TILT METERS

User Manual

INDEX

Notes on the use of product

For a safe and efficient use of the instrument, please read carefully the following instructions before starting any operation.

Any use of the instrument other then the one described in this manual shall be considered at user's full responsibility.
The same applies for any unauthorized modifications.
In addition to the hereby listed standards, the user must comply with the provisions of the current legislation on the matter of personal safety and health of persons in the workplace.
SISGEO is not responsible for any trouble, breakdowns, accidents etc.. due to the lack of knowledge and/or confidence (or non-compliance with) with the requirements contained in this manual.

Check that the instrument has not been damaged during the transport.
Verify that the package includes all items as well as any requested optional accessories; if anything is missing, please promptly contact the manufacturer.
The user must strictly follow all the operations described in this manual.
Maintenance or repair of the instrument is allowed only to authorized operators.
These operators must be physically and intellectually suitable.
For information about instrument or order spare parts request, please always specify data written on the identification label.
When replacing parts, always use ORIGINAL SPARE PARTS.
The manufacturer reserves the right to make changes without prior notice for any technical or commercial requests.
We'll try anyway to keep the manuals updated in order to reflect product's revisions/updates.

Symbols

This symbol will be used used to catch reader's attention on the manual:

Pay special attention to the following instruction.

Identification

Instruments can be identified

- From a production lot number (written on the Compliance Certificate)
- From a serial number *(s/n)* engraved indelibly on the instrument
- From a label on the instrument
- From a label on the cable

Introduction

Tilt meters and tilt beams are used to measure structures inclination changes.

They are employed on several structures: towers, bell towers, monuments, decks, bridges and viaducts masts, superficial foundations, retaining walls, cls dams.

Moreover they can be used to measure blocks or unstable rocky terrain tilt.

The sensor could be servo-accelerometer or with MEMS technology; both can be mono- or biaxial.

Biaxial sensor measures the inclination on 2 perpendicular planes.

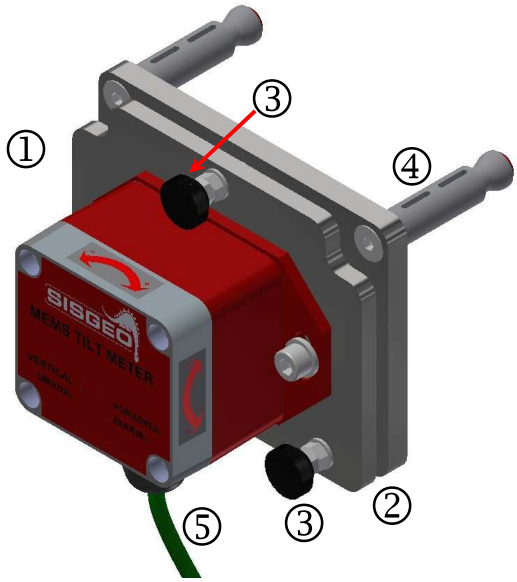
Tilt beams can be connected to form a chain, so they can monitor outline variations.

Different support plates are available for every need.

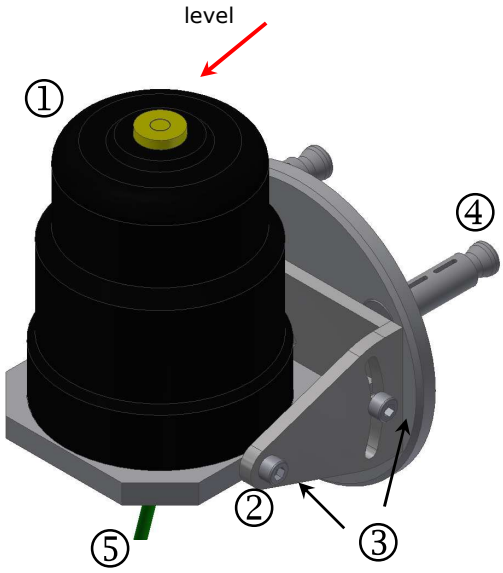
Description

The tilt meter consists in:

1. A box with an internal sensor and a circuit board. In some models there is also the temperature sensor;
2. A double adjustable support plate;
3. Positioning screws;
4. Fixing screws and plugs;
5. Electric cable for the connection to the readout.



