

## User Guide

### Loadsensing Digital Logger and Measurand ShapeArray Version 1.1



## Table of contents

1. Loadsensing Digital Logger (LS-G6-DIG-2) Specifications	3
2. System requirements	3
3. Compatibility with Measurand ShapeArray Specifications	3
4. Equipment Provided	9
5. Digital Logger Installation	10
5.1 Digital Logger Mounting	11
5.2 Sensor Connection	12
5.3 Powering the Wireless Data Logger	12
6. Digital Logger Configuration: Measurand ShapeArray	15
6.1 Step 1: Connecting the Loadsensing Mobile App	16
6.2 Step 2: The Loadsensing Mobile App's main menu	18
6.3 Step 3: Sensor Configuration (Dlog version 1.7.35)	20
6.3.1 Update Measurand SAA Protocol Functionality	21
6.4 Step 4 - Sensors data	23
6.5 Step 5: Radio Configuration	24
6.5.1 Radio Configuration Advanced Options	25
6.6 Step 6: Radio Signal Coverage Test	26
6.6.1 Test Results Interpretation	28
7. Safely Closing the Digital Logger	28
8. Maintenance	31
8.1 Digital Logger Firmware Upgrade Procedure	31
8.2 Battery Lifespan	31
8.3 Data Acquisition and Storage	32
8.4 Node Surge Protection	33
9. Troubleshooting	34
9.1 Connection Problems	34
9.2 Missing ShapeArray	35
9.3 Missing Packages	35
9.4 Bad readings	36
10. FAQs	38

11. Annex 1: Managing Measurand SAA data on the Connectivity Management Tool (CMT) by Loadsensing Software	39
11.1 CMT Edge and CMT Cloud Data Format and Display	39
11.2 Readings Errors	41
12. ANNEX 2: Data conversion with Measurand SAASuite software	42
12.1 Automating Conversions	45
12.2 Useful links to Measurand Documentation	45
13. Environmental best practices	46
14. CONTACT WORLDSENSING	47



## 1. Loadsensing Digital Logger (LS-G6-DIG-2) Specifications

The Loadsensing Digital Logger [datasheet](#) may be downloaded from the Worldsensing website.

## 2. System requirements

The compatibility with Measurand ShapeArray needs the following prerequisites:

- Digital Logger firmware: From version 2.55 onwards.
- Loadsensing Mobile App version: From version 1.7.35 onwards.
- CMT Edge version: From version 2.5 onwards.
- CMT Cloud version: From version 1.4.0 onwards.

## 3. Compatibility with Measurand ShapeArray Specifications

The Loadsensing Digital Logger provides long-range wireless connectivity and autonomous power supply for the Measurand ShapeArray (SAAV and SAAX).

SAA is used to measure subsurface movements and deformations. ShapeArray construction combines rugged joints and thick-walled stainless steel segment tubes. The construction contains a compact array of three-axis micro electro mechanical system (MEMS) accelerometers.

### Key Monitoring Features

- Data management and autonomous power supply of up to 100 SAA segments and up to 7.4 years.\*
- Long-range wireless connectivity of up to 12 kilometers or 7 miles through a LoRa star network topology that is not affected by radio signal obstructions, doesn't require repeaters or network planning and is not critical-path dependent.
- Auto-detection of the segments and SAA protocol configuration (regular and low power) through the Loadsensing Mobile App (Dlog).
- Robust, small and weatherproof box that has an IP67 ingress protection rating and has been tested from -40°C to 80°C.
- Proven track record, pioneer in the field.



## Applications

- Deformation profile measurements
- Tunnel linings (horizontal, vertical or in-arch installation)
- Construction and foundations
- Mining and tailing dams
- Concrete and gravity dams
- Tunnels and convergence
- Natural hazards

## Main specifications

- **General**
  - One RS485 channel and two SDI-12 channels.
  - Power supply: Regulated 12 V DC up to 200 mA in continuous operation. Maximum start-up current peak of 1.5 A, up to 50 milliseconds.
  - RS485 full or half duplex supported.
  - Battery type: 3.6V C-size user-replaceable high energy density batteries (we recommend Saft LSH 14 products).
  - Sampling rate: 30 seconds to 1 day. The frequency depends on the number of segments connected to the chain.  
E.g. for a 100 SAA-segment array, the highest frequency is every 5 minutes.
  - Time synchronization by radio: Time discipline  $\pm 30$  seconds or better.
  - Configuration via an Android app.
  - App features: Auto-detection of segments and regular and low-power SAA protocol configuration.
- **Memory - Circular buffer structure**
  - Up to 4,000 readings including time and 100 SAA segments.
  - Up to 8,000 readings including time and 50 SAA segments.
- **Mechanical**
  - Box dimensions (WxLxH): 100 x 200 x 61 mm.

- Overall dimensions: 140 x 220 x 61 mm (excluding antenna).
- Operating temperature: -40°C to 80 °C (-40°F to 175°F).
- Weather protection: IP67 with proper use of cable entry points.
- Weight (excluding batteries): 1 154 g.
- External antenna:: 114 mm length, including connector.
- Configuration and external power via mini USB.
- Box material: Aluminium alloy.
- Clamping range Ø: 4-10 mm.
- Batteries: from 1 to 4.
- Grounding connector: Integrated.

## Radio

To optimize its radio coverage and capacities, the Loadsensing Digital Logger operates in [Spreading Factor](#) (SF) 7 and 8.

The SF, measured from 7 to 12, represents a way of modulating data. The lower the SF number, the shorter the message; thus, more messages can be sent on the network.

The SF is proportional to the distance between the data logger and gateway. Higher SFs are capable of transmitting data over greater distances, while lower SFs reach smaller distances.

The range estimates below are for North America and Europe when the digital logger is collecting and transmitting data from a Measurand ShapeArray.

RADIO RANGE	US 902-928MHz (FCC)	EU 868 MHz
Open sight	12 km	7.5 km
City street	3.2 km	2 km
Manhole in a city street	1.6 km	1 km
Tunnel	3.2 km	2 km
<p>Note: The distances have been tested by Worldsensing in actual projects using standard antennas. However, radio range depends on the environment so these distances are only indicative. Contact Worldsensing to discuss the details of your application.</p>		

Note: The radio range of other Loadsensing data loggers (such as a vibrating wire 5-channel or a digital logger reading other digital sensors) can be longer when operating in higher SFs. You will find additional information in the device user guides.

Bidirectional communications: Remote sampling rate change/clock synchronization

Sensitivity (SF8):	-129 dBm	-129 dBm
Maximum link budget:	149dB	143dB
Configuration: Star (no repeaters needed)		

For other regional radio channel plans, the expected coverage will depend on the spreading factors available in each region.

As an estimate, assume that where it is possible to operate in SF7 to SF11, like in Europe, the radio coverage achieved operating in SF8 when reading Measurand ShapeArray will be 50% lower than other Loadsensing data loggers (e.g. vibrating wire 5-channel or digital logger reading other digital sensors).

And for regions where it is possible to operate in SF7 to SF9, like in the USA (FCC), the radio coverage achieved operating in SF8 when reading Measurand ShapeArray will be 20% lower than other Loadsensing data loggers.

See **Annex 01: LS G6 Gateway Radio Specifications** in the Worldsensing Support Center for additional information about the spreading factors available in each regional radio channel plan.

The Loadsensing system collects ShapeArray measurements according to a given sampling period and splits the reading in different radio messages. The first radio message is 11 segments long and the rest are 13. The Loadsensing Connectivity Management Tool (CMT) merges the messages in a single ShapeArray measurement.

## Compatibility with Measurand ShapeArray

- Data management up to 100 SAA segments, corresponding to an array of 50 meters with a 500 mm segment length.
- Typical segment lengths: 250 mm, 500 mm, 1,000 mm.
- Autonomous power supply for up to 100 SAA segments in low power or regular mode<sup>1</sup>.
- Data from the SAA Top segment is collected by the digital logger, transmitted to the gateway and presented in the CMT software in a .DAT file compatible with SAASuite software, for further analysis.

- Compatibility:

Regular mode. SAA units with a serial number above 199 999.

Low power mode. The low power protocol is available only for SAAs with a serial number above 350 000.

The resolution of the measurement collected by Loadsensing from a ShapeArray configured in regular mode is similar to the measurements provided by a ShapeArray configured in low power mode.

- Battery life estimation.

ShapeArray segments	Sampling rate 5 minutes	Sampling rate 1 hour	Sampling rate 6 hours
20 segments in low power mode	7 months	4 years	7.4 years
40 segments in low power mode	3.8 months	2.7 years	6.4 years
60 segments in low power mode	2.7 months	2.1 years	5.8 years
80 segments in low power mode	61 days	1.7 years	5.2 years
100 segments in low power mode	49 days	1.4 years	4.7 years
20 segments in regular mode	6 months	4 years	7.3 years
40 segments in regular mode	3.5 months	2.6 years	6.3 years

<sup>1</sup> The Measurand ShapeArray has two possible configurations: low power and regular mode. When using Loadsensing, the preferred configuration is the low power mode. The Loadsensing Mobile App (Dlog) can be used to select the SAA protocol configuration.

60 segments in regular mode	75 days	2 years	5.6 years
80 segments in regular mode	54 days	18 months	5 years
100 segments in regular mode	42 days	14 months	4.3 years

Note: Battery life may vary considerably from specifications depending on the actual setup and working conditions, including sensor version, sampling rate, wireless network status and environmental conditions. The battery life rating is only achieved on the specific sensor models and configurations tested by Worldsensing under the specific test settings at the time of publication and is not an estimate of a system's battery life under any conditions other than the specific test settings.

