MOVE SOLUTIONS

DATASHEET OF
TRIAXIAL TILTMETER

SYSTEM FOR MONITORING

Move Solutions™ is a leading company in **Smart Structural Health Monitoring** thanks to our world-class service in both dynamic and static structural analysis. We offer unique **wireless SHM systems** for all civil infrastructures. Our sensors are wireless, cost-effective, non-destructive, robust and small. Easy to install and to configure, they are also perfect for structures with difficult access, where wired systems would involve complex and expensive installations, or for historic buildings that require special attention and non-invasive technology. By combining the latest **IoT technology** with deep industry knowledge, Move Solutions™ is disrupting the world on Structural Health Monitoring.

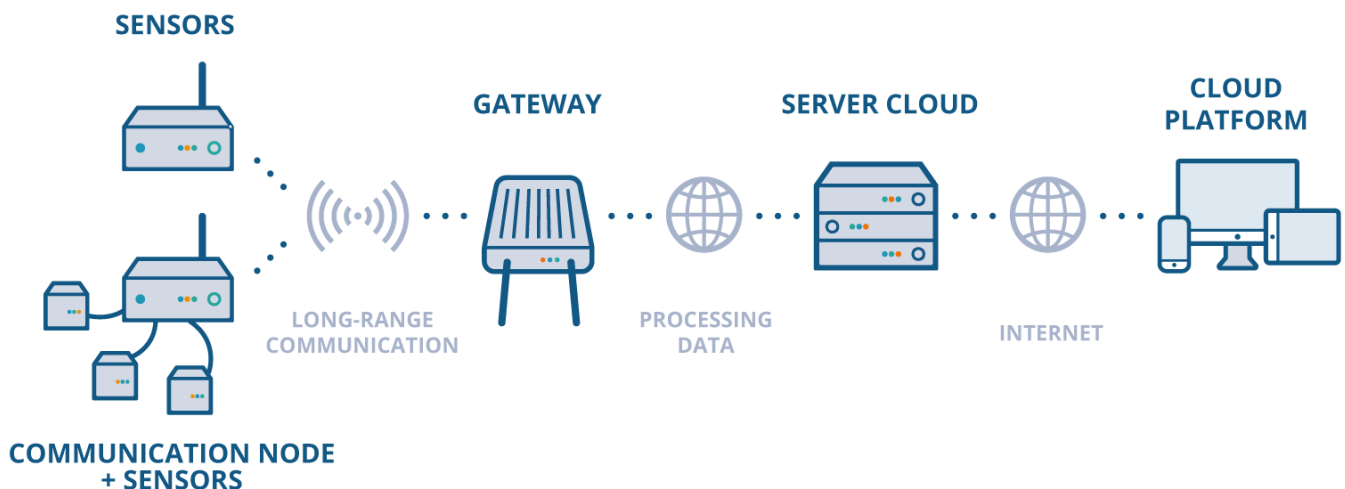| FEATURES	MEASUREMENTS
• High precision	• Dynamic displacement amplitude monitoring
• Data analysis with advanced algorithms	• Modal analysis of the structure
• No wiring	• Vibrational study of the structure
• Long-range communication	• Static monitoring of the inclination of the structure
• Modular system	• Analysis of the amplitude of the dynamic deformation
• High autonomy	
• Complete management and customization	• Monitoring of cracks and openings
• Minimum maintenance required	• Real-time water pressure monitoring
• Strong design	• Highlighting of seismic vibrations

HOW IT WORKS

Move Solutions™ includes a complete package of wireless devices and a **Web Platform** for data visualization and sensor management. Once the sensors and system gateways are properly installed on site, they are ready to receive, store and send data.
You can view all this data in real time through a Web interface that allows users to remotely monitor the site or infrastructure. The user can set different parameters for each individual sensor, including sampling rates, resolution, alarm thresholds, activation and much more. The Move Solutions™monitoring system guarantees accuracy, safety and reliability and a significant reduction in overall monitoring costs.

