V1.2 March 2015

MEMS IN-PLACE TILT METER

DIGITAL

INSTRUCTION MANUAL

CE

GEOSENSE

CONTENTS

1.0 INTRODUCTION

This manual is intended for all users of the **Geosense® MEMS Tilt Meter** and provides a guide for its installation, operation and maintenance.

It is VITAL that personnel responsible for the installation and use of the MEMS Tilt Meter READ and UNDERSTAND the manual, prior to working with the equipment.

1.1 General Description

The **Geosense® MEMS Tilt Meter** comprises either a single tilt sensor (uni-axial) or a pair of tilt sensors (bi-axial) mounted in an environmentally sealed enclosure. This enclosure would be mounted onto a surface to register changes in the tilt (rotation) of that location. Commonly these Tilt meters are used for monitoring structural elements within civil engineering, but they are suitable for many other applications where the measurement of rotation is required.

A **Geosense® MEMS Tilt Meter** can be installed or included in many types of monitoring regime and can be linked to various types of readout equipment.

The primary use for **Geosense® MEMS Tilt Meters** is for the measurement of tilt of structures and retaining walls.

Examples of other applications are:-

- Monitoring of compensation grouting works.
- Effects of construction e.g. tunnelling or excavations on adjacent structures.
- Analysis of the performance of bridges, beams and dams under loading.
- Structural safety monitoring in areas of mass movement.
- Monitoring of retaining wall rotation.
- Convergence monitoring within tunnels (in association with other sensors).

Particular features of the **Geosense® MEMS Tilt Meter** are:-

- Reliable long term performance.
- Suitably rugged for use in demanding environments.
- High accuracy and repeatability
- Designed to be resistant to EMF
- Suitable for long cable lengths or RF data transmission
- Digital units can be ‘bussed’ to form a chain of sensors.

Geosense® MEMS Tilt Meter sensors are particularly suitable for the demanding environments of civil engineering projects since the signals are capable of long transmission distances, without degradation. They are also ***water resistant*** and can be shielded from interference from external electrical noise.

1.2 EMC - Electro Magnetic Compatibility

EMC is the electromagnetic interaction of electrical and electronic equipment with other electrical and electronic equipment. All electronic devices have the potential to emit and be affected by electromagnetic fields. With the reduction in size of electrical components and the ever increasing amount of electrical & electronic devices such as mobile phones, two-way radios, safety control systems, signalling, generators, welding equipment, power cables etc in all environments, especially construction sites, there is a huge potential for devices to interfere with each other.

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1.4 Theory of Operation

Geosense® Tilt Meters employ 'State of the Art' MEMS sensor technology. MEMS (Micro - Electro - Mechanical Systems) are an integration of mechanical elements, sensors, actuators and electronics on a common silicon substrate through micro fabrication technology.

The mechanical structure of a typical MEMS sensor is shown in Figures 1 & 2 below.

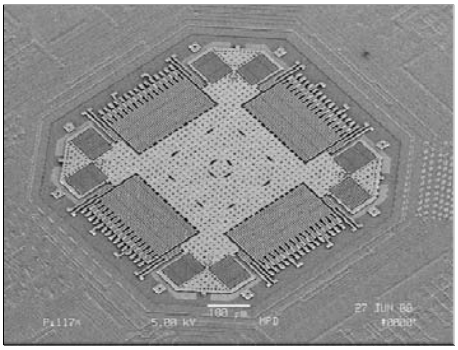


Figure 1

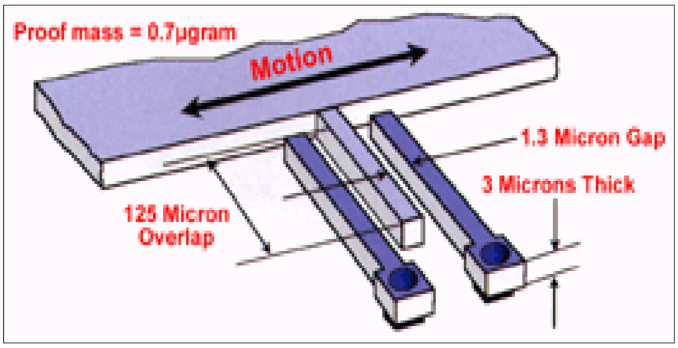


Figure 2

Polysilicon springs suspend the MEMS structure above the substrate such that the body of the sensor (also known as the 'proof mass') can move in the X and Y axes. Acceleration causes deflection of the proof mass from its centre position. Around the four sides of the square proof mass are 32 sets of radial fingers.

