Spectromarine-one - fully autonomous submersible optical spectroscopy water quality sensor

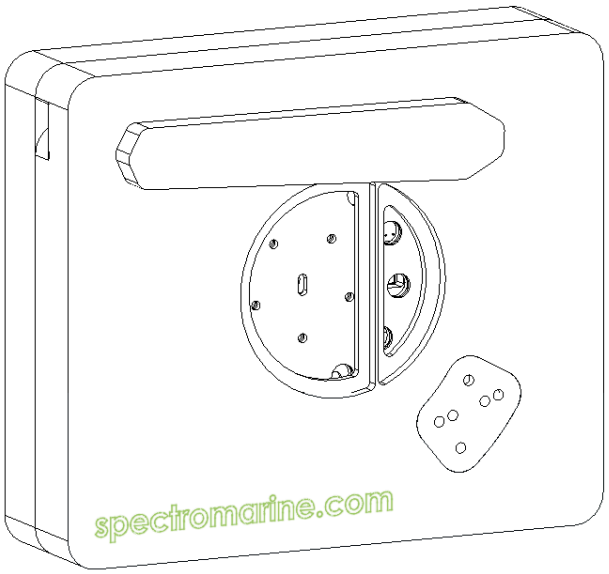

Fig. 1. Overview of the device

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1 Features

- Fully autonomous assessment of water quality
- 12 different parameters from a single device - fluorescence/absorption, temperature, conductivity, pressure
- Visible light spectrometer for full spectral analysis
- CMOS camera for image and video capture
- Automated on-device data analysis for a selection of parameters
- Waterproof casing rated to 20m depth (3bar)
- Single-wire POE+ operation - up to 100m cable length
- Plug-and-Play IoT operation
- Integrated SQL database

2 General description

Spectromarine is a platform that consists of three main components - hardware, data collection/analysis software and database. The aim of the technology is to utilize novel measurement sensors in combination with on-device automated spectral analysis to bridge the gap between high quality laboratory data and well-automated and durable on-line sensors. Thus, the focus is on getting high-sensitivity measurements of many different characteristics of water using a single detection system while still keeping the ease of installation and operation of the device. The device is tailored to be used in fully automated systems, data-driven processes and “industry 4.0” facilities and supports data output in raw form for machine learning systems, if necessary.

Spectromarine-one device is a submersible unit with a single wire attached to it. It should be mounted underwater and connected to the internet and power through all operation time.

