interface for the new TriOS G2 sensors. This makes it possible to establish a connection to a single sensor or even to set up a complex sensor network.

Network with a single G2 sensor

The easiest way to establish a connection with the RAMSES G2 is with the G2 InterfaceBox. It serves to establish the connection as well as the power supply for the sensor and can be used universally for all TriOS G2 sensors.

The following figure shows a connection setup to a single sensor:

The TriOS G2 InterfaceBox translates the 8pin-M12 sensor connector to the standard connectors for power supply (2.1mm hollow connector) as well as for network access (RJ-45 female connector).



The TriOS G2 InterfaceBox WiFi translates the 8-pin M12 sensor connector to the standard connectors for power supply (2.1mm hollow connector) and provides wireless network access (WiFi).

G2 InterfaceBox

There are three connectors on the housing of the G2 InterfaceBox:

1. Power supply 12 or 24 VDC; 2.1 mm hollow plug
2. Sensor connection 8pin-M12
3. Ethernet connection RJ-45 jack or WiFi antenna

Proceed as follows to connect the sensor to an Ethernet-capable device using the G2 InterfaceBox:

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

Step 2) Plug the M12 connector at the cable end of the sensor into the M12 socket (2) of the G2 Interface Box and close the screw cap.

Step 3) Connect the 12 or 24 VDC power supply to the G2 InterfaceBox to supply power to the sensor.

Step 4) Wait at least 3 seconds before finally connecting your Ethernet LAN cable to your Ethernet enabled device and the G2 InterfaceBox. If a WiFi connection is available is available, refer to the status LED.

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

http://ramses/

http://ramses_0160XXXX/ (0160XXXX is the serial number)

http://192.168.77.1/

If the web interface cannot be accessed, make sure that the LAN cable has been connected after the sensor has been powered and try all three URL possibilities.

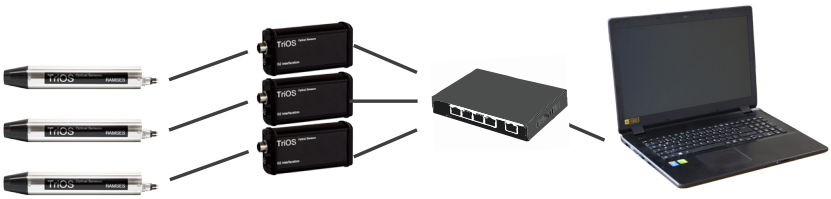
When an Ethernet-capable device is connected, the automatic measurements of the RAMSES G2 are suspended. As soon as the LAN connection between the sensor and the Ethernet-capable device is disconnected, the measurements are continued at the set interval, provided that the timer is activated.

3.3.2 Network with multiple G2 sensors

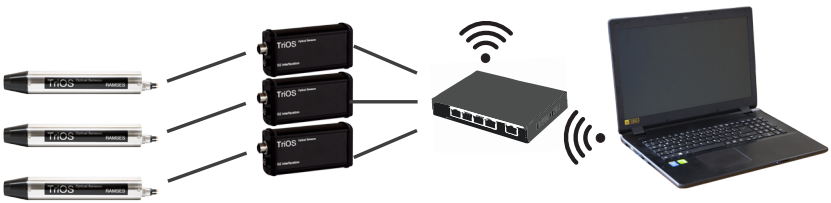
With the help of an Ethernet switch or hub or commercially available router, it is possible to connect several sensors in a complex network and use them simultaneously. In the sensor network, each sensor requires its own G2 InterfaceBox for the power supply.

RAMSES G2, like any TriOS G2 sensor, provides a simple DHCP server as well as a simple DNS server configured exclusively for direct single connection - as described in the previous section. For a complex sensor network it is necessary that these servers are provided by the user. RAMSES G2 automatically detects them and then shuts down the internal servers. Ask your network administrator for advice on how this can best be implemented in your case.

The following figures show examples of different ways of setting up a sensor network.



G2 Sensors	G2 InterfaceBox	a) Ethernet-Switch / Hub b) Router with DHCP Server	a) Ethernet-capable device with DHCP server b) Ethernet-capable device



G2 Sensors	G2 InterfaceBox	a) Access Point b) WLAN Router with DHCP Server	a) Wireless-capable device with DHCP server b) Wireless-capable device

RAMSES G2 can only be used from one Ethernet-enabled device at a time.

If several sensors are used in a network, the web interface can be reached via the host name http://ramses_0160XXXX/ (0160XXXX is the serial number) or via the IP. Ask your network administrator for advice.

NOTICE **Damage caused by improper use is excluded from the warranty!**

3.3.3 TriBox3 Connection

TriBox3 is an online display and control system for fixed stations, e.g. environmental monitoring stations, industrial plants, etc.. It allows the connection of four sensors (in the standard configuration), offers data logging functionality and different types of interfaces (e.g. 4..20mA, network, USB).

In connection with RAMSES sensors the TriBox does not output single parameters but only collects spectra and triggers measurements.

The connection on the TriBox3 side is an M12 industrial connector. The required cable for the RAMSES G2 connection is PUR-SUB8-M12 / xx m.

The COM ports of the TriBox3 are already configured for RAMSES G2 connection at the factory.

Once the sensor has been connected to the TriBox3, it should appear under the respective COM port after a sensor search.

Please note that when operating the TriBox3 with RAMSES G2, only RAW spects can be triggered and displayed.

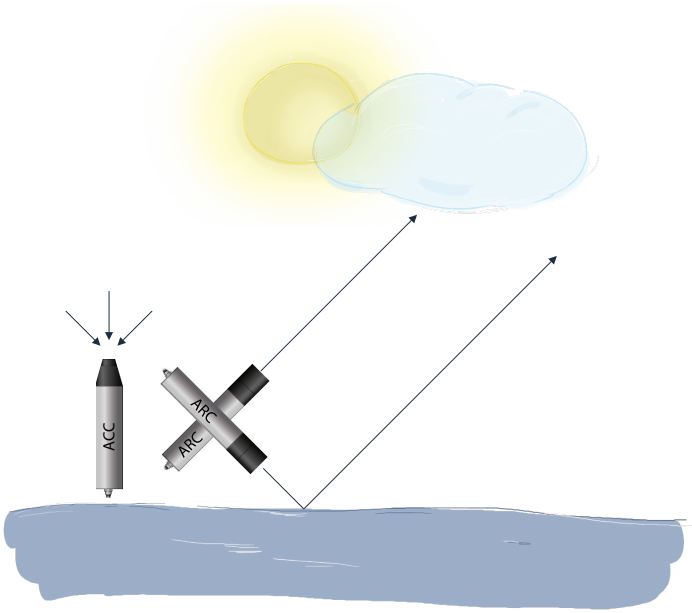
4 Use

4.1 Normal Operation

RAMSES radiometers are spectrally resolving radiometers for measuring radiance, irradiance or scalar irradiance in the UV, VIS or UV/VIS range. Due to low weight and size as well as very low power consumption, they are especially suitable for portable or autonomous use. Thus, the sensors can be held by hand as well as mounted in measuring stations by different mounting options (see 4.2 and 4.3).

Standard applications can be made in air and at the surface as well as in water. Please make sure that the correct calibration is used for the respective application.

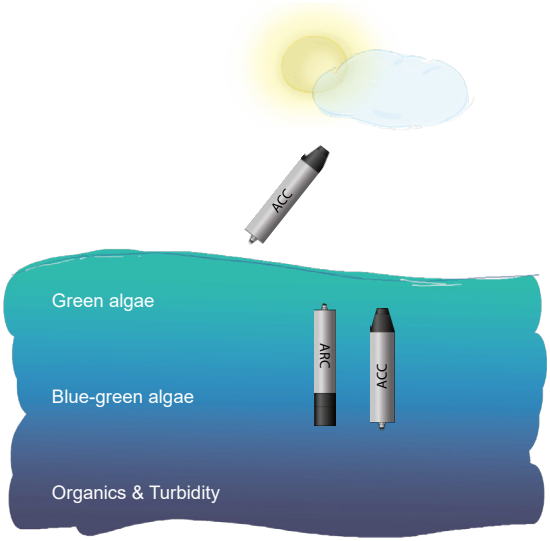
Application on air and at the surface



An ACC sensor pointing straight up measures the total available light irradiance. To determine the real reflection of the surface, an ARC sensor (radiance) is positioned at an angle of approx. 45° to the surface. This minimizes distortions due to reflections. A second ARC sensor is positioned skyward and used to compensate for atmospheric interference.

Such a structure can either be constructed by the user or with the help of frame 3 (see chapter 4.3).

Application in water



In the water application, it is measured how much light is still present in deeper water areas. For this purpose, an ACC sensor is directed upwards in the water column to measure the incident light under water. An ARC sensor is pointed downward to measure the reflected light from the depth. A second ACC sensor above the water surface is used as a control device.

Such a setup can either be constructed by the user or with the help of Frame 1 (see chapter 4.3).

4.2 Mounting with clamps

For mounting the sensors, suitable clamps can be obtained from TriOS. They are offered in two versions: CL48 as a pure plastic clamp and CL48-R with a rubber seal. The clamps are suitable for all RAMSES variants and should be mounted close to the device covers.

