



# Aqua-Meter Clamp with LoRaWAN

SKU: AQMLWU01

Version: 1.1



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## 1. Product Description

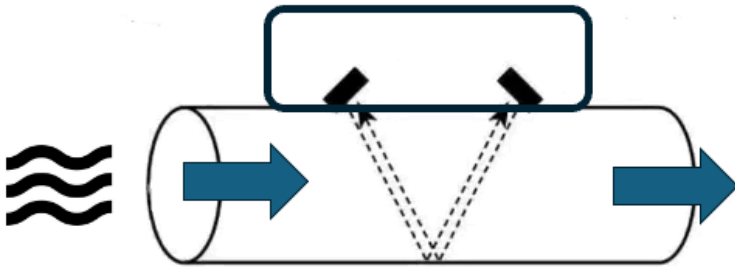
The Aqua-Meter Clamp measures the flow and temperature in a water pipe using a "Time of Flight" measurement method and transmits the data wirelessly. It is easily attached to the existing water pipe from the outside without the need to interrupt the water supply. The best position is right after the water meter. Due to adjustable transducer positions and innovative software the Aqua-Meter Clamp works with pipe diameters between 15 and 50 mm and it supports many contemporary pipe materials such as PEX, PEX AL, copper or PE. It registers water consumption from approximately 1 liter/hour and it distinguishes between normal water usage, dripping faucets, stuck toilets, pipe breaks, etc. And alerts the user.

The device meets all the requirements of the European Metering Directive (MID). With a footprint of only 60 mm above the water pipe and a length of 110 mm, the device is very slim and short, making it easy to find a suitable spot to install.

The Aqua-Meter Clamp can be powered either by an USB-C or by two standard AA batteries. Whenever an external power source is available, it is used independently of the inserted batteries.

The device is controlled via LoRaWAN commands and operates as a LoRaWAN Class A device. The use of the device requires LoRaWAN network coverage. Otherwise, you need to install and operate your own LoRaWAN gateway.

## 2. Measurement Principle



The water sensor clamp utilizes ultrasonic waves and the "differential time of flight (DTOF)" method to measure water flow. In this method, two ultrasonic transducers, called transducers, are employed to send signals in opposite directions through the pipe and water. The signal sent by the upstream transducer travels along the direction of water flow and is detected by the downstream transducer. The second signal sent by the downstream transducer moves against the direction of water flow, progresses more slowly, and meets the upstream transducer later. The difference in travel time between the two signals is directly proportional to the speed of the water in the pipe and thus the flow rate. To better understand this method, one can imagine it like swimming in the current of a river. By swimming upstream and downstream and comparing the time it takes to cover the same distance in each direction, one can estimate the speed of the water flow in the river. Similarly, in the case of the water sensor clamp, the movement of the transducers generates a wave that serves as a swimmer to estimate the speed of the water flow.

The test signal of the device has a frequency of 1 MHz and is of very low power, making it inaudible and harmless to humans and animals. Furthermore, the sound waves of this high frequency are strongly attenuated by the atmospheric pressure of the air and, in practice, cannot radiate beyond the pipe. Therefore, the water sensor clamp will not disturb people or other devices.

### 3. Design of the Sensor

The sensor consists of two main components:

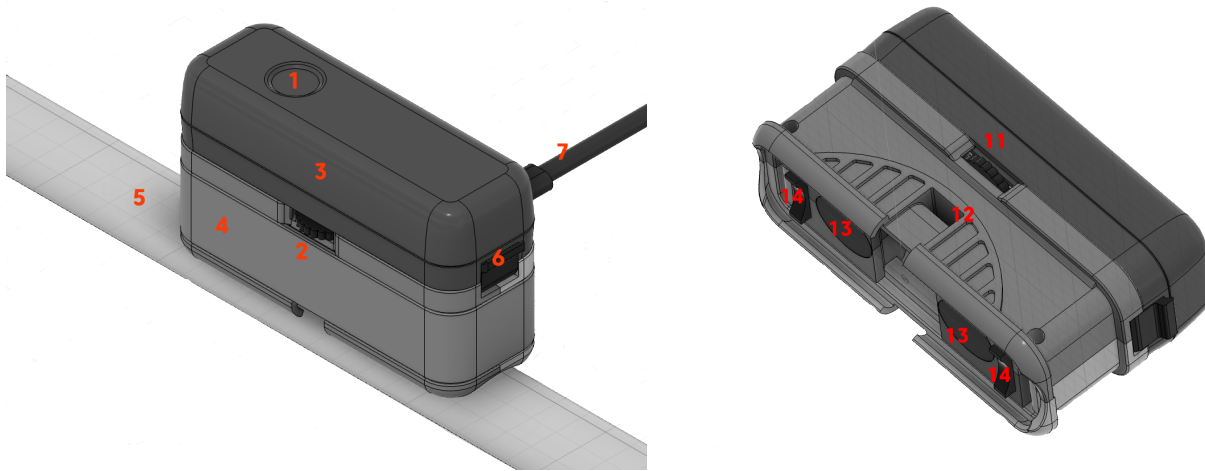
- The sensor base (4), which is connected to the water pipe. It contains the temperature sensor and the two ultrasonic transducers (13). Their distance from each other can be adjusted using the handwheel (2/11) to accommodate the existing pipe thickness (5) and the material of the water pipe.
- The electronics capsule (3) with electronics, batteries, LED (1), button (1), etc. is placed on the sensor base and secured with a flap (6). Alternatively to batteries, the sensor can be powered via a USB-C power supply (7).

Two small intermediate adapters (14) are required to fix the base to the pipe, which



correspond exactly to the diameter of the water pipe. A selection for the important pipe diameters is included with the product. Furthermore, the sensor must be securely mounted to the water pipe using a cable tie or alternatively a hose clamp (not shown in the image).

During operation, the capsule is firmly connected to the base. For maintenance purposes or for battery replacement, it can be safely separated from the base. If the capsule is powered without the base, **a corresponding alarm message** will be issued, and no water consumption measurement is possible.