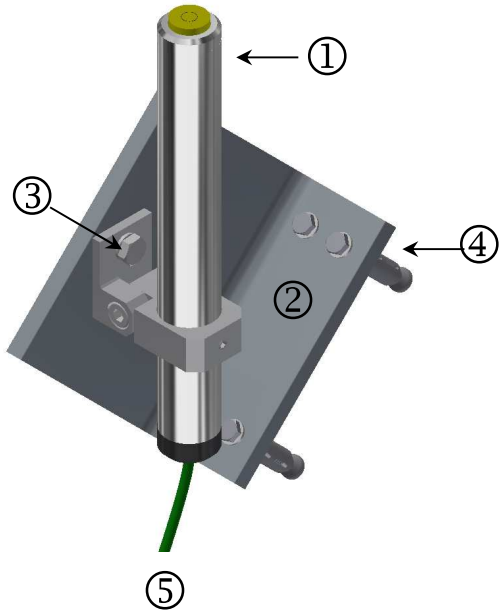
MEMS tilt meter



Servo-acelerometer tilt meter

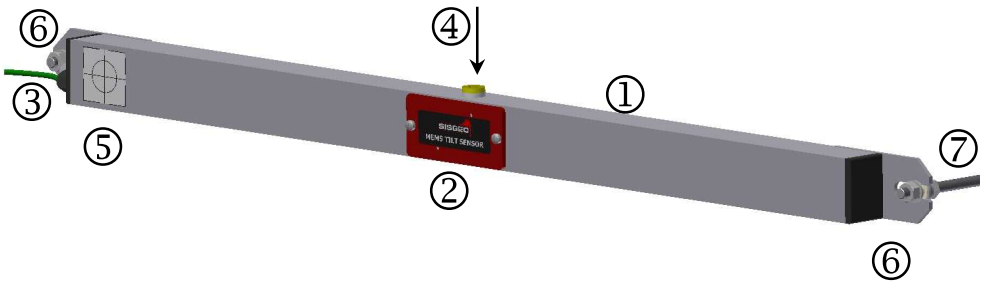
Waterproof clinometer IP68 (1.0MPa) consists in:

1. a cylindrical body with an internal sensor and electronic board; some models includes a thermistor;
2. a double adjustable support plate;
3. screws for a precise positioning;
4. screws and plugs for the fixing;
5. electric cable for the readout connection.



The tilt beam consists in:

1. An aluminium bar 1, 2, 3 meters long
2. A box with the sensor, the electronic board and temperature sensor.
3. Cable for the connection to datalogger
4. A level for the positioning
5. An optical target
6. Fixing plates
7. Threaded bars for the anchor



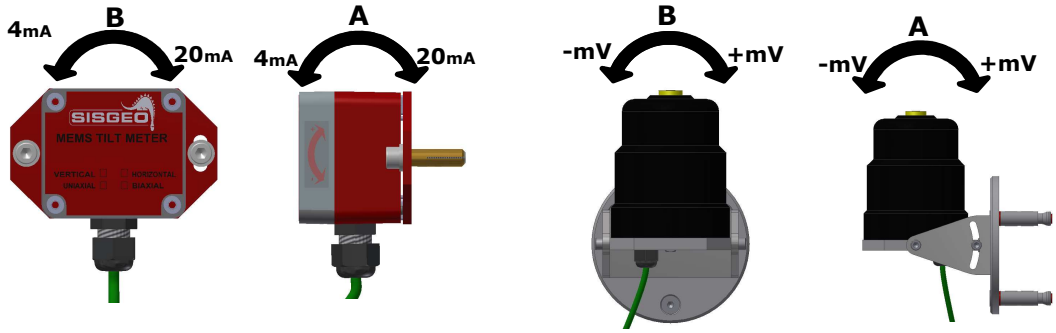
Preliminary checks

Before the installation, check the instrument connecting it to a readout (see "Taking measurements").

