

User Guide

Loadsensing LS-G6 Digital Data logger - Geokon Digital Sensors



LS-G6-DIG-2

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1. Important instructions prior to use

Please read these instructions carefully and ensure that the required conditions specified in this document are met before using the product. Each of our edge devices includes this information inside the packaging

General warnings

- Follow these precautions to avoid a battery explosion or leakage of flammable liquid or gas:
 - Use the correct battery type. Dispose of the batteries according to instructions. Do not dispose of the batteries by throwing them into a fire or a hot oven, or mechanically crush or cut them.
 - Do not leave the batteries in an extremely high-temperature environment.
 - Do not subject the batteries to extremely low air pressure. It may result in an explosion or leakage of flammable liquid or gas.
 - Do not short circuit the batteries. This will blow the protection fuse.
- Batteries and equipment to be connected via the data port must meet IEC 62368-1 ES1 and PS1 requirements.
- Equipment to be installed in restricted access areas.

Symbol	Description
	Caution. Do not proceed until the instructions are clearly understood and all required conditions are met.
	Read the instructions for use carefully before using.
	Caution, hot surface.
	According to the European Union WEEE Directive 2012/19/EU, this product and its batteries should not be discarded as unsorted waste. Please send them to separate collection facilities for recovery and recycling. It is your responsibility to dispose of your waste equipment and batteries properly. The correct disposal of your old equipment and batteries will help prevent potential negative consequences for the environment and human health.

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

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

Geokon digital protocol for in-place inclinometers systems and addressable thermistor strings has been integrated in the LS Digital node; some requirements to be considered are present in this document.

The different particularities of each compatible brand/sensor will be captured in different documents. You will find them at :

<https://worldsensing.zendesk.com/hc/en-us/categories/203914247-LOADSENSING>

Note:

More models will be and can be added with the development of drivers by Worldsensing. If you are interested in using one particular sensor with the LS digital node, please contact Worldsensing technical support to discuss that.

3. System requirements

The compatibility with Geokon needs the following prerequisites:

- Digital logger firmware: From version 2.47 onwards.
- Dlog app version: From version 1.7.32 onwards.
- CMT Edge version: From version 2.4.1 onwards.
- CMT Cloud version: From version 1.4.0 onwards.

4. Compatibility, limitations and output data of Geokon Digital Sensors

4.1 Compatibility with Geokon Digital sensors

The digital sensors currently compatible with the Loadsensing digital logger are listed in the digital logger [datasheet](#).

4.1.1 Model 6180

Although the following model: <https://www.geokon.com/6180> has a measuring range of +/-90° and a the calibrated range of +/-30°, the Loadsensing system can only read and transmit the measurements within +/-15°, covering the needs of most applications.

If the in-place inclinometer measurements are out of the +/-15° limits, the Loadsensing system will transmit an out of range error.

4.1.2 Discontinued models

Loadsensing system is compatible with the following models currently discontinued by Geokon:

Model 6150E: <https://www.geokon.com/6150ABCDE>

Model 6150F: <https://www.geokon.com/6150F>

4.2 Chain size limitations

Each Geokon's digital sensor is equipped with a digitization board on which Geokon uploads a predetermined configuration.

To optimize the radio transmission of the data, the maximum number of sensors that can be connected on the same chain for each sensor model has been restricted.

The chain size limitations are listed in the table below (fig. 1), this information can also be found in the digital logger [datasheet](#).

Sensor model	Maximum number of sensors per data logger	External power is needed	Remarks
In-place Inclinometer Systems	50	Yes	The digital logger can power up to 20 sensors with internal batteries
Addressable Thermistor Strings	50	-	

Figure 1: List of Geokon digital sensors currently compatible with LS Digital Loggers

4.3 Sampling Rate Limitations

Sampling rate: 30 seconds to 1 day. The maximum sampling frequency will depend on the number of digital sensors connected to the chain.

- E.g. for a 20 in-place inclinometers array, the highest frequency is every 2 minutes.
- E.g. for a 50 addressable thermistors array, the highest frequency is every 2 minutes.

4.4 Output data

For the in-place inclinometers array, the output data that the digital node will capture is:

- A-Axis and B-Axis in degrees within +/-15° and with 3 significant decimals.
- Temperature from -20°C to 80°C with 1 significant decimal.

For the addressable thermistors array, the output data that the digital node will capture is:

- Temperature from -20°C to 80°C with 2 significant decimals.

5. Equipment Provided

The Loadsensing Digital Loggers are shipped with the following accessories:

- Data 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 supports

6. 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.

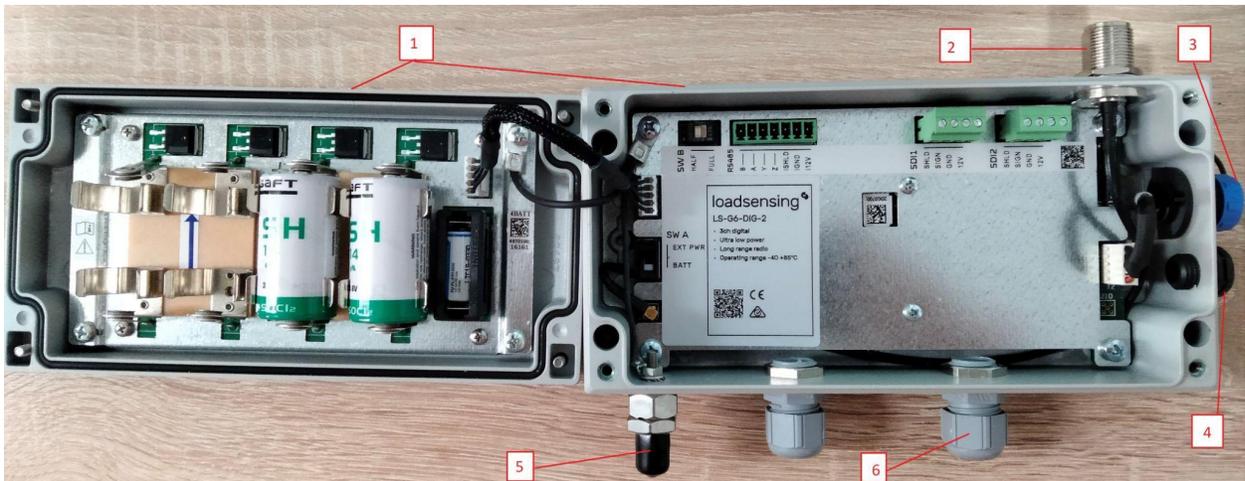


Figure 2: Loadsensing Digital Logger components

6.1 Mounting the Digital Logger

The digital nodes 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 there is an easy-to-use grounding screw (Figure 3) next to the cable glands, which may be connected to guarantee protection.



Figure 3: Detail of the grounding screw

6.2 Sensor Connection

Geokon sensors connect to the RS485 port of the Loadsensing Digital Logger. The RS485 terminal block accepts wires that are prepared by stripping a short length of the insulation from the end.

The type of sensors that can be connected to the digital node work in a duplex communication system that can be either half or full system. To date, compatible sensors are half system type, therefore the SW B switch is set to half system by default.

The wiring of the compatible sensors is determined by the colour code indicated in each sensor's manual, please refer to them at Geokon's website: <https://www.geokon.com/Products>

6.3 Powering the Digital Logger

The data logger arrives closed and without batteries installed. In order to initialize it, the user should follow these steps:

1. Use a 2.5 mm Allen wrench to open the data logger following the recommended positions (Figure 3) in order 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**, a small battery included to keep the Real Time Clock of the logger (Figure 4). The RTC battery keeps time in the data logger regardless of whether or not C-type batteries are also inserted. The data logger always uses UTC time. However, the data can be visualized in local time in the gateway or the Android configuration app. The RTC battery is only available for multichannel data loggers.
3. Insert **C-type batteries** in the battery holders (Figure 5). Between one and four batteries can be connected. Polarity is indicated (see Annex 4 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. USB position: the data logger is powered by the USB cable connected to the Android device used to configure the node or to any external power kit. BATT position (default): the data logger is powered by the batteries inserted on the battery holder.