3 Device dimensions

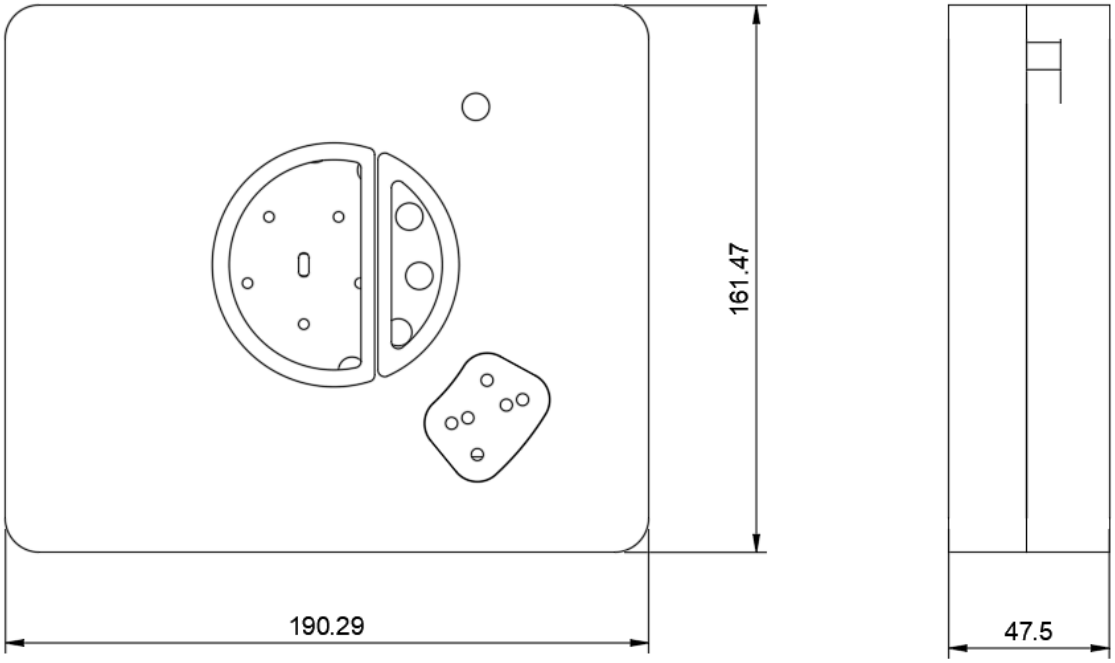


Fig. 2. Device dimensions (sizes are in mm)

4 Mounting of the device

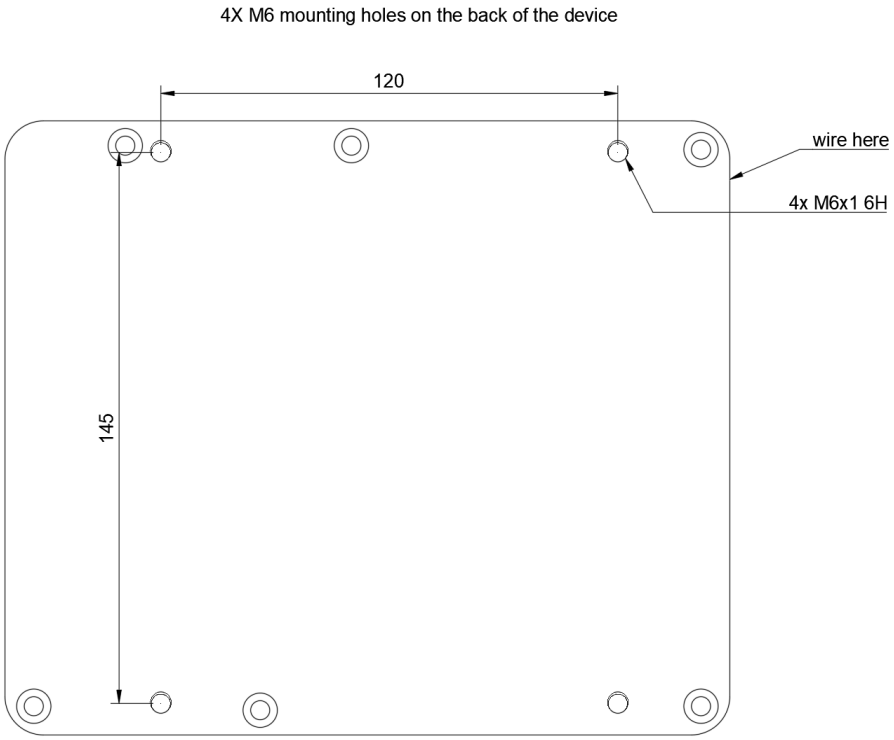


Fig. 3. mounting holes for the device.

