SODAQ

Building a sustainable internet of things

# WEC

## USER MANUAL


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# Chapter 1

# Introduction


Figure 1.1: Water EC meter

The purpose of the Water Electrical Conductivity (WEC) sensor is to provide an indication of (drinking) water quality. Electrical conductivity (EC) reflects the ability of a specific material to conduct an electric current, in micro Siemens, or $\mu$S/cm. For reference, tap water in the Netherlands has a value of 200 to 300 $\mu$S/cm, seawater around 50,000 $\mu$S/cm depending on where the sample is taken from.

To read the values, the sensor unit needs to be connected with a cable to a smartphone. A mobile app, Akvo Caddisfly, is used to display the water electrical conductivity.

# Chapter 2

# Specifications

| | |
|---|---|
| **Powered by** | micro-USB, 5V |
| **Output** | Digital, USB |
| **Operating current** | 30mA |
| **Operating temperature** | -10℃ to 60℃ |
| **Recommended Operating temperature** | 20℃ to 25℃ |
| **Waterproofing** | epoxy filling, rated for 1.5m depth of water |
| **Probe material** | Stainless steel 316 |
| **Casing** | Aluminum, polyurethane |
| **Measurement range** | 50-12800$\mu$S/cm |

# Chapter 3

# Using the device

## 3.1 Setting up

- Make sure, that the Caddisfly app is installed on your phone and start the app. You can obtain the application by downloading it from the Google Play Store (listed as Akvo Caddisfly)
- Plug the sensor in the micro-USB port of the phone
- Take a sample of the water to be tested (has to be taken in a clean and dry sample container)

## 3.2 Using

- The sensor is placed in the measuring container
- When inserting the sensor in the water sample, **make sure the probes are fully submerged in the sample!**
  - For the most constant reading, it is advised to stir the sample slightly with the sensor when inserting the sensor.
- Click 'read' in the app. The display on the smart-phone provides the value of the EC in $\mu$S/cm immediately, nevertheless the operator should wait until the output reading stabilizes
- The actual value of the water is read, stored to the memory and sent to the database
- After the measurement the unit has to be rinsed with clean water and dried with a clean cloth

# Appendix A

# Settings and Debugging

## A.1 Installing the Arduino IDE and drivers

Info on `www.support.sodaq.com`

1. Download the Arduino IDE `https://www.arduino.cc/en/Main/Software`
2. Install the Arduino IDE and start it
3. Click on File → Preferences and at the bottom you should see 'Additional Boards Manager URLs'. This is where you need to paste the following URL: `http://downloads.sodaq.net/test/package_sodaq_index.json`
4. When you have pasted the URL, click 'OK' and you are ready for the next step.
5. Click on Tools → Board → Boards Manager
6. Scroll all the way to the bottom, you should see SODAQ SAMD Boards. Click on it, and install the latest version.

Now it is possible to use the built in serial monitor of the Arduino IDE (Tools > Serial Monitor) or use a different serial monitior i.e. PuTTY.

## A.2 Programming the sensor

The micro-USB connector that sends the data to the smartphone or the computer, is also used to program new software on the microcontroller of the sensor.
After downloading the SODAQ board files, the sensor can be updated to the latest software. For connecting the micro-USB to a computer, a micro-USB female to male USB converter is needed. The sensors are programmed by the manufacturer with the latest software, but is otherwise fully open source to the buyers.

## A.3 Menu

The sensors come pre-programmed and pre-calibrated. The following commands can be used with a computer to get different values from the device or whenever necessary recalibrate or change certain values.

| **COMMAND** | **RESPONSE/KEY** |
|---|---|
| STATUS | "OK" |
| DEVICE | Identifier ID (e.g. "WaterEC 101") |
| READING | Temperature, EC,<br>ranges 0-50, 0-100000 (e.g. 25.1,254.3) |
| R (same like reading, for compatibility with older versions) | Temperature, EC,<br>ranges 0-50, 0-100000 (e.g. 25.1,254.3) |
| RAW | Temperature, Resistance,<br>ranges 0-50, 0-100000 (e.g. 25.1,254.3) |
| READWITHOUTTEMP | EC 0-100000 (e.g. "352") |
| GET <KEY> | The value of KEY or NOT_SUPPORTED<br>Water EC KEY options:<br>"POINT <NUMBER 1-6>" (no space)<br>"POINTS"<br>"ID"<br>(e.g. "55.55") |
| SET <KEY> "VALUE" | Water EC set KEY options:<br>"POINT<NUMBER 1-6>" (no space)<br>"ID" |
| PROCESS | Water EC Calibration process<br>Instructions in the terminal |