Test settings in terms of radio: US 902-928MHz (FCC) radio configuration. Spreading factor 8. Radio transmit power 20 dBm. Considering standard laboratory conditions. Estimations for 4 Saft LSH14 batteries based on the lifetime mathematical model.

- **Output data:**
  - X, Y, Z and temperature raw data for each sensor.
  - Data from SAA Top segment including input power voltage, current draw and top and first-segment serial numbers.
  - DAT file format compatible with Measurand SAASuite software.
  - Measurand SAASuite software is needed to process, view, and analyze ShapeArray data. SAASuite tools enable automated exports to third-party data delivery and viewing software.
- **Data retrieval<sup>2</sup>**
  - Manually or automatically download sensor readings and custom aggregations as CSV files.
  - Send files via FTP and FTPS.

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<sup>2</sup> A MODBUS TCP feature is not available for the Measurand SAA integration. MQTT pusher and HTTP API are available, depending on the CMT version. In the case of gathering data through MQTT pusher and HTTP API it is important to ensure that the data visualization software used in the project is able to manage the raw data from the ShapeArray. The referred data visualization software needs a feature to process and analyze ShapeArray data.

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## 4. Equipment Provided

The Loadsensing Digital Loggers are shipped with the following accessories:

- Digital logger.
- Antenna.
- Antenna adapter.
- Real Time Clock (RTC) battery

The package does not include:

- A USB-OTG configuration cable.
- Batteries.
- A grounding cable or earthing rod.
- Mounting support.

## 5. Digital Logger Installation

The parts of the digital logger are marked in the Figure 1, following the numbers on the list:

1. Casing.
2. Reverse polarity (RP) N female connector. (Compatible with Male RP N connector to RP-SMA male and aerial with RP-SMA male.)
3. External mini USB B female connection.
4. Gore valve for protection against condensation.
5. A grounding screw for metallic nodes.
6. Cable gland.

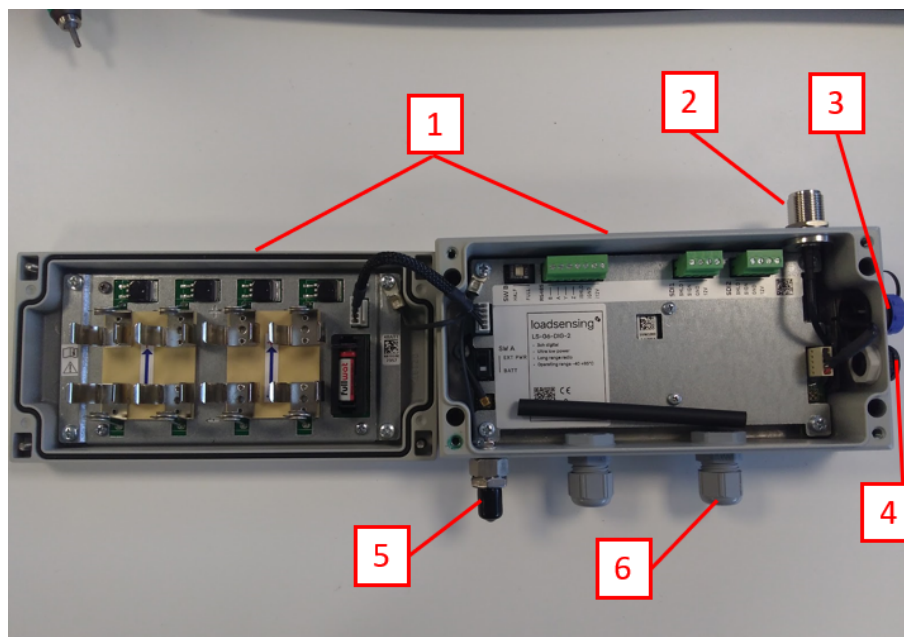


Figure 1: Loadsensing Digital Logger components

## 5. 1 Digital Logger Mounting

The digital loggers can be mounted:

- On a wall: mounting brackets are available as additional accessories.
- On a metallic structure: strong magnets are available as additional accessories.
- On a pole: plates for 35 and 50 mm pole diameters are available as additional accessories.
- Inside a manhole (with a plastic or metallic cover): no special accessories are available for this mounting type. Even though the data loggers are IP67 certified when they are closed following the instructions in the chapter on *Safely closing the digital logger* of this User Guide, it is strongly recommended you read the [Data Logger Installation in Manholes](#) guide, which will help you certify the logger for a higher ingress potential level. We recommend installing the loggers in holes with proper drainage so that they won't be permanently covered with water.

All Loadsensing data loggers are protected against lightning and to guarantee protection there is an easy-to-use grounding screw (Figure 2) next to the cable glands.



Figure 2: Detail of the grounding screw

**Note:** To protect the data logger from surges, especially in installations with long cable runs, the data logger must be properly grounded via a connection to the grounding screw.

You can find drawings for the device supports in our Support Center [Accessories List](#).



## 5.2 Sensor Connection

Measurand's SAA connects to the RS485 port of the Loadsensing Digital Logger with the following wiring:

- RS485 A - White
- RS485 B - Blue
- RS485 SHLD - Shield
- RS485 GND - Black
- RS485 12V - Red

Check wires and their pinouts with the manufacturer's sensor data sheet. As a workaround, pairs can be checked with a multimeter.

After connecting the Measurand SAA, we recommended you take a sensor reading, following steps 3 and 4 of the node configuration section, to make sure the connections are correct. Also, taking several readings will help ensure that the sensor is correctly wired to the logger and the sensor wires.

An alternative can be to compare the sensor reading at installation with a portable readout unit.

## 5.3 Powering the Wireless Data Logger

The data logger arrives closed and without batteries. To initialize it, follow these steps:

1. Use a 2.5 mm Allen wrench to open the data logger following the positions in Figure 3, to avoid damaging the lateral gore valve. The batteries are inserted into the cover, so be careful not to snap the cable between the cover and the main board.
2. Remove the plastic band from the **RTC battery** (Figure 4). The RTC battery keeps time regardless of whether or not C-type batteries are inserted. The data logger always uses UTC time. However, the data can be visualized in local time in the gateway or the Loadsensing Mobile App. The RTC battery is only available for multichannel data loggers.

3. Insert **C-type batteries** in the battery holders, observing the correct polarity (Figure 5). Between one and four batteries can be connected. (See [ANNEX 08: RECOMMENDED BATTERIES](#) for further information on the batteries.)

Note: The device has reverse battery protection but it is not safe to keep batteries reversed in the data logger for a long time.

4. Check that the power switch (SW A, Figure 6) is in the correct position. When switched to EXT PWR, the data logger is powered by a USB cable connected to an Android device or to any external power kit. In the default BATT position, the data logger is powered by the batteries.

Note: Some Android devices cannot power the data logger, especially when performing a reading. If reading fails, set the switch to BATT mode in order to power the data logger with batteries during the configuration.

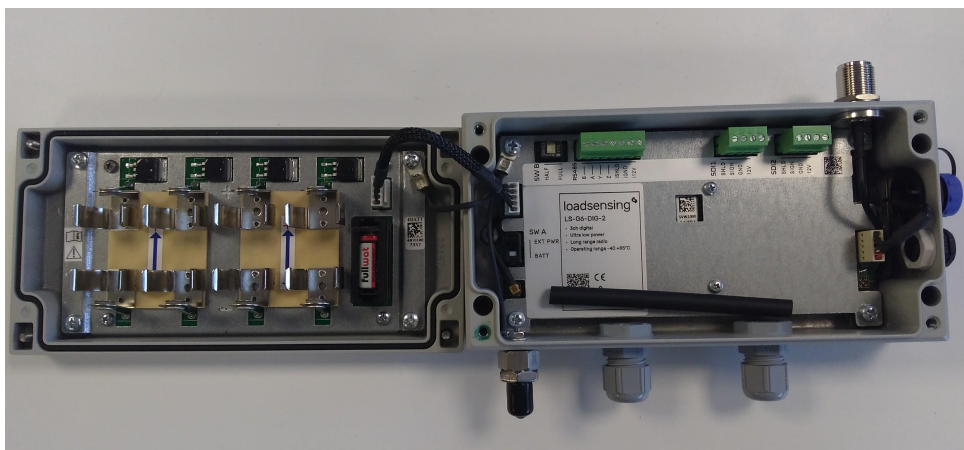


Figure 3: Opened digital node

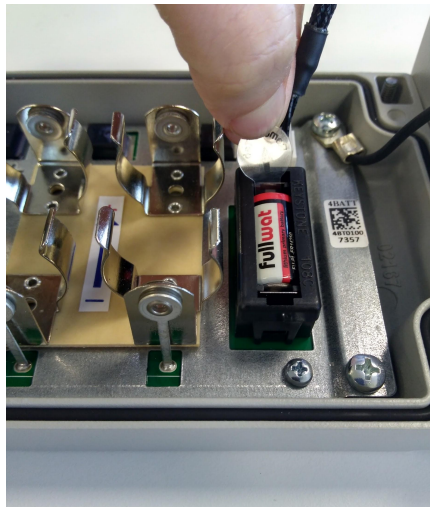


Figure 4: Plastic band to be removed from the RTC battery holder



Figure 5: Insert C-type batteries

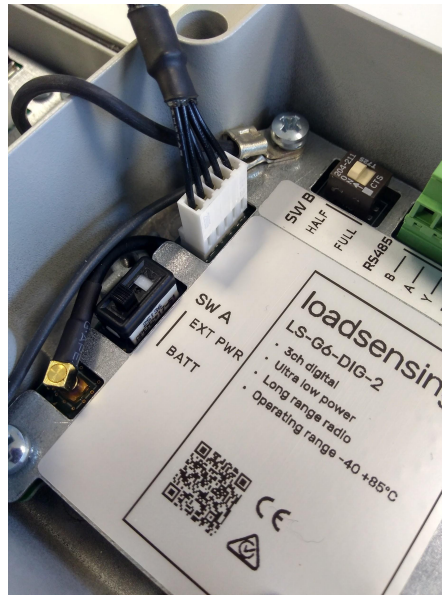


Figure 6: Switch must be in the right position depending on the power source

To use different batteries to the ones recommended, to check Saft LSH 14 batteries' specifications at [Saft LSH-14](#) as current peak and high pulse capabilities are required to power the chain of sensors.