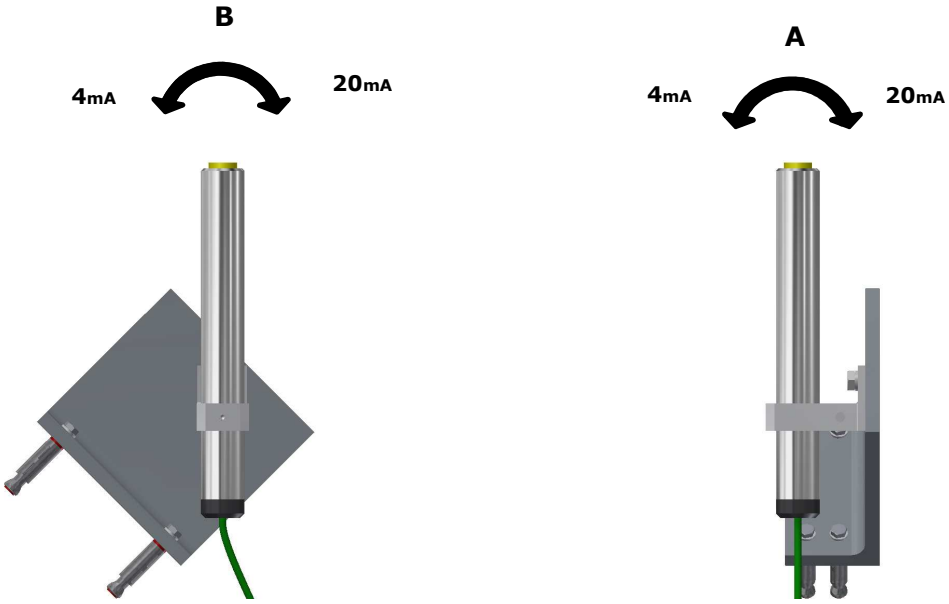
Verify the correspondence of the signal according to the following drawings:

Letters A and B refers to channels/sensors.

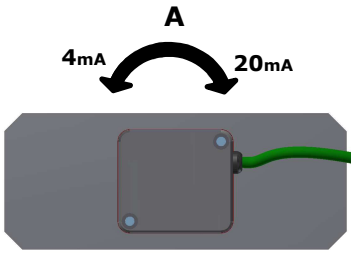
Mono- and biaxial tilt meters



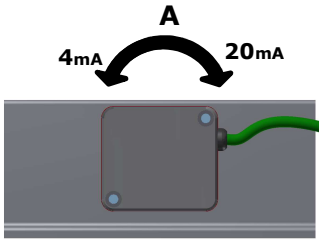
Waterproof clinometer



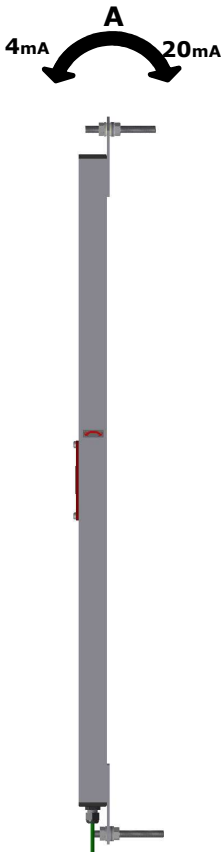
Mono-axial tilt meters

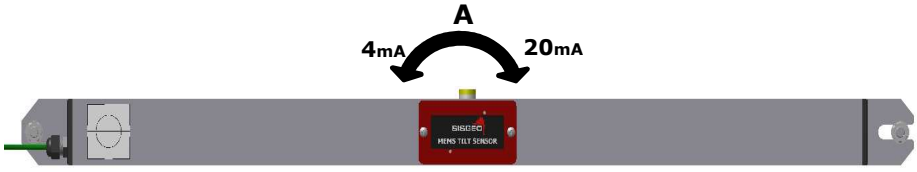


Tilt meter plate to be fixed



L tilt meter plate





Useful tools, not supplied, depending on the model:

- SW3 and SW5 allen key
- Spanner n.13, n.10
- Drill/drill bit Ø 6mm, Ø 10mm, Ø 12mm, Ø 14mm

Installation

Sisgeo has a wide range of plates and supports.

