

User Guide

Loadsensing Wireless Tiltmeter LS-G6-LASTIL90 Version 0.1



Wireless Laser distantiometer with Tiltmeter (LS-G6-LASTIL90)





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Important instructions prior to use

Please read these instructions carefully and ensure that the required conditions are met before using the product.

All our Loadsensing edge devices have the following information on the casing.

Symbol	Description
\wedge	Caution. Read the instructions carefully and ensure that the required conditions are met before using the product.
<u>(</u>)	Caution, hot surface.
X	Ensure proper waste segregation and follow electronic waste disposal protocols.





Device Overview

This user guide explains how to configure and operate Worldsensing's Loadsensing Wireless Tiltmeter. Further technical descriptions are available in the datasheets.

The Loadsensing Wireless Laser and Tiltmeter is a long-range, low-power wireless data logger distance meter and inclinometer in a compact box. It measures distance with a highly precise Leica Laser module and also can measure tilt on three axes perpendicular to the plane of the base with a precise microelectromechanical systems (MEMS) sensor.

The wireless Laser and Tiltmeter can be used as a standalone logger for manual monitoring and can be easily configured by connecting it to an Android phone with a USB cable.

It is designed for different applications including monitoring convergences in tunnels, on civil works, and in underground mining, and also for continuous remote monitoring of landslides and slope movement, in particular open pits.

Tiltmeters measure changes from vertical on the ground or in structures. This makes them key sensors for monitoring inclinations, movements and differential settlements in slopes or infrastructures.

Tiltmeters can be attached to vertical structures, such as columns, piers, pylons, facades or retaining walls, to track changes in inclination and detect differential settlement; or they can be installed to verify over time the geometry and stability of tunnels or bridges and the cant, twist and vertical alignment of railway tracks.

They have also been extensively used in monitoring slope stability in landslide-prone areas, embankments and mines.





Device Specifications Tiltmeter

SENSOR			
Туре:	MEMS inclinometer with internal offset compensation		
Range:	+/-90°		
Axes:	Up to 3		
Accuracy within +/-5°	+/- 0.006°		
Accuracy within (+/-15°)	+/- 0.013°		
Resolution	0.0001°		
Repeatability LS-G6-TIL90-X	<0.0003°		
Repeatability LS-G6-TIL90-I	<0.001°		
Offset temperature dependency LS-G6-TIL90-X ^(*)	+/-0.002°/°C		
Offset temperature dependency LS-G6-TIL90-I ^(*)	+/-0.005°/°C		
Time required for reading	10 secs approximate		

^(*)Note that temperature dependency can be positive or negative depending on each MEMS sensor manufacturing process. Temperature dependency is given as the maximum value.





Device Specifications Laser

SENSOR			
Measuring range at favorable conditions	0.05 - 150 m		
Typical measuring accuracy	+/- 1 mm		
Resolution	0.1 mm		
Repeatability (1 sigma)	0.15 mm		
Laser type (light source)	Visible Laser Class II, Laser wi	th 655 nm	
Laser power	0.75-0.95 mW		
Accuracy	In favourable conditions*	In unfavourable conditions**	
@1 m	+/-1mm	+/- 2 mm	
@10 m	+/-1mm	+/- 2 mm	
@20 m	+/- 1.5 mm	+/- 3 mm	
@50 m	+/- 4 mm	+/- 7 mm	
@100 m	+/- 9 mm	+/- 15 mm	
@150 m	+/- 16 mm	not applicable	
Size of the Laser spot			
@5 m	5mm x 2.5mm (smallest value)		
@10 m	7mm x 3mm		
@20 m	14mm x 6mm		
@50 m	35mm x 15mm		





MEMORY: CIRCULAR BUFFER STRUCTURE

Memory records up to 200,000 readings, including time and 1 sensor

MECHANICAL	
Box dimension (WxLxH)	100 x 100 x 61 mm
Overall dimensions	150 x 100 x 61 mm (excluding antenna)
Operating temperature	-10 to +50 °C
Water ingress protection	IP67
Weight (excluding batteries)	841 g
Antenna	External: 100 mm length (including connector)
Mounting options	Clearance holes for M4 hexagon socket head cap screws in bottom. Blind holes for M4 screws on the side.
USB (configuration/EXT power)	MiniUSB port for configuration and data access. Can also be used to power the node
Box material	Aluminium alloy
Lid material	Aluminium alloy
Batteries	Up to 2
Vibration resistance	Laser modules comply with standard ISO 9022-3, Method 36, Severity 05 (0.15mm, 10Hz55Hz)

*** The wireless tiltmeter is impact resistant but should be treated carefully, like any precision instrument.





Equipment Provided

The Worldsensing LS-G6-Laser node is shipped with the following accessories:

- Laser and tiltmeter node
- Antenna
- Antenna adapter

Wireless Laser Mounting Brackets

The Laser node needs to be mounted on a support. Depending on the application, the Laser node needs to be installed with a certain inclination to achieve curved surfaces and on others applications it can be just installed aligned to the surface.