## 6. Digital Logger Configuration: Measurand ShapeArray

Try to carry out this step in the place where you are going to install the node. That way, you can perform an on-site radio coverage test at the same time.

You will need to carry out the node configuration process using Loadsensing's Mobile App called Dlog, which is compatible with USB On-The-Go (OTG) Android devices. To make sure the mobile app works properly, we recommend purchasing one of the mobile models in stock from Worldsensing. Please contact the technical support team for more information.

To configure and read the Measurand ShapeArray with a Loadsensing Digital logger you need the Loadsensing Mobile App v1.7.35 or higher.

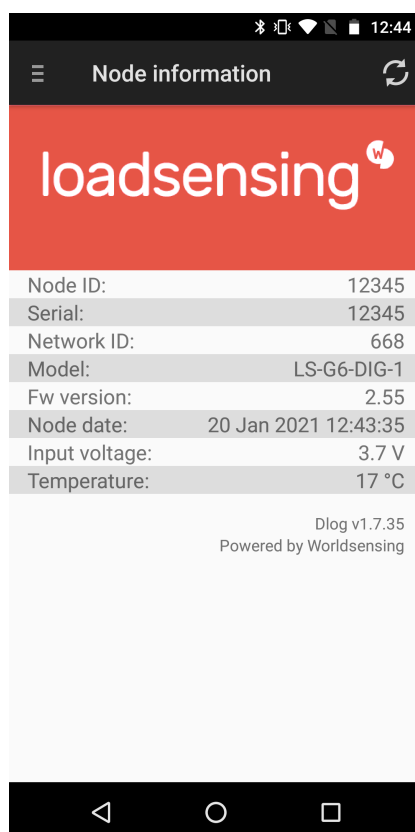


Figure 7: Node information: device details for a digital device as displayed in the Loadsensing Mobile App.

The Loadsensing Mobile App starts up once you have connected the device to the data logger using an USB-OTG cable. You do not need to start it up manually.

The Loadsensing Mobile App automatically displays a message when a new version is available.

The whole configuration process takes no more than five minutes. From then on, the logger will start taking readings and sending data to the gateway.

## 6.1 Step 1: Connecting the Loadsensing Mobile App

Download the Loadsensing Mobile App onto your Android device from <http://wsop.cat/industrial/Dlog/Dlog.apk>. Install it and connect your device to the logger using a

USB-OTG cable. Make sure the data logger has batteries. The mobile app will automatically display the logger's basic information.

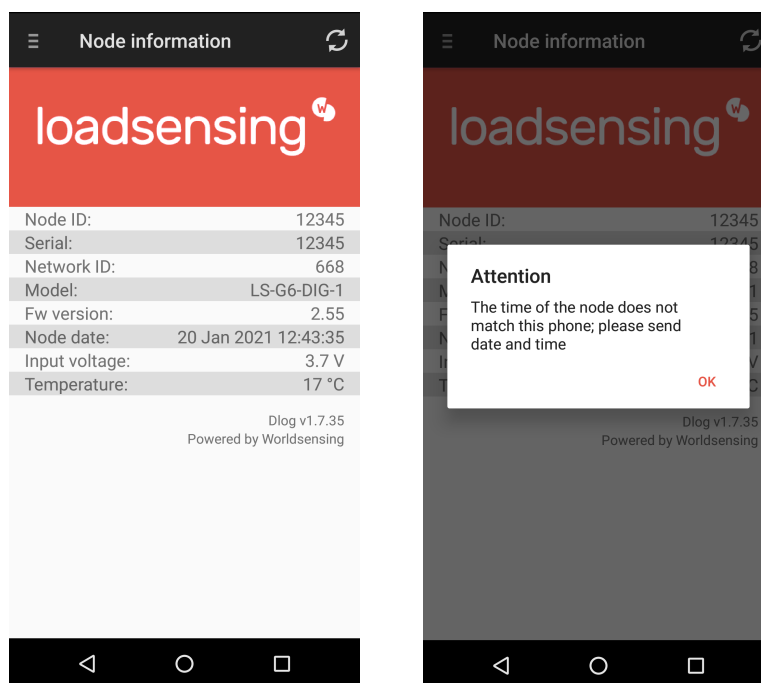


Figure 8: Node information page in the Loadsensing Mobile App

The Loadsensing Mobile App lets you synchronize the logger's date and time with your mobile device. It is important you accept the pop-up message to allow this to happen. Otherwise, the node could have an invalid date and the gateway won't be able to read its messages until you've corrected the problem.

Since the date and time information is lost when you switch to battery mode, we recommend you set the node to battery mode by default if you are powering the unit with batteries.

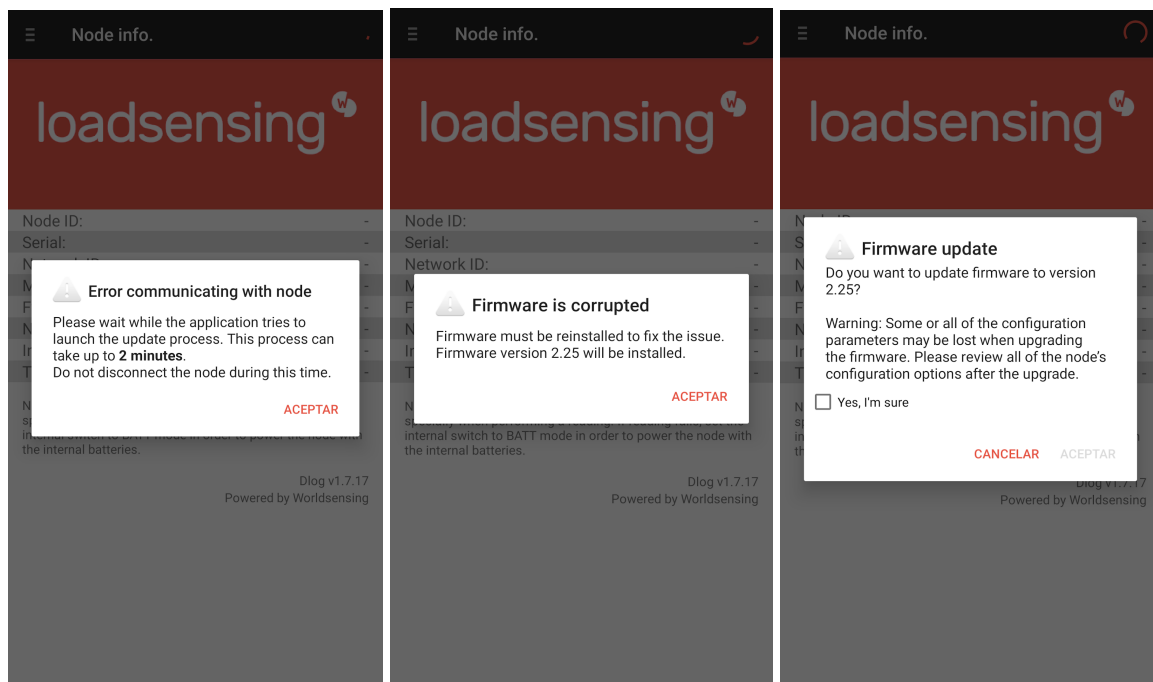


Figure 9: Loadsensing Mobile App firmware screens

If the logger needs to be recovered for some reason, it will display an error prompt on the screen. Click on 'OK' and a warning message about firmware corruption will come up. After that, you'll need to update the firmware to recover the node.

## 6.2 Step 2: The Loadsensing Mobile App's main menu

The Loadsensing Mobile App's main menu, opened with the  icon, includes:

- 1) **Node information:** Basic information about the node, such as the version, ID and temperature.
- 2) **Sensors data:** Access to real-time sensor readings and data stored on the node.
- 3) **Node configuration:** Use this menu to configure the node as follows:
  - a) **Change node ID:** By default, the node ID is the same as the serial number of the sensor. This tool lets you change the node ID and use a different number. We

recommend only changing the ID in case of replacement, to keep it the same as the previous node.

- b) Set date and time.
- c) Setup wizard: sensor and radio configuration.
- 4) **Factory reset:** This resets the configuration parameters and removes all stored data. It is designed to allow the node to be used in different sites. Don't use it for other purposes unless suggested by Worldsensing technical support.
- 5) **Installation tools:** This option relates to other types of nodes and so can be ignored when working with the LS-G6-DIG1.

To continue to the sensor configuration (step 3), select 3) Node Configuration and c) Setup Wizard from the menu above.