***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.*

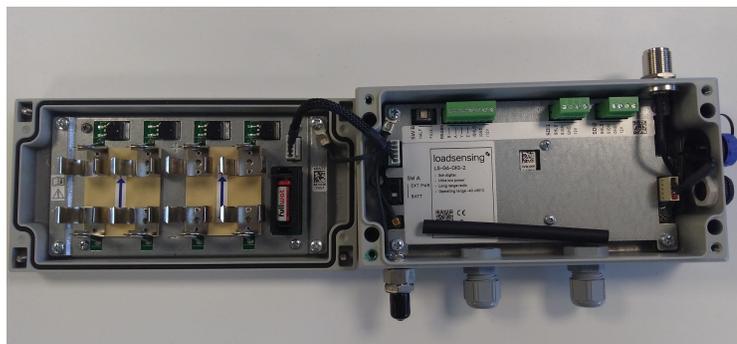


Figure 4: Open digital node

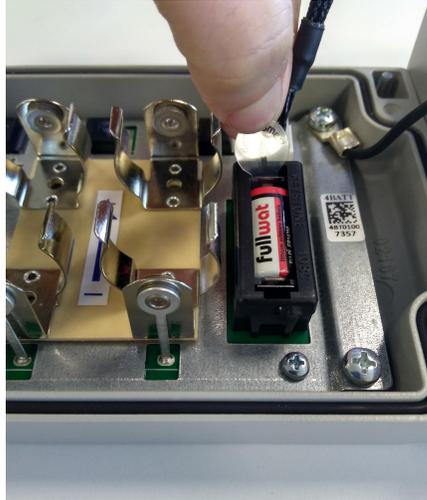


Figure 5: Plastic band to be removed from the RTC battery holder



Figure 6: Insert C-type batteries

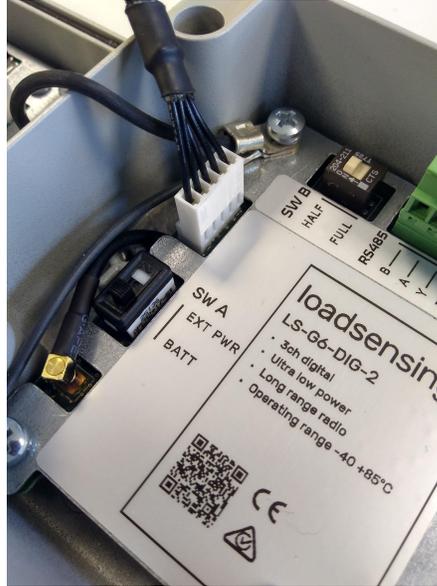


Figure 7: Switch must be in the right position depending on the power source

To use different batteries to the ones recommended it is advisable to check Saft LSH 14 batteries' specifications: [Saft LSH-14](#) as a current peak and a high pulse capability are required to power the chain of sensors.

6.3.1 External power supply

The digital logger can power up to 20 in-place inclinometers or up to 20 addressable thermistors within a string with internal batteries. If a higher number of these digital sensors need to be connected to the LS Digital logger, up to 50, it is required to externally power the sensors.

Note: the external power requirement might vary depending on the digital sensor or chain of sensors connected to the digital node. The user should refer to the specific requirements of the manufacturer and check the recommendations stated on this guide for every particular case, if any. In any case, the use of an external power supply is only meant to power the chain of sensors, the digital logger, however, MUST still be powered with the corresponding batteries.

7. Digital Logger Configuration: Digital Sensors from GEOKON

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.

Dlog starts up once the device has been connected to the node using the USB-OTG cable. Manual startup is not necessary.

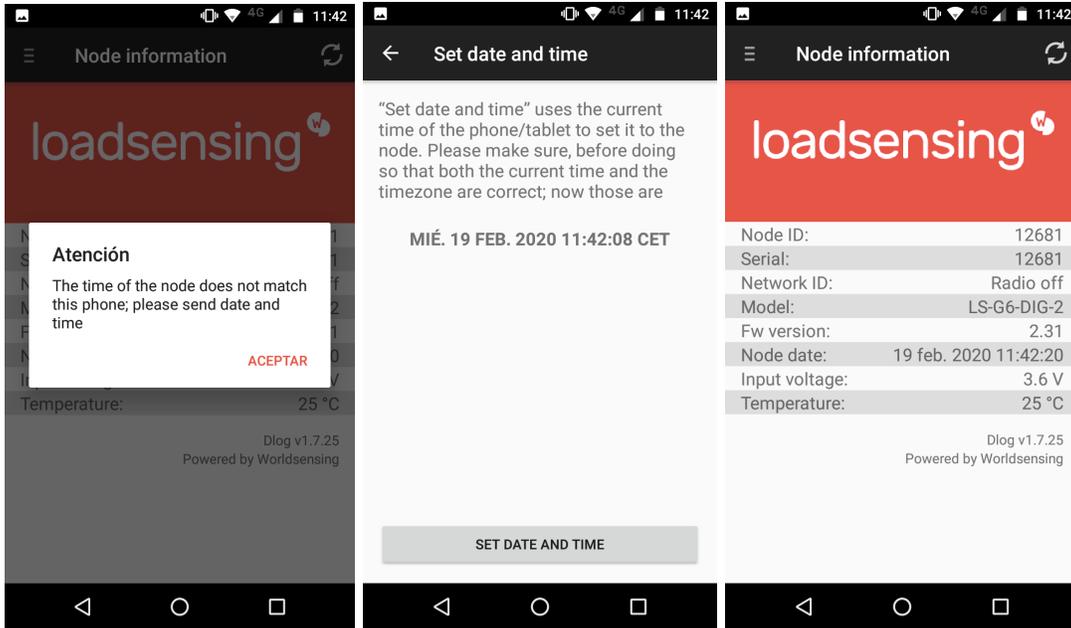
When a new version of the app is available, the Dlog app will automatically display a message.

The whole configuration process does not take more than five minutes and, from that moment, the node will start taking readings and sending data to the gateway (the gateway should be already on and running). The user can refer to the following document for further information [DLOG: LS-G6 configuration app](#).

7.1 Step 1: Connect Dlog Android application:

Download the app onto your Android device from the download website: <http://wsop.cat/industrial/dlog/Dlog.apk>

Install it and connect your device to the node using the USB-OTG cable (Accessories list). Make sure the battery or batteries are correctly inserted. The app will automatically appear and display a message (Figure 8) requesting to set the date and time of the node (it will take them from the mobile phone or tablet in use, Figure 9), afterwards, the node's basic information will appear (Figure 10).



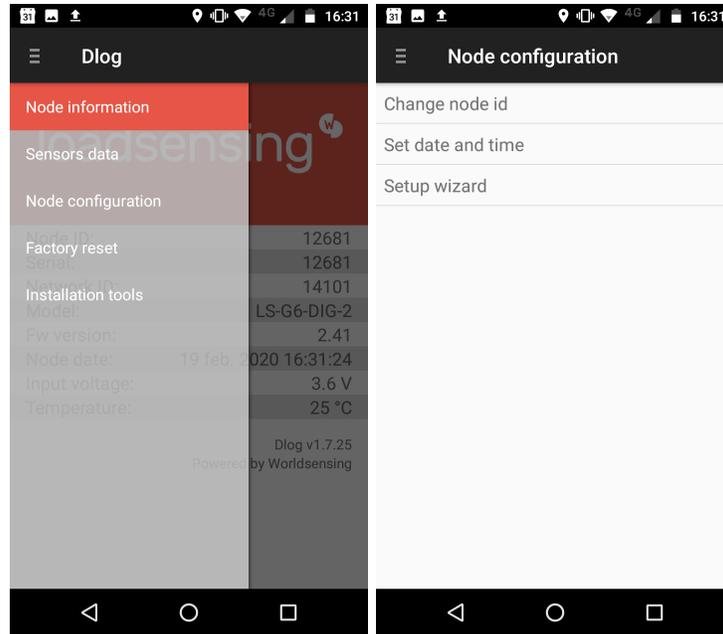
Figures 8, 9 and 10, in sequence, showing the first Dlog steps to set up a digital node through the Dlog app.

7.2 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:** Access this menu to configure the node.
 - 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: this info will be taken from the mobile phone or the laptop in use.
 - c) Setup wizard: sensor and radio configuration

To access node configuration, go to **"Node configuration"** from the main menu and then **"Setup Wizard"** (figures 11 and 12).



Figures 11 and 12, main configuration menu and Node configuration settings options respectively.

- 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), the user must select 3) Node Configuration and c) Setup Wizard, from the menu above.

7.3 Step 3: Sensor Configuration

7.3.1 Protocol

The user has to select Geokon protocol, according to the type of sensor that it is connecting, from the drop-down list (fig. 13).

