Spectromarine - fully autonomous submersible optical spectroscopy water quality sensor

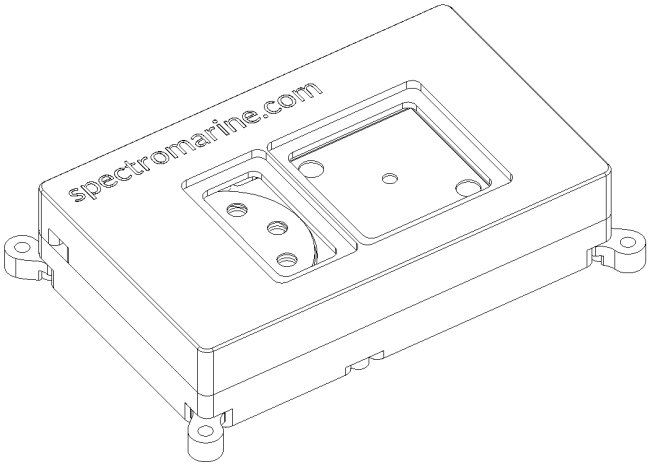


Fig. 1. Overview of the device

Table of contents

1 Features

- Fully autonomous assessment of water quality
- Array of different excitation LEDs and tailored detection filters for calibrated fluorescence and absorption measurements
- 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)[1]
- Single-wire POE+ operation - up to 100m cable length
- Plug-and-Play IoT operation

2 General description

Spectromarine is a technology developed in the Institute of Solid State Physics, University of Latvia and 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.

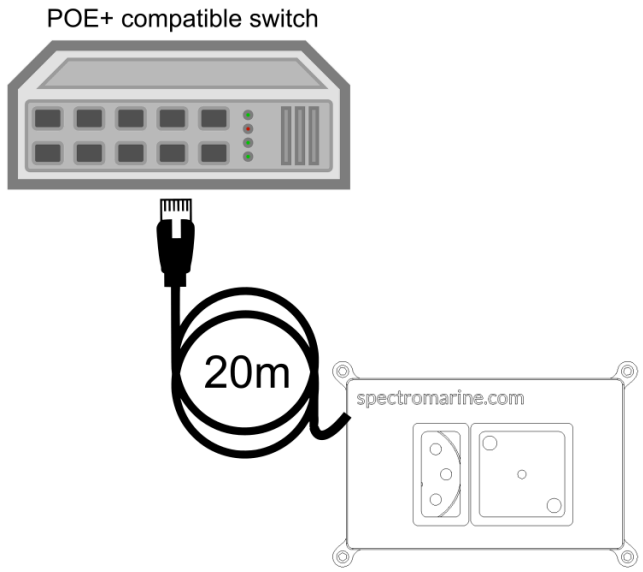
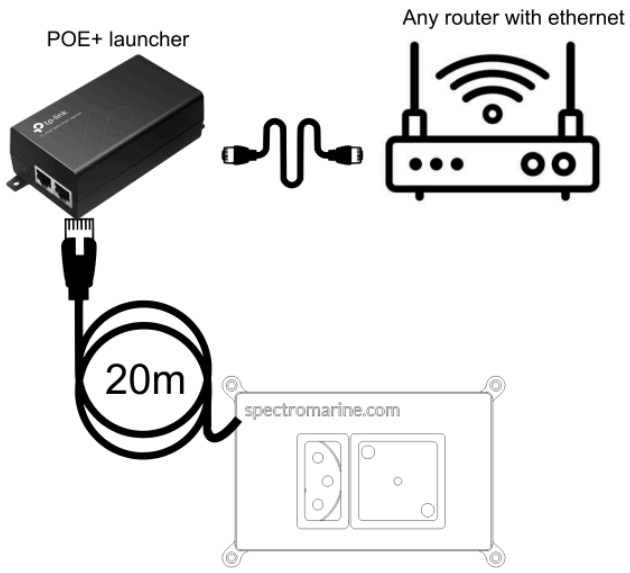
This is not a ready product. As of this (Q4 2024) revision, technology readiness level (TRL) is **6** - device was tested in relevant environments; however, real performance may vary and should be thoroughly verified before further “real world” use.

