



LORA: ASWLW01

Aqua-Scope Sensor with LoRaWAN

Version 0.7

Introduction



The Aqua-Scope water sensor records **all usage of water in the home** and it **detects damaging water leakages**.

For this purpose, one single sensor will be placed in the home on a location meeting the installation requirements. This single sensor monitors the whole home or apartment and communicates sensor values and alarms to a LoRaWAN server.

Installation Requirements



The Aqua-Scope monitors the water pressure and noise by connecting the Aqua-Scope water microphone to the water pipe system. Ideal connection points are edge valves located below sinks or beside toilets. It is recommended to find a place as low in the home as possible (ideally basement or first floor) **but it will work on every place in the home** that meet the following two further requirements:

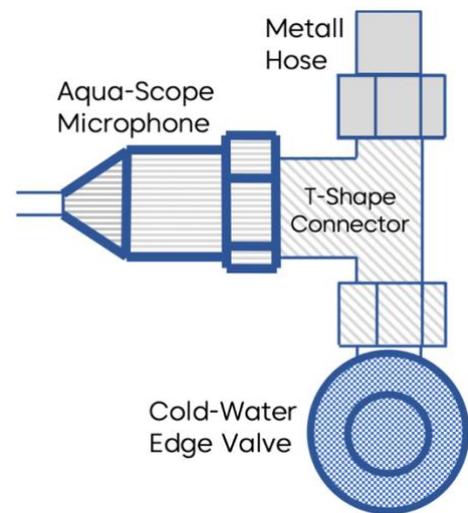
- Next to the device is a power outlet for the supplied USB power plug.
- Your home needs reasonable coverage by the LoRaWAN network of choice.

The device expects a Pressure Reducing Valve (PRV) installed in the home. The presence of a PRV will be detected automatically and the behavior of the device adapts accordingly.

Mechanical Installation

To make it short and easy – the video on aqua-scope.com/install explains the installation step by step:

1. In case there are two edge valves under the sink, please identify the cold-water supply. Just open hot water and check which valve warms up.
2. Close the faucet and close the edge valve by turning clockwise.
3. Remove the metal hose from the edge valve using the 19 mm wrench.
4. Mount the T-shaped connector on top of the edge valve and fasten the nut using the 19 mm wrench.
5. Connect the metal hose to the upper end of the connector and fasten the nut using the 19 mm wrench.
6. Screw the Aqua-Scope microphone into the side opening of the connector and fasten it by hand. There is no need to make this super-tight.
7. Re-Open the edge valve by turning the knob anti-clockwise.
8. Please check all three connections for some seconds that there are no leaks.
9. Attach the Aqua-Scope on a suitable location using the double sided tape and plug the microphone into one of the two round sockets. Attach the optional water contact sensor to the other outlet if desired.
10. Power the device using the USB Power Plug.



Factory Default

To return to factory default and reset all configuration parameters push the button right after the initial buzzer beep (but not earlier!) and keep it pushed for 5 seconds. 5 short beeps will help you counting. After 5 seconds you will see three short green LED pulses with a low frequency sound. Now release the button!

Pairing with the LoRaWAN Network

The device supports **LoRaWAN Class A and OTAA** activation. It requires LoRaWAN coverage from your LoRaWAN provider of choice. Your LoRaWAN service must register the new device before the OTAA operation. LoRaWAN OTAA requires three device-specific keys for this process:

- Device-EUI (unique key to identify this device)
- Application-EUI (unique key to identify the service of this device)
- App-Key (unique secret key to secure network connection setup)

You find all three keys printed out as label printed out inside the package. Furthermore, you find a QR-code with the Device-EUI right in the device.

Using the service <http://io.aqua-scope.com/lora/> you can download the complete set of keys plus additional device information. Please contact support@aqua-scope.com to receive your access credentials for this service.

During pairing the LED will blink red/green. Once connected successfully the LED will glow green indicating normal operation.

During the first 24 hours the system will perform an initial calibration. In this time water usage is not monitored.