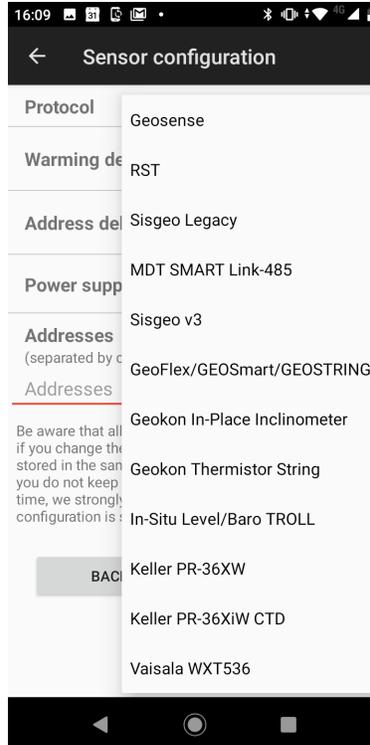


Figure 13, List of protocols compatible with LS-G6-DIG node

7.3.2 Addresses

In Addresses, the user has to enter the bus addresses of the sensors connected to the node in the corresponding sequence, separated by commas.

Note:

In a vertical chain of sensors, the sequence can start with the bus address of the sensor placed nearest to the head and followed by the sensors placed at a deeper location or the other way around. It is advisable that the user takes record of the sequence and their relative position (figure 14).

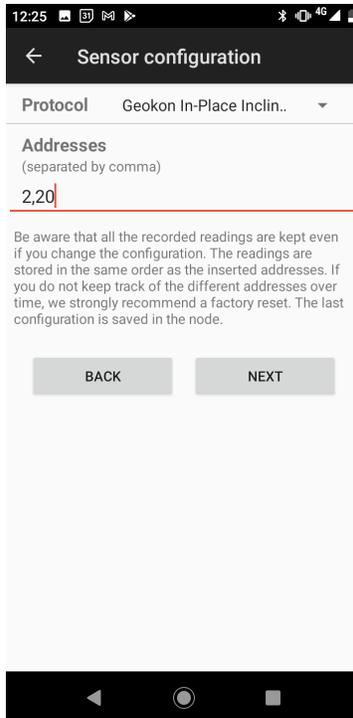


Figure 14, Bus addresses of the digital sensors connected (chain of sensors)

In case there were two or more sensors with the same digital bus addresses connected in the same chain, these sensors would not be readable, the user should contact Geokon Support to get the bus addresses changed accordingly.

7.4 Step 4: **Sensor's data**

The Dlog app will show the sensors' data as shown in figure 15. If the configuration is correct, the data is displayed.

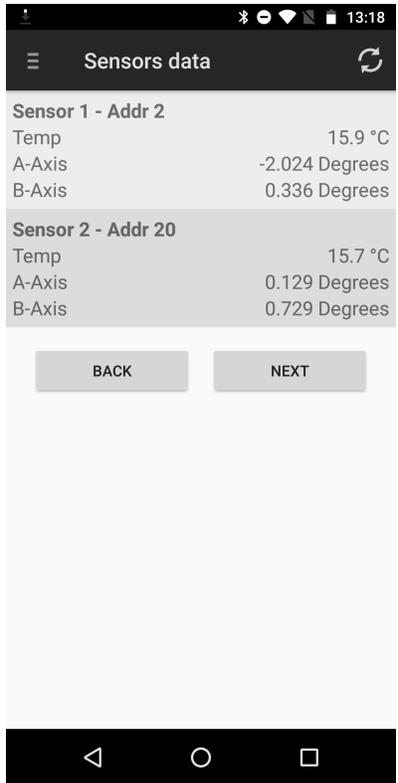
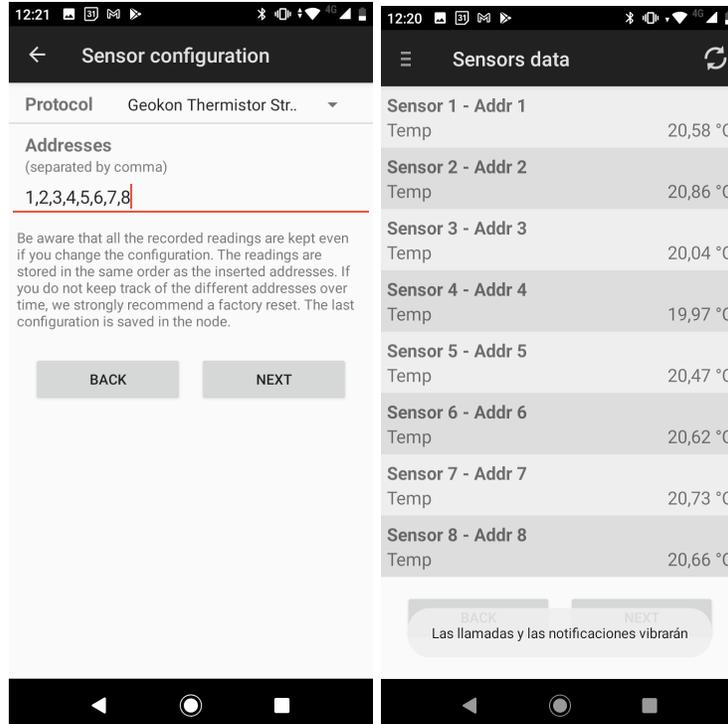


Figure 15, Sensors data reported in sequence

If the user is reading a string of Geokon thermistors, the protocol to chose and the data output after entering the corresponding bus addresses, will be different as shown in the images below (figures 16 and 17):



Figures 16 and 17, bus addresses of the Geokon thermistors in sequence and data output, respectively

7.5. Step 5: Radio Configuration

The radio settings are as follows (fig. 18):

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

Note: The default configuration parameters should be suitable for the majority of networks.

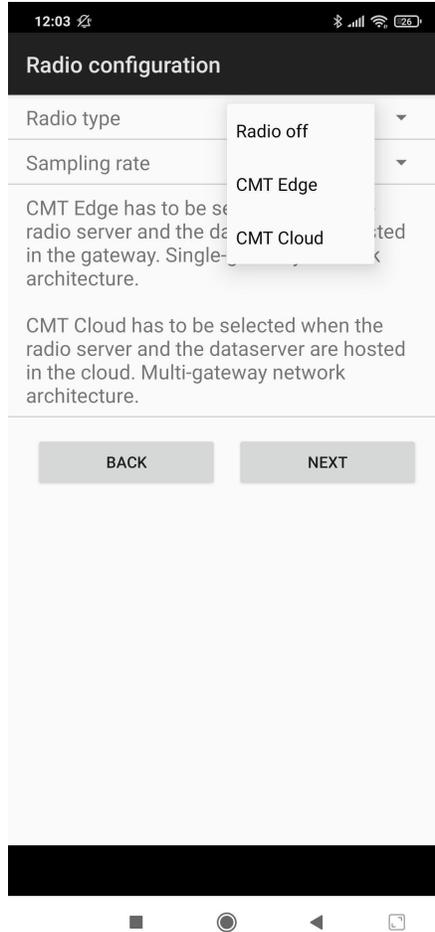


Figure 18, Radio type configuration.

Next, set the **Sampling rate**. Several sampling rates are displayed on the screen and their availability will depend on the **Network Size**. 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 sensors that are being read. Smaller networks and short chains of sensors can read up to every minute and frequency is progressively reduced on bigger networks and on increased numbers of digital sensors in the same chain. Dlog will show the available sampling rates accordingly.

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 that can be found at [Zendesk-LOADSENSING-USER-GUIDES](#).

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, please refer to the [knowledge base](#) where the user guides can be downloaded.

Enter the **Network ID** and password provided in the Gateway Information Sheet that is supplied along with the gateway. All messages are encrypted with the network password.

7.5.1 Radio Configuration Advanced options

1. See the Radio specification chapter of the Gateway User Guide or [Annex 01_LS G6 Gateway Radio Specifications](#) for more details on radio models and settings.
2. 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.

7.6 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.