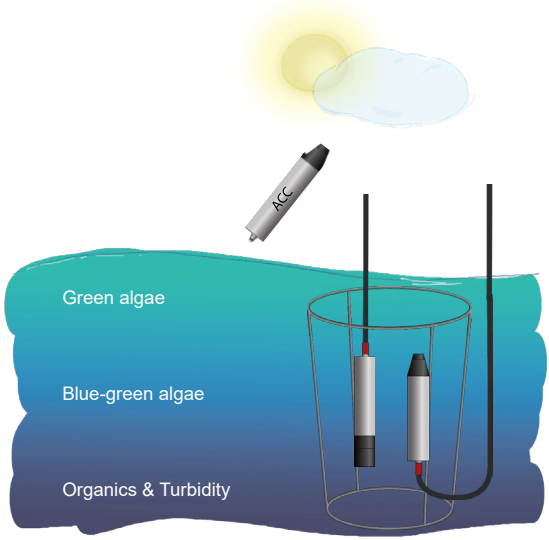
4.3 Mounting in Frames

To facilitate the installation and application variations described in 4.1, TriOS offers different frames for mounting and aligning the sensors.

For air and surface applications, Frame 3 can be used to install the sensors.

Frame 3 is adjustable and adjusts the ARC sensors in proportion depending on what latitude you are measuring at and what time of year.

Frame 1 is recommended for underwater applications. This holds the submerged sensors in position. The ACC above the water surface is used here to check whether the frame may be tilting and the alignment is no longer correct.



5 Calibration

The RAMSES radiometers are supplied with appropriate calibration files and a calibration certificate. A certified NIST standard lamp is used for the calibration of the spectrometer module (SAM).

The sensors have excellent long-term stability. Nevertheless, we strongly recommend to have a factory recalibration and check-up performed every 2 years.

5.1 Factory supplied data

The calibration files for internal spectrometer module (SAM) and a configuration file are supplied with each sensor. For SAMIP, the serial number for the configuration file changes due to the inclination or pressure sensor.

SAM

Back_SAM_8600.dat	Dark current measurement
Cal_SAM_8600.dat	Calibration in air
CalAQ_SAM_8600.dat	Calibration in water
Calibration certificate.doc	Calibration certificate
SAM_8600.ini	Configuration file

SAMIP

Back_SAM_86F1.dat	Dark current measurement
Cal_SAM_86F1.dat	Calibration in air
CalAQ_SAM_86F1.dat	Calibration in water
Calibration certificate.doc	Calibration certificate
SAMIP_5121_ALL.ini	Configuration file

G2

Back_SAM_86DC.dat	Dark current measurement
Cal_SAM_86DC.dat	Calibration in air
CalAQ_SAM_86DC.dat	Calibration in water
Calibration certificate.doc	Calibration certificate
SAM_86DC.ini	Configuration file

5.1.1 Dark current measurement (Back_SAM_8xxx)

An essential point for a precise light measurement is an accurate handling of the dark current of the detectors. This is mainly influenced by the currently selected integration time in the normal operating state. In addition, attention must be paid to the temperature behavior of the connected electronics. This electronic offset should be subtracted from the raw data. An effective method for monitoring dark currents and electronic drift is to use “blackened” diodes. This means that during the spectrometer manufacturing process, some of the 255 diodes are blackened, depending on the type. The VIS version of the RAMSES hyperspectroradiometers uses the infrared portion of the spectrum (above 950 nm) for this purpose. The “spectral” signature of the dark currents is due to small variations in the active area of each diode caused by the production process. Since this is constant, it can be used as a “fingerprint” of the individual spectrometer that remains stable with time and environmental conditions. This

“fingerprint” is supplied with the sensor in the BACK_SAM_8xxx.dat file. Which pixels exactly serve as dark pixels can be taken from the respective .ini files under DarkPixelStart and DarkPixelStop (see chapter 5.1.4).

File Back_SAM_8577.dat:

(Exemplary figure for illustration, values can deviate).

```
[Spectrum]
Version             = 1
IDData              = DLAB_2018-02-02_10-10-17_273_360
IDDevice            = SAM_8577
IDDataType          = SPECTRUM
IDDataTypeSub1      = BACK
IDDataTypeSub2      =
IDDataTypeSub3      =
DateTime            = 2018-02-02 10:04:00
PositionLatitude    = 0
PositionLongitude   = 0
Comment             =
CommentSub1         =
CommentSub2         =
CommentSub3         =
IDMethodType        = SAM Calibration Station
MethodName          = SAM_Calibration_Station
Mission             =
MissionSub          = 0
RecordType          = 0

[Attributes]
CalFactor = 1
IDBasisSpec =
IDDataBack =
IDDataCal =
IntegrationTime = 8192
P31 = -1
P31e = 0
PathLength = +INF
RAWDynamic = 65535
Temperature = +NAN
Unit1 = $05 $00 Pixel
Unit2 = $03 $05 Intensity counts
Unit3 = $03 $05 Intensity counts
Unit4 = $f1 $00 Status
[END] of [Attributes]
[DATA]
 0 12 0 0
 1 0.0159105266132445 0.0206769539153184 0
 2 0.0157508760258628 0.0206506530389835 0
 3 0.0158064063311709 0.0206759425042856 0
 4 0.0158596213325481 0.0206646926949281 0
 5 0.0158560243238189 0.0206804252511481 0
 6 0.0158048950152215 0.020793715506143 0
 7 0.0158024427471923 0.0208123740948597 0
 8 0.0157873123145192 0.0208240592336202 0
 9 0.0158455311291165 0.0208808265543733 0
 10 0.0157942812572172 0.0205880195691528 0
 11 0.0158205518436715 0.0204725581145678 0
...
 240 0.015848179683274 0.0210930793814588 0
 241 0.0158710516408459 0.0207764824167443 0
 242 0.015840231927083 0.0207502236098017 0
 243 0.0158662374836449 0.020862859432632 0
 244 0.0158419351672467 0.0208994100538082 0
 245 0.0158624628577792 0.0209273003152747 0
 246 0.0158608454600823 0.0209784957981343 0
 247 0.0158843373328665 0.020942277018928 0
 248 0.0158550716818097 0.0209428062902865 0
 249 0.0158929847400569 0.0208881377259793 0
 250 0.015870460863219 0.0207133308475098 0
 251 0.0159175915180496 0.0208759068793411 0
 252 0.0158875115848945 0.020864406224686 0
 253 0.0159377899713163 0.0209245953057194 0
 254 0.0159822185076861 0.0208058547078395 0
 255 0.016449005415222 0.02218175076587 0
[END] of [DATA]
[END] of [Spectrum]
```

B_0

B_1

5.1.2 Calibration file for measurement in air

For air calibration of irradiance sensors (ACC, ASC), the NIST lamp is aligned perpendicular to the collector.

In the air calibration of the radiance sensors (ARC), a reflective spectralon plate is aligned perpendicular to the NIST lamp and the sensors measure (aligned at a 45° angle) the reflected light.

File Cal_SAM_8577.dat:

(Exemplary image for illustration, values can deviate)

```
[Spectrum]
Version             = 1
IDData              = DLAB_2018-02-07_12-50-12_009_812
IDDevice            = SAM_8577
IDDataType          = SPECTRUM
IDDataTypeSub1      = CAL
IDDataTypeSub2      = Air
IDDataTypeSub3      =
DateTime            = 2018-02-07 12:49:23
PositionLatitude    = 0
PositionLongitude   = 0
Comment             =
CommentSub1         =
CommentSub2         =
CommentSub3         =
IDMethodType        =
MethodName          =
Mission             = No Mission
MissionSub          = 1
RecordType          = 0

[Attributes]
CalFactor = 1
IDBasisSpec =
IDDataBack = DLAB_2018-02-02_10-10-17_273_360
IDDataCal =
IntegrationTime = 64
P31 = -1
P31e = 0
PathLength = +INF
RAWDynamic = 65535
Temperature = +NAN
Unit1 = $05 $00 Pixel
Unit2 = $04 $04 1/Intensity (m^2 nm Sr)/mW
Unit3 = $04 $04 1/Intensity (m^2 nm Sr)/mW
Unit4 = $f1 $00 Status
[END] of [Attributes]
[DATA]
 0 5 0 0
 1 +NAN 0 0
 2 +NAN 0 0
 3 +NAN 0 0
 4 +NAN 0 0
 5 0.84304912815335 0 0
 6 0.977735005565213 0 0
 7 1.05180750801423 0 0
 8 1.09089697563764 0 0
 9 1.09766817482793 0 0
 10 1.09079841311672 0 0
 11 1.09938292524598 0 0
...
 241 +NAN 0 0
 242 +NAN 0 0
 243 +NAN 0 0
 244 +NAN 0 0
 245 +NAN 0 0
 246 +NAN 0 0
 247 +NAN 0 0
 248 +NAN 0 0
 249 +NAN 0 0
 250 +NAN 0 0
 251 +NAN 0 0
 252 +NAN 0 0
 253 +NAN 0 0
 254 +NAN 0 0
 255 +NAN 0 0
[END] of [DATA]
[END] of [Spectrum]
```

5.1.3 Calibration file for measurement in water

The water calibration of the irradiance sensors is performed in the same way as in air, except that the collector is covered with ultrapure water.

The water calibration of the radiance sensors is determined by calculation.