[1] tested to 3 bar for 2h without failure-state - actual rating may vary

3 Connectivity

The device uses a single 20 meter non-detachable ethernet CAT-5 cable for connection of the device[2]. Power delivery and network connectivity are established using the Power over Ethernet (PoE+) protocol.

There are various connection possibilities:

	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.

Our current field tests have employed a PoE+ compatible 4G router to send data to a server and enable the control of the device remotely for troubleshooting purposes. On the server side, applications like ThingsBoard can be used to integrate a device into a local network environment for data storage and analysis.

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

4 Mounting of the device

The device is mounted using four M6 bolts with windows facing up

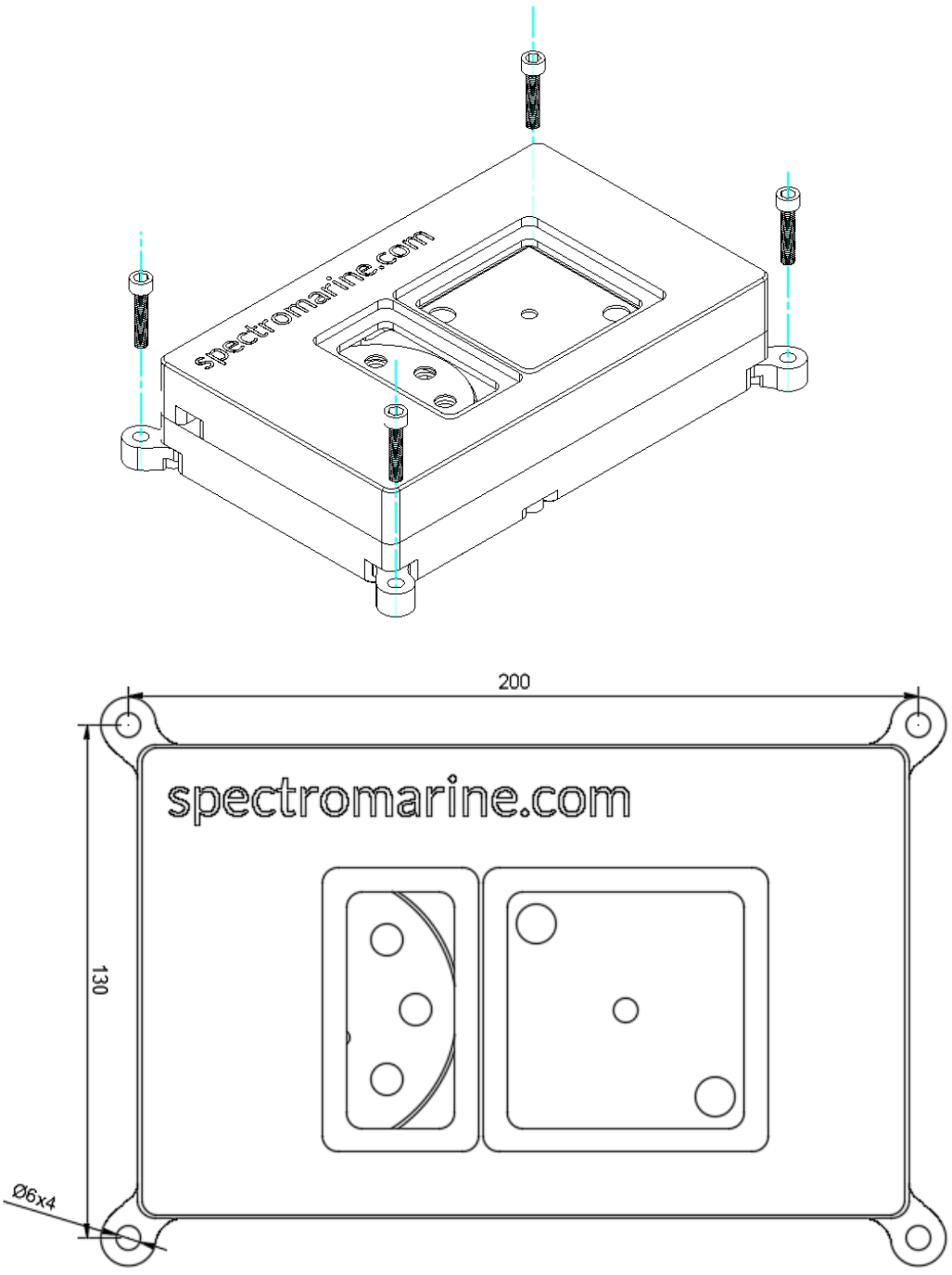
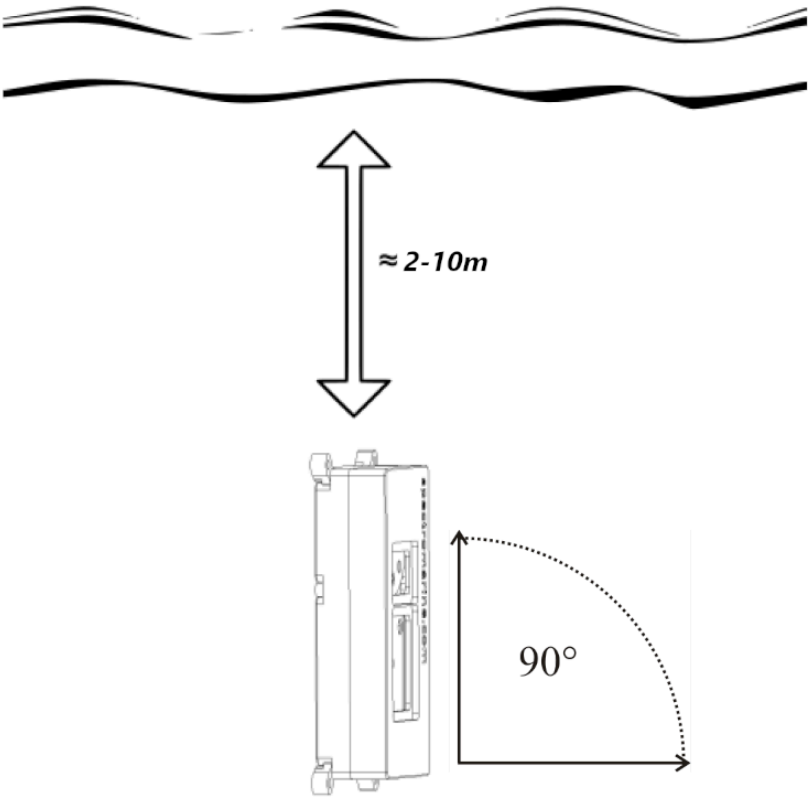