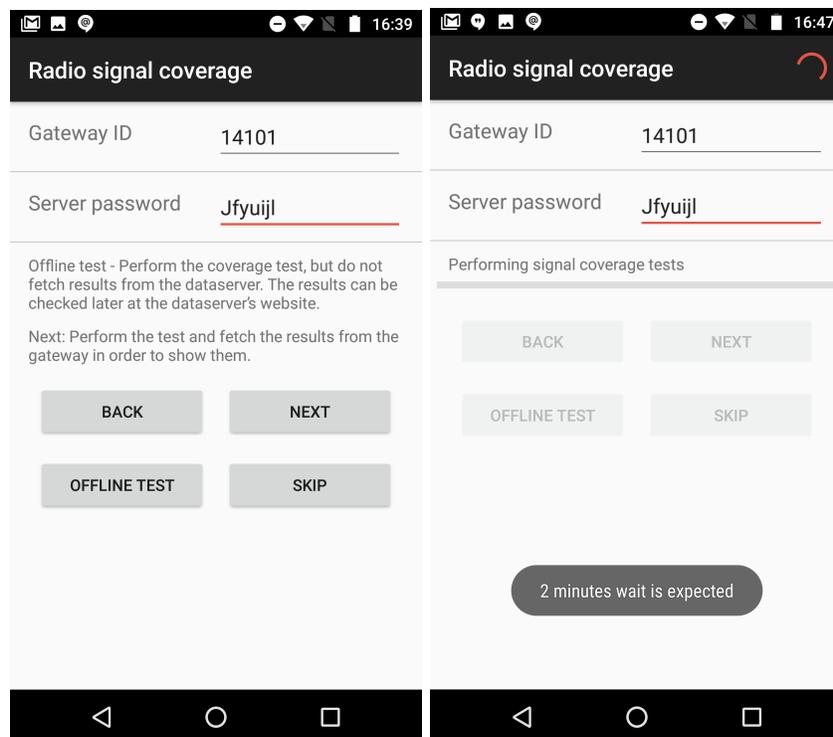
The node sends test packages. The Loadsensing Mobile App then checks the gateway (using an Internet connection) to see if these packets have arrived. Hence, the test will check for:

- 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 entered in the Loadsensing Mobile App (figures 19 and 20). 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)



Figures 19 and 20, Gateway ID and password are needed to perform a radio coverage test, it takes two minutes to be completed.

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 device 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 (figure 21). 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**.

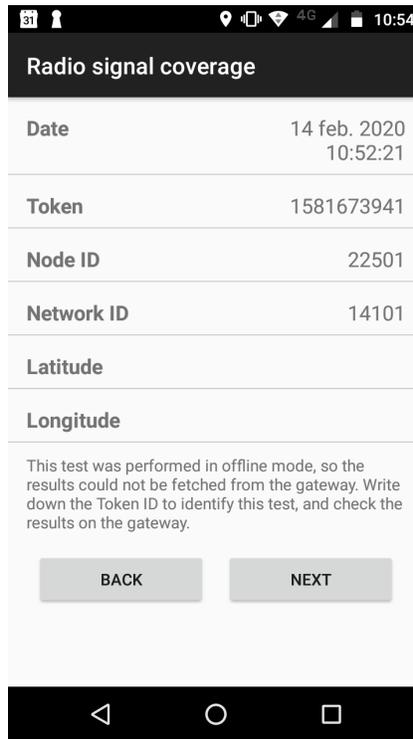


Figure 21, Token number generated out of an offline radio coverage test.

7.6.1 Test results interpretation

The results of an online coverage test are shown when the test is finished. For offline coverage tests, they can be downloaded to the Gateway (CMT Edge) or to the data server (CMT Cloud). For more information on how to download them, please refer to the [knowledge base](#) where the user guides can be downloaded.

The results are displayed for each Spreading Factor (SF) (figure 22). During a radio signal coverage test, a data logger sends 5 or 10 data packages from SF7 to SF11. The number of data packages that reach the gateway is captured and gives an idea of the quality of the communication. A coverage test is considered successful if any of the SFs available on the network is able to deliver at least half of the packages sent.

The SF represents a way of modulating data. The SF is proportional to the distance between the data logger and gateway: higher SFs are capable of transmitting data at higher distances, while lower SFs reach lower distances, consequently the lower the SF number is, the shorter the message; thus, more messages can be sent on the network.

For further information, please check the following link: [Spreading Factor](#).

Radio signal coverage	
Date	13 Oct 2020 13:25:46
Token	1602588346
Node ID	7060
Network ID	21784
Latitude	
Longitude	
SF7	10 / 10
SF8	10 / 10
SF9	10 / 10
SF10	5 / 5
SF11	5 / 5
SF12	5 / 5
<p>For the coverage test to be successful, the highlighted SFs should receive an average of at least one third of the messages sent, and one of them should receive at least half of the messages sent. For more information consult the documentation.</p>	
<p>BACK NEXT</p>	

Figure 22, Coverage test results (online test)

Note: Performing the Radio signal coverage test takes approximately 2 minutes.

8. 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 23). 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 23, 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 also held with a 19 mm open spanner . (Figure 24)

Note: The digital loggers with serial numbers below 29394 have plastic internal nuts instead of the current metallic ones. For those devices it was required to hold the internal nut with a 22 mm open spanner (e.g. Ref *Bahco 894M-22, 22 mm single-ended open spanner*).

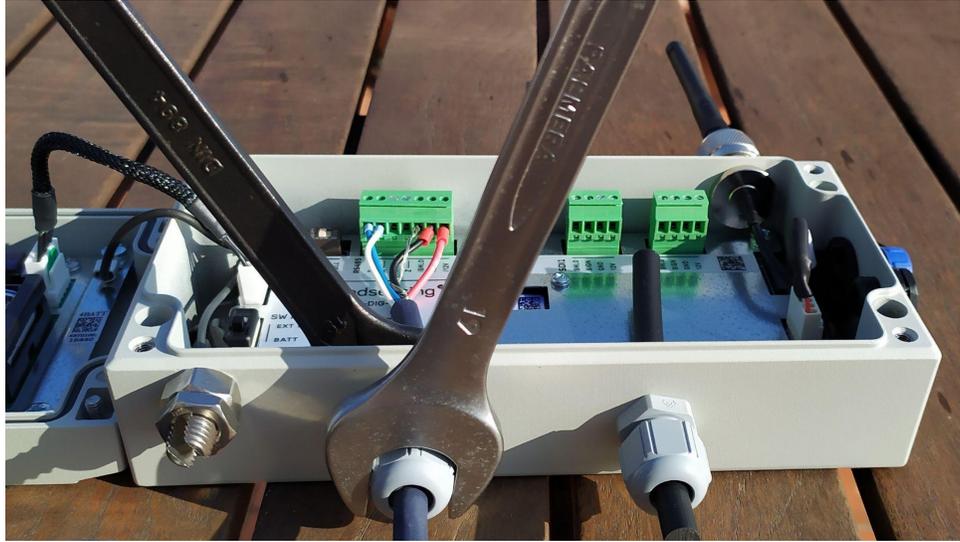
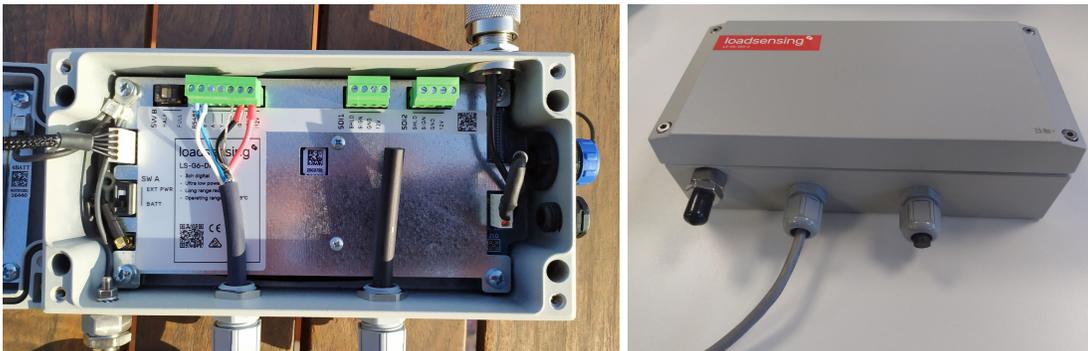


Figure 24, Tightening the cable glands

- A piece of rubber rod to seal the unused cable glands is provided in each box (Figures 25 and 26).
- 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 25 & 26, 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.

9. Maintenance

9.1 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 27). Your mobile phone or tablet needs to have an Internet connection. Otherwise, contact Worldsensing technical support for assistance.