LOGISTICAL-ECONOMIC ADVANTAGES

- Remote monitoring of difficult to access structures
- Ease of installation and use of the system
- Data processing to optimize operations
- Easy addition of sensors to extend the monitored area
- Cost reduction through easy maintenance
- No wiring, saving on installation materials
- Consequent labor savings
- Risk reduction and high reliability

SENSORS

GATEWAY

SERVER CLOUD

CLOUD PLATFORM

LONG-RANGE COMMUNICATION

PROCESSING DATA

INTERNET

COMMUNICATION NODE + SENSORS

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TRIAXIAL TILTMETER

The triaxial Tiltmeter is able to measure the variation of the static angular inclination of the structure with respect to the horizontal plane, i.e. perpendicular to the gravitational axis. By installing an entire system it is possible to reconstruct the static deflection of the structure. All Tiltmeters can be synchronized with each other, which is perfect for static load tests. The Tiltmeter is also able to measure temperature. It is battery powered and has a LoRaWAN wireless transmission. The data acquisition methods can be set by the user through the Web Platform provided by Move Solutions™.

OUTPUT TILTMETER
The Tiltmeter outputs angles that describe the variation in inclination of the body on which the device is installed. The calculation of these angles is based on the projections of the gravity vector on the three axes of the sensor, averaged over an acquisition interval of 16 seconds. The sensor also acquires the temperature. By installing an entire system it is possible to reconstruct the static deflection of the structure during a load test.
To have a precise and accurate view of the three-dimensional movement of the structure on which the Tiltmeter device has been installed, it is necessary to observe two different angles provided by the device, "Phi - φ" and "Theta - θ", in pairs or, alternatively, a third angle defined as "3D variation angle".

φ - PHI ANGLE
It represents the angle between the Z axis, represented on the orientation label, and its projection on the hori-zontal plane.
θ - THETA ANGLE
It represents the angle between the Y axis, represented on the orientation label, and its projection on the hori-zontal plane.

DOWNLOAD DOCUMENTATION
Visit the website at www.movesolutions.it to download further documentation relating to technical specifications and/or information on the Move Solutions™ structural monitoring system.
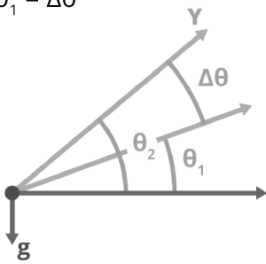
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Δφ – Δθ – INCLINATION COMPENSATION

With the Web Platform provided by Move Solutions™, it is possible to activate or deactivate (it is activated by default) a feature called "Data compensation", thanks to which compensation is activated with respect to the installation position. In this way, it is possible to view the variation of inclination of the structure. The data displayed in the respective graphs therefore refer to the angular variations of Phi (Δφ) and Theta (Δθ) with respect to the initial installation position.

If the "Data Compensation" feature is deactivated, the Web Platform will display the absolute angles with respect to the horizontal plane. These absolute angles may carry on measurement errors caused by an incorrect installation not completely parallel to the horizontal plane of the Tiltmeter device. It is recommended to keep the "Data compensation" option always active; the measurement of the variation (Δφ and Δθ) is to be considered more accurate.
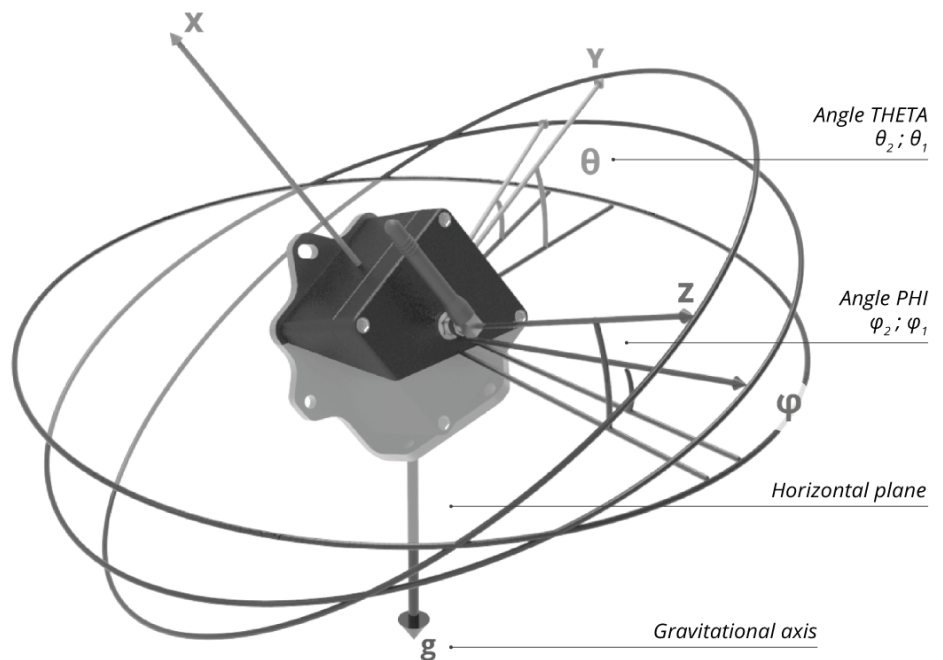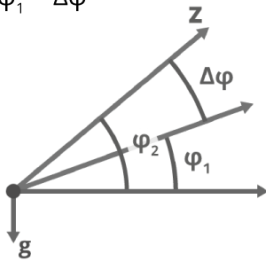
THETA ANGULAR VARIATIONS