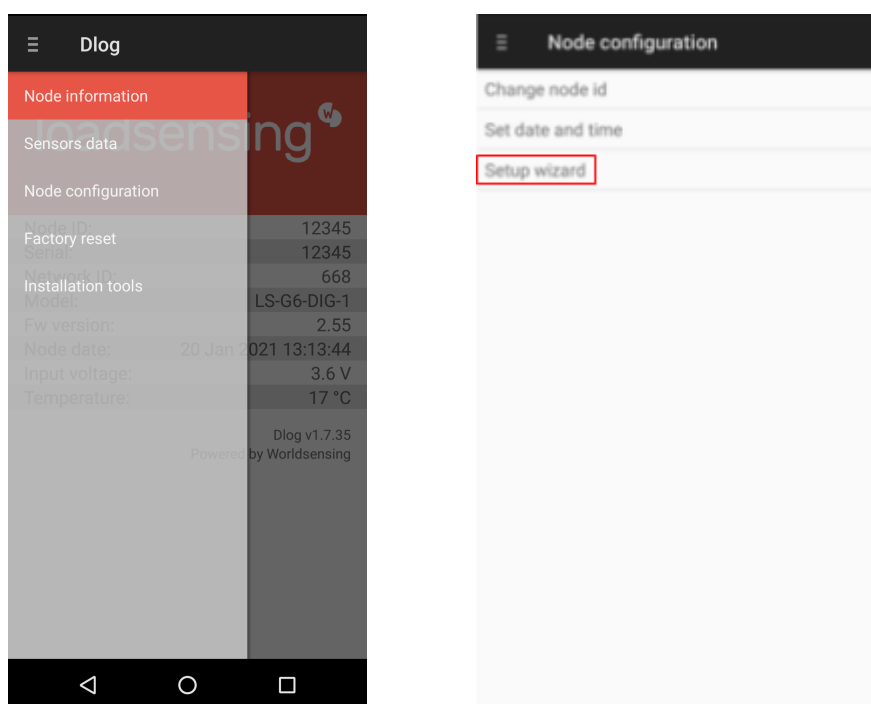


Figure 10: Node information section of the Dlog app and nested menus.



### 6.3 Step 3: Sensor Configuration (Dlog version 1.7.35)

In this step you need to select the 'Measurand SAA' from the protocols list. If you already know the number of segments and the ShapeArray protocol it is not necessary to use the 'Update protocol' option, just introduce the corresponding configuration. If not, use the 'Update protocol' option to configure the ShapeArray protocol and auto detect the number of segments that are present in the array (see more explanation below).

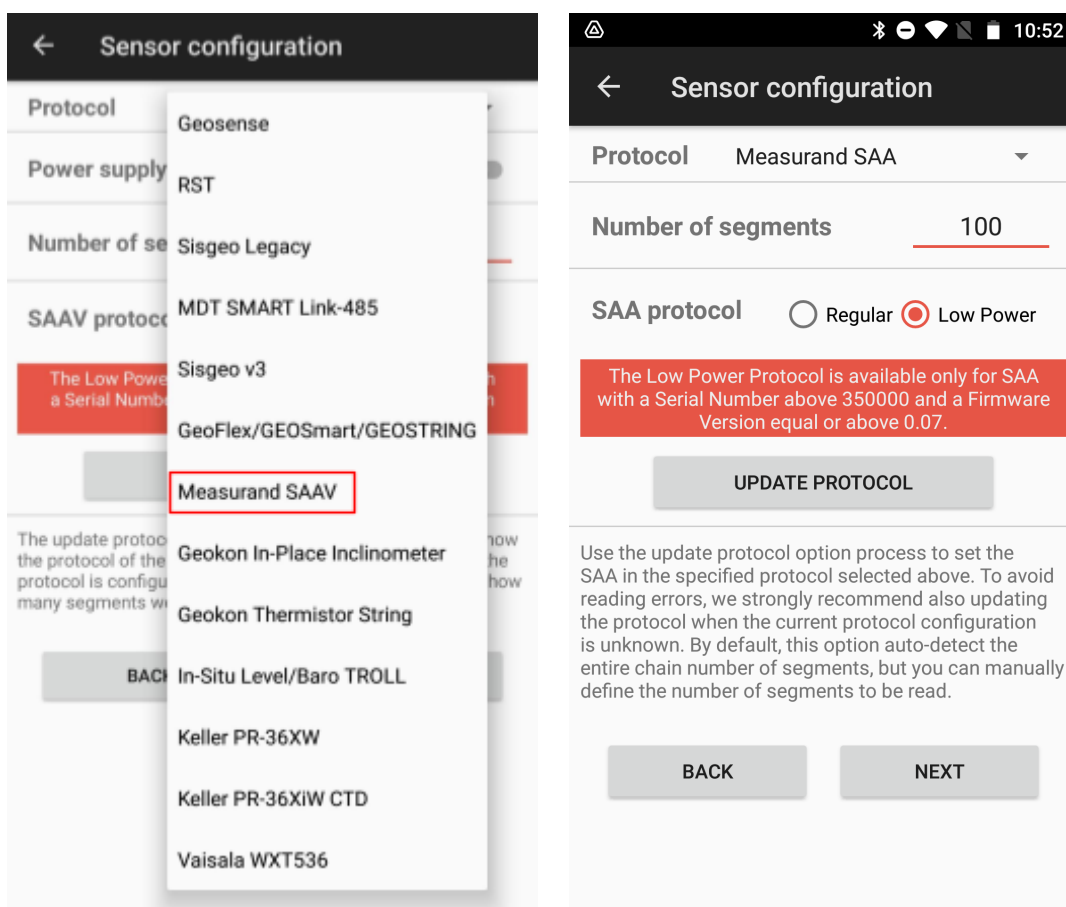


Figure 11: Digital node sensor protocol selection and configuration.

### 6.3.1 Update Measurand SAA Protocol Functionality

The sensor configuration screen asks first about the number of segments. Note that by using the option 'Update protocol', the entire chain segment number will be set. Nevertheless, here you can manually define the number of segments to be read.

Later, select the protocol configuration. The Measurand ShapeArray has two protocol configurations: low power and regular mode. When using Loadsensing, the preferred configuration is the low power mode. The Loadsensing Mobile App can be used to select the SAA protocol configuration and, if possible, switch between the two protocols.

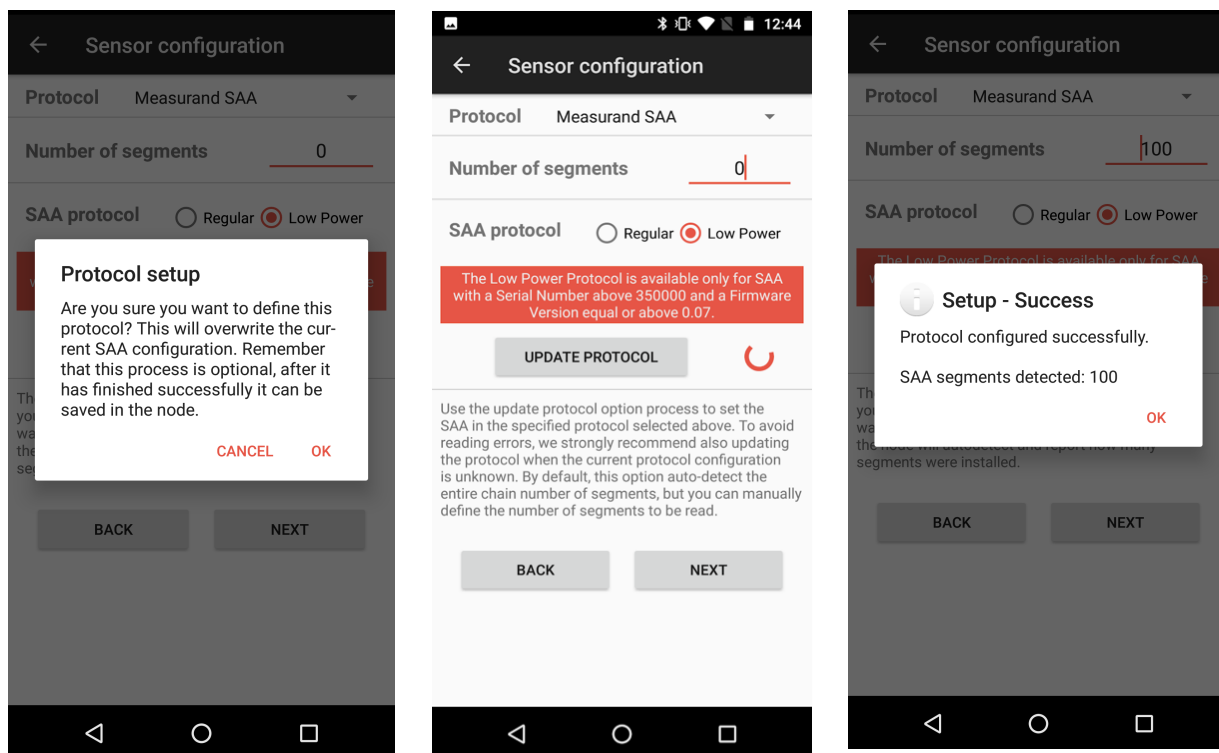


Figure 12: Update protocol configuration.

Below there is an update protocol button. If you don't know the protocol, click this button and the SAAV protocol will be configured in the chain if possible.

This feature also lets you see how many segments are connected to an array. The node counts the segments and reports it to the app. It also allows you to update the protocol configuration.

The digital logger will check if the ShapeArray is compatible with the selected protocol configuration before updating it. If not, you will get an error message.

