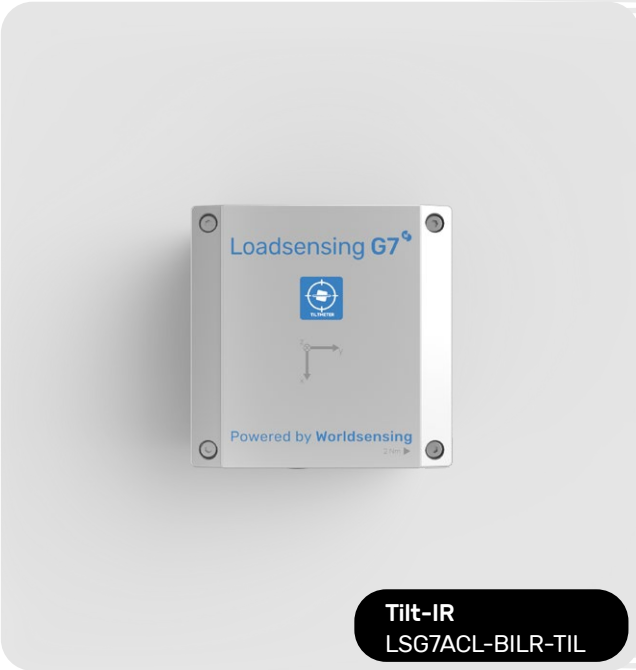
Loadsensing **G7**

Tiltmeter

The Tiltmeter is a 3-axis wireless tiltmeter designed to provide measurements of changes from the vertical level, either on the ground or in structures. This makes them key sensors to monitor inclinations, movements and differential settlements of slopes or infrastructures.

With two operational modes (an energy-efficient trigger-based mode and an event detection mode delivering real-time alerts with latency under 2 seconds), the device supports a new class of event-driven applications in industries such as railway infrastructure, mining, and geotechnical monitoring.

Tilt-XHP
LSG7ACL-BXLH-TIL



Tilt-IR
LSG7ACL-BILR-TIL

Key features

MULTIPLE OPERATIONAL MODES

Enhanced processing capabilities, enabling more adaptive and autonomous monitoring strategies. Devices can now analyze incoming data locally and react in real time, reducing transmission, optimizing battery life, and enabling new use cases.

INTEGRATED SENSORS

Built-in sensors that enhance reliability and expand monitoring applications, without requiring additional hardware.

Internal environmental monitoring: Integrated temperature and humidity sensors monitor internal conditions to detect issues like enclosure failure or improper sealing.

Motion detection: A low-power accelerometer enables trigger-based monitoring in response to seismic activity or ground movement.

EXTENDED BATTERY LIFE

Supports high-capacity D-size batteries, enabling up to 17 years of operational lifespan depending on configuration and use.

MODEL VARIANTS

The Tiltmeter is offered as Tilt-XHP with an external antenna for maximum range, or as Tilt-IR with an internal antenna for use in environments, such as railway tracks, where external components must be minimized. Tilt-IR is also designed for easy encapsulation if extra protection is needed.

SEAMLESS CONNECTIVITY & CONFIGURATION

Bluetooth connectivity to allow for fast, wireless configuration via the Worldsensing App. The USB-C interface ensures universal compatibility for configuration and provides external power to the device when necessary.

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Operational modes

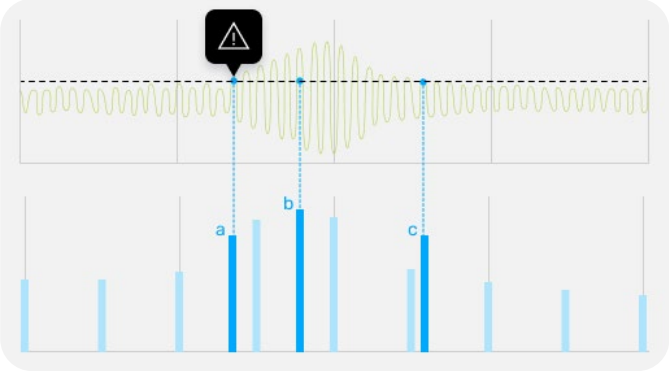
In addition to periodic readings, the Tiltmeter offers multiple operational modes, allowing you to tailor data collection to your project needs. These modes help you optimize workflows, extend battery life, and reduce the number of devices required in the field.