File CalAQ_SAM_8577.dat:

(Exemplary image for illustration, values can deviate)

```
[Spectrum]
Version             = 1
IDData              = DLAB_2018-02-07_12-50-13_240_813
IDDevice            = SAM_8577
IDDataType          = SPECTRUM
IDDataTypeSub1      = CAL
IDDataTypeSub2      = Aqua
IDDataTypeSub3      =
DateTime            = 2018-02-07 12:50:13
PositionLatitude    = 0
PositionLongitude   = 0
Comment             =
CommentSub1         =
CommentSub2         =
CommentSub3         =
IDMethodType        =
MethodName          =
Mission             = No Mission
MissionSub          = 1
RecordType          = 0

[Attributes]
CalFactor = 1
IDBasisSpec =
IDDataBack = DLAB_2018-02-02_10-10-17_273_360
IDDataCal =
IntegrationTime = 64
P31 = -1
P31e = 0
PathLength = +INF
RAWDynamic = 65535
Temperature = +NAN
Unit1 = $05 $00 Pixel
Unit2 = $04 $04 1/Intensity (m^2 nm Sr)/mW
Unit3 = $04 $04 1/Intensity (m^2 nm Sr)/mW
Unit4 = $f1 $00 Status
[END] of [Attributes]
[DATA]
 0 5 0 0
 1 +NAN 0 0
 2 +NAN 0 0
 3 +NAN 0 0
 4 +NAN 0 0
 5 0.472497925220349 0 0
 6 0.548461027168504 0 0
 7 0.590507517666204 0 0
 8 0.612950056869681 0 0
 9 0.617238292648881 0 0
 10 0.613840514012727 0 0

...

 241 +NAN 0 0
 242 +NAN 0 0
 243 +NAN 0 0
 244 +NAN 0 0
 245 +NAN 0 0
 246 +NAN 0 0
 247 +NAN 0 0
 248 +NAN 0 0
 249 +NAN 0 0
 250 +NAN 0 0
 251 +NAN 0 0
 252 +NAN 0 0
 253 +NAN 0 0
 254 +NAN 0 0
 255 +NAN 0 0
[END] of [DATA]
[END] of [Spectrum]
```

5.1.4 Configuration file

The ini-file of the SAMs contains an overview of the respective sensor properties.

- Sensor type
- Calibration date
- Blackened pixel area
- Names of the current calibration spectra
- Wavelength coefficients of the spectrometer

File SAM_8577.ini:

(Exemplary image for illustration, values can deviate)

```
[Device]
Version           = 0
IDDevice          = SAM_8577
IDDeviceType      = SAM
IDDeviceTypeSub1  = ARC
IDDeviceTypeSub2  = VIS
IDDeviceTypeSub3  =
RecordType        = 0
DateTime          = 2018-02-07 12:51:04
IDDeviceMaster    =
Comment           = ARC VIS

[Attributes]
DarkPixelStart = 237
DarkPixelStop = 254
Firmware = 2.06
IDDataBack = DLAB_2018-02-02_10-10-17_273_360
IDDataCal = DLAB_2018-02-07_12-50-12_009_812
IDDataCalAQ = DLAB_2018-02-07_12-50-13_240_813
IntegrationTime = 0
Reverse = 0
SerialNo MMS =
c0s = 298.083
c1s = 3.31734
c2s = 0.000393391
c3s = -1.85401e-06
c4s = +0.000000000E+00
[END] of [Attributes]
[END] of [Device]
```

Darkened pixels for correction of temperature influences on dark current

```
DarkPixelStart = 237
DarkPixelStop = 254
```

Coefficients for wavelength calibration

```
c0s = 298.083
c1s = 3.31734
c2s = 0.000393391
c3s = -1.85401e-06
c4s = +0.000000000E+00
```

ID of the calibration spectra

```
IDDataBack = DLAB_2018-02-02_10-10-17_273_360
IDDataCal = DLAB_2018-02-07_12-50-12_009_812
IDDataCalAQ = DLAB_2018-02-07_12-50-13_240_813
```

If it is the device file of a SAMIP, the calibration data for the inclination or inclination sensor and for the optional pressure sensor are also stored here.

File SAMIP_5121.ini:

(Exemplary image for illustration, values can deviate)

```
[DEVICE]
Version                         = 0
IDDevice                        = IP_C161
IDDeviceType                    = IP
IDDeviceTypeSub1                =
IDDeviceTypeSub2                =
IDDeviceTypeSub3                =
DateTime                        = 2021-03-18 12:05:43
Comment                         =
RecordType                      = 0
IDDeviceMaster                  = SAMIP_5121

[ATTRIBUTES]
Incl_KRef                       = 0.1264
Incl_KBG                        = 1.1940
Incl_XGain                      = 0.94
Incl_YGain                      = 0.94
Incl_XOffset                    = 126
Incl_YOffset                    = 127
Incl_Orientation                = down
Press_Gain                      = 5.4453
Press_Current_mA                = 1.08906
Press_Surface_bar               = 2.73
Press_max_dBar                  = 50
Press_Sens_mV_bar_1mA           = 4.87
Press_Sens_mV_bar_4mA           = 19.48
Press_Type                      = PA-10TAB/8838.4-50
Press_Zero_mV                   = -0.3
WithIncl                        = 1
WithPress                       = 1
[END] of [ATTRIBUTES]
[END] of [DEVICE]
```

The RAMSES G2 also receives a configuration file for the internal SAM.

5.2 General data processing

5.2.1 Measurement Data from RAMSES

Header information about the type of spectrum

```
IDData = 01600015_2021-07-16_10-42-03_RAW_Light_570
IDDevice = 01600015
DateTime = 2021-07-16 10:42:03
Comment =
CommentSub1 =
CommentSub2 =
CommentSub3 =
IDDataType = SPECTRUM
IDDataTypeSub1 = RAW
IDDataTypeSub2 = LIGHT
```

Integration time in milliseconds

```
IntegrationTime = 4096
```

Spectrum

```
[DATA]
0 11 0 0
1 1639 0 0
2 1640 0 0
3 1638 0 0
4 1646 0 0
5 1654 0 0
6 1658 0 0
7 1663 0 0
8 1687 0 0
9 1716 0 0
...
```

Binary integration time

In order not to have to search for the integration time in the header, which can be quite different depending on the source, the integration time is transmitted again in binary form (integers 0 to 12) for the first pixel instead of the intensity.

That means the value of the first pixel (with the number 0) is not light intensity but the integration time, which is always transmitted as the beginning of the spectrum.

The counting of the pixels starts at 0, therefore the last pixel of the 256 pixels has the number 255.

The integration time changes only in binary steps from 4ms to 4096ms in automatic mode depending on the available light intensity.

Binary 1 corresponds to 4ms

Binary 2 corresponds to 8 ms

Binary 3 corresponds to 16 ms

…

Binary 11 corresponds to 4096 ms

Manually the integration time can also be set to fixed 8192ms (binary 12), this is not done automatically.

NOTICE **If the integration time is fixed, the spectrometer may be damaged if too much light is incident.**

5.2.2 Wavelength calibration

The wavelength per pixel is calculated via a polynomial:

$$\lambda(n) = C0s + C1s\,(n+1) + C2s\,(n+1)^2 + C3s\,(n+1)^3 + C4s\,(n+1)^4 \qquad n = 1...255$$

Whereby the wavelength coefficients can be taken from the SAM_xxxx.ini device data of the factory-supplied calibration data.

Example:

Pixel number	Wavelength
0	303.14
1	306.45
2	309.77
3	313.08
4	316.39
5	319.71
6	323.02
7	326.34
8	329.66
9	332.97
10	336.29

```
c0s = 299.832
c1s = 3.31
c2s = 0.000431875
c3s = -2.03554e-06
c4s = +0.000000000E+00
```

The wavelength of Pixel 3 is thus

299,832 + 3,31 · 4 + 0,000431875 · 16 + 0,00000203554 · 64 = 313,08

5.2.3 Data Conversion and Normalization

The data from the sensor are 16-bit unsigned integer data from the interval [0..65535]. They are divided by 65535 to obtain floating point figures from the interval [0.0 .. 1.0].

$$M(n) := I(n) \div 65535 \qquad n = 1...255$$

Note here that **n** is the pixel number and counting starts at 0. Instead of the measured value of pixel 0, the integration time is transmitted.

The electronic offset or dark current on the photodiode array **B(n)** is subtracted from the raw data **M(n)**.

$$C(n) := M(n) - B(n) \qquad n = 1...255$$

With $B = B_0 + t/t_0 \cdot B_1$

Where $B_0(n)$ and $B_1(n)$ can be taken from the 3-column BACK_SAM_xxxx.dat of the factory-supplied calibration data (see chapter 5.1.1).

Here

t is the current and

t_0 the maximum integration time with t_0 = 8192 ms.

For the adjustment of the dark current correction to the current conditions, a possible remainder is determined via the factory-taped pixels on the diode array (dark pixels):

$$A = Average(C(n_i))$$

where n_i are the pixel numbers of the masked pixels (from DarkPixelStart to DarkPixelStop), which can be taken from the device data SAM_xxxx.ini of the factory-supplied calibration data.

$$D(n) = C(n) - A \qquad n = 1...255$$

Now the spectra are normalized to the maximum integration time

$$E(n) = D(n)\ t0 \div t \qquad n = 1...255$$

Finally, the measured values are normalized to physical units

$$F(n) = E(n) \div S(n) \qquad n = 1...255$$

where **S(n)** is the spectral sensitivity, which can be taken from the Cal_SAM_xxxx.dat or CalAQ_SAM_xxxx.dat of the factory-supplied calibration data.

6 Malfunction and Maintenance

6.1 Cleaning and Upkeep

Depending on the type of application, the optical window or collector should be cleaned regularly to obtain reliable measured values. Its strongly recommended to rinse the instruments after every use with fresh water to avoid corrosions and damages.

First step of the cleaning process should be to rinse the sensor with freshwater to remove mud and particles. Use a clean tissue to dry the window afterwards.