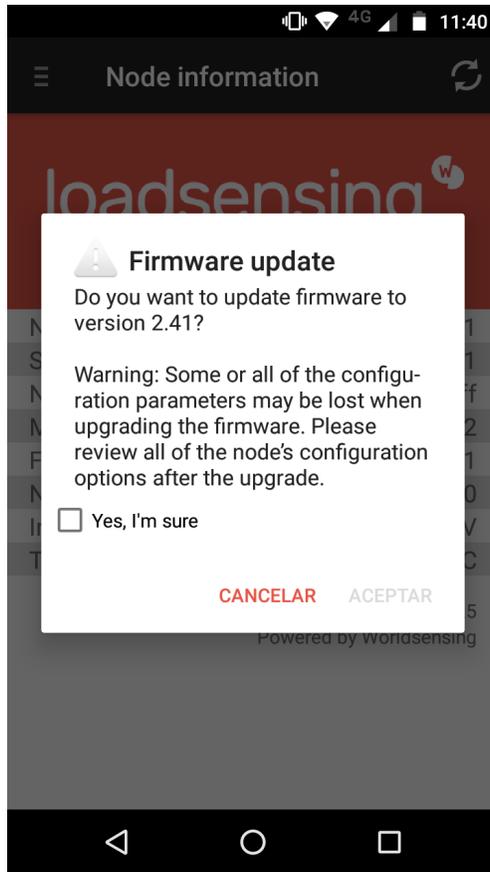


Figure 27, Firmware update message displayed on a screen

9.2 Battery Lifespan

Battery consumption varies depending on the number of sensors connected in a chain, the sampling rate and the environmental and wireless network conditions.

The digital logger runs on four battery cells and according to the tests conducted in lab conditions (at a temperature of 25°C) using four SAFT LSH 14 batteries with a nominal voltage of 3.6 ([SAFT LSH 14 batteries product sheet](#)), the node is capable of powering up to 20 Geokon in-place inclinometers and up to 50 Geokon thermistors as shown in figures 28, 29, 30 and 31 shown below.

9.2.1 Geokon in-place inclinometers (only applicable to model 6150E / 6150F)

Test settings in terms of radio:

FCC countries radio configuration: Spreading factor 8. Radio transmit power 20d.

SF8@20dBm				
number of sensors/ sampling	5min	30min	1h	6h
5 sensors	1.3	4.6y	6y	8.2y
10 sensor	0.47y	2.2	3.5y	7.1y
20 sensors	72 Days	1y	1.9y	5.5y

Europe radio configuration: Spreading factor 9. Radio transmit power 14d.

SF9@14dBm				
number of sensors/ sampling	5min	30min	1h	6h
5 sensors	1.1y	4.2y	5.7y	8.1y
10 sensor	0.4y	2y	3.3y	7y
20 sensors	68 Days	1y	1.8y	5.4y

Figures 28 & 29, Estimated battery life for two different radio settings

9.2.2 Geokon addressable string of thermistors

Test settings in terms of radio:

FCC countries radio configuration: Spreading factor 8. Radio transmit power 20d.

SF8@20dBm				
number of sensors/ sampling	5min	30min	1h	6h
10 sensor	0.8y	3.5y	4.8y	7.8y
20 sensors	0.3y	1.8y	3y	6.7y
30 sensors	0.2y	1.3y	2y	5.6y
50 sensors	0.1y	0.6y	1.1y	4.2y

Europe radio configuration: Spreading factor 9. Radio transmit power 14d.

SF9@14dBm				
number of sensors/ sampling	5min	30min	1h	6h
10 sensor	0.7y	3.1y	4.6y	7.7y
20 sensors	0.3y	1.8y	3y	6.7y
30 sensors	0.2y	1y	1.9y	5.5y
50 sensors	0.1y	0.6y	1.1y	4.1y

Figure 30 & 31, Estimated battery life for two different radio settings

Note: Battery life may vary considerably from specifications depending on the actual set-up and working conditions; such as 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.

9.3 Data Acquisition and Storage

The digital logger has an internal memory of 4 MB. A Loadsensing Digital Logger connected to a chain of inclinometers stores up to 90,000 readings, these readings include the sensors' data and other relevant information depending on the type of the sensor.

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 (CSV type for both readings and health data). You can download readings and health files using the Loadsensing Mobile App. The user can refer to section 3 of the following doc [LS-G6 Dlog user guide](#).

9.4 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 lightning strike or one so close that it overloads the capacity of the surge protection.

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

10. Troubleshooting

10.1 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*:

If all the above points have already been checked and radio communication issues still occur:

- 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.

10.2 Missing Packages due to radio connectivity issues

Taking the example of a chain of in-place inclinometers, a Loadsensing digital logger sends the data in packages of 5 sensors. Consequently, if the reading files recorded in the gateway show missing data of 5 IPIs (i.e. showing blank readings for 5 consecutive channels in a row,) or missing data of channels in multiple of 5 (i.e 10, 15, 20, etc channels in a row), it means that the node is experiencing a poor radio coverage.

As an example, see data from node 7480 in figure 32. Data with timestamp 10/4/2019 05:00:00 from IPI 1 to 5 IPIs is blank, however, readings from IPIs 6 onwards have data.

9	Timezone	America/Los Angeles																				
10	Date-and-time	Temp-7480-C	Aaxis-7480-C	Baxis-7480-C	Temp-7480-C	Aaxis-7480-C	Baxis-7480-C	Temp-7480-C	Aaxis-7480-C	Baxis-7480-C	Temp-7480-C	Aaxis-7480-C	Baxis-7480-C	Temp-7480-C	Aaxis-7480-C	Baxis-7480-C	Temp-7480-C	Aaxis-7480-C	Baxis-7480-C	Temp-7480-C		
28	5/4/2019 23:00																					
29	10/4/2019 02:00																					
30	10/4/2019 05:00																					
31	10/4/2019 06:00																					
32	10/4/2019 08:00	24.2	-0.1835	-0.9888	24.2	-1.294	-0.5621	24.1	-0.0559	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.723	24.1	-0.6565	0.0297	25.2	0.4065	0.2273
33	10/4/2019 09:00	24.2	-0.1835	-0.9897	24.2	-1.294	-0.563	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7221	24.1	-0.6565	0.0288	25.2	0.4056	0.2273
34	10/4/2019 11:32	24.3	-0.1835	-0.9888	24.2	-1.2931	-0.563	24.1	-0.055	-0.4721	24.1	-0.0323	-0.0192	24.1	-0.2745	0.7221	24.2	-0.6565	0.0297	25.2	0.4047	0.2273
35	10/4/2019 12:00	24.3	-0.1844	-0.9897	24.2	-1.2931	-0.563	24.1	-0.055	-0.4712	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6565	0.0297	25.2	0.4047	0.2273
36	10/4/2019 13:00	24.2	-0.1835	-0.9897	24.2	-1.2922	-0.5621	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.2	-0.6557	0.0297	25.2	0.4056	0.2273
37	10/4/2019 14:00	24.2	-0.1835	-0.9897	24.2	-1.2922	-0.563	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6574	0.0288	25.2	0.4039	0.2273
38	10/4/2019 15:00	24.2	-0.1835	-0.9897	24.2	-1.2931	-0.563	24.1	-0.0559	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6565	0.0288	25.2	0.4039	0.2273
39	10/4/2019 16:00	24.2	-0.1835	-0.9897	24.2	-1.2931	-0.563	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0201	24.1	-0.2753	0.7212	24.2	-0.6565	0.0297	25.2	0.4047	0.2273
40	10/4/2019 17:00	24.3	-0.1835	-0.9897	24.2	-1.2931	-0.563	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6565	0.0297	25.2	0.4039	0.2273
41	10/4/2019 18:00	24.2	-0.1835	-0.9888	24.2	-1.2922	-0.563	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.2	-0.6565	0.0288	25.2	0.4039	0.2273
42	10/4/2019 19:00	24.2	-0.1835	-0.9897	24.2	-1.2922	-0.5621	24.1	-0.0559	-0.4721	24.1	-0.0314	-0.0192	24	-0.2745	0.7204	24.1	-0.6565	0.0297	25.2	0.4039	0.2273
43	10/4/2019 20:00	24.2	-0.1835	-0.9897	24.2	-1.2931	-0.563	24.1	-0.055	-0.4721	24.1	-0.0323	-0.0192	24.1	-0.2753	0.7212	24.2	-0.6574	0.0297	25.2	0.4039	0.2273
44	10/4/2019 21:00	24.2	-0.1835	-0.9897	24.2	-1.2931	-0.563	24.1	-0.055	-0.4712	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6574	0.0297	25.2	0.4039	0.2273
45	10/4/2019 22:00	24.2	-0.1835	-0.9897	24.2	-1.2922	-0.563	24.1	-0.0559	-0.4721	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6574	0.0297	25.2	0.4039	0.2273
46	10/4/2019 23:00	24.2	-0.1844	-0.9897	24.2	-1.2922	-0.563	24.1	-0.0559	-0.4721	24.1	-0.0323	-0.0192	24	-0.2753	0.7212	24.1	-0.6565	0.0297	25.2	0.4039	0.2273
47	11/4/2019 00:00	24.2	-0.1835	-0.9897	24.2	-1.2931	-0.563	24.1	-0.0559	-0.4721	24.1	-0.0314	-0.0192	24	-0.2753	0.7212	24.1	-0.6565	0.0297	25.2	0.4039	0.2273
48	11/4/2019 01:00	24.2	-0.1827	-0.9897	24.2	-1.2931	-0.563	24.1	-0.055	-0.4721	24.1	-0.0314	-0.0192	24	-0.2753	0.7212	24.1	-0.6565	0.0297	25.2	0.4047	0.2273
49	11/4/2019 02:00	24.2	-0.1844	-0.9897	24.2	-1.2922	-0.563	24.1	-0.0559	-0.4712	24.1	-0.0314	-0.0192	24.1	-0.2753	0.7212	24.1	-0.6565	0.0297	25.2	0.4047	0.2273

Figure 32. Data missing in multiples of 5 (channels), indicative of radio issues.