Triggered Measurements | Activated by motion

The motion detection sensor detects activity events from variations in absolute angle, angular velocity, or acceleration. When a threshold is exceeded, the primary sensor is triggered to acquire measurements.

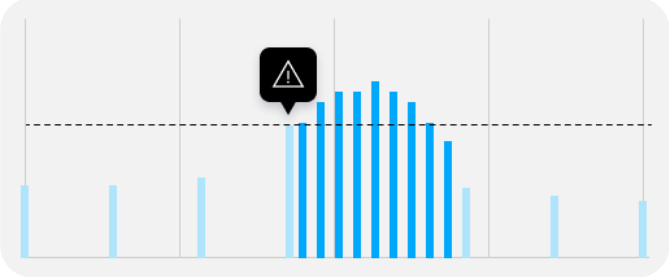
The acquisition timing and number of data points can be configured as per: on event (a), on and after event (a, c), after an event (c), or multiple events (a,b,c).

Users can also configure delays and cooldown times to better adapt the measurement process to their monitoring requirements.



Event Detection | Built for early warning

Tilt is measured at high frequency (3.9 Hz) and continuously evaluated against axis-specific thresholds. When a threshold is exceeded, the system immediately sends an alert and increases the reporting period to capture detailed event data. Monitoring returns to baseline once readings fall below threshold values.



Main applications

The Loadsensing Tiltmeter provides a versatile and cost-effective solution for measuring inclination, settlement, and deformation across a range of civil and rail infrastructure projects. It is ideal for long-term tilt monitoring, helping to better understand ground–structure interaction and ground movement trends. It also supports event-based measurements to assess structural response when thresholds are exceeded and can be integrated into early warning systems for risk-prone sites.

TRACK GEOMETRY

Mounted on sleepers for cant and twist assessment of rail tracks after train passage with trigger measurements

A chain of tiltmeters can be directly attached to the rail using magnets or mounted on rigid beams for vertical alignment and elevation profile monitoring

TUNNELING & DEEP EXCAVATIONS

Building response to tunneling and excavation-induced ground movements

Settlement and heave with tiltmeters attached to a rigid beam and installed in a chain configuration

SLOPE STABILITY

Stability monitoring of slopes and embankments

Rotation of retaining structures due to earth pressure.

For applications requiring rapid detection and real-time decision-making, use Tiltmeters in Event Detection mode. Combine with in-field cameras connected via ThreadX3 to create a complete Early Warning System

STRUCTURAL HEALTH

Static deflections of piers and decks of bridges and other structures

Ground movements in foundations

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TECHNICAL SPECIFICATIONS

GENERAL

Primary sensor	Tiltmeter
Secondary sensors	• Motion detection sensor • Temperature sensor • Humidity sensor
Operating temperature	–40 °C to 80 °C (–40 °F to 175 °F)
Power source	1x3.6 V D-size LSH20 Li-SOCl2 battery cell
Reporting period	Selectable from: 30 s 1, 2, 5, 10, 15, 30 min 1, 2, 4, 6, 12, 24 h
Reporting format	• Angle in x,y, z • Temperature • Standard deviation
Operational modes	• Periodc mode • Triggered Measurements mode • Event Detection mode
Time synchronization discipline by radio	Better than ±30 seconds
Device configuration	• Worldsensing App • CMT Cloud • CMT Edge
App advanced functionalities	• Field samples and signal coverage test when connected to the app • Set the previous configuration to quickly configure tiltmeters for installation in the same project • Tiltmeter calibration parameters check using the app