To prevent the system from damages, we are recommending to use the parts included in the ‘optical cleaning set’ from TriOS and to follow the supplied instructions. This set contains an empty vial for dosing acetone, optical wipes and a special tool for handling. The use of other solvents might damage the material. Damages caused by an improper cleaning are out of warranty.

In addition to the cleaning, a regular visual inspection of the instruments for damages should be performed by the operator.

6.2 Validation

A user check of the calibration can be done using the TriOS FieldCAL unit. This is not a replacement for a high-quality re-calibration with a NIST lamp, but allows user check instrument functioning in the field.

6.3 Returns

Please follow the instructions carefully when returning items.

If you need to return the sensor, please contact customer service first. In order to ensure a smooth return process and to avoid incorrect shipments, each return must first be reported to customer service. You will then receive a numbered RMA form, which you should fill out completely and return to us. Please write the number clearly visible from outside on the return package. This is the only way your return shipment can be correctly assigned and accepted.

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

Please note that the sensor must be cleaned and disinfected before shipping. To send the goods undamaged, it is best to use the original packaging. If this is not available, make sure that a safe transport is guaranteed and that the sensors are secured by sufficient packing material.

7 Technical Data

7.1 Technical Specifications

Measurement technology	Detector	High-end miniature spectrometer	
		256 Channels	
Measurement Principle		Radiance, irradiance, scalar irradiance	
Parameter		see parameter list	
Measuring range		see parameter list	
Measurement accuracy		see parameter list	
T100 response time	**RAMSES**	≤ 10 s (burst mode)	
	RAMSES G2	≤ 24 s (burst mode)	
Measurement interval	**RAMSES**	≤ 8 s (burst mode)	
	RAMSES G2	≤ 12 s (burst mode)	
Housing material		Stainless Steel (1.4571 / 1.4404) or Titanium (3.7035), POM	
Dimensions without IP Module, without SubConn Connector (L x Ø)		ACC 260 mm x 48.5 mm ARC 300 mm x 48.5 mm ASC 245 mm x 48.5 mm	ACC ~ 10.2” x 1.9” ARC ~ 11.8” x 1.9” ASC ~ 9.6” x 1.9”
Dimensions with IP Modul, without connector		ACC 284 mm x 48.5 mm ARC 322 mm x 48.5 mm	ACC ~ 11.2” x 1.9” ARC ~ 12.7” x 1.9”
Weight	VA	ACC 0.9 kg; with IP cover 1.2 kg	ACC ~ 2 lbs; with IP cover ~ 2.6 lbs
	Titanium	ACC 0.7 kg; with IP lid 0.9 kg ACC G2 (so far only available in titanium) 0.7 kg; with IP lid 1 kg	ACC ~ 1.5 lbs; with IP lid ~ 2 lbs ACC G2 (so far only available in titanium) ~ 1.5 lbs; with IP lid ~ 2.2 lbs
Interface digital	**RAMSES**	RS-232	
	RAMSES G2	RS-485; Ethernet (TCP/IP)	
Data logger	**RAMSES**	-	
	RAMSES G2	~ 2 GB	
Power consumption	**RAMSES**	≤ 0.85 W	
	RAMSES G2	typically 1 W	
Power supply	**RAMSES**	8...12 VDC (± 3 %)	
	RAMSES G2	9…24 VDC (± 10%)	
Maintenance effort		≤ 0.5 h/month (typically)	
Calibration-/Maintenance Interval		24 months	
System compatibility	**RAMSES**	RS-232 (TriOS Protocol)	
	RAMSES G2	RS-485 (Modbus RTU)	
Warranty		1 Year (EU & USA : 2 Years)	

Max. pressure	with SubConn	30 bar	~435 psig
	DeepSea version	100 bar	~1450 psig
Protection type		IP68	NEMA 6P
Sample temperature		+2...+40 °C	~ +36…+104 °F
Ambient temperature		+2...+40 °C	~ +36…+104 °F
Storage temperature		-20...+80 °C	~ -4…+176 °F
Inflow velocity		0...10 m/s	~ 0…33 fps

* For clarity, only the weights for ACC sensors are given here. Weights for ARC and ASC are about ~ 0.6 lbs higher than those listed here.

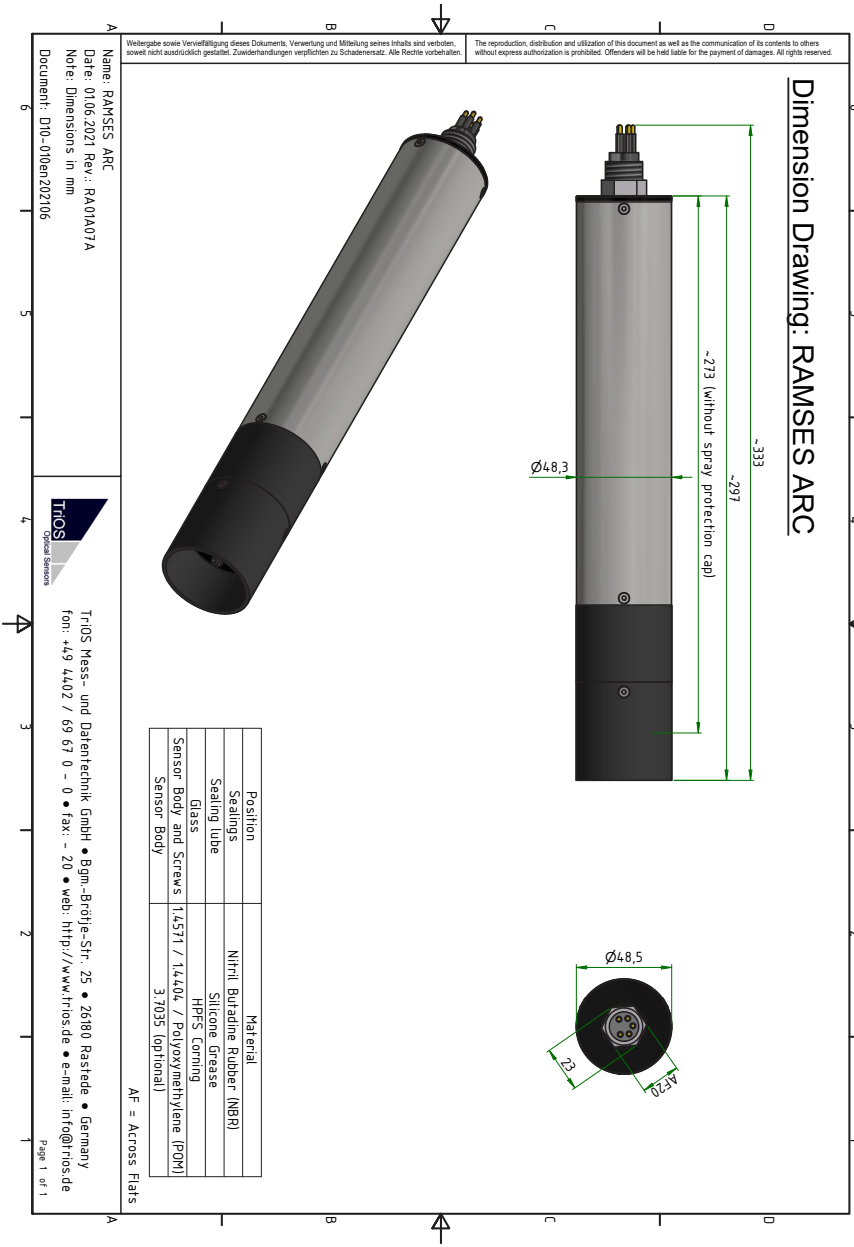
	ACC			ARC	ASC
					
	UV	UV/VIS	VIS	VIS	VIS
Wavelength range* [nm]	280...500	280...720	320...950	320...950	320...950
Detector*	256 Channel silicon photo diode array				
Pixel dispersion* [nm/ pixel]	2.2	2.2	3.3	3.3	3.3
Wavelength accuracy*	0.2	0.2	0.3	0.3	0.3
Usable channels	100	200	190	190	190

	ACC-UV UV A / UV B irradiance	ACC-VIS VIS irradiance	ARC-VIS VIS radiance	ASC-VIS VIS scalar irradiance
Wavelength range*	280...500 nm	320...950 nm		
Type Saturation (IT: 4 ms)**	20 W m^{-2} nm^{-1} (at 300 nm) 17 W m^{-2} nm^{-1} (at 360 nm) 18 W m^{-2} nm^{-1} (at 500 nm)	10 W m^{-2} nm^{-1} (at 400 nm) 8 W m^{-2} nm^{-1} (at 500 nm) 14 W m^{-2} nm^{-1} (at 700 nm)	1 W m^{-2} nm^{-1} sr^{-1} (at 500 nm)	20 W m^{-2} nm^{-1} (at 400 nm) 12 W m^{-2} nm^{-1} (at 500 nm) 15 W m^{-2} nm^{-1} (at 700 nm)
Type NEI** (IT: 8 s)**	0.85 µW m^{-2} nm^{-1} (at 300 nm) 0.75 µW m^{-2} nm^{-1} (at 360 nm) 0.80 µW m^{-2} nm^{-1} (at 500 nm)	0.4 µW m^{-2} nm^{-1} (at 400 nm) 0.4 µW m^{-2} nm^{-1} (at 500 nm) 0.6 µW m^{-2} nm^{-1} (at 700 nm)	0.25 µW m^{-2} nm^{-1} sr^{-1}	0.8 µW m^{-2} nm^{-1} (at 400 nm) 0.6 µW m^{-2} nm^{-1} (at 500 nm) 0.8 µW m^{-2} nm^{-1} (at 700 nm)
Collector	Kosinus		FOV: 7° in air	Spherical, 2 Pi
Accuracy	Better than 6...10% ***		Better than 6% ***	Better than 5% ***
Integration time	4 ms...8 s			