Fig. 2. mounting holes for the device.

The 1:1 drawing (A4 page) is available in printable Annex 1. for easy hole drilling in constructions and mounting plates.



The device can be mounted on a stationary mount, movable vessel. Recommended depth for the mount is 2m-10m, facing 90 degrees to the surface of the water. Preferably, without the direct sunlight (in a shaded area).
If the sensor is mounted inside pipes or without access to artificial or natural lighting, absorption measurements will be performed using diffuse scattering - much less precise, although still usable, method of measurements. This will not affect fluorescence and turbidity measurements.

5 Measurable parameters

- Chlorophyll (distinction of different types a-, b-)
- Phycocyanin
- Dissolved organic matter (with separation to components)
- Hydrocarbons - oils, fuels
- Any fluorescent compound with excitation 270-600nm and emission 330-800nm

Spectrometer - laboratory calibration tests:
Detection limit of the device was tested in laboratory conditions for two main substances in water: chlorophyll and phytocyanin.

- Chlorophyll was tested using *Chlorella vulgaris* dried powder - still detectable at 0.75 mg/L (projected chlorophyll concentration of 15µg/L) [3]
- Phycocyanin was measured using *Spirulina fusiformis* dried powder and was still detectable at 0.75 mg/L

[3] Real detection limit is varied based on ambient lighting and is lower than these values. Tests were stopped due to the limit being outside of “real world conditions”. Additional tests will be performed in Q2 2024.

Full list of parameters is available upon request - its changing with the data analysis timeline.

As of version 17121xxxxx, a CMOS sensor was added in the device capable of measuring turbidity, particle flow speed/direction and fluorescence turbidity - no tests were performed yet - ETA Q1 2025.

6 Contacts and support

The device was developed in the Laboratory of Optical Materials, Institute of Solid State Physics, University of Latvia.

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