# Appendix B

# Calibration

The sensors come pre-programmed and pre-calibrated from the factory. If a sensor needs to be re-calibrated, the following steps have to be followed:

1. The Water EC is calibrated using 6 measurements. Prepare the salt-water solutions using the readily available solutions:
   - 141$\mu$S/cm (mix of 50ml of 1413 and 450ml distilled water)
   - 235$\mu$S/cm (mix of 50ml of 1413 and 250ml distilled water)
   - 471$\mu$S/cm (mix of 100ml of 1413 and 200ml distilled water)
   - 1413$\mu$S/cm (fixed number)
   - 3000$\mu$S/cm (fixed number)
   - 12880$\mu$S/cm (fixed number)
2. Open the serial monitor (in Arduino IDE: Tools > Serial Monitor) and type 'process'→ENTER to start the calibration process
3. Follow the instructions on serial monitor.

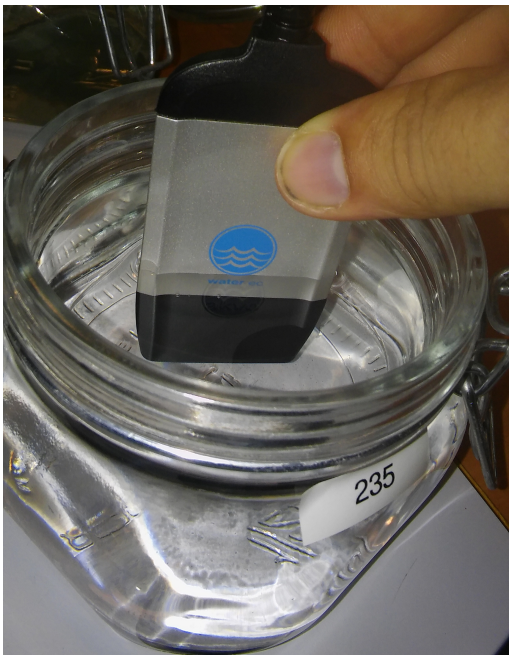


Figure B.1: Calibrating the Ec sensor in 235 liquid

# Appendix C

# Validation

The water EC meter validation document from water quality laboratory of UNESCO-IHE in Delft, The Netherlands (3 pages, written by Arthur Heijstek of Akvo):

# Performance of the Akvo Caddisfly EC sensor.

## Validation of Akvo's EC sensor

### 1. Methodology

The following section discusses the methodology that is used in performing a validation test of a sample of random selected Akvo Caddisfly EC sensors. The test has been performed on 10-10-2016 at the water quality laboratory of UNESCO-IHE in Delft, The Netherlands. This test is performed in order to describe the accuracy of Akvo Caddisfly EC sensors.

#### 1.1 Definition of accuracy: trueness and precision

**Accuracy** is defined as the 'closeness of agreement between a test result or measurement result and the true value'. Accuracy refers to a combination of trueness and precision (ISO 3534-2:2006, clause 3.3.1). See figure 1 for a visual explanation of trueness and precision.

**Trueness** is defined as the 'closeness of agreement between the expectation of a test result or a measurement result and a true value'. In practice, the accepted reference value is substituted for the true value (ISO 3534-2:2006, clause 3.3.3).

- Trueness is determined by calculating the deviation percentage of the mean of the sample in relation to the reference value.

**Precision** is defined as the 'closeness of agreement between independent test / measurement results obtained under stipulated conditions (ISO 3534-2:2006, clause 3.3.4).

- Precision is determined by the standard error formula and then transformed into relative standard error in %.