Four types of support have been designed in order to cover these applications:

- Fixed mounting for vertical surfaces (LS-ACC-IN15VP-4)
- Fixed mounting for horizontal surfaces (LS-ACC-IN15HP)
- Adjustable mounting plate (LS-ACC-LAS-AP)
- Swivel mounting bracket (LS-ACC-LAS-SB)
- Vertical mounting plate (pole mounting) (LS-ACC-IN15VPP2)

For the first three types of supports (fixed, adjustable, and swivel), supports can be attached to the Laser node using threaded rods and chemical anchors (bonded anchors) or using torque-controlled expansion anchors that go into the surface. Three-point mounting is the best option because it prevents bending and torsion that can lead to unstable readings. Single-anchor mounting is more prone to drift and disturbance. It is not recommended for long-term applications.





For long-term applications, chemical anchors are preferable because their performance is more stable and their vibration resistance is higher. Torque-controlled expansion anchors can also be used, but only if the mounting plate or bracket is drawn tight against the surface and cannot shift laterally.

We recommend sourcing the chemical anchors locally because they are considered dangerous goods for air transportation. If you want to install chemical anchors, Worldsensing can supply the mounting plates with the M4 lock washers and socket screws required to attach the tiltmeter to the mounting plate. Please contact us with questions or for additional details. Further information and drawings can be found in the accessory user guides.

Powering up the Device

Loadsensing devices are shipped closed and without batteries. To power up the device:

- 1. Open the device using a 2.5 mm Allen wrench.
- Insert C-type batteries in the battery holders, checking they match the polarity indicated. You can connect one or more batteries; the more you use, the longer the device will operate in the field. See our <u>LS G6 Datalogger recommended batteries</u> <u>guide</u> for further information on the batteries.

Please note that the device has reverse battery protection but it is not safe to keep batteries reversed in the device for a long time.

Note: The Loadsensing Wireless Tiltmeter does not have an real-time clock battery to keep time, so it is very important for the device to be powered with batteries when the time is set during installation. Otherwise the device will default to the year 1970 and data will not appear in the gateway. A warning will appear in the log's tab.





 The device can be powered with batteries or external power. If a power supply of 5 Volts is powering the USB port, the device will be automatically powered by the 5Volts upply

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.
 - \circ $\,$ $\,$ 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.





Figure 3. Wireless tiltmeter information

Loadsensing Device Configuration

Ideally, this step of the process should be carried out in the same location where the node is going to be installed. This way, users can perform an on-site radio coverage test.

The node configuration process is done using the Worldsensing app, known as the Loadsensing App, which is compatible with any Android device equipped with OTG technology (OS Android HoneyComb 3.1 or higher required). WorldSensing has tested Motorola Moto G4 and G5 and ensures that they are able to configure and test all nodes.

Loadsensing App 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, DLog 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.

Safely Closing the Device

The wireless laser tiltmeter has undergone watertightness testing by an external laboratory and has been given the following ratings:

Device	LS-G6-LASTIL90
Water ingress protection	IP67, IP68 (at 2 m for 2 hours)





To guarantee water tightness:

- Lock the box by tightening screws crosswise on the lid. Adjust the screws using a torque wrench. If this is not done properly, 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 O-ring (seal) may not be properly sealed and the degree of protection against water intrusion could be compromised.
- Screw the box at 2 Nm (the force that needs to be applied is marked on the outside of the device) using a torque screwdriver (e.g. Ref. 1227107 from WERA).
- Mount the antenna or cover the antenna connector with a cap.
- Make sure the sealing ring has not been physically or chemically manipulated.

Note: There is no need to seal the GORE valve to comply with IP67/IP68.

Note: We can't guarantee the IP67/IP68 rating if any of the above conditions are not met or if one or several components (e.g. the GORE valve) are damaged.

Note that box screws shouldn't be torqued more than 2 Nm. If you exceed the torque, the Helicoil insert may be damaged. We do not recommend using electric drills or electric screwdrivers.





Battery Life Estimates

The following table provides the battery lifespan indicated for two SAFT LSH14 batteries lifetime estimates are based on distance measurements in the range 10 to 20 m and a model following a Barcelona temperature profile. Bear in mind that consumption varies depending on the sampling rate and environmental conditions.

Note: European radios work between SF7 and SF11, and FCC radios work between SF7 and SF9.