TTN Integration

The Things Network (TTN) is a free community based LORAWAN network with global reach. If there is a TTN Gateway near your home you can use the water sensor without any further hardware. If no – may be this is a good reason to join the community with your own gateway.



After the registration of the device with TTN please use the “HTTP Integration” to forward all data to [,io.aqua-scope.com/lora/ttn_in.php](https://io.aqua-scope.com/lora/ttn_in.php)’. Convenient access for test purposes is possible using [,io.aqua-scope.com/lora/ttn_out.php?dev=TTNDEVNAME](https://io.aqua-scope.com/lora/ttn_out.php?dev=TTNDEVNAME)’. The link [,io.aqua-scope.com/lora/ttn.zip](https://io.aqua-scope.com/lora/ttn.zip)’ allows downloading the two scripts for change, inspection and further use on own server.

Functions and Usage

Water Flow

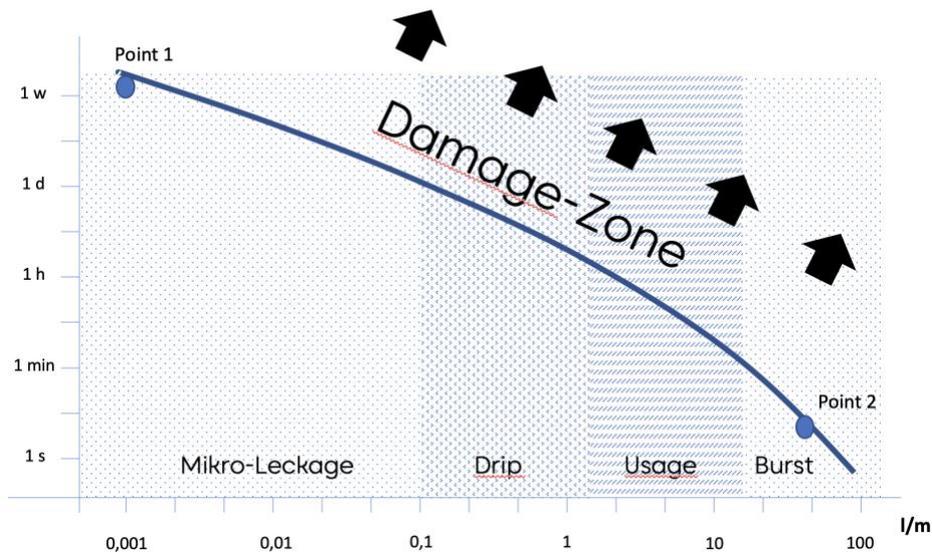
The device will report each take of water including the duration plus the consumed amount of water. This function is deactivated on default but can be activated using configuration parameter #28.

Ambient Sensors

The current water pressure, the ambient temperature and the incremental water consumption from last report is reported in periods of 15 minutes. The reporting period can be defined using configuration parameter #29.

Leakage Detection

To detect leaks some water must have escaped from the water system. Hence, leak detection does not protect you from leaks but minimizes the damage of leaks. Damage happens if a certain amount of water has enough time to impact construction material and furniture.



The diagram above shows the relationship between flow speed of water (in liter/minute) and the time this water flows out. The thick curve marks the area where damage will happen (about 10 liter of water, one full bucket). The required reaction time to a detected leak depends on the flow speed of the water. For micro leakages - point 1- its ok to act after few days or even weeks while a fatal burst of a pipe requires a reaction within seconds – point 2 .

Aqua-Scope uses different techniques to identify leaks in four different areas separated by their flow speed. The lines between the area are determined by calibration are frequently re-adjusted for optimal results. The four sub areas result in different alarms because the user action on these alarms may be different.