*) Specifications of Carl ZEISS AG, Germany **) Integration time ***) Depends on wavelength rang ****) Noise-equivalent irradiance

7.2 External Dimensions

7.2.1 RAMSES



Dimension Drawing: RAMSES ACC
~295
~259
Ø48,3
AF 20
23
Ø48,5
AF = Across Flats
Position | Material
Sealings | Nitril Butadine Rubber (NBR)
Sealing Lube | Silicone Grease
Glass | Optical Glass
Sensor Body and Screws | 1.4571 / 1.4404 / Polyoxymethylene (POM)
Sensor Body | 3.7035 (optional)
Name: RAMSES ACC
Date: 01.06.2021 Rev.: RA02A07A
Note: Dimensions in mm
Document: D10-010en202106
TriOS Mess- und Datentechnik GmbH • Bgm.-Brötje-Str. 25 • 26180 Rastede • Germany
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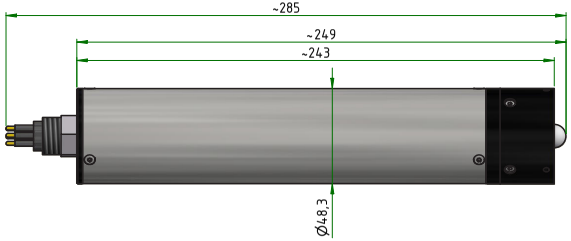
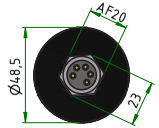
Dimension Drawing: RAMSES ASC





Position	Material
Sealings	Nitril Butadine Rubber (NBR)
Sealing lube	Silicone Grease
Colletor	Polytetrafluorethylen (PTFE)
Sensor Body and Screws	1.4571 / 1.4404 / Polyoxymethylene (POM)
Sensor Body	3.7035 (optional)

AF = Across Flats

Name: RAMSES ASC
Date: 01.06.2021 Rev.: RA03A07A
Note: Dimensions in mm

Document: D10-010en202106

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Dimension Drawing: RAMSES ARC IP
358,2
322
298 (without spray protection cap)
Ø48,3
Ø48,5
Ø4,5
11
7,3
23
AF20
Position | Material
Sealings | Nitril Butadine Rubber (NBR)
Sealing lube | Silicone Grease
Glass | HPFS Corning
Sensor Body and Screws | 1.4571 / 1.4404 / Polyoxymethylene (POM)
Sensor Body | 3.7035 (optional)
AF = Across Flats
Name: RAMSES ARC IP
Date: 01.06.2021 Rev.: RA041201
Note: Dimensions in mm
Document: D10-010en202106
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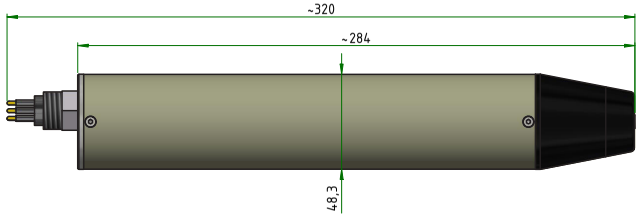
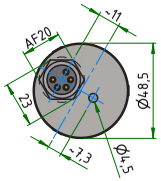
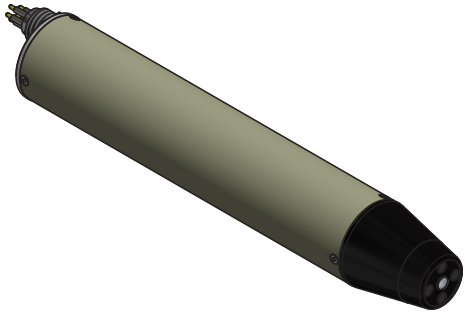
Page 1 of 1

Dimension Drawing: RAMSES ACC IP







Position	Material
Sealings	Nitril Butadine Rubber (NBR)
Sealing lube	Silicone Grease
Glass	Optical Glass
Sensor Body and Screws	1.4571 / 1.4404 / Polyoxymethylene (POM)
Sensor Body	3.7035 (optional)

AF = Across Flats

Name: RAMSES ACC IP
Date: 01.06.2021 Rev.: RA050805
Note: Dimensions in mm

Document: D10-010en202106

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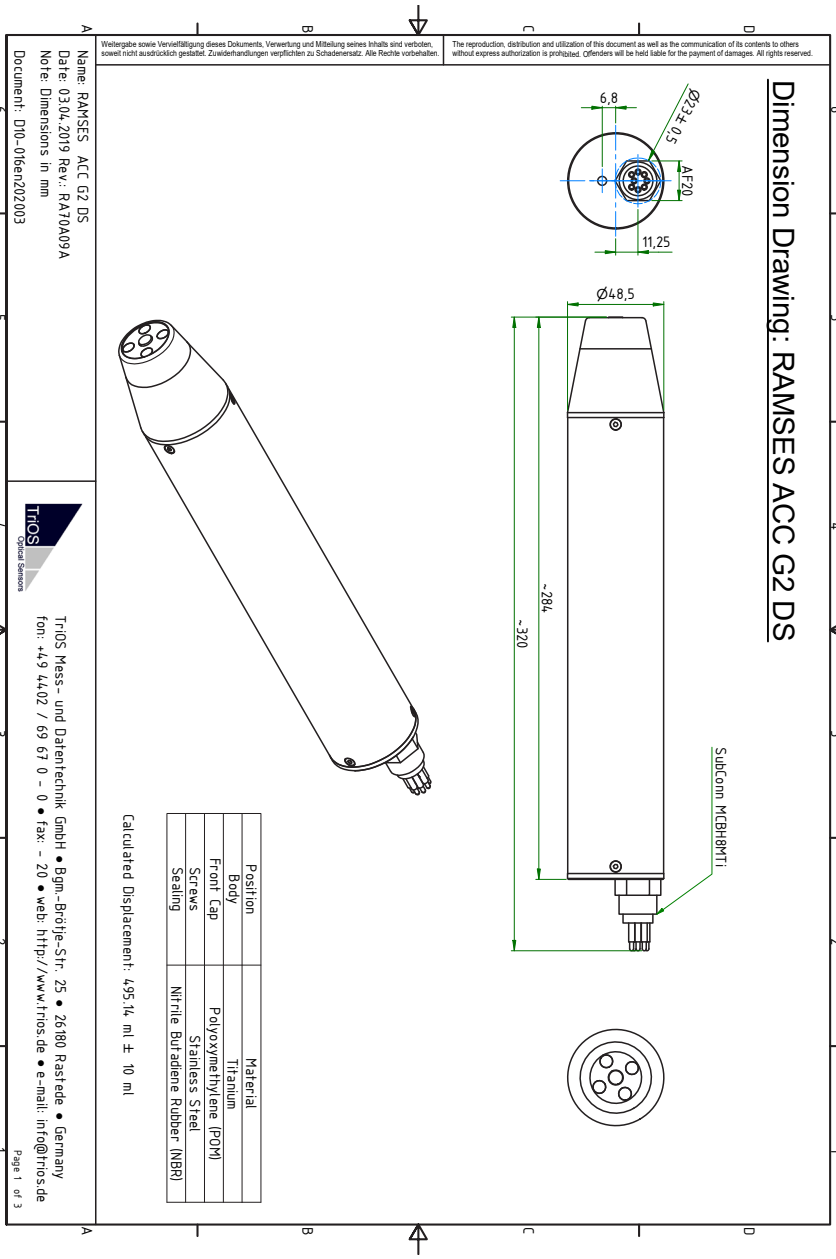
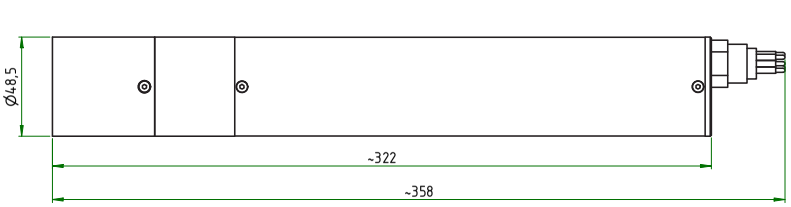
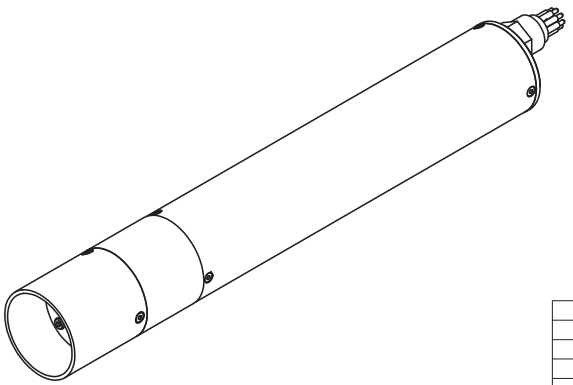
7.2.2 DeepSea (1000m)



Dimension Drawing: RAMSES ARC G2 DS





Position	Material
Body	Titanium
Spray protection	Polyoxymethylene (POM)
Screws	Stainless Steel
Sealing	Nitrile Butadiene Rubber (NBR)