#### 1.2 Standard Solutions

The following standard solutions have been used in performing the validation test.

| Concentration (Mols/L) | Electric Conductivity (µS/cm) |
|---|---|
| 0,10 | 11550 |
| 0,02 | 2600 |
| 0,0030 | 458 |
| 0,0013 | 223 |
| 0,0010 | 137,4 |

## 1.2 Test procedures

Six random selected Akvo Caddisfly EC sensors were selected for analysis. With every sensor, 5 measurements were performed on each standard solution. Moreover, a reference value of the standard solution was created by measuring the conductivity with a **…… meter.** The average of the 5 measurements for each sensor and the reference value were used to calculate trueness and precision, according to the definitions of the previous section. In between measurements sensors were rinsed with distilled water and dried with dry paper. For every sensor measurement were performed starting at the lowest EC-standard solution and ending the highest EC-standard solution in order to minimize the effect of the mixing of different standard solutions (a small concentration has fewer impact on high concentration then vice versa). The results are displayed in the next section.

## 1.3 Results

| | | EC standard solution (uS/cm) | | | | |
|---|---|---|---|---|---|---|
| | | **205/235** | **205/220** | **435/454** | **2680** | **12580** |
| PVC-EC1 | EC-lab value | 205 | 205 | 435 | 2680 | 12580 |
| | Average EC (n=5) | 200 | 199 | 430 | 2616 | 12267 |
| | Relative STDEV (%) | 0,55 | 0,22 | 0,27 | 0,11 | 2,89 |
| | Trueness | 98 | 97 | 99 | 98 | 98 |
| PVC-EC2 | EC-lab value | 205 | 205 | 435 | 2680 | 12580 |
| | Average EC (n=5) | 203 | 200 | 431 | 2643 | 12553 |
| | Relative STDEV (%) | 0,66 | 0,57 | 0,26 | 0,06 | 1,52 |
| | Trueness | 99 | 97 | 99 | 99 | 100 |
| PVC-EC3 | EC-lab value | 205 | 205 | 435 | 2680 | 12580 |
| | Average EC (n=5) | 203 | 198 | 443 | 2616 | 10344 |
| | Relative STDEV (%) | 0,41 | 0,57 | 0,20 | 0,11 | 1,61 |
| | Trueness | 99 | 97 | 98 | 98 | 82 |
| REGGS-EC1 | EC-lab value | 226 | 220 | 454 | 2680 | 12580 |
| | Average EC (n=5) | 225 | 218 | 439 | 2639 | 11731 |
| | Relative STDEV (%) | 0,58 | 0,38 | 0,12 | 0,06 | 0,31 |
| | Trueness | 100 | 99 | 97 | 98 | 93 |
| REGGS-EC2 | EC-lab value | 205 | 205 | 453 | 2680 | 12580 |
| | Average EC (n=5) | 213 | 203 | 432 | 2623 | 11893 |
| | Relative STDEV (%) | 0,33 | 1,02 | 0,38 | 0,03 | 0,55 |
| | Trueness | 96 | 99 | 95 | 98 | 95 |
| REGGS-EC3 | EC-lab value | 235 | 205 | 455 | 2680 | 12580 |
| | Average EC (n=5) | 224 | 205 | 433 | 2626 | 12142 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Relative STDEV (%) | 0,45 | 1,14 | 0,26 | 0,13 | 0,24 |
| | Trueness | 95 | 100 | 95 | 98 | 97 |

## 2. Software improvement.

In this version of the Akvo Caddisfly EC sensor, the following items are changed:

- Timing and duration of the measurement
- Measure open circuit voltage as part of the calibration, and use it in computations (and store it in flash memory)
- Avoid computing resistance, but compute conductivity directly from measured voltage
- Optimization of averaging
- Use Steinhart-hart temperature formula instead of B-parameter
- A number of other small items.

## 3. Conclusion

Taking into account the software improvement the following conclusions can be drawn
(note: the higher the trueness percentage, the smaller the error (1), the higher the precision percentage, the higher the error (2):

- Concerning the standard solutions of 205 until 2680 us/cm trueness ranges from 97 till 100%. The average trueness for this range for the six random selected sensors is 98%.
- Concerning the standard solutions of 205 until 2680 us/cm precision ranges from 0.1 till 0,7%.
- Concerning the standard solution of 11.550 us/cm trueness ranges from 82 till 100%. The average trueness for this range for the six random selected sensors is 94%.
- Concerning the standard solution of 11.550 us/cm precision ranges from 0.2 till 2,9%.