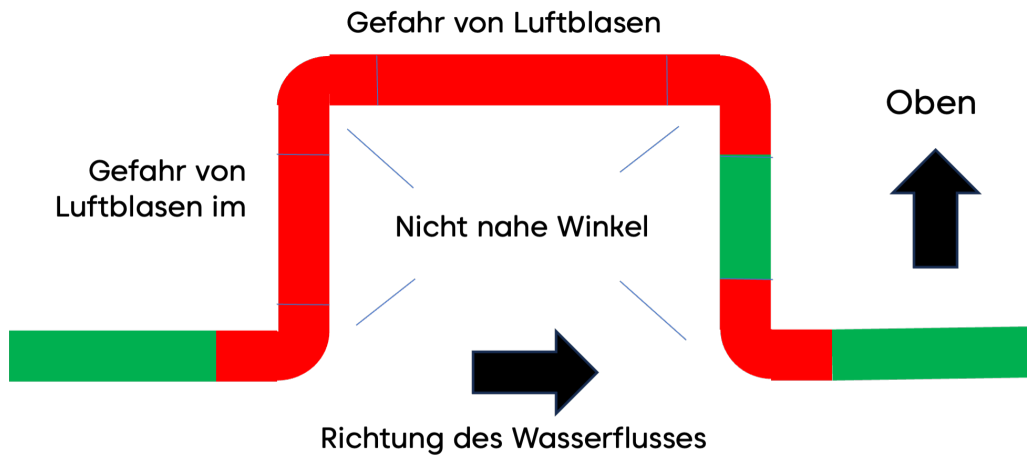


## 4. Mounting of the device

The installation location and proper attachment of the sensor to the pipe have a decisive influence on the accuracy of the measurement. An unfavorable installation location or incorrect attachment of the sensor can, in extreme cases, result in the sensor not providing any measurement results.

### 4.1. Finding Suitable Installation Locations

(1) For accurate measurement, the water must be free from turbulence and air bubbles. Therefore, the device should **not be installed near pipe bends or other water installations** such as main shut-off valves, check valves, or pressure reducers. It must be ensured that there is a minimum distance of 20 cm on each side of the pipe bends, etc., and that the installation point does not allow accumulation of small air bubbles, which occur whenever water flows quickly through the pipe. The figure below provides some hints for the best installation position.



(2) The pipe at the installation site must be **smooth and free of rust**, so that there are no air pockets on the outside to disrupt the measurement process. For plastic pipes, cleaning the surface is sufficient, while for metallic pipes, it may be useful to polish them with fine sandpaper.

(3) Lastly, the installation site must be **reachable by radio**. A stable radio connection is easiest to test by integrating the sensor into the radio network even before the final installation. Details can be found in the section 'Connection to the Radio Network'.

#### Note

- **Clean rust-free pipe**
- **Minimum 20 cm distance to bends and fittings**
- **No downstream Pipes**
- **Select adapter pieces according to pipe diameter**

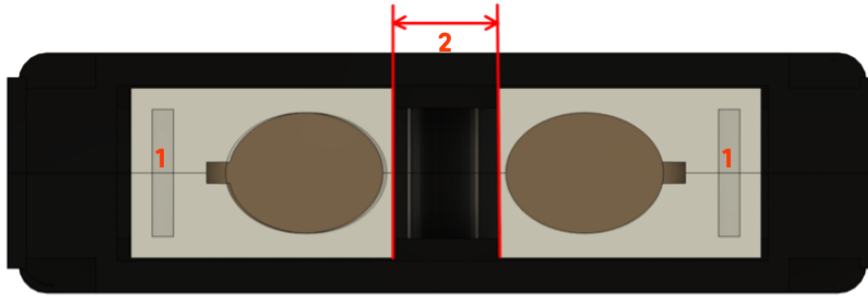
## 4.2. Preparing Sensor for Installation

It is recommended to connect the sensor to the radio network at the location of installation, but before the final mounting on the water pipe. However, this is not a prerequisite for installation.

1. From the set of spacers, select the two parts corresponding to the pipe diameter and insert them next to the transducers (1 in the figure below) into the corresponding slots.
2. The transducers on the sensor base are adjustable using the small handwheel on the side, allowing them to be adapted to different pipe diameters and materials. The transducers can be extended up to 26 mm apart. Table 1 provides the necessary distance in millimeters for various pipe diameters and materials. If the pipe is sheathed (for example, PEX with aluminum sheath or copper with plastic sheath), then the base material from the table should be selected. The distance should be set with an accuracy of



+/- 2 mm.



Diameter	20 mm	26 mm	33 mm	42 mm	56 mm
Steel	0 mm	5 mm	15 mm	20 mm	26 mm
Copper	0 mm	0 mm	5 mm	13 mm	20 mm
PEX	0 mm	0 mm	5 mm	20 mm	20 mm
PP	0 mm	0 mm	5 mm	15 mm	18 mm

Table 1: Transducer distances depending on the water pipe used

3. Remove the red protective film from the contact pads of the transducers. The buffer pads are very sticky and will hold the sensor in place without further fixation. Initially, press the pads only lightly so that they can be repositioned if necessary. If you damage one or both pads while removing them, replacement pads are included with the product.
4. Paying attention to the flow direction (large arrow on the device's nameplate), attach the sensor to the water pipe and loosely fix it with the cable tie.

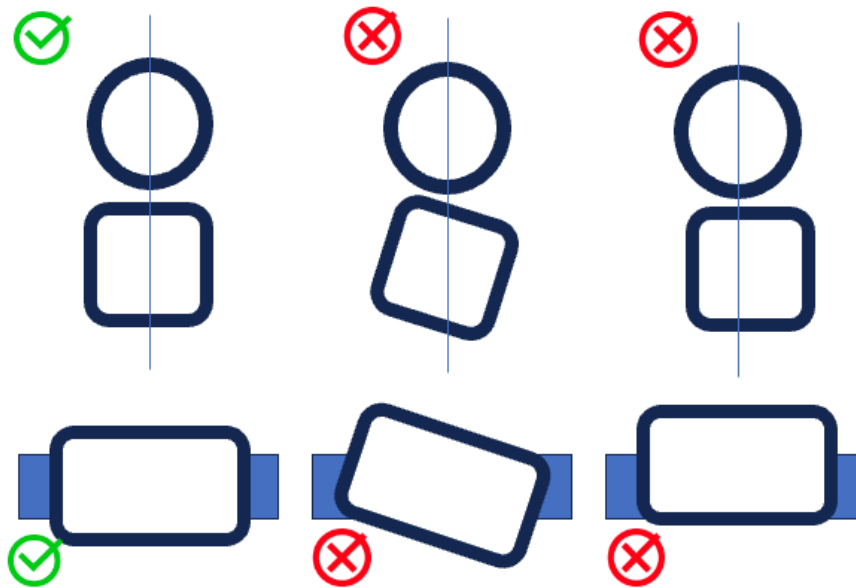
### Note

- **Adjust transducer distance**
- **Do not press the contact pads too hard**
- **Observe the water flow direction**

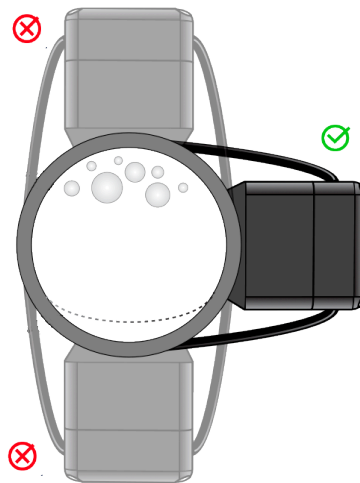
### 4.3. Attaching the Sensor to the Pipe

The exact positioning of the sensor on the pipe is crucial for the device's functionality and accuracy. Please adhere to the following guidelines:

- **Parallel Alignment:** The sensor must be placed absolutely parallel to the pipe. Spacers are provided to help achieve this alignment.