Name: RAMSES ARC G2 DS
Date: 24.03.2020 Rev.: RA60A11A
Note: Dimensions in mm

Document: D10-016en202003

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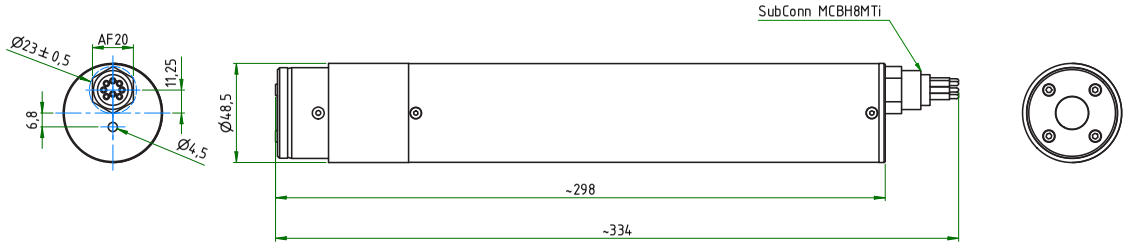
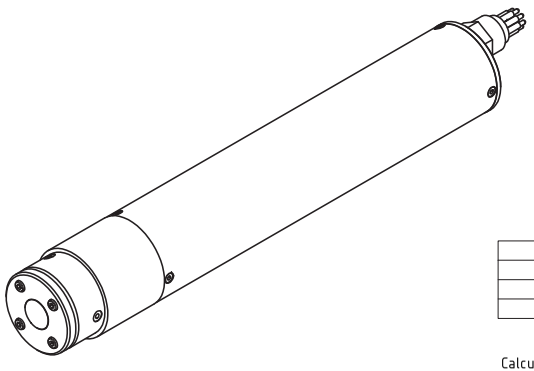
Dimension Drawing: RAMSES ARC G2 DS





Position	Material
Body	Titanium
Screws	Stainless Steel
Sealing	Nitrile Butadiene Rubber (NBR)

Calculated Displacement: 542.93 ml ± 10 ml

Name: RAMSES ARC G2 DS
Date: 24.03.2020 Rev.: RA60A11A
Note: Dimensions in mm

Document: D10-016en202003

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8 Accessories

8.1 Power Supply

8.1.1 PS101+ / IPS104

For the power supply of the RAMSES sensors TriOS offers the interface and supply units PS101 and IPS 104. While the PS101 can supply one sensor, 4 sensors can be connected to the IPS104.

8.1.2 G2 InterfaceBox

RAMSES G2 sensors can be powered via the G2 InterfaceBox. The G2 Interface Box is available with and without WiFi. It can be used to configure and control the G2 sensors of TriOS Mess- und Datentechnik GmbH. This is done via the web interface of the G2 sensors. The access takes place either via a WiFi or LAN connection. The web interface can be accessed with any browser.

8.2 Controller

8.2.1 TriBox3

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

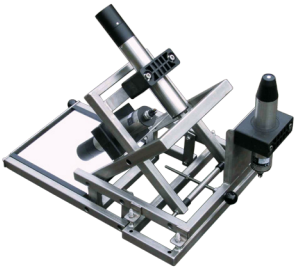
TriBox3 is a measurement and control system for all TriOS sensors. The device offers 4 sensor channels with selectable RS232 or RS485 function. In addition to the Modbus RTU, various other protocols are available. A built-in valve allows the use of compressed-air cleaning for the sensors. The TriBox3 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.

8.3 Frames

TriOS offers different frames for mounting the RAMSES sensors.

Frame 1

Allows the mounting of two sensors under water. The sensors are mounted in clamps.



Frame 3

Allows mounting of three sensors for measurement at air and surface.

8.4 FieldCAL

Secondary standard for RAMSES radiometer

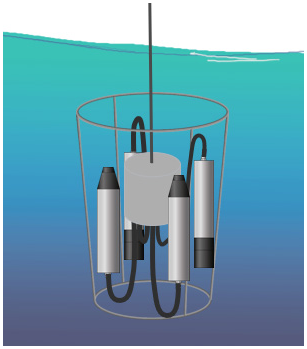
With the FieldCAL secondary standard, reliable calibration and functional tests of RAMSES radiometers can be performed in the field. Due to the special design, both radiance (ARC) and irradiance (ACC) sensors can be checked. For radiance sensors an adapter is used, which is included in the set. Small dimensions and a robust transport box make FieldCAL a useful accessory for light measurements in the field.

8.5 Underwater distributor 4-channel

In order to reduce signal processing and power supply to one cable for underwater measurements with multiple sensors, TriOS offers a suitable distributor with a maximum operating depth of 3000 m. The distributor is equipped with four SubConn connectors (8-pin) for the sensors and one SubConn connector (8-pin) for the control and power supply unit.

It is equipped with four SubConn sockets (8-pin) for the sensors and one SubConn plug (8-pin) for connection to a control and power supply unit.

The distributor can also be integrated in a frame 2.



9 Warranty

The warranty period of the devices within the EU and USA 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 the TriOS technical support.

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

Tel.: +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 the devices. Visit our website for news.

If you have found an error or bug in one of the 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

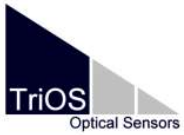
Germany

Tel.	+49 (0) 4402 69670 - 0
Fax	+49 (0) 4402 69670 - 20

12 Keyword Index

Annex

CE Declaration of Conformity



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	**RAMSES**
Typ / Type / Type	**ACC, ARC, ASC** **(VIS, UV/VIS, UV)**
Mit den folgenden Bestimmungen With applicable regulations Avec les directives suivantes	2014/30/EU EMV-Richtlinie 2011/65/EU RoHS-Richtlinie + (EU) 2015/863 + (EU) 2017/2102
Angewendete harmonisierte Normen Harmonized standards applied Normes harmonisées utilisées	EN 61326-1:2013 EN 61010-1:2010 +A1:2019 +A1:2019/AC:2019 EN IEC 63000:2018
Datum / Date / Date	Unterschrift / Signature / Signatur
26.10.2021	 R. Heuermann

D05-010yy202110

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TriOS Data protocol

Interface

IIn the delivery state, the RS-232 interface of the RAMSES is configured with the following settings:

- Baudrate: 9600
- Databits: 8
- Parity: None
- Flow Control: Software (Xon/Xoff)

Data transmission

Each frame starts with 0x23 and ends with 0x01. Since software flow control is used, the characters used for this, as well as frame start (0x23) and replacement characters (0x40) must be masked.

Masking bytes

If the characters #, @, 17, 19 occur in the data to be sent, then the corresponding bytes must be masked to avoid misinterpretation. Tab. 1 shows the masking for the TriOS protocol.

Masking of bytes for data transmission

Characters	Description	Replacement
@ (40hex)	Start for replacement Replacement	0x40 0x64
# (23hex)	Data package start	0x40 0x65
Xon (11hex)	Xon	0x40 0x66
Xoff (13hex)	Xoff	0x40 0x67

Thus, a serial number (Ex. SN# 12DF) can be sent and received as follows. This is only an example of masking and not a correct TriOS data protocol.

Sent: 0x23 0x53 0x4E (0x23 → 0x40 0x65) 0x20 0x31 0x32 0x44 0x46 0x01

Received: 0x23 0x53 0x4E (0x40 0x65 → 0x23) 0x20 0x31 0x32 0x44 0x46 0x01

0x23 [Data packet start] 0x53 [S] 0x4E [N] 0x23 / 0x40 0x65 [#] 0x20 [Empty space] 0x31 [1] 0x32 [2] 0x44 [D] 0x46 [F] 0x01 [Start of Header]

Sending commands

An instruction always consists of 8 bytes, as shown in Table 2. Thereby byte 4 can be used for instructions to certain modules of the RAMSES.

Send commands (8 bytes) for one device on one interface

Byte	Name	Description	Interpretation
0	Data package start	0x23	Start
1	Device ID 1		
2	Device ID 2		
3	I²C Address		Modul ID
4	Instruction		Einstellung ändern
5	Parameter 1		
6	Parameter 2		
7	Data package end	0x01	Ende

Receiving data

Data from RAMSES is received by the control unit as described in the following table.

Query data received from the device

Byte	Name	Description
0	Data package start	Start
1	DeviceID 1	Bit [7, 6, 5] Number of additional data bytes [hex → binary → number of data bytes] • 0x00 → 000 → 2 • 0x20 → 001 → 4 • 0x40 → 010 → 8 • 0x60 → 011→ 16 • 0x80 → 100 → 32 • 0x0A → 101 → 64 • 0x0C → 110 → 128 • 0x0E → 111 → 256 Bit [4] = always ZERO Bit [3, 2, 1, 0] = Device ID
2	DeviceID 2	
3	Module ID	
4	Data package type	FF: Information data package FE: Error data package
5	Reserved	
6	Reserved	
7	Serial number [Uint16]	Serial number Low Byte
8		Serial number High Byte
9	Firmware [Uint16]	Firmware Low Byte
10		Firmware High Byte
11	Reserved	Ignore
a..x	N Data bytes	individual information (Settings)
x+1	Data package end	End

Possible commands to the sensor

This section describes the possible commands to a RAMSES (SAM) or RAMSES with IP module (SAMIP). The commands to the sensor follow the structure given in the table on p.42 (“Sending commands”) and are valid only if a RAMSES has been connected directly to a COM port.