- All normal water consumers in a home limit the flow of water. Even parallel take of water will not result in flow beyond a certain level. In case the system detects a very high flow speed the usual root cause is a bursting pipe. Depending on the measured flood speed the Aqua-Scope will issue a **Heavy Flow-Alarm** after few seconds.
- The „Usage“ area defines flood speeds typical for normal water takes by toilets, appliances or out of faucets. For this area there are two used defined thresholds:
 - Max time in seconds, factory default is 900 s = 15 m, Parameter #10
 - Max amount of water in liter, factory default is 200 liters, Parameter #11
Exceeding these thresholds will cause a **Usage-Alarm**.
- Additional protection is provided by the external wired water contact sensor, connected to one of the two sockets of the Aqua-Scope. This will recognize e.g. spill overs or other loss of water. A **Flood-Alarm** is sent out in this case.
- The most dangerous and most common type of leaks are caused by chemical reaction in the water pipe leading to small orifice, also called micro-leaks. Since these orifices are very tiny in the beginning they are usually not seen. However, these very tiny leaks indicate a much larger problem later on. The device has a built-in process to detect these small leaks. It is called Pipe-Check. It requires to shut off the water for about 3 minutes. The LoRaWAN application need to control this process by shutting off the water automatically (or advise the user to manually shut off before triggering the pipe check. The completion of the pipe check is indicated with an uplink Water Status command or in case of a problem a **Pipe-Check Alarm**. The report

includes the estimated flow of water in ml /min plus the estimated elevation of the leak relative to the elevation of the water microphone. This is the reason why the Microphone should be installed in low elevation in the home. The Pipe-Check will detect leaks as tiny as 4 ml /hour.

- The “Drip”-range defines flow speeds between about 100 ml/m and 2000 ml/m. This is still quite low, but a Pipe-Check would come too late here. Hence, this range is monitored permanently and detected leaks or dripping faucets will cause a **Drip-Alarm** within minutes.

Additional Monitoring

- The system is permanently monitoring the water flow to detect typical pattern indicating a jamming toilet flap a **Jamming-Alarm** is issued.
- If the water pressure is too high the pipes may be damaged in the home. The Aqua-Scope will determine automatically the highest acceptable pressure and report an **Overpressure-Alarm** if this threshold is exceeded.
- The internal temperature sensor allows issuing a **Frost-Alarm** when a certain threshold for frost danger is hit. The factory default for this threshold is 4 °C but can be adapted using configuration parameter #11.

Alarm and Alarm Clearing

All alarms are indicated with

- a buzzer sound on the device,
- a red LED blinking on the device,
- a LoRaWAN alarm message sent to the LoRaWAN Application Server

Alarms are cleared automatically if the reason for the alarm disappeared. Only the Flow-Alarm must be cleared by a wireless command or pushing the single button on the device even when the sensor does not have contact with water anymore.

LED-Signals

- Green slow glowing of the LED: Normal operation, no flow of water
- Green LED fast blinking: Flow of water
- Red fast blinking: Alarm
- Red/Yellow/Green LED light up one time with beep right after power up: ongoing Pipe-Check
- Green/red blinking: Pairing with LoRaWAN still ongoing
- Sequential red LED blink: Fatal hardware error
 - 1-time blinking: general error
 - 2 times blinking: FLASH memory error
 - 3 times blinking: RAM memory error
 - 4 times blinking: ADC access error
 - 5 times blinking: LORA access error

PRV Impact

The current sensor expects and installed pressure reducing valve (PRV) that is common practise in almost all European home water installations. Typically, the PRV is installed right next to the main water meter. Without PRV the Aqua-Scope is still usable but some functions are limited.

| Function | Without PRV |
|---------------------|---|
| Water Usage | Higher detection threshold of 3 Liter/m |
| Pressure Monitor | No Impact |
| Temperature Monitor | No Impact |
| Usage Alarm | Less precise |
| Jamming-Alarm | Less precise |
| Flood-Alarm | No Impact |
| Frost-Alarm | No Impact |
| Overpressure-Alarm | No Impact |
| Pipe-Check | No Impact |
| Drip-Alarm | Not possible |

Scope of Delivery

- Aqua-Scope main device
- Aqua-Scope water microphone with 80 cm cable and audio jack
- 3/8 Inch water pipe connector
- One external water contact sensor with cable and audio jack
- USB power cable and Power supply
- 19 mm wrench to unfasten and fasten the 3/8 Inch connections of the pipe connector
- Manual