Sampling rate	SF9@14dBm	SF8@20dBm
5 min	3.3 years	3.5 years
30 sec	9 weeks	12 weeks
1 min	18 weeks	23 weeks
5 min	18 months	22 months
30 min	5 years	5.5 years
1 h	6.5 years	7 years
6 h	8.5 years	8.6 years
12 h	8.8 years	8.9 years
24 h	9 years	9 years

Table 1: Battery lifespan in years assuming intermediate environmental conditions for European and FCC radios





Data storage

The internal data logger memory size is 4 MB. The wireless tiltmeter stores up to 200,000 readings. Data storage periods are indicated in Table 3. Memory mode is a circular buffer. When the memory is full, logging continues by overwriting the earliest readings. Aside from the sensor readings, the device also collects health data hourly, which indicates the battery voltage, the internal temperature of the device and the device uptime.

Number of	Sampling rate		
sensors	60 minutes	30 minutes	10 minutes
1	more than 10 years	more than 20 years	3.5 years

Table 4: Data storage periods (without overwriting) for the wireless tiltmeter

Data is stored in comma-separated value (CSV) files. You can download readings and health

Calibration

All wireless laser tiltmeters are assembled, calibrated and tested under stringent quality control standards.

In case recalibration is needed, Worldsensing provides a calibration service. Please contact industrialsupport@worldsensing.com for more information.

For the calibration process, Worldsensing will disassemble the wireless tiltmeter to inspect the mechanical parts before recalibrating the device.





Maintenance

The wireless laser tiltmeter is packaged in a rugged aluminum box and should provide many years of trouble-free operation.

Wireless laser tiltmeters require no maintenance other than normal cleaning, battery replacement and inspection of the seals. Apart from this maintenance, the devices are not field serviceable.

The wireless laser tiltmeter is a precision instrument. Minor external actions or changes in the initial conditions of the structure, such as rust in the supports, construction pathology or thermal behavior, can cause changes in the tilt readings. Visual inspections can help to understand the cause of some registered movements.

The wireless laser tiltmeter is a robust product but it should be handled carefully like any precision instrument. In particular, take care to avoid any impact, to protect the internal MEMS tilt sensor and to avoid distorting the mechanics of the device.





Regulatory notices

FCC - Regulatory Notices

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules.

Operation is subject to the following two conditions:

- 1. This device may not cause harmful interference.
- 2. This device must accept any interference received, including interference that may cause undesired operation.

Permitted Antenna

This radio transmitter has been approved by the FCC to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Interface and frequency range	Туре	Max Gain
	Unlicensed bands	
LoRA @900 MHz	Stubby dipole	-3.2 dBi

RF exposure safety

This device complies with the FCC RF exposure limits and has been evaluated in compliance with **mobile** exposure conditions.

The equipment must be installed and operated with minimum distance of 20 cm of the human body.





Class A device notice

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.





ISED - Regulatory Notices

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with ISED license-exempt RSS(s).

Operation is subject to the following two conditions:

- 1. This device may not cause harmful interference.
- 2. This device must accept any interference received, including interference that may cause undesired operation.

Permitted Antenna

This radio transmitter has been approved by the ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Interface and frequency range	Туре	Max Gain
	Unlicensed bands	
LoRA @900 MHz	Stubby dipole	-3.2 dBi

RF exposure safety

This device complies with ISED RF exposure limits and has been evaluated in compliance with **mobile** exposure conditions.

The equipment must be installed and operated with minimum distance of XX cm of the human body.

CAN ICES-00x (A)

This Class A digital apparatus complies with Canadian ICES-00x.







Avis de Conformité Réglementaire - ISED

Les changements ou modifications non expressément approuvés par la partie responsable de la conformité peuvent annuler le droit de l'utilisateur à utiliser l'équipement.

L'équipement est conforme aux CNR d'ISED applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:

- 1. L'appareil ne doit pas produire de brouillage;
- 2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement

Antennes autorisées

Cet émetteur radio a été approuvé par l'ISDE pour fonctionner avec les types d'antennes listés ci-dessous avec le gain maximum autorisé indiqué. Les types d'antennes non inclus dans cette liste, ayant un gain supérieur au gain maximum indiqué pour ce type, sont strictement interdits pour une utilisation avec cet appareil.

Interface et bandes des fréquences	Туре	Max Gain	
Bandes sans licence			
LoRA @900 MHz	Stubby dipole	-3.2 dBi	

Sécurité d'exposition aux RF

Cet appareil est conforme aux limites d'exposition RF d'ISDE et a été évalué conformément aux conditions d'exposition mobile.

L'équipement doit être installé et utilisé à une distance minimale de 20 cm du corps humain.

CAN NMB-00x (A)

Cet appareil numérique de classe A est conforme à la norme canadienne NMB-00x.







CONTACT WORLDSENSING

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

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