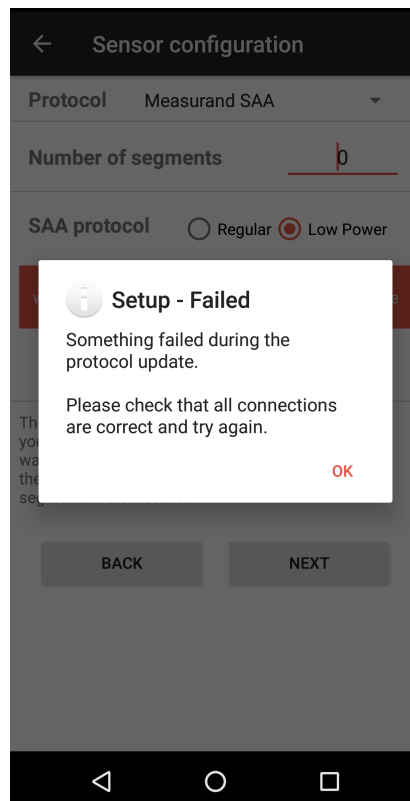


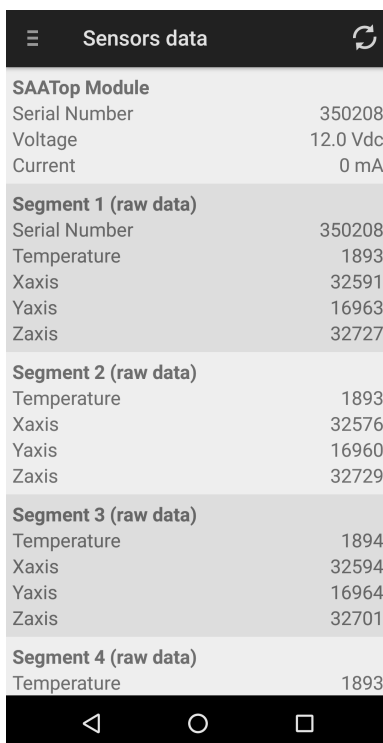
Figure 13: Update protocol unsuccessful configuration. General error.

**Note:** All SAAs are compatible with regular mode. Low power mode is only compatible with SAA units with a serial number above 35000 and a firmware version above 0.07.

**Note:** The regular and low power modes support up to 100 segments and can be powered by the digital logger's internal batteries.

## 6.4 Step 4 - Sensors data

The **Sensors data** screen displays the data logger's current readings.



Sensors data	
<b>SAATop Module</b>	
Serial Number	350208
Voltage	12.0 Vdc
Current	0 mA
<b>Segment 1 (raw data)</b>	
Serial Number	350208
Temperature	1893
Xaxis	32591
Yaxis	16963
Zaxis	32727
<b>Segment 2 (raw data)</b>	
Temperature	1893
Xaxis	32576
Yaxis	16960
Zaxis	32729
<b>Segment 3 (raw data)</b>	
Temperature	1894
Xaxis	32594
Yaxis	16964
Zaxis	32701
<b>Segment 4 (raw data)</b>	
Temperature	1893

Figure 14: Sensors data.

- The screen shows:
  - SAATop module parameters: serial number, voltage and current.
  - Segments raw data: temperature, XYZ axis. The serial number is also shown in the first segment fields, following Measurand's format requirements for further conversion.
  - If any error is reported, check the wiring and the configured SAA protocol as explained in the previous sections.
- The node takes a new reading every time the Refresh button (top right) is clicked.
- Note that taking a reading might take some time.

## 6.5 Step 5: Radio Configuration

The default configuration parameters should be suitable for the majority of networks. In this step, you'll select radio settings as follows:

- Radio off if you want to work in standalone mode.
- CMT Edge for embedded gateway configuration.
- CMT Cloud for multi-gateway configuration.

Radio configuration	
Radio type	CMT Edge
Sampling rate	1 h
Network Config	
Region	Europe
Network Size	1-4 nodes
Edit network ID and password	<input checked="" type="checkbox"/>
Network ID	1234
Password	
Advanced options	
ETSI limit duty cycle	<input checked="" type="checkbox"/>
Max. spreading factor	8
ADD	

Figure 15: Radio type configuration.

Next, set the **Sampling rate**. Several sampling rates are displayed on the screen, and their availability will depend on the **Network Size** and on the **configured SAA segments**. Choose your desired reading frequency from the drop-down menu. The highest possible sampling rate is limited by the network size and the number of segments that are being read. Smaller networks

and ShapeArrays can read up to every minute and frequency is progressively reduced on bigger networks and ShapeArrays. Dlog will show the available sampling rates according to the network size and the ShapeArray segments chosen in the previous steps.

For more information regarding network size limitations, see the **Tables, Number of nodes, Sampling rate** and **Slot time** chapters in the Gateway User Guide, CMT Edge Software User guide and [CMT Cloud Software User guide](#).

Select the **Region** that matches your LoRa region regulations. The same region must be applied in the gateway radio configuration.

The **Network Size** is the number of nodes. We recommend you set it to the final number of nodes that your wireless network will have, since this parameter determines the available sampling rates. Larger networks do not allow the selection of small sampling rates.

The correct configuration of your network size and sensor sampling rate is crucial to prevent data transmission collisions and data loss at the gateway.

In this regard, once the data loggers are connected and configured, we recommend you set up the sampling rate again from the gateway as it will be able to optimize slot time radio communication. For further information, please refer to the **Radio specification** chapter in the [Gateway User Guide](#).

Enter the **Network ID** and password provided in the [Gateway Information Sheet](#). All messages are encrypted with the network password.

### 6.5.1 Radio Configuration Advanced Options

1. To optimize radio coverage and capacities, Loadsensing Digital Loggers configured with Measurand's ShapeArray will operate in SF7 and SF8.
2. Adaptive Data Rate (ADR) is also disabled, so we recommend using SF8 as a default option to obtain better coverage.

3. For more information regarding network size limitations, see the **Tables, Number of nodes, Sampling rate** and **Slot time** chapters in the Gateway User Guide.
4. See the **Radio specification** chapter of the Gateway User Guide or **Annex 01: LS G6 Gateway Radio Specifications v1.8** for more details on radio models and settings.
5. Remember the Loadsensing Mobile App saves and maintains radio settings to simplify configuration of all the nodes in a network. To modify these settings, the radio must be enabled again.

## 6.6 Step 6: Radio Signal Coverage Test

The final step in configuring the data logger with the Loadsensing Mobile App is to perform a signal coverage test to check the quality of communication with the gateway. The gateway must have been previously connected and configured.

The node sends test packages. The Loadsensing Mobile App then checks the gateway (using an Internet connection) to see if these packets have arrived. Hence, the test will check for:

- Correct gateway operation and communication.
- Correct radio configuration of the gateway and data logger (including matching region and ID/password configurations).
- Quality of the signal received by the gateway from the data logger.

By clicking the **Next** button, the Loadsensing Mobile App will run an **Online test**. For the results of this test to be immediately displayed on the Android phone, the gateway and the Android phone must be connected to the Internet.

To perform an **Online test**, the gateway serial number and remote access password must be available to the Loadsensing Mobile App. The remote access password is used to protect the gateway from access via a local network or the Internet. It is different from the radio network password even though it's set to the same value by default (see the Gateway Information Sheet).

Radio signal coverage		Radio signal coverage	
Gateway ID	668	Date	26 Jan 2021 17:07:12
Server password	aemausadu	Token	1611677232
<p>Offline test - Perform the coverage test, but do not fetch results from the dataserver. The results can be checked later at the dataserver's website.</p> <p>Next: Perform the test and fetch the results from the gateway in order to show them.</p>		Node ID	12345
<p>BACK</p> <p>NEXT</p>		Network ID	668
<p>OFFLINE TEST</p> <p>SKIP</p>		Latitude	
		Longitude	
		SF7	10 / 10
		SF8	10 / 10
		SF9	10 / 10
		SF10	5 / 5
		SF11	5 / 5
		SF12	5 / 5

Figure 16: Radio signal coverage test setup and sample results.

When carrying out the **Radio signal coverage** test, the position of the Android device is saved (if you gave the app permission to access GPS data) and a security token number identifies each test.

If the gateway and/or the Android phone are not connected to the Internet during the test, the online test will fail and you will need to perform an **offline test**. In this mode, however, the results of the test cannot be displayed on the Android phone. A security token number identifies each test. Write down the token number along with a description of where and under what conditions the test was taken. Check the results of the coverage test on the gateway web interface by going to **Network**, then **Signal coverage test map**, and then **Download all tests of this network**.



### 6.6.1 Test Results Interpretation

The results displayed are listed for each **Spreading Factor**. During the radio signal coverage test, the node sends 5 or 10 data packages at SF7 to SF12. The number of data packages that reach the gateway can be viewed in the results in order to ensure correct communication.

The results for SFs that are not allowed, according to radio regulations or limitations, will be greyed out.

Note: When reading Measurand's ShapeArray, the allowed spreading factors are reduced to 7 and 8. Consequently, the relevant results of the signal coverage test are those received in SF7 and SF8.

For the coverage test to be successful, SF8 should receive at least half the messages. For more information, please refer to the 01. LS G6 Gateway User Guide v1.8.pdf and the Annex 01\_ LS G6 Gateway Radio Specifications v1.8.pdf.

Note: Performing the **Radio signal coverage** test takes approximately two minutes.

## 7. Safely Closing the Digital Logger

This is important in ensuring logger water tightness and durability. Close the cover by cross-screwing to a torque of 2.5 N.m.

Loadsensing data loggers have undergone water tightness testing by an external laboratory and are rated IPX7 (1 meter for 30 minutes) and IPX8 for extended immersion (1 meter for 7 days).