Technical Data

- External Power 5V / 2 A via standard USB connector
- Wireless Connection: Lora: EU868 MHz, Spreading 7-12, TX Power 16 dBm, RX Sensitivity: -147 dBm @ 300 bps, Class A
- Water Pressure Sensor:
 - o Range: 0 ... 1000 kPa (10 bar)
 - o Overload: 150 %
 - o Connection: G ¼ " female
 - o Precision: < 1 % dynamically
- Water Flow Sensitivity:
 - o With PRV: < 250 ml / m
 - o Without PRV: < 2000 ml / m
 - o Micro Leakage Detection: < 4ml/h
- Dimensions: Diameter = 66mm, Height = 20 mm
- Weight: 50 gr.
- User Interface: 3 color LED, single touchless button
- Temperature Range: - 20 °C ... + 40°C

Technical Support

Connecting to the water system: The Aqua-Scope is supplied with a connector suitable for European 3/8 Inch water connectors on edge valves. If you do not find a proper connector next to a toilet or

below the sink and you do not find any opening to connect a ¼ inch water sensor please contact our support at support@aquascope.com for further advise.

LoRaWAN Payloads and Functions

General:

The payload protocol uses simple a single byte commands followed by a command-specific number of additional bytes. The payload can daisy-chain multiple commands.

Packets Uplink (from Sensor to Server)

Version Report 0x03 – HW – SW_MSB – SW_BYTE2 - SW_BYTE3 - SW_LSB (6 Bytes)

This command reports the version of the device. It is sent unsolicited as first command during boot up and as reply to downlink command 'Version Get'. HW is a single byte indicating the version of the hardware, the 32-Bit SW value is the version of the firmware representing the compile date. Example: 0x03 0x05 0x00 0x03 0x10 0xdd => Device Hardware Version 5, Firmware 200925 (firmware was created on 25th of September 2020)

Configuration Report: 0x04 – IDX – VAL_LSB – VAL_MSB (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 its values.

Sensor Report: 0x06 – ID – VAL_MSB - VAL_LSB (4 Bytes)

This command reports sensor values. The ID indicates the sensor type and defines the format of the 16-Bit VAL

- 0x01: Temperature: VAL is temperature in 1/10 °C (*). Example: 0x06 0x01 0x20 0x20 => Temperature 0x00CD = 205 = 20.5 C.
- 0x10: Water Pressure: VAL is unsigned water pressure in mBar (*). Example: 0x10 0x011 0x0D 0x48 => Pressure 0x0D48 = 3400 = 3.4 Bar.
- 0x11: Water Consumption: VALUE is water consumption in Liters since last report (*).

Water Status Report: 0x07 - STATE - VAL1_MSB – VAL1_LSB - VAL2_MSB – VAL2_LSB (6 Bytes)

This command reports every single water flow event and the result of a Pipe-Check. STATE contains the status of the operation and defines the meaning of the two 16-bit values.

- 1: Water Flow complete, VAL1 contains the duration of the water flow in seconds, VAL 2 contains the amount of water consumed in Liter (*). The amount of water can be adjusted using a correction value of calibration parameter #16 (PRV present) or #26 (no PRV present).
- 2: Pipe-Check completed without Alarm. VAL1 contains the pressure decay, VAL 2 is the water pressure at the end of the Pipe-Check. (*)
- 3: Pipe-Check completed with Alarm. VAL1 contains the estimated water loss in ml/h (*), VAL 2 contains the estimated position of the leak in meters above the position of the Aqua-Scope microphone.
- 4: Pipe-Check aborted because of unexpected regular water use. VAL1 and VAL2 have no meaning.
- 5: Pipe-Check aborted because of preparation of hot water. During this time it is not possible to perform a Pipe-Check. VAL1 and VAL2 have no meaning.

Logging 0x08 – V1 – V2 – V3

This command is used to send certain logs to the server. V1 defines log event, V2 and V3 may add certain logging values.