- **Position of the Ultrasonic Transducers:** Attach the sensor to the side of the pipe. Avoid the top of the pipe, as air bubbles can accumulate there, and the bottom of the pipe, where sediment may collect.



- **Mounting Position of the Ultrasonic Sensor:** The sensor must maintain a specific distance from the pipe, completely filled by the contact buffers. Spacers are provided to help achieve this.
- **Optimal Contact Pressure:** The sensor's contact pressure must be optimal, which can be adjusted during installation. A positioning aid is available if needed.
- **Securing the Sensor:** Use the included cable tie to fasten the sensor securely. The cable tie must be as tight as possible. After securing the sensor, supply power to it. Once connected to the wireless network, the LED will blink either slowly red or slowly green:



- Slow green (every 5 seconds): The device is operational.
- Slow red: The positioning needs to be optimized.

## 4.4. Positioning Aid

The sensor includes a built-in positioning aid that helps you:

- Find the optimal position on the pipe.
- Adjust the optimal contact pressure of the sensor.
- Set the optimal distance between the transducers.
- Correct tilted or misaligned sensor placement.

### Activating the Positioning Aid:

Press the button three times to activate the positioning aid. The sensor functions similarly to a car's parking assistance system: The LED will blink red and yellow with varying proportions, later switching to red and green. The sensor emits beeps that change in speed based on positioning accuracy.

### Guidelines

- **More green and faster beeping: Better positioning.**
- **No green: No functional position detected.**

### Adjustments

Modify the contact pressure or adjust the transducer distance and sensor position until the LED shows at least some green. End the process with a short press of the button. The sensor will perform a 30-second recalibration, during which the LED blinks yellow. If no acceptable position is found, the sensor will revert to blinking red, indicating it cannot yet measure water consumption. Repeating the Positioning Process: You can repeat the positioning process at any time. During operation, you can press and hold the button for three seconds to check and adjust the sensor's position.

## 4.5. Reasons for Positioning Aid Failures

- **No water in the pipe or excessive air bubbles:** Move the sensor to a location farther from bends or pipes that lead downward.
- **No water pressure in the pipe:** Ensure the pipe is under pressure.
- **Contaminated pipe surface:**
  - Remove rust using the included sandpaper.
  - Degrease the pipe if necessary.
  - Apply the included ultrasonic gel to improve the connection between the sensor and the pipe.



- **Insufficient contact pressure:** This is especially problematic with metal pipes (e.g., copper or iron). Consider using a pipe clamp instead of the provided cable tie for better results.

## 5. Operation and User Interface on the device

### 5.1. Operation States

The sensor can be in various operating states depending on its connection status to the network, the calibration of the measurement system, or a detected alarm. Each state is indicated by a specific LED blinking sequence.

- (1) **Alternating red/yellow/green every 200 ms (fast):** The sensor is booting after powering on or performing a reset and is searching for a network connection.
- (2) **Alternating red/green every second (slow):** The sensor does not yet have a configured network connection and is waiting for network setup.
- (3) **Alternating red/green every 100 ms (fast):** The sensor is in WPS mode for quick connection to a Wi-Fi network (if available).

If any of these three LED combinations are visible, the sensor is connected to the network. It is then either in normal operation mode, alarm mode, or not yet calibrated. It is not possible to calibrate the sensor on the water pipe while no network connection is established.

- (4) **Red blinking for one second (slow):** The sensor has not been successfully calibrated. It will therefore only transmit temperature values but no consumption data. Calibration is required. In this state, no alarms are activated.
- (5) **Alternating red/green with varying lengths of green and red phases:** Feedback during calibration and positioning of the system.
- (6) **Yellow blinking every second (slow):** Calibration after positioning.

After successful calibration and with an established network connection, there are two possible operating states. If the sensor has not yet been calibrated but is successfully mounted on a water pipe and receives a clean test signal, the calibration phase is skipped, and the sensor automatically switches to normal operating mode.

- (7) **Green light every 5 seconds:** The sensor is calibrated and operating normally. Temperature and consumption data are transmitted regularly, and all alarms are active. During water flow the green LED will blink fast.



(8) **Red light every 5 seconds:** The sensor is calibrated and operating normally, but an alarm is active. The reason for the alarm is transmitted over the network. Once the cause of the alarm disappears, the alarm will be cleared. The alarm can also be manually cleared using the local button, even if the alarm cause is still present. The corresponding alarm cause will then remain deactivated until the next boot (power-on or reboot).

#	State	Start	End
1.	Boot	After power-on or reset	Automatically transitions to (2), (4), or (7) based on network availability or calibration status
2.	Network Search	Automatically from (1)	Successful connection to the network
3.	WPS	During (2), single-click	Single-click returns to (2)
4.	Uncalibrated	Network successfully connected	Triple-click transitions to (5)
5.	Positioning	Triple-click in (4)	Single-click transitions to (6)
6.	Calibration	Single-click in (5)	Ends automatically after 30 seconds
7.	Normal	End of (6), (1), or (2) or successful installation	Transitions to Alarm
8.	Alarm	Alarm	Double-click clears the alarm

## 5.2. LED Signals

- Short red: Alarm active
- Long red: Normal but not calibrated
- Short yellow: -
- Long yellow: Calibration
- Short green: Normal
- Fast green: Water flow
- Fast red/green: WPS active
- Slow red/green: Searching for network
- Variable red/green with beep: Positioning
- Red/yellow/green alternating: Booting

## 5.3. Button Operations

- Single-click: During positioning: stop positioning. During normal operation: send status message to the network.
- Double-click: Clear alarm.
- Triple-click: Start positioning plus calibration.
- Hold for 3 seconds: Start positioning without calibration.
- 10x clicks: Reset to factory settings.



## 5.4. Beeper Signals

- Three short beeps: OK.
- Approximately 3 seconds long: Error.
- Varying lengths: Positioning of the sensor.

## 6. Operating the Device

### 6.1. Sensor Notifications

The sensor regularly sends its status via LoRaWAN. The transmission frequency can be freely chosen using configuration parameter 29. The factory setting is 900 seconds = 15 minutes.

The status message contains the following data, which are encoded according to the LoRaWAN command structure - see below.