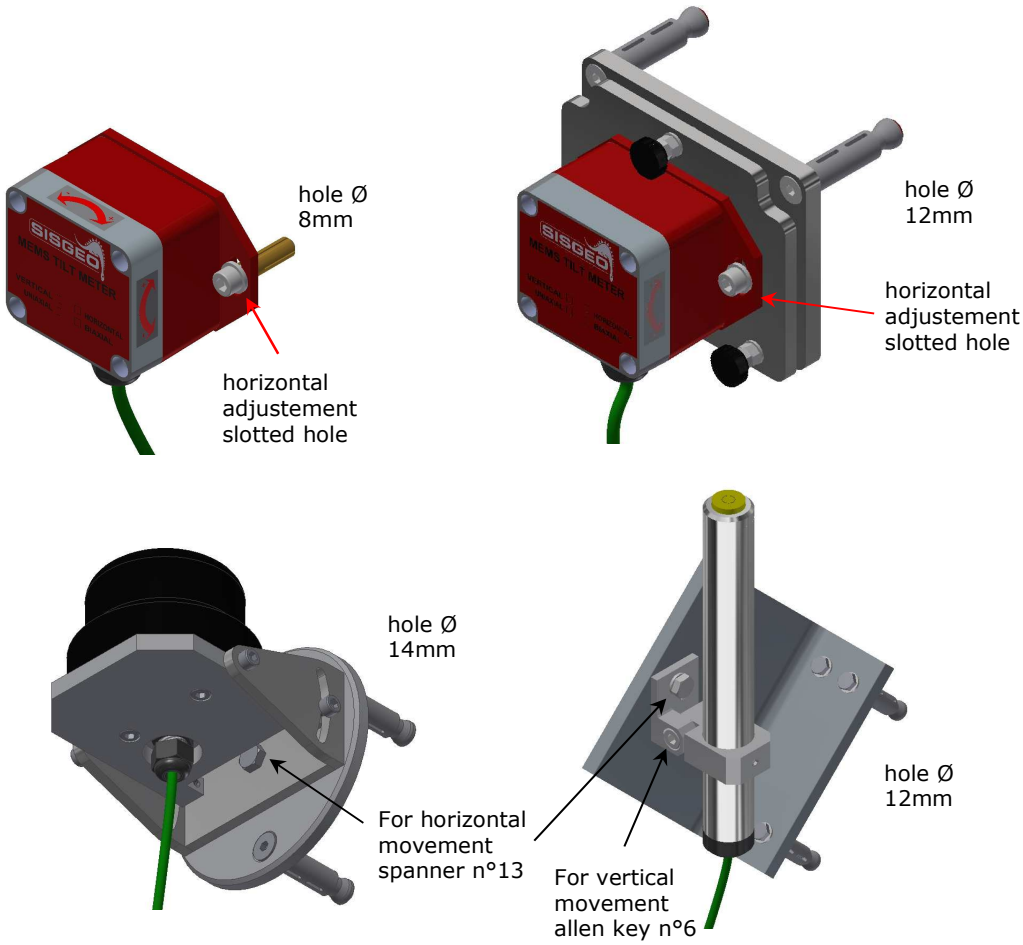
The following are the general installation phases:

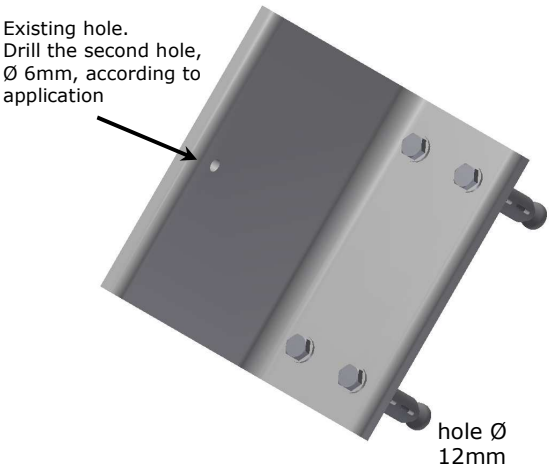
- Mark holes position according to the expected movement;
- The holes must be drilled in whole material with suitable drill and drill bit;
- Clean the hole;
- Fix the tilt meter or the plate;
- If needed, cement the threaded bars;
- Adjust the tilt meter in order to obtain a value close to the zero value on the Calibration Certificate (using a level or a readout);
- Tighten the screws to block.