- 1: Device in Factory Default
- 2: Pressure Sensor Lost
- 3: Pressure Sensor reconnected

- 4: Quick Calibration done, V2 = average pressure in mBar, V3 = average noise in mBar
- 5: Standard Calibration done, V2 = average pressure in mBar, V3 = average noise in mBar
- 6: Long Term Calibration, V2 = average pressure in mBar, V3 = average noise in mBar
- 7: Pressure Reduction Valve Detection: V2 = 1, PRV present, V2 = 0, no PRV

Alarm Report: 0x0b – STATE – TYPE - VAL_MSB – VAL_LSB (5 Bytes)

This command reports starts and end of alarms. The STATE-Byte indicate 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.

- 0x01: Flow: Water sensor recognized water, VAL is 0x01 or 0x00.
- 0x02 Freeze: Ambient temperature dropped below threshold. VAL is actual temperature.
- 0x03: Usage: Usage exceeds threshold or max. time or max water flow. VAL is the time in s.
- 0x04: Heavy Flow: Unusual heavy water flow, usually indicates a pipe burst. VAL is an estimation of the water loss in mLiter/min (*).
- 0x05: Jamming: A jamming toilet flap is detected. The value is 0x00.
- 0x06: Overpressure: Water pressure exceeds the calibrated maximum water pressure. The threshold can be changed in configuration parameter #6. VAL is the measures pressure value.
- 0x07: Drip:
- 0x08: Pipe-Check Result: VAL_MSB is an indicator for the estimated loss of water in milliliters/hour. VAL_LSB is an indicator for the estimated height of the location of the micro leakage measured from the height of the sensor in the home.

Packets Downlink (from Server to Sensor)

System Commands 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: Start Pipe-Check. The behavior of the Pipe-Check can be defined in configuration parameters.

Version Get 0x03 (1 Byte)

This command calls for a Version Report sent upstream

Configuration Set 0x04 – IDX – VAL_LSB – VAL_MSB (4 Byte)

This command allows to set 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.

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 alarm to be clears please refer to the uplink command 0x0b.

Configuration Get 0x14 – IDX (2 Byte)

This command allows to read the configuration value IDX. The device will respond with an upstream command Configuration Report

(*) The scale of this report can be changed into US metrics using configuration command # 18.

Configuration-Parameters:

| Id | Default | Description |
|----|---------|-------------|
|----|---------|-------------|

| | | |
|----|------|---|
| 3 | 0 | Defines if individual Flow Info is sent. 1 = on, 0 = default = off |
| 5 | nn | Pressure set by PRV in mBar, determined by calibration |
| 6 | nn | Over-Pressure warn threshold in mBar, determined by calibration |
| 8 | nn | Under-Pressure warn threshold in mBar, determined by calibration |
| 11 | 40 | Temperature Threshold for frost alarm IN 1/10, default is 4 °C |
| 13 | 240 | Duration of Pipe-Check in seconds, default is 4 minutes |
| 9 | 200 | Threshold to detect Jamming (time for 10 events), default = 200 s. |
| 10 | 900 | Threshold for flow time to cause alarm, default is 600 sec. |
| 11 | 200 | Threshold for water flow to cause alarm, default is 200 Liter |
| 16 | 1000 | Correction factor for liter displays, Default = 1000, impacts linear |
| 17 | 1000 | Correction factor for liter displays, Default = 1000, impacts linear |
| 18 | 0 | Scales, bitmapped. Bit 1: °F/°C Bit 2: Gallon/Liter, Bit 3: PSI/Bar, 0 = Metric Scales, 1 = US Scales, default 0x00 |
| 19 | nn | PRV present, determined by calibration, 0=unknown, 1=PRV, 2=No PRV |
| 29 | 900 | Report Interval for Temperature, etc. in s. |

Information related to Drinking Water Directive EU 98/83/EC

The T-Piece needed to install the Aqua-Scope Mic is subject to the European Drinking Water Directive: The used material CW509L which is in the approved list of materials of the German Environment Agency (UBA) in the version from May 14th, 2020 under section 2.1.3.1.

Contact

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

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Declaration of Conformity

Aqua-Scope Technology OÜ, Sakala 7-2, 10141 Tallinn, Republic of Estonia. The radio emitting device works on frequency 869 MHz with output power of 4 dBm. (2.5 mW) and on 2.4 GHz

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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.