- Water consumption in the last report interval (default 15 minutes) in liters. The sensor type is 0x11.
- Water temperature at the time of the report in 1/10 °C. The sensor type is 0x01.
- Uptime (time since the last reboot) in hours. The sensor type is 0x03.
- Battery voltage at the time of the last report in mV. This value is sent as a battery report (command 0x12).
- Battery consumption in mAh. This value is sent as a battery report (command 0x12).

Immediately after booting, an initial message with the firmware and hardware version is sent according to the LoRaWAN command structure.

### 6.2. Alarm Messages and Their Causes

The following alarm messages are reported according to the LoRaWAN command structure.

- **No water flow, alarm type 0x01:** If no water is needed over a longer period (threshold is 30 days), the water should be turned off and the pipes drained or used regularly, e.g., by flushing the toilet, to prevent the pipes from being damaged and destroyed by standing water. The alarm is cleared when either water usage is detected again or no water is detected in the pipe.
- **Temperature outside allowable range, alarm type 0x02:** The alarm is triggered if the water temperature moves outside an allowable range. The factory setting is assumed to be 5 to 40 degrees Celsius. The threshold values can be adjusted in the app.



- **Prolonged water usage, alarm type 0x03:** The water flows for a very long time. The threshold is set at 15 minutes from the factory and can be adjusted in the app under 'Configuration'. The alarm is automatically cleared when the water usage stops.
- **Stuck toilet, alarm type 0x05:** A stuck toilet will not cause damage but will unnecessarily consume water. A stuck toilet creates a very characteristic usage pattern and is therefore easily recognized. The problem is usually resolved by pressing the toilet flush button. The alarm is also cleared when no sticking is detected anymore.
- **Excessive water usage, alarm type 0x06:** This usually indicates a pipe burst. The water flow is consistently higher than the threshold allows over a period of one minute. The threshold is set at 28 liters per minute from the factory and can be adjusted in the app under 'Configuration'. If the usage intensity drops below the threshold or stops, this alarm is automatically cleared.
- **Dripping faucet, alarm type 0x07:** Any water usage above the measurement inaccuracy and below normal water usage is recognized as a dripping faucet. If the water flows minimally over a period of at least one hour, an alarm is triggered. The cause of such an alarm can also be a small leak in a water pipe (micro-leakage). Therefore, the matter should be investigated and the cause rectified.
- **Negative water usage, alarm type 0x08:** Due to modern installations, such as legally required backflow preventers, it is actually impossible for water to flow back into the supply line in the opposite direction. If this happens, a plumber needs to investigate the issue. The alarm is triggered if water flows in the wrong direction for 30 seconds continuously. The alarm is cleared when no abnormal flow is detected or when normal water flow is restored.
- **Battery low, alarm type 0x0c:** The battery is running low and needs to be replaced. This message is also displayed if there is no battery installed at the start of the device. Unlike other alarm types, this alarm is NOT locally indicated by a red LED.
- **Attempted tampering with the device, alarm type 0x0e:** This alarm is always triggered when the electronics capsule is removed from the base unit. Please note that changing the batteries will **always** trigger a corresponding tampering alarm.
- **No water in the pipe, alarm type 0x0f:** This is possible when the water is turned off, e.g., during repair work. The sensor can no longer operate then. Permanent air bubbles in the pipe are also conceivable. Observe the installation conditions.

### 6.3. LED

The device has a three-color LED (red/green/yellow) directly under the button on the top of the device. Different colors and blinking sequences indicate the operating states of the sensor.



- Red/green blinking with a blink frequency of 2 seconds: The device is (still) not connected to the wireless network. This message overrides all other LED messages, meaning that even if an alarm is detected on the device, the alarm will only be displayed once the device is connected to the wireless network and the red/green blinking has stopped.
- Permanently red: The device has not yet been calibrated.
- Green LED briefly blinks every 5 seconds: The device is in normal operating mode. It is calibrated, connected to the wireless network, and there is no active alarm.
- Green LED blinks every second: Water is currently flowing.
- Red LED blinks every second: An alarm is active. This alarm is transmitted via the wireless network.
- Rotating red/yellow/green blinking: A process is active, such as calibration or a firmware update.
- No LED: Battery operation or no power supply connected.
- If the positioning aid is active:
  - Permanently yellow: The device is not connected to the pipe at all, or there is no water in the pipe.
  - Alternating red/green with different frequencies: Different quality of coupling to the water pipe.
  - Permanently green: Perfect coupling between the sensor and the water pipe.

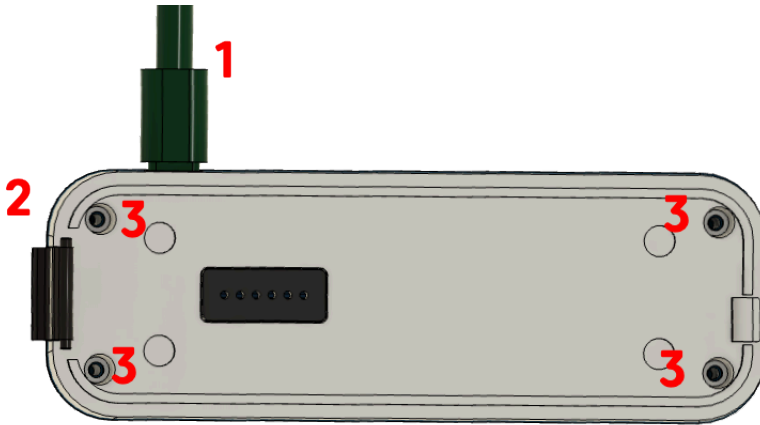
## 6.4. Button Operation

Different commands can be triggered by pressing the button for varying lengths of time. After the button is pressed, the device beeps every second, allowing for easy estimation of the press duration.

- Up to 1 second: A possible alarm is cleared, an active positioning aid is ended, otherwise, a status message is sent to the wireless network.
- 2 seconds: Positioning aid without calibration is started.
- 3 seconds: Positioning aid with calibration is started.
- 10 seconds: The device is reset to factory settings.

## 7. Power Supply and Battery Operation

The device can be powered either via a USB-C power adapter (included in the package) or with two standard AA batteries. No batteries are pre-installed upon delivery.



To use the device with batteries, the battery compartment must be opened:

1. Disconnect the device from the power supply.
2. Detach the electronic module from the sensor base.
3. Loosen all four screws and remove the cover from the electronic module.

After inserting two AA batteries (1.5V Alkaline), reattach the cover and secure it with the four screws. At this point, the red LED will blink to indicate an alarm, as the electronic module has been removed from the sensor base. The alarm will be automatically cleared once the electronic module is reattached to the sensor base.