TILTMETER

Sensor type	3-axis MEMS accelerometer	
Range[1]	±90°	
Device variants	**Tilt-XHP**	**Tilt-IR**
Accuracy *f* (*ϴ*)		
+/-2° +/-5° +/-45° +/-85°	+/- 0.003° +/- 0.006° +/- 0.08° +/- 0.23°	+/- 0.005° +/- 0.007° +/- 0.08° +/- 0.23°
Resolution	0.0001°	0.0001°
Repeatability	<0.0003°	<0.0015°
Offset temperature dependency	±0.002°/°C	±0.005°/°C
Stability@ 14 h	<0.003°	<0.010°
Vibration resistance per MIL-STD-883 method 2007[1]	Test Condition A (20g)	Test Condition C (70g)
Time required for a reading	9.6 s	
Measure of dispersion	Standard deviation of the set of measurements collected during the reading and transmitted with each tilt measurement. It can be used to filter noisy data	

MOTION DETECTION SENSOR

Sensor type	Low power, 3-axis MEMS accelerometer
Peak-to-peak noise	200 ug/Hz
Offset temperature dependence	±0.68 mg/°C

TEMPERATURE SENSOR

Range	–40° to 80 °C
Accuracy	±0.2 °C
Resolution	0.1 °C

HUMIDITY SENSOR

Sensor type	Humidity sensor to detect lack of sealing/ locking of the enclosure. Statistics of the relative humidity measurements transmitted in the health messages

MECHANICAL

Device variants	**Tilt-XHP**	**Tilt-IR**
Overall dimensions (WxLxH)	203x100x61 mm With straight antenna 122x100x122 mm With L-antenna	106x100x61 mm
Weight (excluding batteries)	475 g	463 g
Antenna	External antenna Includes elbow connector	Internal antenna
Vibration resistance	Vibration test according to level C.2, on sleeper, EN 50125-3:2003 (Tilt-IR only)	
Weather protection	IP68 (at 2 m for 2 h)	
Impact resistance[2]	1 m drop onto concrete (20 000 *g* shock)	
Mounting options	Clearance holes for M4 hexagon socket head cap screws in bottom	
Communication port	Internal USB-C	
Box material	Aluminum alloy	
Lid material	Polycarbonate	
Battery holder	1 x D-size battery holder	

[1] The recommended measuring range is ±85°. Outside of this range, the margin of error increases. However, when one of the axes is close to 90°, the other axis will be close to 0° and measuring the same inclination. Any Axis, Powered, or Unpowered.

[2] The Tiltmeter has good impact resistance. However it should be treated carefully like any precision instrument.

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MEMORY

Memory structure	Circular buffer
Memory capacity	169 days data (30 s reporting period)
	4.6 years data (5 m reporting period)

OPERATIONAL MODES

TRIGGERED MEASUREMENTS MODE (TMM)

Configurable parameters	• Trigger type • Threshold value • Response strategy • Delay and cooldown values • Enable/disable statistics report
Response strategies	Data collection from primary sensor configurable from: • On event • After event • On and after event • Multiple events (3 max)

Trigger types
Threshold breach configurable from:

Absolute angle variation	θ_{current}
Angular velocity	$\frac{\theta_{\text{current}} - \theta_{\text{previous}}}{30\text{s}}$
Acceleration[3]	$\lvert a - a_{\text{ref}} \rvert$

Trigger type specifications

Parameter	Absolute angle	Angular velocity	Acceleration
Range	±90°	6° s^{-1}	±2 *g*
Sampling rate	30 s	30 s	100 Hz
Resolution	0.2°	0.01° s^{-1}	0.1 m*g*
Repeatability	0.3°	0.03° s^{-1}	2 m*g*