This can also be checked at the node status reported on the gateway as a panel of messages sent/received (showing the total number of messages sent from its initial configuration and also the past 5 days in detail): Login into the gateway, go to status tab and then the received/lost radio messages can be seen.

In this particular example (figure 33), 2273 messages (in green) have been received in total, 122 messages (in red) have been lost and 69 messages (in orange) have been lost due to power interruption .

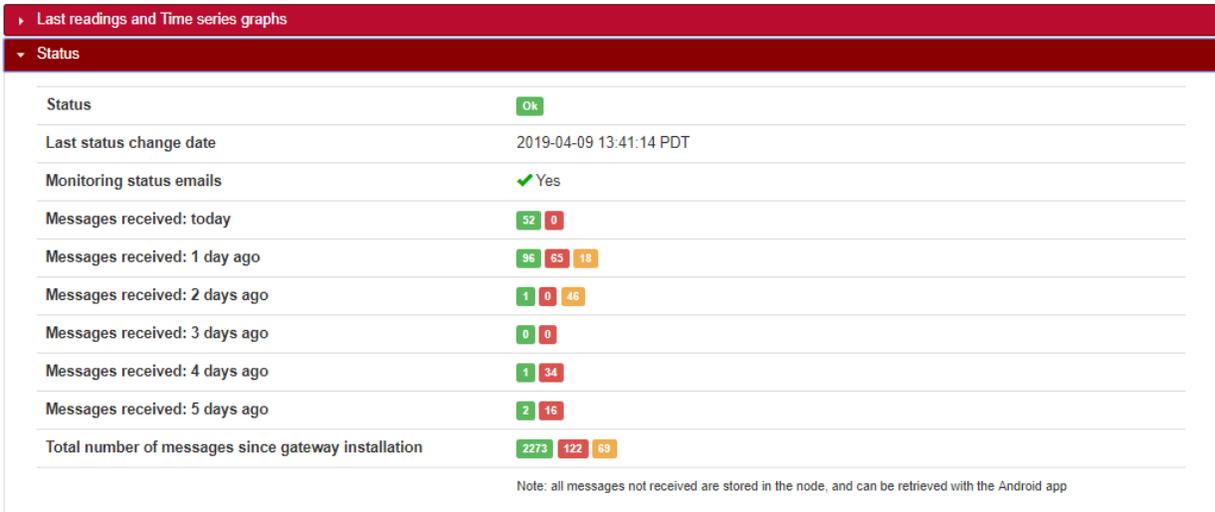


Figure 33, Radio messages status recorded on the gateway

10.3 Missing packages due to low battery level or signal issues

Contrary to what happens when there are radio communication issues, when the batteries start to fail or there is a need of improving the way the data is read (Modbus protocol), the data missing does not go in packages of five, consequently it could happen that the data chain is only incomplete for a few channels. As highlighted in figure 34 (extracted from node 7489 which is connected to a gateway), data loss might happen in just one single channel or in several but does not necessarily have to be in multiples of 5.

Another sign that can lead us to suspect there is a battery or signal reading issue is to have empty data rows with the timestamp recorded (refer to rows 207 to 209 as an example).

#	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
10	Date and time	Temp-7489-A	Aaxis-7489-C	Baxis-7489-C	Temp-7489-Ch2	Aaxis-7489-C	Baxis-7489-C	Temp-7489-C	Aaxis-7489-C	Baxis-7489-C	Temp-7489-C	Aaxis-7489-C	Baxis-7489-C	Temp-7489-Ch5	Aaxis-7489-C	Baxis-7489-C	Temp-7489-C	Aaxis-7489-C	Baxis-7489-C	Temp-7489-C	Aaxis-7489-C	Baxis-7489-C
193	22/03/2019 23:00	26.8	-0.1739	-0.0445	27.1	-0.3497	0.1267	27.4	-0.4764	0.7466	27.7	-0.4677	1.2406	28	0.3934	0.7763	28.2	0.2019	0.5796	28.4	-0.229	1.4645
194	22/03/2019 0:00	26.8	-0.1748	-0.0437	27.1	-0.3505	0.1267	27.4	-0.4764	0.7466	27.6	-0.4677	1.2415	27.9	0.3934	0.7754	28.1	0.2019	0.5805	28.4	-0.229	1.4645
195	22/03/2019 1:00	26.8	-0.1739	-0.0445	27.1	-0.3505	0.1258	27.4	-0.4764	0.7466	27.6	-0.4677	1.2415	28	0.3934	0.7763	28.2	0.201	0.5796	28.3	-0.229	1.4654
196	22/03/2019 2:00	26.8	-0.1748	-0.0437	27.1	-0.3505	0.1267	27.4	-0.4764	0.7466	27.6	-0.4677	1.2415	28	0.3934	0.7754	28.2	0.2019	0.5796	28.3	-0.229	1.4645
197	22/03/2019 3:00	26.8	-0.1748	-0.0437	27.1	-0.3505	0.1267	27.4	-0.4764	0.7466	27.7	-0.4677	1.2415	28	0.3934	0.7763	28.2	0.2019	0.5796	28.3	-0.229	1.4654
198	22/03/2019 4:00	26.8	-0.1739	-0.0445	27.1	-0.3497	0.1267	27.4	-0.4764	0.7466	27.7	-0.4677	1.2406	28	0.3934	0.7754	28.2	0.2019	0.5805	28.4	-0.229	1.4645
199	22/03/2019 5:00	26.8	-0.1739	-0.0445	27.1	-0.3497	0.1267	27.4	-0.4764	0.7466	27.6	-0.4677	1.2406	27.9	0.3934	0.7763	28.2	0.201	0.5796	28.4	-0.2281	1.4628
200	22/03/2019 6:00	26.8	-0.1748	-0.0437	27.1	-0.3497	0.1267	27.4	-0.4764	0.7466	27.6	-0.4677	1.2415	28	0.3925	0.7754	28.2	0.201	0.5805	28.3	-0.2281	1.4636
201	22/03/2019 7:00	26.8	-0.1748	-0.0437	27.1	-0.3497	0.1267	27.4	-0.4764	0.7466	27.6	-0.4686	1.2415	28	0.3925	0.7754	28.2	0.201	0.5796	28.3	-0.2281	1.4626
202	22/03/2019 8:00				27.1	-0.3488	0.1267	27.4	-0.4764	0.7467	27.6	-0.4668	1.2406	27.9	0.3925	0.7763	28.2	0.201	0.5813	28.3	-0.229	1.464
203	22/03/2019 9:00				27.1	-0.3488	0.1267	27.4	-0.4764	0.7457	27.6	-0.4659	1.2406	28	0.3907	0.7763	28.1	0.1993	0.5822	28.4	-0.229	1.4575
204	22/03/2019 10:00	26.8	-0.1748	-0.0445	27.1	-0.3488	0.1267	27.4	-0.4764	0.7466	27.6	-0.4668	1.2406	28	0.3907	0.7763	28.2	0.2002	0.5822	28.4	-0.2281	1.4584
205	22/03/2019 11:00	26.8	-0.1748	-0.0454	27.1	-0.3488	0.1267	27.4	-0.4764	0.7475	27.7	-0.4668	1.2398	28	0.3899	0.7763	28.2	0.1993	0.5831	28.4	-0.2281	1.4558
206	22/03/2019 12:00	26.8	-0.1748	-0.0445	27.1	-0.3497	0.1276	27.4	-0.4764	0.7466	27.6	-0.4677	1.2406	27.9	0.3925	0.7746	28.2	0.2019	0.5796	28.4	-0.229	1.4628
207	22/03/2019 13:00																					
208	22/03/2019 14:00																					
209	22/03/2019 15:00																					

Figure 34, Example of a reading file in which some data from one or more sensor of the chain is not being recorded

9.3.1 If it is a battery issue:

First of all, replace all 4 batteries for new ones, these batteries should be SAFT 3.6V batteries to ensure the battery life specified in the manual.