Whenever an external power source is available, it will be used regardless of whether batteries are installed.

To minimize power consumption in battery mode, the following adjustments are made:

- The LED remains off during normal operation.
- In case of an alarm, the LED and buzzer will activate only briefly and at longer intervals.
- Individual water consumption events are not reported.
- The total water consumption is transmitted only once per hour.
- The minimum detection threshold for dripping faucets is slightly increased.

All other functions of the device, such as leakage detection and drip detection, continue to operate as usual.

## **8. Communication with LoRaWAN**

### **8.1. Connecting to the LoRaWAN Network**

This device must be registered with a LoRaWAN network operator covering the device's location. Registration requires the device's three keys (Dev EUI, Join EUI,



Join Key).

The public Device EUI is printed directly on the device as a QR code and as a 16-character string. This information is also found on the device packaging.

The other two - private - keys can be obtained from your dealer or directly from Aqua-Scope via email. **To request these keys, submit the public Device EUI key and your email address on the website <https://aqua-scope.com/lora>.**

When batteries are inserted or a power supply is connected, the device will attempt to connect to the LoRaWAN network to which you have provided the three keys. During this process, the LEDs will blink. After approximately 25 seconds, this process, called "JOIN," will either be successful or aborted. If unsuccessful, the device will immediately enter sleep mode if operating on battery power.

If the sensor loses connection to the server for any reason, it will automatically restart the connection process. This process is known as "Rejoin" and will occur whenever the device attempts to send a message to the LoRaWAN network.

Pressing the button on the device will always trigger LoRaWAN communication, which, as explained above, also initiates a "Rejoin" if the connection to the LoRaWAN network is lost. Please note the duty-cycle regulation in LoRaWAN. Sending messages or initiating Rejoins too frequently may be ignored by the LoRaWAN network.

## 8.2. Using the Device in the TTN Network

The device can operate in any LoRaWAN network, including The Things Network (TTN). The device is already listed in the TTN device repository, and a valid payload decoder is activated during setup.

## 8.3. LoRaWAN Payload Commands (Payload Format)

LoRaWAN commands can be daisy chained into the payload up to the defined maximum payload size of 51 bytes. This means that for all commands sent to a defined number of bytes in the payload is required to avoid misinterpretation of command and/or command values in the receiver side. **All uplink and downlink commands use FPort=10.**

- **Uplink Command Hardware Version Report: 0x03 - HW - CAP\_MSB CAP\_LSB (4 Byte):** This command reports the hardware version and a bitmap of the capabilities of the device. It is sent unsolicited as the first command during boot-up and as a replying command to a downlink command *Hardware Version Get*. HW is a single byte indicating the version of the hardware. The bitmap indicates the different capabilities of the device.
- **Uplink Command Configuration Report: 0x04 - IDX - VAL\_MSB -**



**VAL\_LSB (4 Byte):** This command reports a configuration parameter of the device: IDX is the number of the configuration parameter. The 16 Bit VAL is the parameter itself. Configuration parameters are always 16 Bit values. The table below describes the configuration parameters and their values.

- **Uplink Command Sensor Report: 0x06 - ID - VAL\_MSB - VAL\_LSB (4 Byte):** This command reports sensor values. The ID indicates the sensor type and defines the format of the 16-Bit VAL. The sensor types of this devices are listed below.
- **Uplink Command Firmware Version Report: 0x0a - VER\_MSB VER\_2 VER\_3 VER\_LSB (5 Byte):** This command reports the 32-bit value of the current firmware. It is sent unsolicited as the first command during boot-up and as replying command to downlink command 'Hardware Version Get'.
- **Uplink Command Alarm Report: 0x0b - STATE - TYPE - VAL\_MSB - VAL\_LSB (5 Byte):** This command reports start and end of alarms. The STATE-Byte indicates the status of the alarm (0x01 = active, 0x00 = inactive). The TYPE Byte indicates the type of alarm and defines the content of the 16 Bit VAL. Possible alarm IDs and the values reported are listed below.
- **Uplink Command Battery Report: 0x12 - VOLT - BAT\_MSB - BAT\_LSB (4 Byte):** This command reports the status of the battery. VOLT is the measured voltage of the battery in 100 mV steps, the BAT value is the consumption of the current battery - as counted inside the system - in mAh.
- **Downlink Command System Command: 0x01 - CMD (2 Byte):** This command sends a system command to the devices. CMD defines the type of command:
  - CMD = 0x01: System restart
  - CMD = 0x02: System Reset - back to factory default
  - CMD = 0x03: Enter a While loop, can only be terminated by local power off/ob
- **Downlink Command Configuration Set: 0x04 - IDX - VAL\_MSB - VAL\_LSB (4 Byte):** This command allows setting configuration parameters of the device: IDX is the number of the configuration parameter. The 16 Bit VAL is the parameter itself. Configuration parameters are always 16 Bit Values. The table below describes the configuration parameters and its values.
- **Downlink Command Sensor Get: 0x06 - ID (2 Byte):** This command requests the report of sensor values. The ID indicates the sensor type. The sensor types of the devices are listed below.
- **Downlink Command Alarm Clear: 0x0b - TYPE (2 Byte):** This command clears an alarm. TYPE is the type of alarm to be cleared. Type = 0 clears all active alarms. For other types of alarms to be cleared please refer to the uplink command 0x0b.
- **Downlink Command Configuration Get: 0x14 - IDX (2 Byte):** This command allows reading the configuration value IDX. The device will respond with an upstream command Configuration Report



## 8.4. LoRaWAN Configuration Parameters

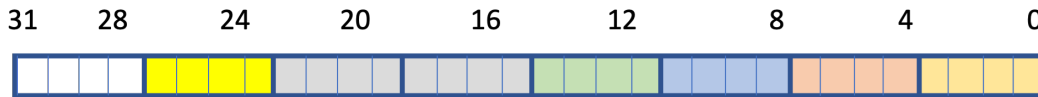
All Configuration Parameters are 2 Byte values that can be set and read out using LoRaWAN 'Configuration Get' and 'Configuration Set' commands. Here is an overview of the configuration parameters currently used:

### **Parameter 1 (0x01): System Register (Default: 0x0be4 = dec 3044)**

The bitmap defines the general behavior of the device. Bit = 1 means function enabled, and Bit = 0 means function disabled.