Setting the integration time

With RAMSES an integration time between 4-8192 ms can be set. Alternatively, the integration time can be set to automatic. To set the integration time, the command below must be sent. The sensor does not send a response to this command. To read out the integration time nevertheless, a measurement command must be sent (see Trigger measurement).

Command for setting the integration time:

Interpretation of the hexadecimal values for the integration time

0xXX	Integration time [ms]
0x00	automatic
0x01	4
0x02	8
0x03	16
0x04	32
0x05	64
0x06	128
0x07	256
0x08	512
0x09	1024
0x0A	2048
0x0B	4096
0x0C	8192

Trigger measurement

To start a measurement, a measurement command must be sent to the sensor. In the section “Response to a measurement command” a possible response of the sensor is described.

Trigger measurement command:

0x23 0x00 0x00 0x80 0xA8 0x00 0x81 0x01

Start	Device ID1	Device ID2	I²C Address	Trigger measurement	Parameter 1	Parameter 2	End

176	11:28:13.342	Adv. Info	COM9	COM9 -> SAM_83FB_$0200$30: 02 00 30 78 05 00 - IT=automatic
177	11:28:13.546	Adv. Info	COM9	COM9 -> SAMIP_406B_$0200$80: 02 00 80 a8 00 81 - Measurement
178	11:28:13.671	Adv. Info	IP_C02F	COM9 <- SAMIP_406B:IP_C02F at ->0->$0200$20: Data-frame (0) of size 24 received
179	11:28:13.687	Adv. Info	IP_C02F	IP_C02F: IPData complete
180	11:28:20.105	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (7) of size 72 received
181	11:28:20.200	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (6) of size 72 received
182	11:28:20.279	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (5) of size 72 received
183	11:28:20.375	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (4) of size 72 received
184	11:28:20.454	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (3) of size 72 received
185	11:28:20.552	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (2) of size 72 received
186	11:28:20.648	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (1) of size 72 received
187	11:28:20.727	Adv. Info	SAM_83FB	COM9 <- SAMIP_406B:SAM_83FB at ->0->$0200$30: Data-frame (0) of size 72 received
188	11:28:20.736	Adv. Info	SAM_83FB	SAM_83FB: Spectrum received
189	11:28:20.743	Adv. Info	SAMIP_406B	SAMIP Data complete

Send Query

Basic information about the sensor can be queried with a query command. The response from the sensor contains module or status information, such as the serial number or firmware version of the sensor.

Send query command:

0x23 0x00 0x00 0x80 0xB0 0x00 0x00 0x01

Start	Device ID1	Device ID2	I²C Address	Query	Parameter 1	Parameter 2	End

Receive data from sensor

Response to a measurement command

Example response without IP module:

If the receiver is a RAMSES **without** IP module, it sends back 8 separate spectrum frames. A spectrum frame has the module ID **0x30**. Each frame consists of 64 data bytes. The 32 Int16 values have low - high sequence (little endian) in the data frame. So 0x98 0x09 is the decimal value 2456.

The respective number of the data frame can be read in the frame byte. RAMSES transmits from frame 7 (**0x07**) to frame 0 (**0x00**). When frame 0 has been received, the spectrum is complete.

The 8 frames must then be collected in 256 Int16 arrays.

The first data byte of frame 7 shows no light intensity values and is removed from the spectrum array. The second data byte shows the integration time, which are interpreted as shown in the table on page 44 (“Setting the integration time”). In the following example, the individual frames have already been separated from each other.

23 A0 00 **30** **07** 00 00 0A 0A 98 09 95 09 A6 09 C9 09 CA 09 E6 09 FC 09 1D 0A 59 0A 98 0A 0B 0B 9A 0B 76 0C A2 0D 20 0F ED 10 84 13 A2 17 CC 1C 4D 21 02 25 F1 28 20 2B B8 2B 87 2E 29 32 D3 34 69 3B B1 46 5D 4F 60 53 01

23 A0 00 **30** **06** 00 00 40 57 BD 5B 9C 5F 04 63 1A 66 76 67 35 6B 3F 74 90 7F 6D 8A 34 95 4A 9F 85 A6 3D AA 5E AB 47 AB 87 A8 00 A4 F2 9F AF 9C A1 99 01 95 90 8D AF 86 00 83 5B 80 B8 7C D9 78 8E 76 CA 75 C4 74 DC 72 01

23 A0 00 **30** **05** 00 00 4C 72 67 74 80 77 49 7A 97 7C 99 7D 3A 7D 94 7C 3D 7C 3A 7C FC 7B EE 7A 5B 79 98 77 77 75 CC 72 FD 6F 36 6D 19 6B 2A 69 CC 65 29 61 68 5D E0 5B BA 5A 38 59 D8 57 32 55 EE 52 B9 50 DE 4D 8E 4B 01

23 A0 00 **30** **04** 00 00 41 48 EC 44 71 42 90 40 BF 3E 2B 3C 0B 39 C4 35 A2 32 0B 30 87 2E A3 2D 7E 2C 34 2B D8 29 AA 28 6A 27 82 25 11 23 72 21 4E 21 F6 21 8A 22 2D 23 E8 23 6C 24 E0 23 2C 22 B2 20 49 20 B0 20 ED 21 01

23 A0 00 **30** **03** 00 00 CD 23 A9 25 F0 26 AC 27 E5 27 86 27 4F 26 B7 22 1D 1D D7 19 61 1B BF 1E BA 20 2A 21 C0 20 E6 1F B0 1E 64 1D 2F 1C 28 1B 2E 1A 35 19 3C 18 E8 16 23 15 82 13 7B 12 10 12 BC 11 71 11 3D 11 10 11 01

23 A0 00 **30** **02** 00 00 D6 10 82 10 0C 10 76 0F D4 0E 5F 0E 04 0E 97 0D 2F 0D D9 0C 85 0C 38 0C EE 0B AD 0B 67 0B 1B 0B B9 0A 38 0A CA 09 88 09 69 09 2D 09 FC 08 DF 08 D5 08 BA 08 9A 08 50 08 F8 07 C2 07 A2 07 9A 07 01

23 A0 00 **30** **01** 00 00 8E 07 95 07 8C 07 84 07 87 07 8F 07 8C 07 99 07 98 07 97 07 95 07 8F 07 96 07 90 07 88 07 7C 07 76 07 74 07 64 07 60 07 58 07 51 07 44 07 39 07 26 07 22 07 12 07 04 07 FC 06 EE 06 E2 06 DA 06 01

23 A0 00 **30** **00** 00 00 D1 06 CB 06 BA 06 B3 06 B0 06 A1 06 9B 06 94 06 90 06 84 06 84 06 8D 06 84 06 81 06 7E 06 82 06 7C 06 88 06 78 06 7D 06 7E 06 80 06 7C 06 79 06 82 06 79 06 75 06 82 06 83 06 83 06 85 06 AB 06 01

Calculation of the integration time: Time = 2 ^ (x + 1) [ms]

Example response with IP module

If the receiver is a RAMSES **with** IP module, an IP frame is sent in addition to the spectrum frames (**0x30 0x07**...**0x30 0x00**). The IP frame can be located at any position in the frame sequence, not always at the beginning or end. The IP frame can be recognized by the module ID **0x20**. Pressure and inclination can now be calculated from this frame.

23 60 00 **20** 00 00 00 38 5B 00 0D **A3 8D** 3C 01 87 04 FA 04 F9 04 97 00 01

Calculation of the inclination

For the calculation of the slope, coefficients from the supplied ini-file are required in addition to the sent data.

Coefficients from ini file:

Incl_XGain	= 0.94
Incl_YGain	= 0.94
Incl_XOffset	= 126
Incl_YOffset	= 127

23 60 00 20 00 00 00 38 5B 00 0D **A3** **8D** 3C 01 87 04 FA 04 F9 04 97 00 01

X	=	(**Byte11** – Incl_XOffset) · Incl_XGain
	=	(163 – 126) · 0.94
	=	34.780°

Y	=	(**Byte12** – Incl_YOffset) · Incl_YGain
	=	(141 – 126) · 0.94
	=	14.10°

The unit for the angles X and Y is degrees °. For the calculation of the inclination the correct angle measure should be observed.

In the example calculation, the angles were converted to radians and converted back to degrees for the output.

$$\text{Inclination} = \operatorname{atan}\left(\sqrt{\left(\left(\tan\left(X \cdot \frac{pi}{180}\right)\right)^2 + \left(\tan\left(Y \cdot \frac{pi}{180}\right)\right)^2\right)}\right) \cdot \frac{180}{pi}$$

Inclination = 36.4469°

Calculation of the pressure

For the calculation of the pressure, coefficients from the ini file are required in addition to values from the IP frame. With these coefficients and further values to be read from the frame the pressure can be calculated.