To guarantee watertightness, you must be sure that:

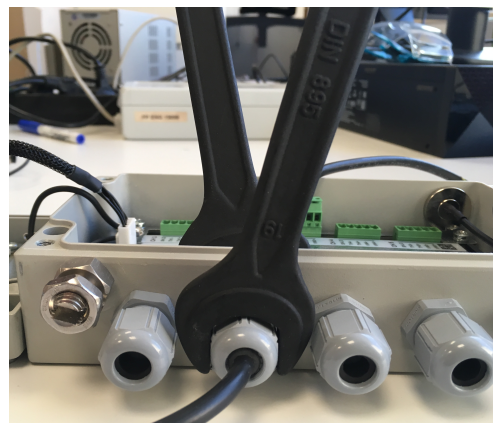
- The box is closed in a cross-shaped order after sensor connection (Figure 17). All the screws must first be inserted and screwed in until they are connected to the box and then adjusted using the torque wrench. If these steps are not followed, the base faces and cover may not be parallel, screwing may become more difficult and the screw threads or

the Helicoil inserts may be damaged. Moreover, the sealing joint may not be properly fitted and the degree of protection against water intrusion could not be guaranteed.



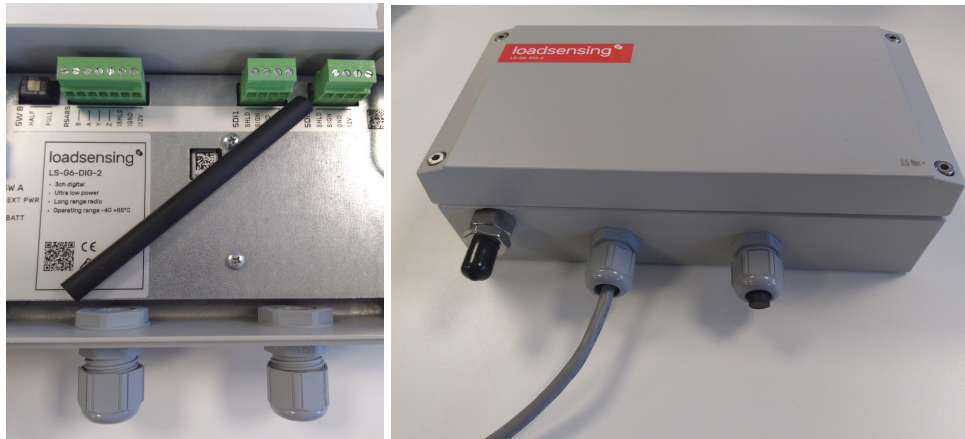
Figure 17: Sequence to close the box correctly

- The box is screwed at 2.5 N.m using a torque screwdriver (e.g. Ref: *Wera 7441 ESD*),
- The cable glands are closed with a 19 mm open spanner (e.g. Ref *Bahco 894M-19, 19 mm single-ended open spanner*) and the internal nut is held with a 22 mm open spanner (e.g. Ref *Bahco 894M-22, 22 mm single-ended open spanner*). (Figures 18 and 19)



Figures 18 and 19: Tightening the cable glands.

- A piece of rubber rod to seal the unused cable glands is provided in each box (Figures 20 and 21).
- The antenna is mounted. If it is not, the antenna connector should be covered with a cap.
- The sealing ring has not been manipulated either physically or chemically.
- The sealing cap USB connector is coiled.



Figures 20 and 21: Rubber stick to seal the unused cable gland.

If any of these conditions are not met, or if one or several components (e.g. gore valve) are damaged, IPX7 and IPX8 ratings cannot be guaranteed.

Should the data logger need further sealing due to placement in an extreme environment or in a floodable manhole, additional sealants (such as Sikaflex products) will be required to close the box. See [Annex 10 LS G6 Data logger installation on manholes](#).

**Note:** Box screws shouldn't be torqued more than 2.5 N.m, even though they can support a maximum torque of 3.5 N.m. If the torque is exceeded, the Helicoil insert may be damaged. Don't use electric drills or electric screwdrivers.

## 8. Maintenance

### 8.1 Digital Logger Firmware Upgrade Procedure

When a new version of the app is available, the Loadsensing Mobile App will display a message asking you to upgrade it (Figure 23). Your mobile phone or tablet needs to have an Internet connection. Otherwise, contact Worldsensing technical support for assistance.

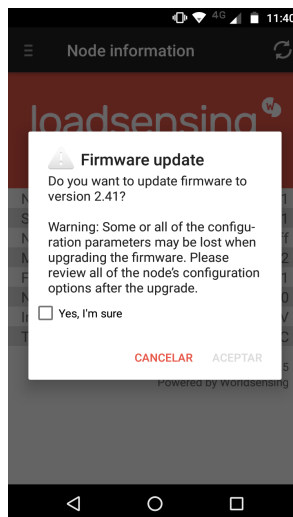


Figure 23: Firmware update message displayed on a screen.

### 8.2 Battery Lifespan

Battery consumption varies depending on the number of segments, sampling rate and environmental and wireless network conditions. The following table provides the battery lifespan in days, months and years per segment according to different wireless network conditions.

Battery life estimation			
ShapeArray segments	Sampling rate 5 minutes	Sampling rate 1 hour	Sampling rate 6 hours
20 segments in low power mode	7 months	4 years	7.4 years
40 segments in low power mode	3.8 months	2.7 years	6.4 years

60 segments in low power mode	2.7 months	2.1 years	5.8 years
80 segments in low power mode	61 days	1.7 years	5.2 years
100 segments in low power mode	49 days	1.4 years	4.7 years
20 segments in regular mode	6 months	4 years	7.3 years
40 segments in regular mode	3.5 months	2.6 years	6.3 years
60 segments in regular mode	75 days	2 years	5.6 years
80 segments in regular mode	54 days	18 months	5 years
100 segments in regular mode	42 days	14 months	4.3 years

Note: Battery life may vary considerably from specifications depending on the actual setup and working conditions, including sensor version, sampling rate, wireless network status and environmental conditions. The battery life rating is only achieved on the specific sensor models and configurations tested by Worldsensing under the specific test settings at the time of publication and is not an estimate of a system's battery life under any conditions other than the specific test settings.

Test settings in terms of radio: US 902-928MHz (FCC) radio configuration. Spreading factor 8. Radio transmit power 20 dBm. Considering standard laboratory conditions. Estimations for 4 Saft LSH14 batteries based on the lifetime mathematical model.

## 8.3 Data Acquisition and Storage

The node has an internal memory of 4 MB. A Loadsensing Digital Logger connected to 100 Measurand SAA segments stores up to 4,000 readings and up to 8,000 readings if connected to 50 Measurand SAA segments. When the memory is full, new readings overwrite the earliest ones. As well as sensor data, the digital logger collects hourly health data on battery voltage, internal temperature and node uptime.

Data is stored in comma-separated value files (DAT for readings and CSV for health). You can download readings and health files using the Loadsensing Mobile App.

To do this, connect an Android device to the node mini USB port with a USB-OTG cable. When the Loadsensing Mobile App loads, download data by clicking on the **Download** icon in the **Sensors Data** tab. You need to set a start and end date for the data you want to download. The Android

device allows these data files to be opened with applications such as email or cloud apps. Files are also stored in the device memory, on the SD card in the Dlog folder.

Sensors data

↓

↺

Sampling rate

5 min

SAATop Module

Serial Number350208

Voltage12.0 Vdc

Current0 mA

Segment 1 (raw data)

Serial Number350208

Temperature1885

Xaxis32342

Yaxis16965

Zaxis32712

←

Download

Start date

04/20/2018

End date

08/20/2020

Timezone

Europe/Madrid

▼

Figure 24: How to download readings to the Android device.

The Readings file is downloaded in a format compatible with Measurand's software (SAASuite version 3.05 and later, including Raw2Data and other modules).

**Note:** If you are installing a Loadsensing Digital Logger that has been used to read a different ShapeArray, do a factory reset of the node to clean out the previous data. If the node has also been sending data to the server, and in the unlikely event that the previous and current ShapeArrays have the same number of segments, we recommend you delete the node data on the CMT software or modify its ID to generate a clean data file for the new SAA.

## 8.4 Node Surge Protection

Following IEC 61000-4-5, digital loggers have been equipped with class 2 surge immunity protection against damaging electrical spikes and transients. That means the node is protected up to 1 kV.

You need to ground the node (metal case nodes come with an easy-to-use grounding screw), otherwise the surge protection cannot prevent the node from being damaged by nearby lightning

strikes. Note that nothing can protect a system from a direct lighting strike or one so close that it overloads the capacity of the surge protection.

Further information can be found on the [Surge protection document](#).

## 9. Troubleshooting

### 9.1 Connection Problems

Several common mistakes can cause a coverage test to fail. Most problems can be traced to the gateway or the node.

Here is a checklist of good practices *before gateway installation*:

- Place the gateway antenna vertically high up, by extending the Ethernet cable or by installing the antenna at the highest point using a long antenna cable. As a rule of thumb, the higher the antenna the farther the communication.
- Don't attach the gateway to a metallic pole or, if you have to, use a mounting bracket to create separation.
- Try to ensure line of sight to and from the gateway and the nodes.
- Ensure that the antenna is in a vertical position. Please also refer to our [recommendations for installing nodes inside manholes/boxes](#).

If you have checked all the above and still have radio communication issues then here is a checklist of good practices *after gateway installation*:

- Check the radio region and user-pass configuration of the nodes is compatible with the one selected on gateway.
- [Extend the node cable antenna](#).
- Increase the sampling rate of the node, bearing in mind that this will shorten battery lifespan.