$\theta_2 - \theta_1 = \Delta\theta$

PHI ANGULAR VARIATIONS

$\varphi_2 - \varphi_1 = \Delta\varphi$

Angle THETA
$\theta_2 ; \theta_1$

Angle PHI
$\varphi_2 ; \varphi_1$

Horizontal plane

Gravitational axis

QUICK GUIDE TO USE

The triaxial Tiltmeter device is "plug and play"; by screwing the special antenna on the cover, the device will immediately start to detect and send data. To ensure correct operation, see the chapter "Tiltmeter Orientation" and "Tiltmeter Installation Guide", the Tiltmeter sensor must be correctly oriented and installed, following these specific steps:

1. **ORIENTATION:**
● The axes shown on the orientation label, which is placed on the sensor cover, must be aligned as the axes of interest of the structure.
● The X axis must always be oriented upwards.
● The X axis must be as parallel as possible to the gravitational axis.
● The plane formed by the Y - Z axis must be parallel to the horizontal plane.

2. **INSTALLATION ON THE STRUCTURE:**
● Agree with the supplier company on the correct place of installation on the structure of the Tiltmeter device.
● Securely install the Tiltmeter on the wall, ceiling or floor using the special plate and screws/wall plugs sup-plied. It is possible to rotate the plate relative to the device to keep the X axis parallel to the gravitational axis and oriented upwards, regardless of the agreed installation location.
● To ensure correct installation, the X axis must have a maximum inclination of 85° with respect to the gravitation axis.
● Install all sensors on the structure before powering and turning on the Gateway device.

3. **SCREWING THE ANTENNA:**
● Before activating the Gateway, screw the LoRaWAN 868 Mhz antenna onto the device cover.

After meeting these orientation and installation requirements, the Tiltmeter device will be able to detect and forward data to the Gateway without interference or data alteration. Verify, through the Web Platform, the correct functioning of the sensor just installed. From the moment the Gateway is powered up, and therefore from the actual start-up and activation moment, a maximum waiting of about an hour is required before it is possible to correctly view all the sensors online.

CORRECT INSTALLATION

When installing the Tiltmeter sensor on the structure, make sure that the X axis (always oriented upwards) is positioned within the "Region of correct positioning". The extent of the region of correct positioning is defined by the total sum of the possible inclinations in which the installation on the structure can be defined as correct. This totality of possible inclinations refer to the X axis of the Tiltmeter with respect to the absolute gravitational axis. We can therefore state that:

- In case of need due to an inclined surface, it is possible to install the device with the X axis having a maximum inclination of 85° with respect to the gravitational axis.
- The X axis must always be oriented upwards.

Figure 1 - Front view of the Tiltmeter
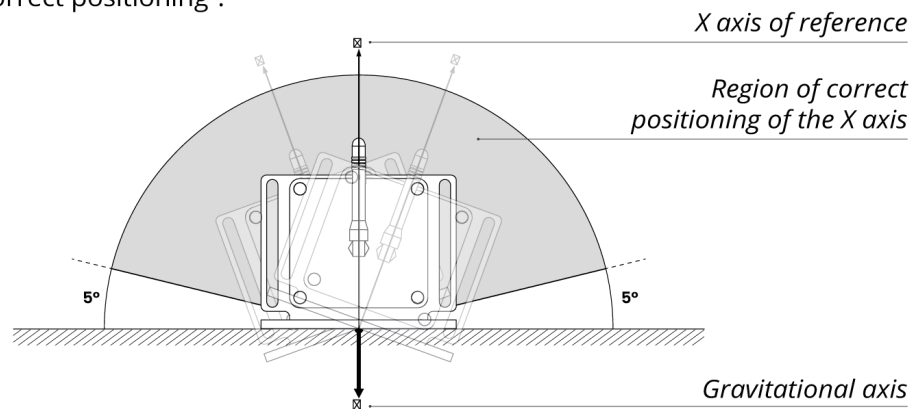Display of the "Region of correct positioning".