- 0x0001 (Bit 00): Main Processor in Sleep Mode
- 0x0002 (Bit 01): Power Status (Sleep/Main) is locked regardless of power state
- 0x0004 (Bit 02): WI-FI enabled (second bit beside COM register), protects against unwanted disconnect from Wi-Fi
- 0x0008 (Bit 03): Meter Mode. This mode (Bit 5 =1) reduces the type of errors and only reports meter value less frequently compared to Leak Mode (Bit 5 = 0)
- 0x0010 (Bit 04): Indicator for Calibration Complete, will be set by the algorithm
- 0x0020 (Bit 05): Buzzer active
- 0x0040 (Bit 06): LEDs enabled, will disable all LED signals (except on boot)
- 0x0080 (Bit 07): Report (and wake up com processor) Begin of Water Flow (BOF)
- 0x0100 (Bit 08): Report (and wake up com processor) End of Water Flow (EOF)
- 0x0200 (Bit 09): Report 1 Second buffer every 450 values
- 0x0400 (Bit 10): Local Button active. Disabling this bit will protect the device from any malfunction caused by local button pushes
- 0x0800 (Bit 11): Zero Drift Compensation active

### **Parameter 3 (0x03): LoRaWAN Register (Default: 0x0ffd = dec 4093)**



Bit 0...3: LoRaWAN MAC Control Bits

Bit 4...7: No of JOIN Retries

Bit 8...11: Interval for Confirmed Packets

Bit 12...15: LoRaWAN TX Power

Bit 16...23: LoRa Application Control Bits

Bit 24...27: LoRaWAN Frequency

The bitmap defines which commands are accepted on the LoRaWAN communication channel. Bit = 1 means function enabled, bit = 0 disables function

- 0x0001 (Bit 00) : CLASS C (default = Class A)
- 0x0002 (Bit 01) : ADR enabled, (default = off)
- 0x0004 (Bit 02) : Duty Cycle Control enabled, (default = off)
- 0x0008 (Bit 03) : not used
- 0x00f0 (Bit 04-07): No of Join retries, (default is 3)
- 0x0f00 (Bit 08-11): Interval for confirmed packets, (default = 10)
- 0xf000 (Bit 12-15): LoRaWAN TX Power (0 = 0 dB, 7 = 14 dB, >11 = 22 dB), (default = 14 db)

The upper 16 Bit of the register are not accessible via LoRaWAN but from serial console or WIFI only (whatever is available):

- 0x00ff0000 (Bit 16-24): Application Control Bits
  - 0x00010000 (Bit 16): Alarm Reporting and Clearing
  - 0x00020000 (Bit 17): Consumption Report
  - 0x00040000 (Bit 18): Sensor Value Report
  - 0x00080000 (Bit 19): Config Parameter Change
  - 0x00100000 (Bit 20): Pipe-Check
  - 0x00200000 (Bit 21): Periodic Config Reporting
  - 0x00400000 (Bit 22): Fixed Payload
  - 0x00800000 (Bit 23): not used
- 0xff000000 (Bit 25-31) : Frequency
  - 0: EU868
  - 1: US915
  - 2: AS923
  - 3: AU915
  - 4: CN779
  - 5: IN865
  - 6: KR920
  - 7: RU864



**Parameter 5 (0x05): Ultrasonic Transducer Signal Strength (Default: 0x0000 = dec 0)**

This value defines the signal amplification needed to achieve good sensor results. This value depends on the quality of the acoustic coupling and the pipe material. It will be set during calibration C01 resp. C0B. **Do not touch this value unless you know what you do.**

**Parameter 6 (0x06): Ultrasonic ADC RX Delay (Default: 0x0000 = dec 0)**

This value defines the delay between sending out the USS signal and receiving it back. The value depends on the size and the material of the pipe and will be set during calibration C02 resp C0C. **Do not touch this value unless you know what you do.**

**Parameter 7 (0x07): Ultrasonic Total Time of Flight (Default: 0x0000 = dec 0)**

This value defines the total time of flight in ns for a USS signal. This is an indicator for the pipe diameter and to a lesser extent the pipe material. The value is set during calibration C02 resp. C0C

**Parameter 8 (0x08): Liter Translation (Default: 0x03e8 = dec 1000)**

The value of 1000 is an arbitrary value to translate the measured velocity of water into liters. This translation depends on the inner pipe diameter and this value can correct the translation.

**Parameter 9 (0x09): Jamming Toilet (Default: 0x00c8 = dec 200)**

This parameter defines the max time in seconds for 10 consecutive small water consumption event typical for jamming toilet flap. The default value of 200 means that the 11th event with a given 200 seconds time interval will cause a jamming alarm sent as uplink message. If your home has heavy water usage in general you may want to increase this value to avoid false alarms but keep in mind that the system will be less sensitive to find possible malfunctions.

**Parameter 10 (0x0a): Max. Water Take Time (Default: 0x0384 = dec 900)**

A Water Flow longer than this value will cause a Usage Alarm The value needs to be defined in  $0,43 * \text{seconds}$ . This means a desired cut-off of 15 minutes results in a value of 2093.

**Parameter 11 (0x0b): Frost Warn Threshold (Default: 0x0028 = dec 40)**

A frost alarm is sent as uplink message when the current temperature falls below the threshold. The threshold value is accepted in 1/10 degree Celsius. The default value is set to 4 degree Celsius.



**Parameter 12 (0x0c): Minimum Flow time to report (Default: 0x0002 = dec 2)**

Any value above zero will suppress any explicit EOF report even when EOF reporting is enabled in the systems register.

**Parameter 13 (0x0d): Ultrasonic Measurement Interval (Default: 0x0008 = dec 8)**

This value defines how often the USS sub-system will detect a flow. More measurements per second means more power consumption but more measurement precision too.

**Parameter 14 (0x0e): Ultrasonic Noise Threshold (Default: 0x0000 = dec 0)**

This value defines the minimal threshold between noise and drip detection in mLiters/minute. The lower this value the better because the more sensitive the device operates. The device will be less sensitive in meter mode compared to the Leakage mode. This value be set during calibration C03 resp. C0D.

**Parameter 15 (0x0f): Flow Detection Threshold (Default: 0x07d0 = dec 2000)**

This value determines the minimum velocity of a water flow that can be recognized as valid. For metering purposes even flow below this threshold will be counted but no explicit BOF or EOF report is generated. Parameter is defined in mLiters/minute.

**Parameter 16 (0x10): High Threshold for Temperature Alarm (Default: 0x01f4 = dec 500)**

If the measured temperature rises beyond this level a temperature alarm is issued. Dropping below the level clears the alarm

**Parameter 17 (0x11): Drip Length Threshold (Default: 0x001e = dec 30)**

Once the DTOF rises above the noise threshold (Parameter 14) but remains below the flow threshold (Parameter 15) there is a delay defined with this parameter. After this time a Drip Alarm is sent. The drip alarm is cleared either when a real water flow is detected or the dTOF falls below the noise threshold.