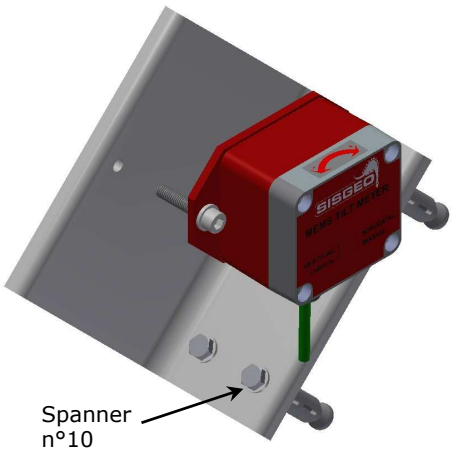
For each model we recommend:

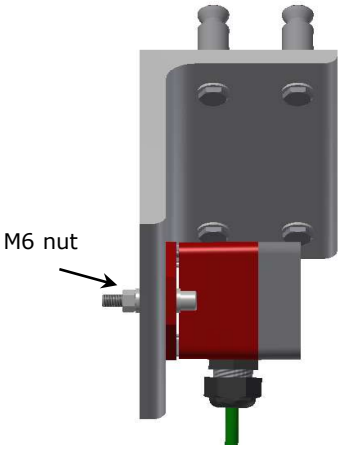
- Handle with care;
- Protect the tilt meter from direct sunbeams;
- Protect the cables end from water;
- Protect the cable from damage.

Following are the most common types.