Then check whether the configuration of the node is according to the manufacturer specs (Geokon in this case). To check on this the user will have to enter the node via the Dlog app.

9.3.2 If it is a low signal issue:

When connecting the sensors, we recommend using resistors. In some cases, this is clearly specified by the sensor manufacturer. See next chapter: Resistor to increase the signal power.

10.4 Using a resistor to avoid signal reflections on the line

Some sensor manufacturers recommend the installation of a termination resistor in the digital data logger which should be the same as the one that is installed at the inclinometer sensor located at the bottom of a chain of IPIs.

Placing a 120 ohm termination resistor in the terminal block (between A and B) as shown in fig. 35 is useful if there are missing readings because the resistor reduces the noise in the RS485 bus.

If there are no missing readings in the csv file, it is not a must to install the resistor.

Geokon works with a 120 ohm termination resistor placed on their sensors (the sensor that goes at the toe of the IPIs chain). It is recommended that the same resistor is installed in the terminal block (between A and B).

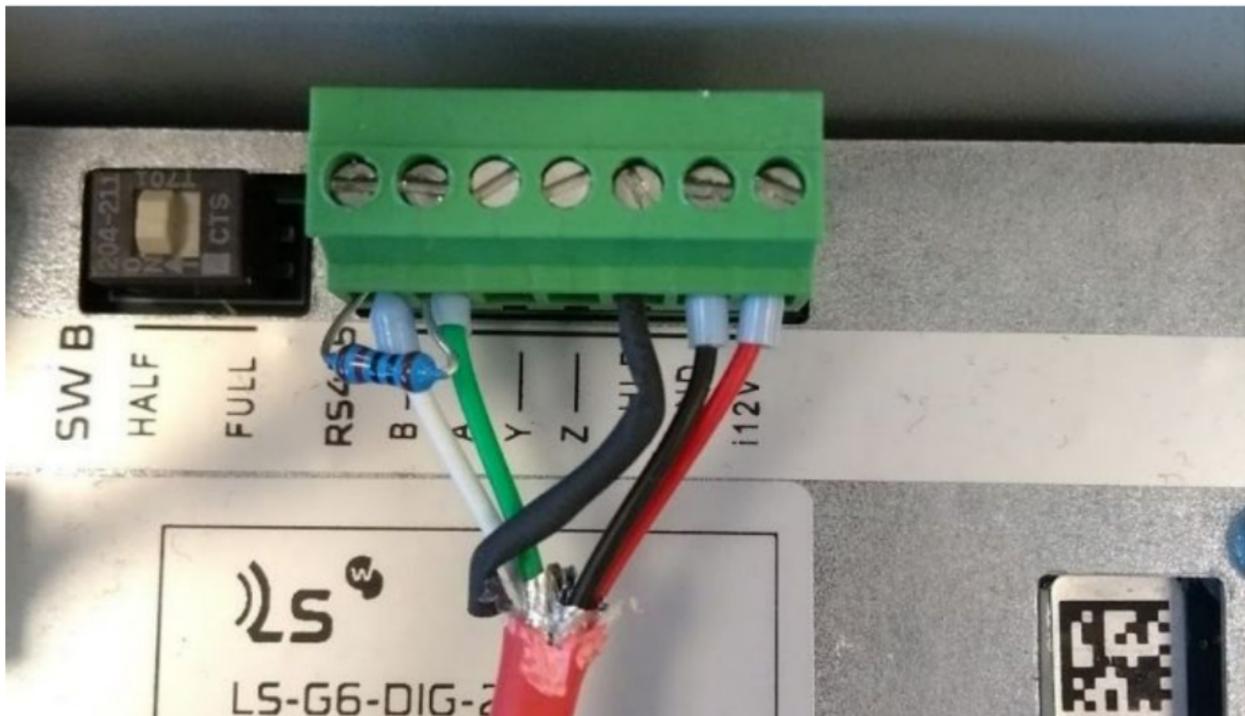


Figure 35, 120 Ohms Resistor to improve the signal communication

Example of resistor that could be purchased: [120Ω Resistor](#)

Specifications:

Resistor TE Connectivity, 120Ω ±1%, 0.6W, Series LR1

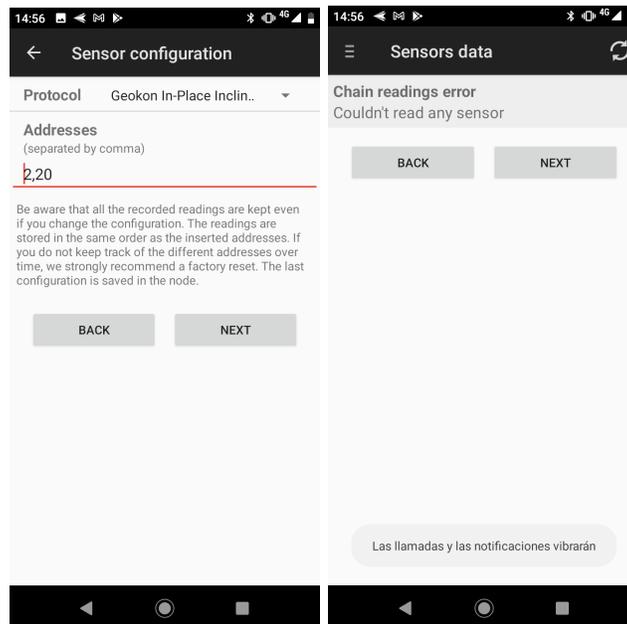
Code RS: 171-1690

Ref.: LR1F120R

Manufacturer:TE Connectivity

10.5 Errors reported by the Digital data logger

If any error occurs on the sensor, like for example when the digital logger cannot recognise any sensor connected to it, an error message will appear on the Dlog app, see figures 36 and 37 below:



Figures 36 and 37, sensors entered in the Dlog app cannot be recognised

Also, if the set up of the chain of sensors is completed and an error occurs, an 'errors file' will be generated and recorded on the gateway, it will appear along the readings and health files recorded for each data logger.

10.6 Reading errors csv file

A readings error csv file is generated and recorded on the datasever, either on the gateway (CMT-Edge architecture) or in the cloud (CMT-cloud architecture) for every digital logger if an error occurs for any reason

Node 62 	
/ Networks / 678 / Node 62	
Name	Digital node
Installation date	2019-07-24
Comments	Sants office
Model	LS-G6-DIG-1-FCC
Firmware version	2.40
Serial number	62
Health CSV files	62-health-current.csv
Reading errors CSV files	62-reading-errors-current.csv

Figure 38, Example of a digital logger that has generated a readings error file

When a general error is reported by the digital logger, a line containing only the timestamp (first column) will be appended to the readings csv (62-readings-current.csv in Image 1) while a line with the error information will be appended to the errors csv (62-reading-errors-current.csv in figure 38).

10.6.1 Information included in the CSV file

The information that can be found in the CSV is described below:

- Same header as the digital logger CSV file (node ID, gateway ID, model,...)
- Columns including:
 - Date and time
 - Message-type-{node id}: This is included because some nodes can have several types of messages, like the digital node.
 - Errors-{node id}
 - Error code. One or more separated by ';' if more than one is present.
 - E.g -> "1;0"
 - Locations-{node id}
 - Up to one location for each error in 'Errors' separated by ';' and in the same order as in the 'Errors' column.
 - E.g. of a specific channel error. If there are errors on sensor 1 channel 3 and sensor 5 channel 1:
 - "S1CH3;S3CH1"
 - E.g. of a general error.
 - "GENERAL"
 - Comments-{node id}

- Column to explain any error deemed necessary for any particular error code or situation. Commonly used for general errors explanation.

Note: The same date and time will be written in the data CSV and reading error CSV to match a specific sample with its errors (if any occurs).