Statistics report

Reporting format	When enabled, it sends: • Trigger type • Number of events • Event duration • Configuration-related values
Reporting period	Selectable from • Per event • Periodic (12 h, 24 h)
Advanced tools	• Baseline reading tool available. Consult user manual

EVENT DETECTION MODE (EDM)

Configurable parameters	• Threshold values for x, y and z • Reporting period for alert state
Trigger type	• Threshold breach of tilt readings in either x, y or z
Response strategy	On threshold breach: • Alert message is sent in real time • Data transmission changes to reporting period for alert state
Communication latency[4] - CMT Cloud	• 2 s for 10 simultaneous alerts • 5 s for 25 simultaneous alerts
Communication latency[4] - CMT Edge	• 5.5 s for 10 simultaneous alerts • 8 s for 20 simultaneous alerts
Radio transmission	WS LoRa/LoRAWAN, Spreading Factor 7
Peak-to-peak noise	<0.006° (Tilt-XHP)

BATTERY LIFE ESTIMATIONS[5]

Reporting period	Periodic mode[6]	TMM enabled[7]	EDM enabled[8]
30 s	0.8 (0.8) year	NA	NA
5 min	5.8 (5.4) years	5.1 (4.7) years	2.4 (2.3) years
30 min	12.9 (11.2) years	10.0 (8.5) years	3.3 (3.2) years
60 min	14.7 (12.3) years	11.1 (9.2) years	3.5 (3.4) years
6 h	16.6 (14.1) years	12.2 (10.0) years	3.6 (3.5) years

[3] Deviation between the current measurements and the value expected at the reference accelerometer orientation in milligravities (m*g*).

[4] Typical values for 99% of the cases when reporting period is set to 30 min. MQTT required to achieve a latency of less than 2 seconds.

[5] Battery life estimations are based on a mathematical lifetime model using the Barcelona weather profile and laboratory conditions. Average values are provided for reference. Actual consumption may vary depending on sampling rate, environmental conditions, and wireless network performance. Values in parentheses = with BLE on.

[6] Conservative radio link scenario: spreading factor 9, radio transmit power 14 dBm.

[7] Conservative radio link scenario: spreading factor 9, radio transmit power 14 dBm. Triggered measurements using acceleration as trigger type and considering 50 event measurements per day.

[8] Favorable radio link scenario: spreading factor 7, radio transmit power 14 dBm. Consult other scenarios in the Tiltmeter user guide.

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RADIO SPECIFICATIONS

Radio band	ISM sub 1GHz
Operating frequency bands	Adjustable
Bidirectional communications	• Remote reporting period adjustment • Clock synchronization • Remote configuration of operational modes • Remote switching between operational modes
Maximum link budget	151 dB / 157 dB
Configuration	WS LoRa / LoRAWAN

RADIO RANGE[9]

	Tilt-XHP	Tilt-XHP EDM enabled	Tilt-IR
Open sight	15 km	7.5 km	15 km
City street	4 km	2 km	2 km
Manhole in a city street	2 km	1 km	1 km
Straight tunnel	4 km	2 km	2 km
Curved tunnel	1 km	1 km	1 km

SERVICES

WS-S-TILT-CAL	Wireless Tiltmeter Recalibration Service. Includes the replacement of the screws and the verification of the different mechanical elements. Shipment to and from Worldsensing warehouse excluded
WS-S-PRECON SEN	Device pre-configuration for wireless sensors

CERTIFICATIONS[10]

North America	FCC, ISED
Latin America	MTC, SUBTEL, ANATEL
Europe and Middle East	CE, UKCA
Asia and Australia	ACMA

ACCESSORIES[11]