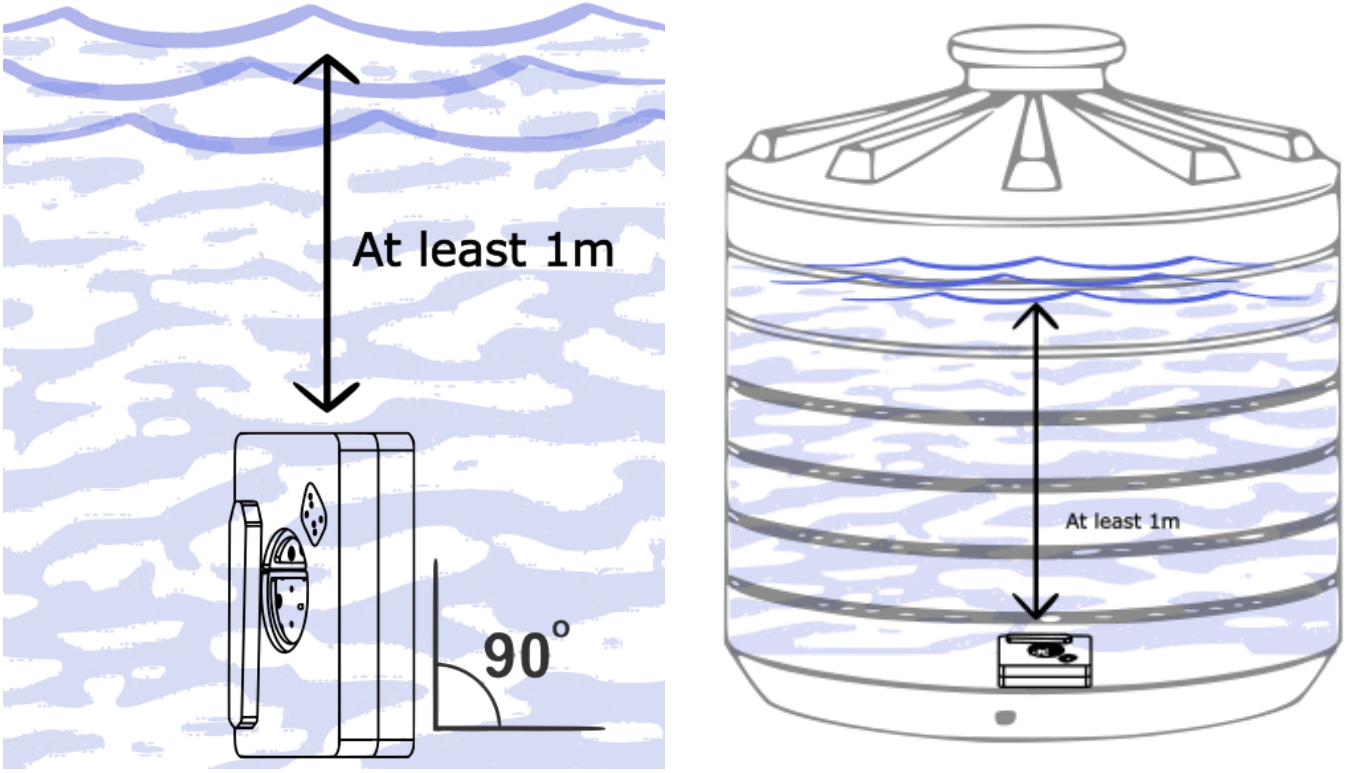


Fig. 4. Mounting examples.

The device can be mounted on a stationary mount, movable vessel or inside a water tank. Recommended depth for the mount is 1m-10m, facing 90 degrees to the surface of the water. Preferably, without the direct sunlight (in a shaded area). When mounted inside the water tank, the minimum length in water to the first obstacle (lid, water surface, pipe etc.) should be at least 1m in front of the device.