- Install an additional gateway to reach nodes with coverage issues.

## 9.2 Missing ShapeArray

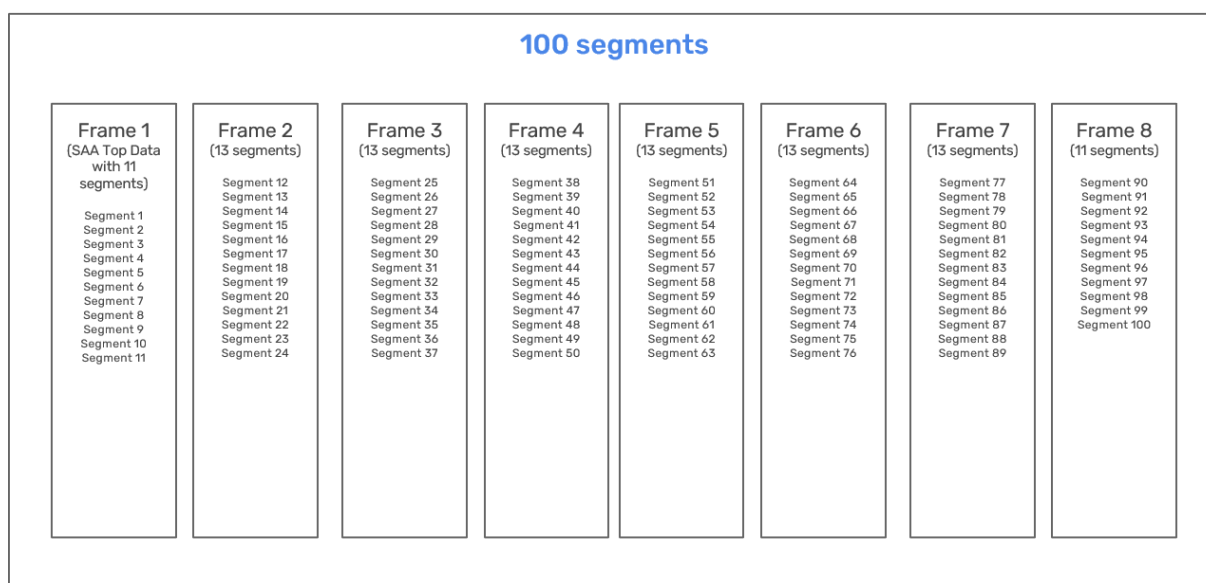
When a ShapeArray is missing, you will get an error with the data which is registered on the reading error CSV file on the gateway (for gateways with CMT Edge software version 2.5 and later). Please refer to the [Gateway Manual](#) for further information.

## 9.3 Missing Packages

SAA radio transmission packages are split as follows:

- First frame: SAATop data and up to 11 segments.
- Other frames: Up to 13 segments.

*Example:*



If the first frame of the message is lost, all the message is discarded. Lost readings are filled with 0s, so a missing message can be detected by getting 13 0s in a row. See **Annex 1: Managing Measurand SSA data on the Connectivity Management Tool (CMT) by Loadsensing Software**.



## 9.4 Bad readings

The reliability of the wireless node reading can be affected by:

- **Impacts:** dents on the node enclosure are a likely sign of impact.
- **High vibration levels:** the node is not proper when the application requests high vibration intensities.
- **Water ingress:** the Loadsensing Digital Logger has IP67 ingress protection, so it can withstand immersion in up to a meter of water for up to 30 minutes. The node should never be submerged in water, however. Sometimes the node can appear to work properly after water damage, but returns unusual readings. Water damage to the internal components voids the warranty.
- **Electrical damage:** After an overvoltage in any component, the node may still work, but integrity of readings can be affected. Electrical damage to the internal components voids the warranty.

## 10. FAQs

**Are the regular and low power modes strictly a sensor configuration? Why would someone select regular mode?**

Yes, the ShapeArrays units can be configured in both modes: "low power mode" or "regular mode". The Loadsensing Mobile App enables configuration in both modes and by default the app attempts to configure the low power mode.

However, the low power mode is only compatible with ShapeArrays with more recent serial numbers. Older devices are not compatible with this mode and thus will not accept this configuration.

**How many segments can be read in regular or low power mode?**

Up to 100 segments can be read in this configuration using the internal batteries of the node.

**Is data read directly from the node ready to visualize?**

The data collected on the Worldsensing node is raw data (in .DAT format) and must be converted into Cartesian engineering units through the Measurand SAASuite Software in order to process it, visualize and analyze it. The Software also allows automated exporting to a third party software.

For more information, please check Annexes 10 and 11.

**How can I push data taken from the Measurand SAA to a third party Software?**

Data can be retrieved through FTP, HTTP API Calls and MQTT (depending on the CMT version). In case of gathering data through MQTT pusher and HTTP API it is important to ensure that the data visualization software used in the project is able to manage the raw data from the ShapeArray and has a feature to process and analyze ShapeArray data.

MODBUS TCP feature is not available for the Measurand SAA integration.

## 11. Annex 1: Managing Measurand SAA data on the Connectivity Management Tool (CMT) by Loadsensing Software

The general operation of the Connectivity Management Tool (CMT) software can be found in the CMT Edge and [CMT Cloud](#) User Guides. Nevertheless, here is a brief review of SAA data management in the CMT.

### 11.1 CMT Edge and CMT Cloud Data Format and Display

In the CMT Edge and CMT Cloud, the data displayed is the same as in the Loadsensing Mobile App sensor's data screen. The SAATop Voltage and SAATop current are the only values that have charts enabled. The data values are displayed as raw data in the input format required by the Measurand software. Note the file has a .dat extension.



Last readings and Time series graphs				
SAATop SN	First Segment SN	SAATop Voltage (Vdc) 	SAATop Current (mA) 	
16777215	350208	12.0	0	
Segment ID	X Axis (raw)	Y Axis (raw)	Z Axis (raw)	Temperature (raw)
1	19759	22384	32842	1896
2	19765	22380	32837	1898
3	19759	22380	32843	1899
4	19753	22376	32843	1899
5	19784	22388	32841	1898
6	19760	22385	32840	1898
7	19750	22375	32840	1897
8	19748	22370	32843	1894
9	19805	22413	32844	1897
10	19768	22391	32845	1897
11	19746	22371	32838	1896
12	19773	22391	32843	1897
13	19793	22402	32849	1898
14	19748	22374	32837	1897
15	19763	22380	32840	1898

Figure 25: CMT Edge screen displaying ShapeArray data.

Inside the Readings file, all of the header information regarding the node, which is usually presented in several rows for other Loadsensing configurations, is translated to the first row, occupying several columns.

The Header (second row) contains the columns for the data. First, there is a timestamp followed by some fields required by the conversion software. The next columns show the information of TOP and related error indicators, followed by all the segments' triaxial data and all the segments' temperature.

Since the Header is adapted to a variable number of segments, every time there is a change in the number of segments received by the data server it generates a new current readings file.

In this way, the latest readings will always be stored with a *XXXXX-readings-current.dat* filename.

After the segments change, the file will be stored as *changeX.dat*, where 0 is the latest change and N is the oldest change (as with custom compacted file modifications).

Health CSV files	<a href="#">64-health-current.csv</a>
Measurand SAA CSV files	<a href="#">64-readings-current.dat</a> <a href="#">64-readings-2021-01.change0.dat</a> <a href="#">- Less</a>

Figure 26: CMT Edge screen displaying ShapeArray CSV files.

**Note:** When the data is pushed externally for data processing, it is important to push a single SAA file instead of merging data from different SAA in a compacted file. The reason is that single chain files are in the exact input format the conversion software is expecting. Using compacted files could lead to further errors if the format is not reshaped.

## 11.2 Readings Errors

Measurand ShapeArray also has a Readings errors CSV file.

When a general error occurs (for example because the ShapeArray does not respond), this is only reported in the Errors CSV file. Specific sensor errors are reported with a corresponding error code and filled with 0s for the relevant segment in the readings file, unlike the usual empty lines that represent errors for other nodes .

The Measurand software doesn't allow an empty SAATop SN field, so if the first frame of the message where it is included is lost the data server will report this situation in the User's Log without adding a new line to the current readings file.

[2021-02-01 09:16:35] User action.INFO: Node 123 Measurand SAATop readings not found, skipping message received at 2021-01-29T17:11:40Z ["admin"] []

Figure 27: CMT Edge screen displaying ShapeArray reading errors

## 12. ANNEX 2: Data conversion with Measurand SAASuite software

To process the raw data obtained from the segments, use Measurand SAASuite software which you can download from

<https://ftp.Measurand.com/?lid=nt7t2o2c>.

To obtain the final data, open the software package and go to *Data Conversion*. After that a dialog box will appear.

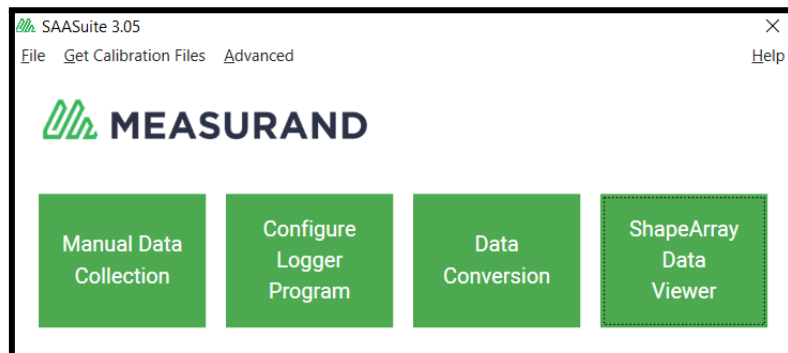


Figure 28: Main view of the SAASuite software.