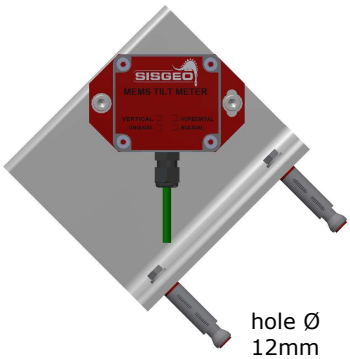


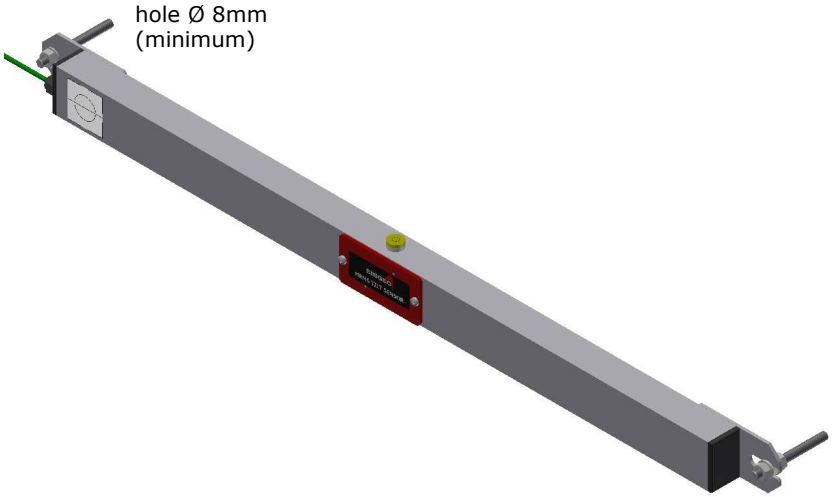




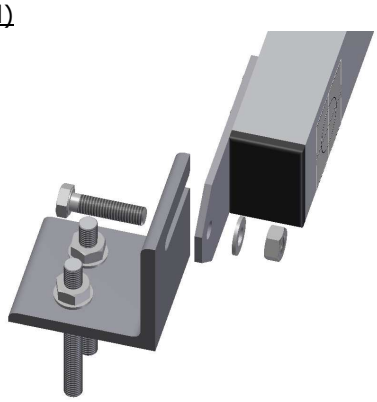


Positioning examples

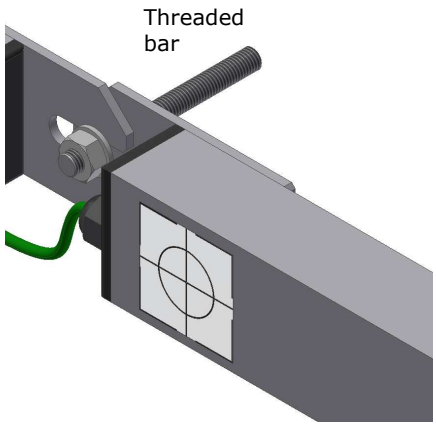


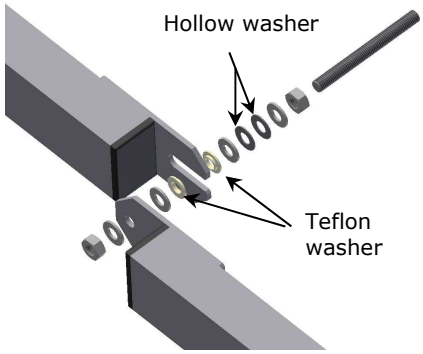


Tilt beam with L bracket (detail)



Tilt beams junction example





Taking measurements

Manual measurements are carried out connecting the cable wires to the readout according to the following scheme:

Mono-axial sensor Current loop signal 4-20 mA	Red	+ Loop
	Black	- Loop
	White	Thermistor
	Green	Thermistor
	Shield	Shield
Biaxial sensor Current loop signal 4-20 mA	Red	+ Loop (A)
	Black	- Loop (A)
	White	+ Loop (B)
	Green	- Loop (B)
	Yellow	Thermistor
	Blue	Thermistor
	Shield	Shield
Servo-accelerometer sensors	Red	+ Vdc
	Black	- Vdc
	White	GND power
	Yellow	+ Out A
	Blue Green	+ Out B (if biaxial)
		GND measure
	Red	+ Vdc
	Shield	Shield

Note: to obtain reliable measures, with mA instruments, we recommend a warm-up time not less than 5-10 seconds.

For automatic measure, connect the instrument to a Data Acquisition System

(i.e. SISGEO OMNIAlog).

Data processing

The following formulas allow to convert the electric measurements into engineer values:

Linear factor➔ $\mathbf{L_{ing} = L_{ele}/S\ [\sin\alpha]}$
Polynomial factor➔ $\mathbf{L_{ing} = (L_{ele}^3 \times A) + (L_{ele}^2 \times B) + (L_{ele} \times C) + D\ [\sin\alpha]}$

L_{ing} = engineering reading
L_{ele} = electric reading
S = sensitivity factor
A, B, C, D = polynomial conversion factors

S, A, B, C, D are stated on calibration report.

Exercise readings refer to the initial reading (zero reading).

$$\Delta I_{[\sin\alpha]} = L_i - L_0$$

L_0 = zero reading
L_i = exercise reading

Zero reading shall be taken carefully once the installation is performed and the instrument is in operating conditions.

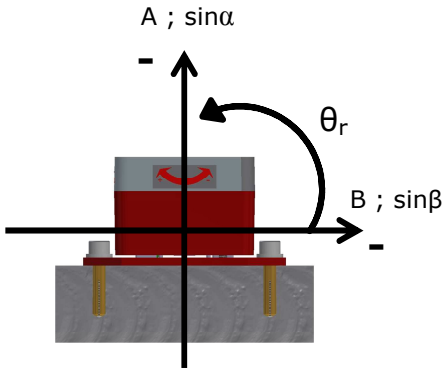
Example

Mono-axial clinometer ; measuring range ±10° ; mA readings
S = 46.29078 mA/sinα
A = -1.483E-06 , B = 5.232E-05 , C = 2.108E-02 , D = -2.789E-01
L_0 = 12.965mA , L_1 = 17.006mA

Using:
Linear factor (L_1-L_0)/S : (17.006 – *12.965)/46.29078 = 0.0873 [sinα]*
Polynomial factor
[(L_1^3 x A)+(L_1^2x B)+(L_1 x C)+D] – [(L_0^3 x A)+(L_0^2x B)+(L_0 x C)+D] =
= 0.08742 – (-0.0000352) = 0.08746[sinα]

The result value is the inclination variation (or tilt) in the clinometer installation point.