**Parameter 18 (0x12): Zero Drift Offset (Default: 0x0000 = dec 0)**

Zero Drift is an effect of USS measurement sensors. Over time the dTOF on still water moves away. The zero drift offset compensates this error increasing the accuracy and sensitivity of the device. This read-only value shows the current offset in ps to reach the zero line and its constantly updated.

**Parameter 19 (0x13): Alarm Enable/Disable (Default: 0xd806 = dec 55302)**

The bitmap defines which alarm type is active and will cause an alarm status command 0x0b. Bit = 1 means function enabled, bit = 0 disables the function. The



different alarm types are shown in the section 'LoRaWAN Alarm Types'.

**Parameter 21 (0x15): Time Delay in Transducer (Default: 0x0000 = dec 0)**

This parameter represents the assumed time delay of the USS signal outside water. It depends on the geometry of the transducers, the geometry and material constants of the pipe, and its inner and outer coating. This value is used for the estimation of the pipe diameter and pipe material after calibration and can be changed to align with user-provided information on these constants. The value is device-specific.

**Parameter 22 (0x16): Threshold for Intense Flow Alarm (Default: 0x0096 = dec 150)**

If the Velocity of the water stream rises above this level for a time defined in config parameter 23, an intense flow alarm will be issued. The value is given in mLiters/minute.

**Parameter 23 (0x17): Duration for Intense Flow Alarm (Default: 0x001e = dec 30)**

If the Velocity of the water stream rises above the level defined in config parameter 22 for a time period defined in this configuration parameter, an intense flow alarm will be issued. The value is given in seconds.

**Parameter 24 (0x18): Threshold for Negative Flow Alarm (Default: 0x07d0 = dec 2000)**

If the Velocity of the water stream rises above a negative level for a time defined in config parameter 25, an intense flow alarm will be issued. The value is given in mLiters/minute.

**Parameter 25 (0x19): Duration for Negative Flow Alarm (Default: 0x001e = dec 30)**

If the Velocity of the water stream rises above the level defined in config parameter 24 for a time period defined in this configuration parameter, an negative flow alarm will be issued. The value is given in seconds.

**Parameter 26 (0x1a): No Flow Threshold (Default: 0x001e = dec 30)**

This value in days indicates after which time of no detected water flow a No Flow Alarm is sent out.

**Parameter 28 (0x1c): Active Communication Channels (Default: 0x0000 = dec 0)**

This register is bit-mapped and defines which communication channels of the device are active. The following bits are recognized:

- Bit 0 (0x0001): JSON Webservice Data is XXTEA encrypted
- Bit 1 (0x0002): JSON Webservice



- Bit 2 (0x0004): MQTT Client
- Bit 3 (0x0008): Bluetooth Low Energy
- Bit 4 (0x0010): local HTTP Service
- Bit 7 (0x0080): WIFI
- Bit 8 (0x0100): LoRaWAN
- Bit 9 (0x0200): LoRa P2P
- Bit 10(0x0400): JSON RAW
- Bit 11(0x0800): Aqua-Scope CCloud

**Parameter 29 (0x1d): Reporting Interval (Default: 0x0384 = dec 900)**

This parameter defines the interval in seconds the device automatically reports sensor values and heartbeat as an uplink message.

**Parameter 30 (0x1e): Heartbeat Interval (Default: 0x003c = dec 60)**

This parameter defines the interval in seconds the device automatically reports sensor values and heartbeat as an uplink message.

## 9. Scope of Delivery

- Measuring clamp main device (without batteries)
- USB-C power cable and power adapter
- Additional contact pads
- Cable ties for installation
- Ultrasound gel
- Pipe clamp for installation
- Two adapters each for different pipe diameters

## 10. Technical Data - Part 1

- Identification:
  - SKU: AQMLWU01
  - EAN: 4251295783 - 697
- Power Supply:
  - Alternative of parallel: ext. power supply or battery
  - Power Supply: 5V/2A USB-C
  - Battery: 2 \* AA, replaceable
- Communication:
  - WLAN IEEE 802.11b/g/n (2.4 GHz WIFI)
    - Aqua-Scope Cloud Protokol
    - MQTT Client
    - JSON Webservice Client
  - LoRaWAN
    - Frequency US915 or as configured



- Class A
- LoRaWAN 1.0.3
- Bluetooth 5 (LE): UART Profile
- Local Usage:
  - one Button
  - 3 Colored LEDs (red/green/yellow)
- Sensing Technology:
  - Approach: differential "Time-of-Flight"
  - Frequency of Signal: 1 MHz Ultrasonic
  - Strength of Signal: -7.5 ... 30 dB (calibrated)
- Supported Pipe Diameters/Materials
  - Diameter Plastics: 15 ... 50 mm
  - Diameter Metall: 15 ... 32 mm
  - Pipe Materials: PEX, PEX AL, Steel, Copper, PP, PE
- Sensitivity of the Sensor:
  - Minimal sensitivity: 0.1 l/m - 3 l/m (user-defined)
  - Drip Detection: from 0.1 l/m (depends on calibration, shown in App)
  - Breaking Pipe Detection: > 30 l/m (user-defined)
- Dimensions/Weight:
  - 110mm x 60mm x 40mm
  - Weight: 310 gr. (without Batteries)
  - Protection: IP 44
  - Storage/Transport: 0 ... 40 C, 10 ... 90 % RH

## 11. Technical Data - Part 2 (MID/OIML-R49)

- Pressure: PN10 (Pipe dependent)
- Temperature: 0.1°C ... 70°C (T70)
- Overload flow rate (Q4): 3 125 l/h
- Electrostatic Class: E1 (residential, commercial, light industrial)
- Climate Class: 5°C ... 30°C in condensating/damp environment
- Environmental Class: B (MID), fixed installation with minimal vibrations

## 12. Support and Contact

Should you encounter any problem, please give us the opportunity to address it before returning this product. Please check our website [www.aqua-scope.com](http://www.aqua-scope.com) and particularly the support section for answers and help. You can also send a message to [info@aqua-scope.com](mailto:info@aqua-scope.com).

While the information in this manual has been compiled with great care, it may not be deemed an assurance of product characteristics. Aqua-Scope shall be liable only to the degree specified in the terms of sale and delivery. The reproduction and distribution of the documentation and software supplied with this product and the use of its contents is subject to written authorization from Aqua-Scope. We reserve



the right to make any alterations that arise as the result of technical development.

- Phone: +372 (0) 6248002
- eMail: [info@aqua-scope.com](mailto:info@aqua-scope.com)
- Web: [www.aqua-scope.com](http://www.aqua-scope.com)

## 13. Declaration of Conformity



Aqua-Scope Technology OÜ, Sakala 7-2, 10141 Tallinn, Republic of Estonia, declares that this radio emitting device works on the following frequencies:

**Български** С настоящото Aqua-Scope Technology OÜ декларира, че този тип радиосъоръжение AQMLWU01 е в съответствие с Директива 2014/53/ЕС. Цялостният текст на ЕС декларацията за съответствие може да се намери на следния интернет адрес: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce).