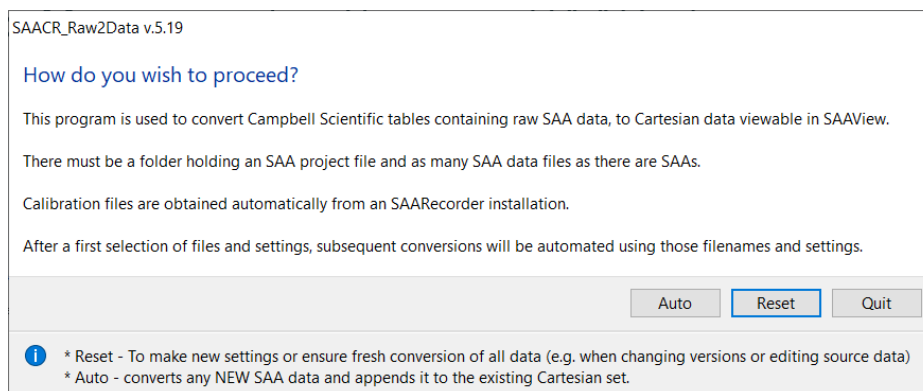


Figure 29: SAASuite Software dialog box.

Start with a Reset conversion to specify important conversion settings such as azimuth offset, software data adjustments and output format. After a complete Reset conversion, select the Auto option.

On the next screen, select *new project* and select the readings filename. Click OK.

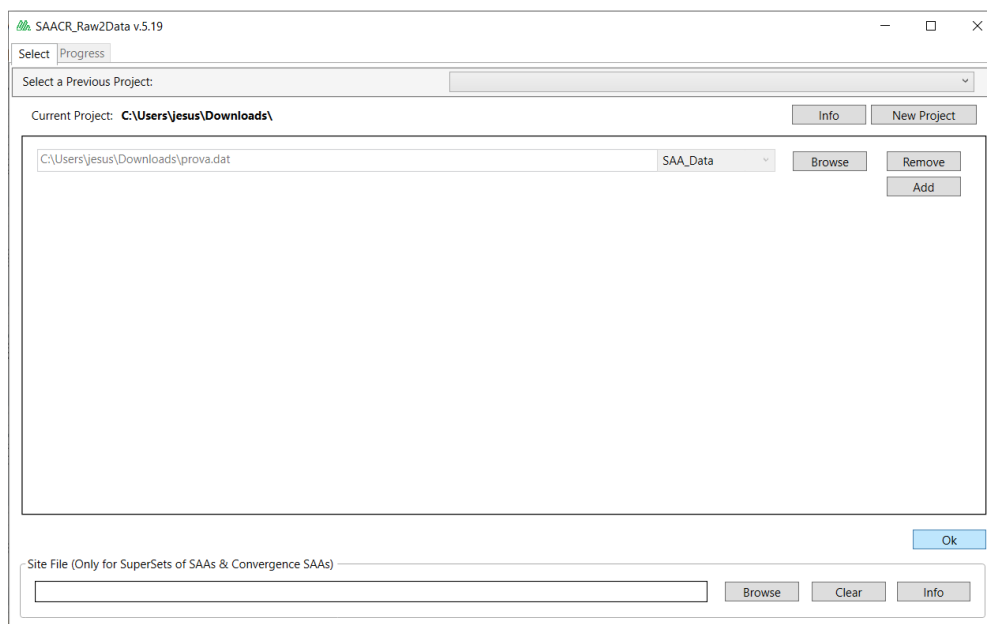


Figure 30: Autoconversion view

Once the conversion process finishes, several files are created in the same folder where the readings are stored.

By clicking on *ShapeArray viewer* -> *Open Project* you can load the new files. Select *multi\_saa\_allcart.mat*. On *quick view*, a 3D view opens so you can see the installation of the ShapeArray and others.

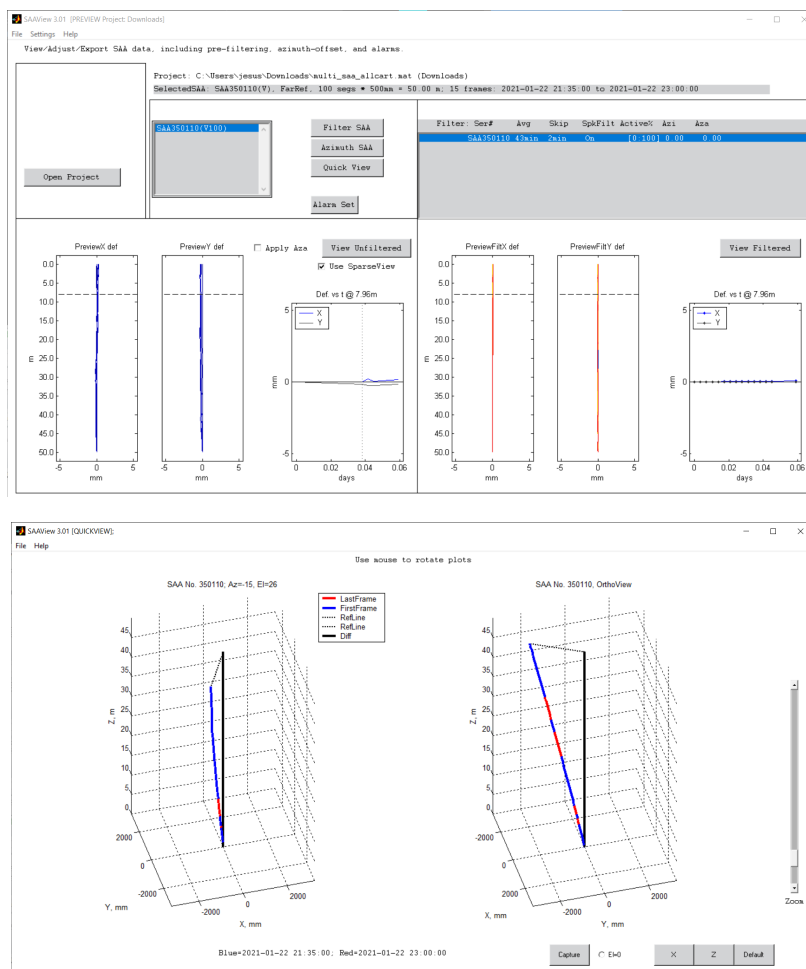


Figure 31: Converted data view.



## 12.1 Automating Conversions

The data collected on the Worldsensing node is raw data that must be converted into Cartesian engineering units by the Raw2Data software in the SAASuite. This conversion will produce a .MAT file that can be used with the Measurand visualization software and a comma-delimited .DAT file with the desired Cartesian units and reading types (e.g. cumulative or incremental deviation, temperature, tilts, etc) that can be imported into any desired third-party data management system.

The very first execution of the Raw2Data software must be done manually. In order to configure settings for the project such as the instrument's orientation, reference end, azimuth offset, etc. This manual conversion (called a Reset conversion) saves these settings so that subsequent conversions can be automated. Once the very first conversion has been completed manually, the Raw2data software can be automated with command line calls to process new readings.

Triggering the command line call to Raw2Data can be done by using scheduling software such as *Windows Task Scheduler* to execute the conversion process on a desired schedule.

For more information, please refer to [Automating Conversions](#).

## 12.2 Useful links to Measurand Documentation

[Conversion steps](#)

[Automating Conversions](#)

[Visualization](#)

## 13. Environmental best practices

### Installation and operation

Please install Worldsensing products in an energy-efficient manner by minimising power usage for computers, mobile phones or other devices needed for setup and configuration. Minimise the use of small components needed for installation, like mounting brackets and other connection materials. Avoid using toxic materials and/or hazardous substances.

- Set the sampling rate only in the nodes you need.
- When configuring the nodes, use "Set last configuration" whenever possible.
- Remove the batteries if you are not using the node.
- For nodes with switch, use the usb mode when not in operation.

### Return Material Authorization (RMA)

In the event of requesting a Return Material Authorization (RMA) please make sure to use the most environmentally friendly mode of transportation possible.

### Product End of Life and disposal

Please take the necessary measures to extend the life of the product and reuse it when possible.

Once the product reaches its end of life (EoL) recycling is crucial to divert material from waste streams into new applications.

Electrical and electronic devices, and batteries must be recycled according to the European Union WEEE Directive 2012/19/EU.

Please separate batteries from equipment.

This product and the batteries it may contain should not be discarded as unsorted waste. Please send them to separate collection facilities for recovery and recycling.

### Product packaging

Worldsensing's product packaging is recyclable. Separate the different materials for a correct waste management.

### Safety and emergency procedures

Please read the safety sheet that comes with our products before installing them. For safety information on batteries and other materials, as well as instructions in case of emergency please read the safety information available at: <https://info.worldsensing.com/safety-information/>

In the case of an emergency and after it has been managed, please evaluate the waste generated in order to dispose of it in accordance with current legislation and local regulation.

**It is your responsibility to dispose of your waste equipment, batteries and packaging properly to help prevent potential negative consequences for the environment and human health.**

The cost of environmental waste management is included in the battery's selling price.

By following these best practices you can help protect the environment. Thank you for your cooperation.

## 14. CONTACT WORLDSENSING

**Need more support?** Get in touch with our Customer Success team:

Email: [support@worldsensing.com](mailto:support@worldsensing.com) Phone: +34 93 418 05 85 (08.30h - 16.30h UTC)

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