The tilt azimuthal direction of the biaxial tiltmeters can be found comparing the following drawing and table:



$$\theta r = artg\frac{\sin\alpha}{\sin\beta}$$

sinα	sinβ	θ_r
<0	<0	θ
<0	>0	180+θ_r
>0	>0	180+θ_r
>0	<0	360+θ_r

As far as the mono-axial tilt beams are concerned, it can be useful to consider the result as the displacement, in [mm], between the threaded bar fixing points.

$$mm = \text{Sin}\alpha \times P$$

P = distance between fixng points (nominal 1000mm, 2000mm, 3000mm)

Temperature reading

SISGEO readout displays the temperature directly in °C.
If the thermistor resistance value is taken, please use the conversion formula in Appendix 1.

Troubleshooting

Current loop signal tilt meters

Problem	Possible cause	Solution
Unstable measure	Tilt meter is not fixed	Fix the tilt meter
0mA measure	Incorrect wiring	Make proper wiring
	Cable cut or damaged	Repair the cable. Cable splicing kit available at SISGEO.
Over range measure	Tilt meter out of range	Bring back the tilt meter (within its measuring range)

Voltage signal clinometer

Problem	Possible cause	Solution
Unstable measure	Tilt meter is not fixed	Fix the tilt meter
	Incorrect wiring	Make proper wiring
0V measure	Incorrect wiring	Make proper wiring
	Cable cut or damaged	Repair the cable. Cable splicing kit available at SISGEO.
Over range measure	Tilt meter out of range	Bring back the tilt meter (within its measuring range)

Maintenance

After-sales assistance for calibrations, maintenance and repairs, is performed by SISGEO service department.
The authorization of shipment shall be activated by RMA "Return Manufacturer Authorization".
Please create your account and then fill in the RMA module clicking on:

http://www.sisgeo.com/repairs.html

Send back the instrument/equipment with the complete accessories, using suitable packaging, or, even better, the original ones.
The shipping costs shall be covered by the sender.

Please return to the following address with suitable delivery document:

SISGEO S.r.l.
Via F.Serpero, 4/F1
20060 MASATE (MI)

On the delivery document is mandatory to indicate the RMA code received.

Technical assistance e-mail: assistance@sisgeo.com

Appendix 1

THERMISTOR TEMPERATURE CONVERSION

Resistance to temperature equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

Where:
T= temperature in °C
LnR= natural Log of the thermistor resistance
A= 1.4051×10^{-3} (coefficents calculated over the -50 to +70°C span)
B= 2.369×10^{-4}
C=1.019×10^{-7}

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
16.60K	-10	5971	10	2417	30	1081	50
15.72K	-9	5692	11	2317	31	1040	51
14.90K	-8	5427	12	2221	32	1002	52
14.12K	-7	5177	13	2130	33	965.0	53
13.39K	-6	4939	14	2042	34	929.6	54
12.70K	-5	4714	15	1959	35	895.8	55
12.05K	-4	4500	16	1880	36	863.3	56
11.44K	-3	4297	17	1805	37	832.2	57
10.86K	-2	4105	18	1733	38	802.3	58
10.31K	-1	3922	19	1664	39	773.7	59
9796	0	3784	20	1598	40	746.3	60
9310	-1	3583	21	1535	41	719.9	61
8851	2	3426	22	1475	42	694.7	62
8417	3	3277	23	1418	43	670.4	63
8006	4	3135	24	1363	44	647.1	64
7618	5	3000	25	1310	45	624.7	65
7252	6	2872	26	1260	46	603.3	66
6905	7	2750	27	1212	47	582.6	67
6576	8	2633	28	1167	48	562.8	68
6265	9	2523	29	1123	49	543.7	69
						525.4	70