X axis of reference

Region of correct positioning of the X axis

5°   5°

Gravitational axis

Figure 2 - Tiltmeter side view
Display of the "Region of correct positioning".

X axis of reference

Region of correct positioning of the X axis

5°   5°

Gravitational axis
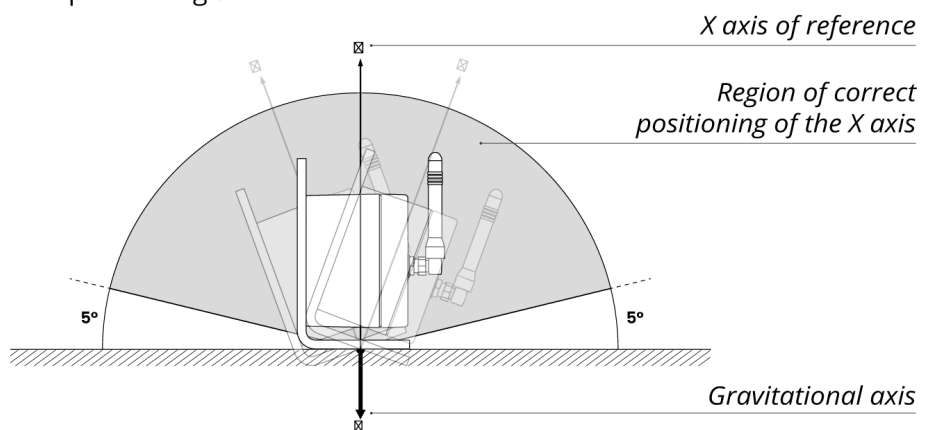
TRIAXIAL TILTMETER

The Tiltmeter measures the inclination and temperature of the point where it is installed relative to the gravitational axis. By installing a system composed of these sensors it is possible to reconstruct the deformation of the structure. All Tiltmeters can be perfectly synchronized with each other, perfect for static load tests. Battery powered and LoRaWAN wireless transmission.
The acquisition methods can be set by the user throu-gh the web interface provided in the service.

TECHNICAL SPECIFICATIONS

OPERATION

Operation with programmed acquisitions	Record of a tilt sample at a fixed cadence as set by the user (once every 2 minutes, 5 minutes, 15 minutes, 30 minutes). Each sample of inclination is derived by averaging 16 seconds of observation. For each acquisition also the temperature is recorded. All sensors are synchronized in time in order to sample the structure at the same time. Acquisition start time is aligned to multiples of the acquisition cadence starting from 00:00. Examples: - cadence is 2 minutes: 00.00, 00.02, 00.04, etc. - cadence is 5 minutes: 00.00, 00.05, 00.10, etc. - cadence is 15 minutes: 00.00, 00.15, 00.30, etc. - cadence is 30 minutes: 00:00, 00:30, 01:00, etc.
Custom Operation Software	It is possible to request custom features that the customer deems necessary for their business.
Synchronization accuracy	± 1 second

MEASUREMENT

Technology	MEMS technology - Triaxial
Acquisition of	● Tilt angle ● Temperature
Resolution	0,000015°
Repeatability	±0,0005°

Accuracy	0,005°
Range	± 90° (on both angles)
Cross Axis Sensitivity	1%
Temperature resolution	0,125°C

RADIO	
Radio channel	LoRaWAN communication protocol
Radio channel frequency	ISM 868Mhz
Link coverage	1km (line of sight with the Gateway)*

GENERAL DATA	
Waterproof class	IP67
Battery	1 lithium battery type "D" 19Ah 3.6V
Operating temperatures	-40°C/+85°C
Dimensions (case)	75 x 80 x 57 mm
Dimensions (with antenna and mounting plate)	123 x 93 x 143 mm
Weight	1.1 Kg
Case material	Lega GD-AlSi12
Corrosion resistance	>1000 hours in salt spray

INSTALLATION	
Method	Two-point mounting using screws and plugs (Ø6mm, L:30mm)
Site	- Fixing on wall - Fixing on ceiling - Fixing on ground

BATTERY AUTONOMY	
Sample rate	Estimated autonomy
Every 30 minutes	8 years*

* *Wireless coverage of the device may vary depending on the scenario*
* *Battery life may shorten when operating in extreme temperatures.*

REVISION HISTORY

Version v2.

Version	Changelog
v1	First revision
v2	Updated time synchronization, averaging period

Note: Specifications are subject to review and change without notice.