LS-ACC-G7-VP	Mounting plate for medium-size nodes for magnetic fix to structures. Attachment option: LS-ACC-MAG
LS-ACC-IN15-HP	Versatile plate for horizontal surface mounting recommended for both horizontal and vertical mounting. Attachment option: anchor rods or glue. Includes a threaded hole available for installing a monitoring prism or a button head screw for precise leveling
LS-ACC-IN-HPTM	Horizontal surface mounting plate for track monitoring. Attachment option: glue
LS-ACC-IN15DP	Versatile double plate for horizontal surface mounting; suitable for applications that need to eliminate the need to open the casing during installation. Attachment option: glue. Includes a threaded hole available for installing a monitoring prism or a button head screw for precise leveling
LS-ACC-MRHP[12]	Mounting plate for medium-sized nodes for magnetic fix to rail tracks. Attachment option: LS-ACC-MAG
LS-ACC-ANC-H[13]	Kit of 3 anchor rods for injection MB. 110 mm length. Nuts and washers included
LS-ACC-MAG[14]	Kit of 3 magnets. 0 32 mm, strength approx. 30 kg, screws included
WS-ACC-1BEAM	1 m aluminum beam mounting. Attachment option: WS-ACC-BEAMFIX
WS-ACC-2BEAM	2 m aluminum beam mounting. Attachment option: WS-ACC-BEAMFIX
WS-ACC-BEAMFIX	Fixation kit for aluminum beam mounting. Includes: anchors, brackets and washer assembly
WS-ACC-CELL-1D	Saft LSH20 D-size spiral cell 3.6 V
LS-ACC-ANTE-G7	Antenna cable extension RP-SMA(M)/RP-SMA(F) 2.5 m
WS-ACC-G7-USBC	1 m USB-C to USB-C cable for G7 Edge devices
LS-ACC-LVP	L-shaped plate for pole installation. Attachment options: pole fixing 50 mm U-bolts or anchor rods

[9] The distances have been tested by Worldsensing and have been accomplished in actual projects using the standard antenna. However, radio range depends on the environment so these distances are only indicative. Consult with us for your application.

[10] Reach out to us for more information on product certifications.

[11] Other mounting brackets and accessories available upon request.

[12] When installed by direct attachment to the rail, the electronics must be encapsulated with resin to enhance vibration protection. Contact Worldsensing for guidance.

[13] The kit can be used to fix the following mounting kits: LS-ACC-IN15-HP. LS ACC-IN15-VP. LS-ACC-LAS-AP, LS-ACC-LAS-SB.

[14] The kit of 3 magnets can be used to fix the LS-ACC-IN15-VP mounting plate. Only available in Europe.

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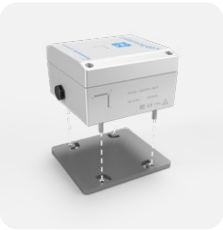
Mounting options

Recommended surface mounting

LS-ACC-IN15-HP plate for horizontal and vertical mounting. Secures with anchor rods or glue and features a threaded hole for a monitoring prism or leveling screw.

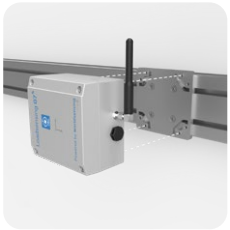
Vertical mounting using magnets

Using the LS-ACC-G7-VP mounting plate with LS-ACC-MAG magnet kit attached to the back of the plate to mount on metallic surfaces.



Horizontal surface mounting for rail tracks

Using the LS-ACC-IN-HPTM horizontal surface mounting plate for track monitoring. Designed to be glued to the surface for fast and robust fixing.



Mounting on a tilt beam

Using the compact LS-ACC-IN-HPTM horizontal surface mounting plate. Designed to be glued to the surface for fast and robust fixing.

Horizontal surface mounting with double plate

Versatile double plate LS-ACC-IN15DP for horizontal mounting without opening the device. Attaches with glue and features a threaded hole for a monitoring prism or leveling screw.

Pole mounting

Using the LS-ACC-LVP L-shaped mounted on a 50 mm pole with WS-ACC-U50 u-bolts.

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