Coefficients from ini file:

Incl_KRef	= 0.1264
Incl_KBG	= 1.1940
Press_Sens_mV_bar_1mA	= 4.87
Press_Sens_mV_bar_4mA	= 19.48
Press_Gain	= 5.4453
Press_Surface_bar	= 2.73

23 60 00 20 00 00 00 38 5B 00 0D A3 8D **3C 01** 87 04 **FA 04 F9 04 97 00** 01

npress	=	Byte14	· 256	+ Byte13
	=	1	· 256	+ 60
nbg	=	Byte18	· 256	+ Byte17
	=	4	· 256	+ 250
nrefh	=	Byte20	· 256	+ Byte19
	=	4	· 256	+ 249
nrefl	=	Byte22	· 256	+ Byte21
	=	0	· 256	+ 151
noffset	=	**nrefl** – (Incl_KRef · (**nrefh**-**nrefl**))		
	=	151 – (0.1264 · (1274 – 151))		
	=	9.1792		
VPress [V]	=	Incl_KBG	· (**npress** – noffset)	/ (**nbg** – noffset)
	=	1.1940	· (316 – 9.1792)	/ (1274 – 9.1792)
	=	0.28964 V		
press_sens	=	Press_Sens_mV_bar_4mA		
	=	19.48		
p [bar]	=	1000 · VPress / (press_sens · Press_Gain)		
	=	1000 · 0.28964 / (19.48 · 5.4453)		
	=	2.73 bar		

Further calculations

Depth pressure	=	p – 1.021 bar
water depth	=	1.709 · 10 m

If press_sens ≤ 0 the following value must be used:
press_sens = 4 · Press_Sens_mV_bar_1mA

Answer to a query

A query response contains important module and status information. A query can be sent to different modules. In the following example the response is given by module ID 80 (SAMIP). However, it is also possible to receive data from the IP module (0x20) or from the SAM module (0x30). For this the module ID must be changed in the command.

Of the 8 data bytes that the sensor sends as a response, the last 4 bytes are only used for internal purposes and can be ignored.

SAMIP

23 **40** **00** **80** **FF** **00** **00** **6B** **40** **93** **01** 05 16 00 20 01

Device ID: contains beside the DeviceID also the block size: 0x40 → **01**00**0000**
Blocksize: 008
Modul ID: 80
Frame Byte: FF → Information Frame
Reserved: 0000
Serial number: 406B
Firmware Version: 1.93

IP Modul

23 40 00 **20** FF 00 00 12 C1 00 01 02 00 48 C8 01

Device ID: contains beside the DeviceID also the block size: 0x40 → **01**00**0000**
Blocksize: 008
Modul ID: 20
Frame Byte: FF → Information Frame
Reserved: 0000
Serial number: C112
Firmware Version: 1.00

SAM-Modul

23 40 00 **30** FF 00 00 8D 85 06 02 04 A7 06 00 01

Device ID: contains beside the DeviceID also the block size: 0x40 → **01**00**0000**
Blocksize: 008
Modul ID: 30
Frame Byte: FF → Information Frame
Reserved: 0000
Serial number: 858D
Firmware Version: 2.06

RAMSES G2 Modbus RTU

Software Version

This Modbus protocol refers to software version 1.0.8 and higher.

Serial interface

At delivery, the RAMSES-G2 sensors serial interface is configured for RS485 operation using the following setting:

- Baudrate: 9600 bps
- Datenbits: 8
- Stopbits: 1
- Parity: none

Data types

Name	Register Count	Format
Bool	1	false: 0x0000, true: 0xFF00
Uint8	1	unsigned 8 bit integer. Value range: 0x0000 - 0x00FF
Uint16	1	unsigned 16 bit integer. Value range: 0x0000 - 0xFFFF
Uint32	2	unsigned 32 bit integer. Value range: 0x00000000 - 0xFFFFFFFF
Float	2	IEEE 754 32 bit floating point value.
Char[n]	$\left[\frac{n}{2}\right]$	ASCII string of n characters.
Uint16[n]	n	Array of n Uint16 values.
Float[n]	2n	Array of n Float values.

Functions

These Modbus function codes are supported by RAMSES-G2:

Name	Code	Description / Application
Read multiple registers	0x03	Read the serial number and firmware version, configuration, calibration data and measurement data.
Write multiple registers	0x10	Write configuration data.
Write single register	0x06	Trigger a measurement process.
Report slave ID	0x11	Read serial number and firmware version.

Default slave address

At delivery, the RAMSES-G2 sensors Modbus slave address is set to 1 (0x01).

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

The following table describes the Modbus register mapping:

Name	R/W	Address	Data type	Description
Modbus slave address	RW	0	Uint16	The Modbus slave address of the RAMSES-G2 sensor. Valid IDs: 1…247
Measurement timeout	R	1	Uint16	The timeout in [10^{-1} s] of a running measurement process (see “Trigger measurement”).
Deep Sleep timeout	RW	2	Uint16	The timeout in [10^{-1} s] of the internal Deep Sleep function. If this counter hits 0, the device will go into Deep Sleep.
Device serial number	R	10	Char[10]	The serial number of the RAMSES-G2 sensor.
Firmware version	R	15	Char[10]	The installed firmware version.
Self-trigger activated	RW	102	Bool	Enables or disables the self-trigger. For external trigger: deactivate the self-trigger. Hint: If used with a control unit it is recommended to disable the self-trigger.
Self-trigger interval	RW	103	Uin32	The interval in [s] for self-triggered measure-ments. Value range: 1s – 86400s. Hint: If used with a control unit it is recommended to disable the self-trigger.
Integration Time	RW	107	Uint16	0: automatic 1: 4 ms 2: 8 ms …n: 2n+1 ms (Max: n=12 for ~8s)
Data comment #1	RW	109	Char[64]	1st custom comment row for meas-ured data.
Data comment #2	RW	141	Char[64]	2nd custom comment row for measured data.
Data comment #3	RW	173	Char[64]	3rd custom comment row for measured data.
Data comment #4	RW	205	Char[64]	4th custom comment row for measured data.
System date and time	RW	237	Uint32	The date and time in seconds since 1970/01/01.
Device description	RW	239	Char[64]	A custom device description. E.g.: „Reference 1“.
Lan Enable State	RW	273	Uint16	Enables or Disables the LAN-Interface to save Power. The state of this setting is saved across restarts. When Turning on, the Device has to be restarted before the Web-Interface works again. 0x0000: off 0xFFFF: on Other values are reserved for future use.
Dark Pixel Start	RW	274	Uint16	First Dark Pixel of the Spectrometer, 0-based
Dark Pixel Stop	RW	275	Uint16	Last Dark Pixel of the Spectrometer, 0-based
Light Pixel Start	RW	276	Uint16	First Functional Pixel of the Spectrometer that is exposed to Light during measurements. 0-based
Light Pixel Stop	RW	277	Uint16	Last Functional Pixel of the Spectrometer that is exposed to Light during measurements. 0-based

PAR	R	1000	Float	Reserved for future use – currently NaN.
Spectrum type	R	2000	Uint16	The type of the last measured spectrum. Values: 0x0004: Raw Light
Integration time	R	2005	Uint16	The integration time of the spectrometer used for the measurement.
Temperature	R	2007	Float	Temperature during last Measurement in °C. Taken from the Pressure Sensor.
Length	R	2009	Float	The count of values in the last measured spectrum. The length varies, because the spectra data is limited to the range of [320nm ; 950nm] for a VIS RAMSES, [280nm ; 500nm] for a UV RAMSES-G2 or rather [280nm ; 720nm] for a UV/VIS RAMSES-G2.
Pressure	R	2011	Float	Pressure during last Measurement in bar.
Pre-Inclination	R	2013	Float	Inclination Angle in Degrees (0-360) taken before the Light-Measurement. Normed so that 0° means the Sensor Points up.
Post-Inclination	R	2015	Float	Inclination Angle in Degrees (0-360) taken after the Light-Measurement. Normed so that 0° means the Sensor Points up.
Temperature Inclination Sensor	R	2030	Float	Temperature measured by the Inclination Sensor during the last Measurement, in °C.
Temperature Pressure Sensor	R	2032	Float	Temperature measured by the Pressure Sensor during the last Measurement, in °C.
Pre-Measurement Inclination X	R	2034	Float	Inclination X-Angle in Degrees (0-360), taken before the Light-Measurement
Pre-Measurement Inclination Y	R	2036	Float	Inclination Y-Angle in Degrees (0-360), taken before the Light-Measurement
Pre-Measurement Inclination Z	R	2038	Float	Inclination Z-Angle in Degrees (0-360), taken before the Light-Measurement
Post-Measurement Inclination X	R	2040	Float	Inclination X-Angle in Degrees (0-360), taken after the Light-Measurement
Post-Measurement Inclination Y	R	2042	Float	Inclination Y-Angle in Degrees (0-360), taken after the Light-Measurement
Post-Measurement Inclination Z	R	2044	Float	Inclination Z-Angle in Degrees (0-360), taken after the Light-Measurement
Pre-Measurement Pressure	R	2046	Float	Pressure before the last Measurement, in bar
Post-Measurement Pressure	R	2048	Float	Pressure after the last Measurement, in bar
Dark Pixel Average	R	2050	Float	Average Value of all Dark Pixels (see Dark Pixel Start and Dark Pixel Stop)
Abscissa	R	2100	Float[Length]	The values of the abscissa of the graph of the last measured spectrum. In general these are the wavelengths.

Ordinate	R	2612	Float[Length]	The values of the ordinate of the graph of the last measured spectrum. In general these are the intensity values.
Raw Ordinate	R	3124	Uint16[Length]	The values of the ordinate of the graph of the last measured spectrum as raw values between 0 and 65535

Write single register (0x06)

A special case of the “write single register” function is writing to the following register. Instead of changing configuration values, special actions are performed.

Name	Address	Description
Trigger measurement	1	A single measurement is triggered. Depending on the value written, a different type of measurement is performed: 0x0400: Raw Light Other values are reserved for future purpose and may result in undefined behavior, yet.

Report slave ID (0x11)

The production Company, sensor name, serial number and firmware version is replied each as null terminated ASCII string.

Example:

T	R	I	O	S	0x00	R	a	m	s	e	s	G	2	0x00	0	1	6	0	0	0	0	0

0x00	1	.	0	.	0	0x00