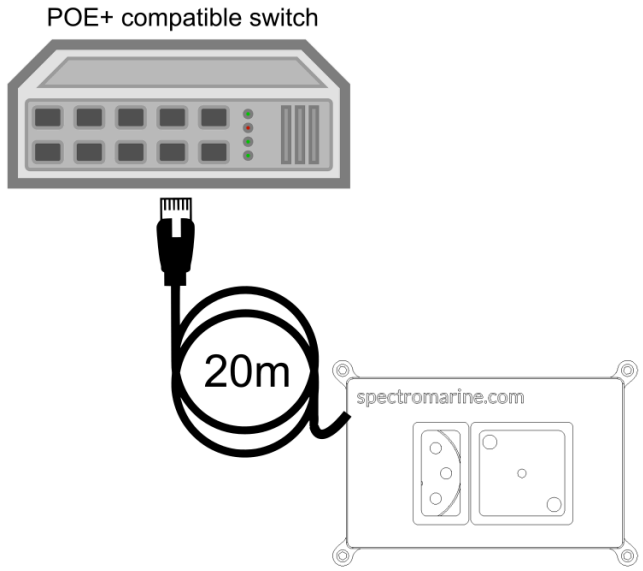
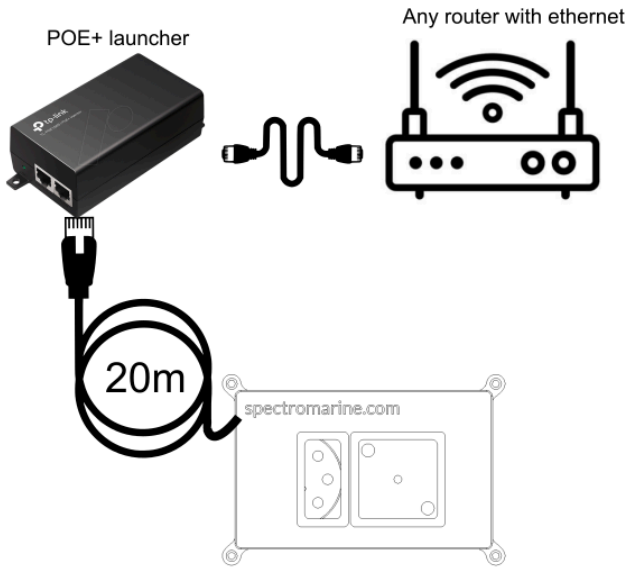
If the sensor is mounted inside pipes or without access to artificial or natural lighting, absorption measurements will be performed using diffuse scattering with an array of leds from the device.

5 Connectivity

The device uses a single 20 meter non-detachable ethernet CAT-5 cable for connection of the device[1]. Power delivery and network connectivity are established using the Power over Ethernet (PoE+) protocol.

There are various connection possibilities:

[1] The cable length can be extended up to 100m with simple female-female ethernet connector provided with the device

	If POE+ system is already available. The device can be connected directly to any POE+ system and will fully utilize available 25W of power.
	If POE+ system is unavailable - POE+ injector can be used, which uses 220V mains input to inject power required for sensor operation to any ethernet-capable system. Wireless routers, repeaters, switches and 4g-5g routers can be used with this configuration. It is recommended to install POE+ injector as close as possible to the sensor to prevent power losses over long cables.

6 Calibration procedure

To ensure reliable performance and accurate data, the sensor requires a one-time calibration at first installation. This process is carried out using the supplied calibration box and should be completed before placing the device in its operating environment.

1. **Preparation**
    - Place the sensor inside the provided calibration box according to the provided instructions inside of the box.
    - Fill the box with the water from the operational environment until the sensor is fully submerged - to the marked line.

- Connect the device to power/network.

2. **Calibration Cycle**
   - Keep the sensor inside of the box.
     Allow the device to operate undisturbed for **30 minutes** while it performs a complete calibration cycle.
3. **Deployment**
   After the cycle is complete, remove the sensor from the calibration box.
   - Position the device in its intended operating environment and begin normal measurements.

⚠️ **Important:** This calibration is required **only once**, at the time of initial installation. Repetition is not necessary unless specifically advised by technical support.

7 Database access

The sensor is equipped with an integrated microprocessor that maintains a structured on-device SQL database (MariaDB). All measurements are stored in tables and updated automatically by the internal software. In addition, the device automatically synchronizes data with cloud SQL database if connection to the internet is available on the network that the device is connected to.
The on-device GUI can be accessed by the users from any device on the same local network, or cloud GUI can be accessed from anywhere else if the device has access to the internet.