**Čeština** Tímto Aqua-Scope Technology OÜ prohlašuje, že typ rádiového zařízení AQMLWU01 je v souladu se směrnicí 2014/53/EU. Úplné znění EU prohlášení o shodě je k dispozici na této internetové adrese: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce).

**Dansk** Hermed erklærer Aqua-Scope Technology OÜ, at radioudstyrstypen AQMLWU01 er i overensstemmelse med direktiv 2014/53/EU. EUoverensstemmelseserklæringens fulde tekst kan findes på følgende internetadresse: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce).

**Deutsch** Hiermit erklärt Aqua-Scope Technology OÜ, dass der Funkanlagentyp AQMLWU01 der Richtlinie 2014/53/EU entspricht. Der vollständige Text der EU-Konformitätserklärung ist unter der folgenden Internetadresse verfügbar: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce).

**Eesti** Käesolevaga deklareerib Aqua-Scope Technology OÜ, et kesolev raadioseadme tüüp AQMLWU01 vastab direktiivi 2014/53/EL nõuetele. ELi vastavusdeklaratsiooni tselik tekst on kttesaadav jrgmisel internetiaadressil: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**English** Hereby, Aqua-Scope Technology OÜ declares that the radio equipment type AQMLWU01 is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available at the following internet address: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Español** Por la presente, Aqua-Scope Technology OÜ declara que el tipo de equipo radioeléctrico AQMLWU01 es conforme con la Directiva 2014/53/UE. El texto completo de la declaración UE de conformidad está disponible en la dirección Internet siguiente: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Ελληνικά** Με την παρούσα ο/η Aqua-Scope Technology OÜ, δηλώνει ότι ο ραδιοεξοπλισμός AQMLWU01 πληροί την οδηγία 2014/53/ΕΕ. Το πλήρες κείμενο της δήλωσης συμμόρφωσης ΕΕ διατίθεται στην ακόλουθη ιστοσελίδα στο διαδίκτυο: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Français** Le soussigné, Aqua-Scope Technology OÜ, déclare que l'équipement radioélectrique du type AQMLWU01 est conforme la directive 2014/53/UE. Le texte complet de la déclaration UE de conformité est disponible l'adresse internet suivante: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Hrvatski** Aqua-Scope Technology OÜ ovime izjavljuje da je radijska oprema tipa AQMLWU01 u skladu s Direktivom 2014/53/EU. Cjeloviti tekst EU izjave o sukladnosti dostupan je na sljedećoj internetskoj adresi: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)



**Italiano** Il fabbricante, Aqua-Scope Technology OÜ, dichiara che il tipo di apparecchiatura radio AQMLWU01 conforme alla direttiva 2014/53/UE. Il testo completo della dichiarazione di conformità UE disponibile al seguente indirizzo Internet: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Latviešu** Ar šo Aqua-Scope Technology OÜ deklarē, ka radioiekārta AQMLWU01 atbilst Direktīvai 2014/53/ES. Pilns ES atbilstības deklarācijas teksts ir pieejams šādā interneta vietnē: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce) Lietuvių AŠ, Aqua-Scope Technology OÜ, patvirtinu, kad radijo įrenginių tipas AQMLWU01 atitinka Direktyvą 2014/53/ES. Visas ES atitikties deklaracijos tekstas prieinamas šiuo internet adresu: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Magyar** Aqua-Scope Technology OÜ igazolja, hogy a AQMLWU01 típus rádiberendezés megfelel a 2014/53/EU irányelvnek. Az EUMegfelelőségi nyilatkozat teljes szövege elérhető a következő internetes címen: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Malti** B'dan, Aqua-Scope Technology OÜ, niddikjara li dan it-tip ta' tagħmir tar-radju AQMLWU01 huwa konformi mad-Direttiva 2014/53/UE. It-test kollu tad-dikjarazzjoni ta' konformit tal-UE huwa disponibbli f'dan l-indirizz tal-Internet li ġej: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Nederlands** Hierbij verklaar ik, Aqua-Scope Technology OÜ, dat het type radioapparatuur AQMLWU01 conform is met Richtlijn 2014/53/EU. De volledige tekst van de EUconformiteitsverklaring kan worden geraadpleegd op het volgende internetadres: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Polski** Aqua-Scope Technology OÜ niniejszym oświadcza, że typ urządzenia radiowego AQMLWU01 jest zgodny z dyrektywą 2014/53/UE. Pełny tekst deklaracji zgodność I UE jest dostępny pod następującym adresem internetowym: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Português** O(a) abaixo assinado(a) Aqua-Scope Technology OÜ declara que o presente tipo de equipamento de rádio AQMLWU01 está em conformidade com a Diretiva 2014/53/UE. O texto integral da declaração de conformidade está disponível no seguinte endereço de Internet: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Română** Prin prezenta Aqua-Scope Technology OÜ declară că tipul de echipamente AQMLWU01 este în conformitate cu Directiva 2014/53/UE. Textul integral al declarației UE de conformitate este disponibil la următoarea adresă internet: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Slovensko** Aqua-Scope Technology OÜ potrjuje, da je tip radijske opreme AQMLWU01 skladen z irektivno 2014/53/EU. Celotno besedilo izjave EU o skladnosti je na voljo na naslednjem spletnem naslovu: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Slovensky** Aqua-Scope Technology OÜ týmto vyhlasuje, že rádiové zariadenie typu AQMLWU01 je v slade so smernicou 2014/53/EÚ. Úplné EÚ vyhlásenie o zhode je k dispozícii na tejto internetovej adrese: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Soumi** Aqua-Scope Technology OÜ vakuuttaa, että radiolaitetyyppi AQMLWU01 on direktiivin 2014/53/EU mukainen. EUvaatimustenmukaisuusvakuutuksen täysimittainen teksti on saatavilla seuraavassa internetosoitteessa: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

**Svenska** Härmed försäkrar Aqua-Scope Technology OÜ att denna typ av radioutrustning AQMLWU01 verensstämmer med direktiv 2014/53/EU. Den fullständiga texten till EUförsäkran om verensstämmelse finns på följande webbadress: [www.aqua-scope.com/ce](http://www.aqua-scope.com/ce)

## 14. Disposal Guidelines



Do not dispose of electrical appliances as unsorted municipal waste, use



separate collection facilities. Contact your local government for information regarding the collection systems available. If electrical appliances are disposed of in landfills or dumps, hazardous substances can leak into the groundwater and get into the food chain, damaging health and well-being.