10.6.2 Errors type

Errors can be divided into two groups:

- **General error:** When this type of error occurs, all readings are invalidated (e.g. a low power supply detection).
 - Just the timestamp is written in data CSV, all the channels will appear blank. Node's data visualization will show the following message:

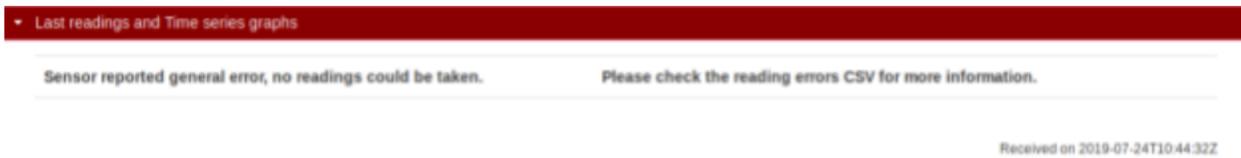


Figure 39, Information displayed when a digital node's last reading presents a general error

- **Specific channel errors:** This type reports an error on a specific sensor channel (e.g. one sensor channel out of range).
 - Cells in data CSV and node's data visualization when an error has happened **will appear blank**:

The screenshot shows a red header bar with the text "Last readings and Time series graphs". Below it is a table with 5 rows and 4 columns. The columns are labeled "Sensor ID", "Temperature (°C)", "X Axis (mm/m)", and "Y Axis (mm/m)". The data is as follows:

Sensor ID	Temperature (°C)	X Axis (mm/m)	Y Axis (mm/m)
1	24.50	850.37	154.83
2	26.40	883.91	14.57
3	26.80		2.82
4	24.80	871.20	384.11
5	24.90	876.74	255.52

The cell for Sensor ID 3 in the X Axis column is empty and circled in red, indicating a specific channel error.

Figure 40, Information displayed when a digital node's last reading presents a specific error in a sensor channel

Note: **This CSV is not available to upload via FTP, but it can be included in a custom compacted CSV:**

	Column	Node	Data source	Header name	
↑	1	62	Sensor1-62-Temp	S1_Temperature	
↑	2	62	Sensor1-62-Xaxis	S1_Xaxis	
↑	3	62	Sensor1-62-Yaxis	S1_Yaxis	
↑	4	62	Errors-62	Node_62_Errors	
↑	5	62	Locations-62	Node_62_error_locations	

Figure 41, Example of a custom compacted file in which the readings errors are included (columns 4 and 5)

To date, this CSV file is only available on the gateway, not in the mobile application, consequently when the csv data is downloaded with the mobile application, cells will appear blank when an error occurs.

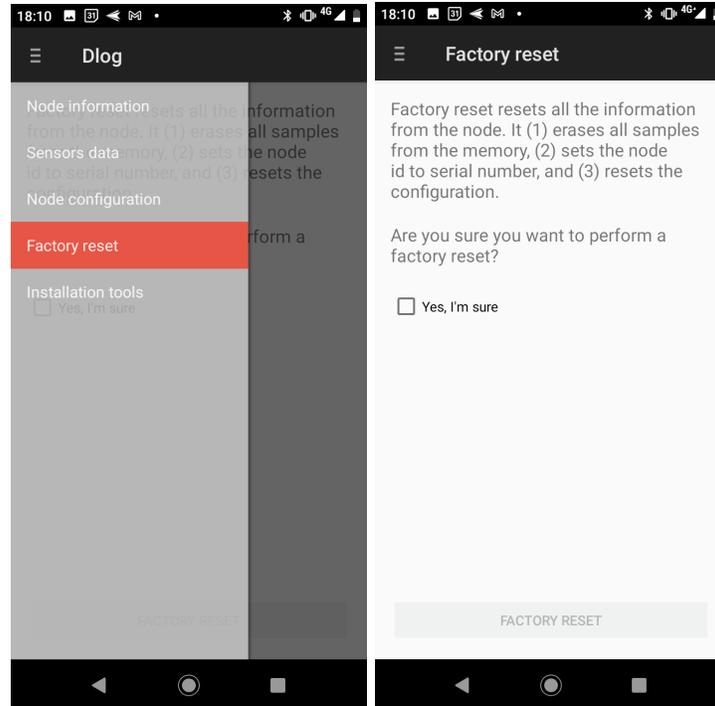
10.6.3 Errors code description

Type	Code	Description
General	-1	Internal error. Contact Worldensing for more information.
	0	When the power supply of the sensors chain can be measure and is lower than the configured threshold, all the readings are invalidated. Error with the power supply.
	1 2 3 4	Internal errors. Contact Worldensing for more information.
	5	No response was received from any of the configured sensors IDs. Couldn't read any sensor. Error with communication.
Specific	0	Value out of range.

Figure 42, List of general and specific errors

10.7 Factory reset

If the standard troubleshooting does not work, a factory reset of the data logger can be done to start over with the setup of the node as shown in the images below (fig. 43 and 44).



Figures 43 and 44, factory reset option

11. CONTACT WORLDSENSING

Need more support? Get in touch with our Customer Success team:
Email: support@worldsensing.com Phone: +34 93 418 05 85 (08.30h - 16.30h UTC)

Want to stay up-to-date about Worldsensing? Sign up for our newsletter: www.worldsensing.com

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blog.worldsensing.com

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www.worldsensing.com/download-center

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12. 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.

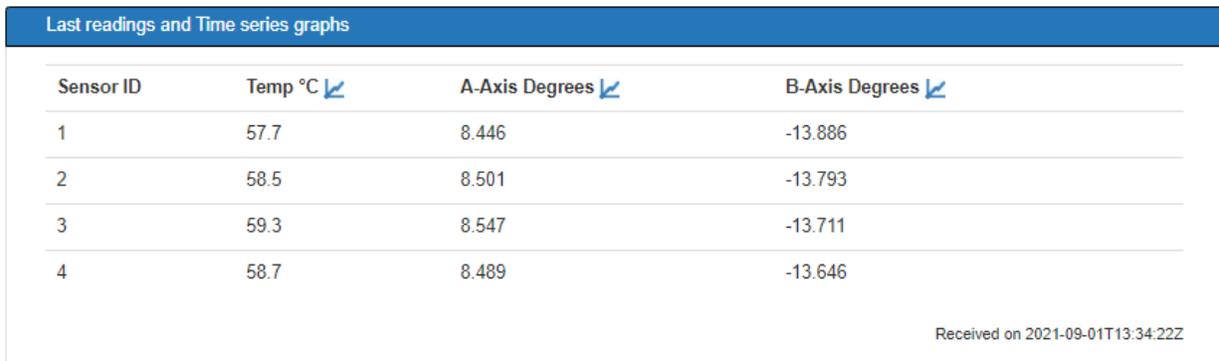
By following these best practices you can help protect the environment. Thank you for your cooperation.

Annex 1: Managing LS DIG + Geokon sensors' 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.

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 temperature and the tilt along the A and B axis have charts enabled.



The screenshot shows a table titled "Last readings and Time series graphs" with four columns: Sensor ID, Temp °C, A-Axis Degrees, and B-Axis Degrees. The data is as follows:

Sensor ID	Temp °C	A-Axis Degrees	B-Axis Degrees
1	57.7	8.446	-13.886
2	58.5	8.501	-13.793
3	59.3	8.547	-13.711
4	58.7	8.489	-13.646

Received on 2021-09-01T13:34:22Z

Figure 45, CMT Edge/Cloud screen displaying a string of 20 Geokon's in-place inclinometers

CSV Files generated

An example of the csv files can be found here [Example of csv file](#).

Data retrieval

Manually or automatically download sensor readings and custom aggregations as CSV files.

Send files via FTP and FTPS, for that it is necessary to select the 'LS-G6-DIG Modbus RTU' option in the FTP Client configuration as shown in the following image.

System Configuration / FTP Client

FTP mode	Extended Passive	
Output	Append to end of file	
Type of file	Enabled	Full path (starting with /) or Relative path (starting with .)
Health	<input type="checkbox"/>	
LS-G6-VW data	<input type="checkbox"/>	
LS-G6-DIG data	<input type="checkbox"/>	
LS-G6-VOLT data	<input type="checkbox"/>	
LS-G6-PICO data	<input type="checkbox"/>	
LS-G6-INC15 data	<input type="checkbox"/>	
LS-G6-DIG MDT data	<input type="checkbox"/>	
LS-G6-DIG Sisgeo data	<input type="checkbox"/>	
LS-G6-DIG GeoFlex/GeoSmart/GeoString data	<input type="checkbox"/>	
LS-G6-DIG Modbus RTU	<input checked="" type="checkbox"/>	
LS-G6-DIG Measurand SAA	<input type="checkbox"/>	
LS-G6-VOLT DGSI IPI data	<input type="checkbox"/>	
LS-G6-LASER data	<input type="checkbox"/>	
LS-G6-INC360 data	<input type="checkbox"/>	
LS-G6-LASER360 data	<input type="checkbox"/>	
SHM data	<input type="checkbox"/>	
Weather data	<input type="checkbox"/>	

Figure 46. CMT Edge/Cloud configuration of the FTP client to transfer the data via FTP.

MQTT pusher and HTTP API are also available options to retrieve the data from CMT but it will depend on the CMT version.