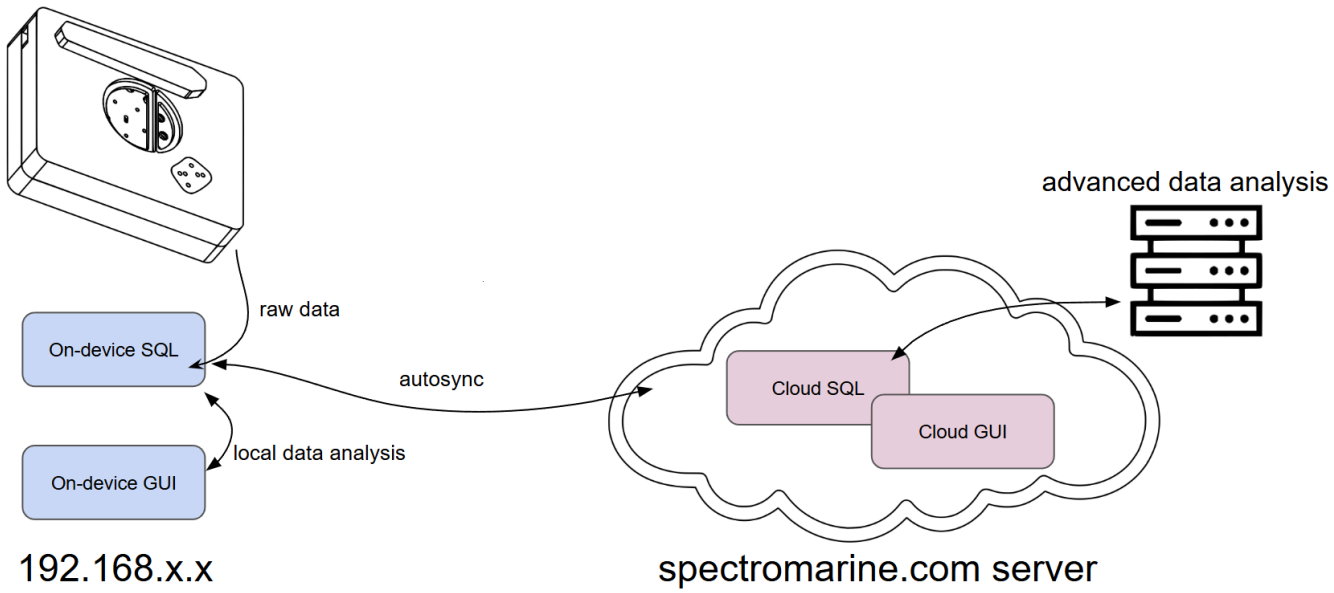


Fig. 5. Mounting examples.

The data control for the device consists of multiple steps:

1) Device performs a measurement and stores the raw data in the on-device SQL database
2) Device performs a partial analysis of the raw data and stores processed data in the on-device SQL database
3) Device connects to the external cloud server and transfers the raw data to the cloud SQL database

4) A separate computer accesses cloud SQL database and performs advanced data analysis, and stores the processed datapoints in the cloud SQL database
5) Cloud SQL database is then synchronised with the on-device SQL database.

The user can access the data from both on-device SQL database as well as cloud SQL database. The connection credentials and database structure are provided with each sensor separately.

To connect to the on-device SQL database, user has to follow following steps:

1. Prerequisites
- A computer connected to the same local network as the sensor.
- An SQL client installed (for example: DBeaver, HeidiSQL, MySQL Workbench, or the standard mysql command-line client).
- Database login credentials (host IP address, username, password, and database name), provided with the device.

2. Locating the Device on the Network
- Connect the sensor to your local network using Ethernet or Wi-Fi.
- Obtain the device's IP address. This can be done by:
    - Using your router's DHCP client list.
    - Running a network scanner (e.g., nmap) on your subnet.

8 Measurable parameters

The Spectromarine One platform is capable of measuring a broad spectrum of biological, chemical, and physical parameters in both freshwater and marine environments. Using multi-excitation optical spectroscopy combined with auxiliary sensors, it provides high selectivity and sensitivity across diverse water quality indicators. The following list summarizes all parameters currently measurable or under validation. In addition, other sensors are present in the device - temperature, pressure and conductivity, providing a holistic insight on the state of the environment. Together, they form a comprehensive dataset that supports applications in desalination, aquaculture, environmental monitoring, and industrial water treatment.

Measurable parameters:

Chlorophyll α
Primary photopigment in photosynthetic organisms. Indicator of algal biomass and growth rate.
Chlorophyll β
Accessory photopigment, often linked to degradation processes in photosynthetic organisms. Useful for assessing stress or mortality in algae.
Phycocyanin (and supporting pigment groups)
Pigment characteristic of cyanobacteria (blue-green algae). Strong marker for harmful algal blooms and related biofouling risks.
Total Organic Carbon (TOC)
Indicator of organic contamination in water, originating from natural and anthropogenic sources. Relevant for process monitoring and fouling risk assessment.

Dissolved Organic Matter (DOM)
Complex mix of organic materials including microbial residues, fecal matter, and dissolved organics. Sensitive parameter for water treatment and environmental monitoring.

Turbidity (TSS)
Assesses concentration of suspended solids larger than microscopic scale, indicating water clarity and particulate load.

Carotenoids
Pigments present in specific algal and microbial groups. Can serve as taxonomic or species-specific markers when concentrated.

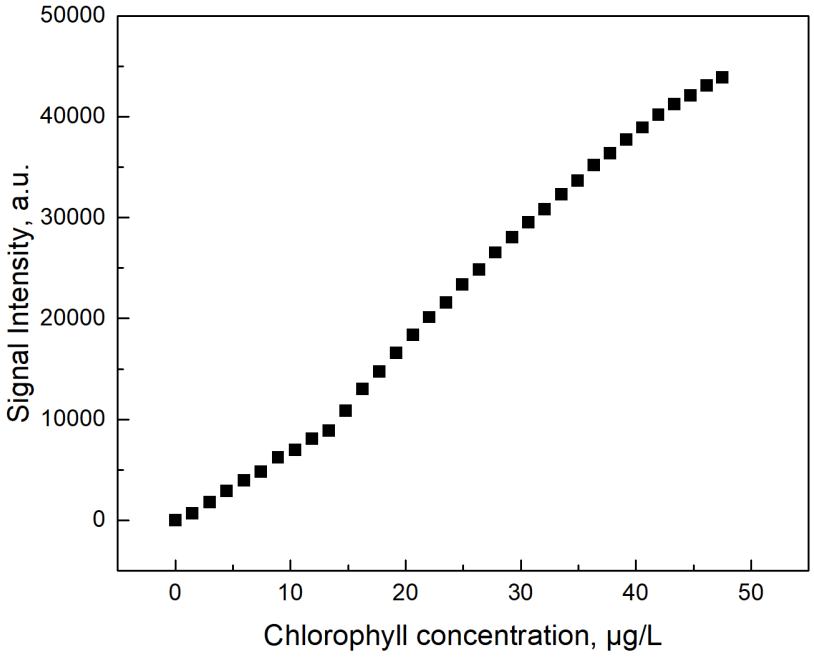
Hydrocarbons
Detects petroleum products, solvents, oils, and polymer residues. Relevant for pollution detection and industrial water quality control.

Water Temperature
High-precision measurement of water temperature across a wide range (-5 to 80 °C, precision of 0.05°C)

Salinity / Conductivity
Measures dissolved salt concentration, a key parameter for seawater and brackish water monitoring.

Water pressure
Measures water pressure - used for water level measurements.

Chlorophyll calibration data:



Chlorophyll can be detected from 0.2µg/L , device is pre-calibrated and data is analysed on-device.

/// ONGOING CALIBRATION - this datasheet will be updated when the calibration activities will finish///

As of version 17121xxxxx, a CMOS sensor was added in the device capable of measuring turbidity, particle flow speed/direction and fluorescence turbidity.

9 Contacts and support

The device was developed in the Laboratory of Optical Materials, Institute of Solid State Physics, University of Latvia, and was transferred to Spectromarine B.V. from Q3 2025.

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