These fingers are positioned between plates that are fixed to the substrate. Each finger and pair of fixed plates make up a differential capacitor, and the deflection of the proof mass is determined by measuring the differential capacitance.

This sensing method has the ability of sensing both dynamic acceleration (i.e. shock or vibration) and static acceleration (i.e. inclination or rotation).

Signal conditioning is carried out within the **Geosense® Tilt Meters** so that a simple output signal is obtained. This output can be used in conjunction with a calibration sheet to easily calculate the amount of tilt that has occurred.

The MEMS sensors within **Geosense® Tilt Meters** are configured measure inclination from vertical. As movement occurs, the **Geosense® Tilt Meter** will move with its mounting, thus changing the inclination of the internal sensors.

The MEMS sensors **within Geosense® Tilt Meters** measure tilt over a range of +/- 15º. In the bi-axial model, a second MEMS sensor is mounted at 90º to the other sensor and measures tilt in the orthogonal direction, on the horizontal plane. Once mounted on a structure they are normally adjusted to read close to zero, their mid-point. An **'initial reading'** is then recorded and any changes in the inclination of the structure are identified by comparing the current readings with the initial readings.

(Continued on page 7)

(Continued from page 6)

Whilst the major advantage of MEMS based measuring systems, over the older electro-level based systems, is their stability and reduced thermal sensitivity, MEMS sensors are also significantly less likely to suffer from ‘long term drift’. The ‘solid state’ construction and robust nature of the MEMS based systems, makes them very suitable for use in geotechnical instrumentation as the instruments are often located in areas that are highly prone to shocks and varying thermal conditions.

The linearity of MEMS accelerometers is very good and provide increases in stability, sensitivity and accuracy. MEMS sensors are suitable for use where long cables are necessary.

2.0 CONFORMITY

Geosense Ltd
Nova House
Rougham Industrial Estate
Rougham, Bury St Edmunds
Suffolk , IP30 9ND
United Kingdom

Tel: +44 (0)1359 270457, Fax: +44 (0)1359 272860
www.geosense.co.uk

EC Declaration of Conformity

CE

We Geosense Ltd at above address declare that the equipment detailed below, complies with the requirements of the following EU Directives:-

- Electromagnetic Compatibility Directive 2004/108/EC
- General Product Safety Directive (GPSD)2001/95/EC
- Restriction on the use of certain Hazardous Substances RoHS2 2011/65/EU

Equipment description:	**MEMS Tilt Meter**
Make/Brand:	**Geosense**
Model Numbers:	**IPTMH-1-485, IPTMH-2-485, IPTMV-1-485, IPTMV-2-485 IPTMH-1-485 BUS, IPTM-2-485 BUS, IPTMV-1-485 BUS, IPTMV-2-485 BUS**

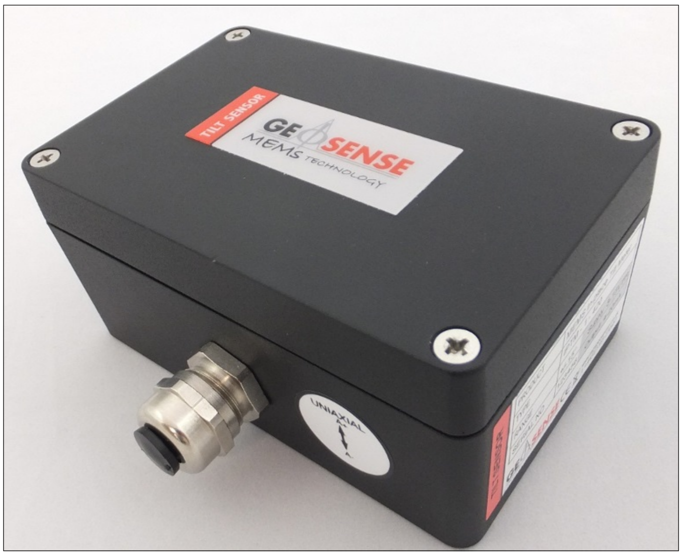
Compliance has been assessed with reference to the following harmonised standards:
EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use. EMC requirements. General requirements.

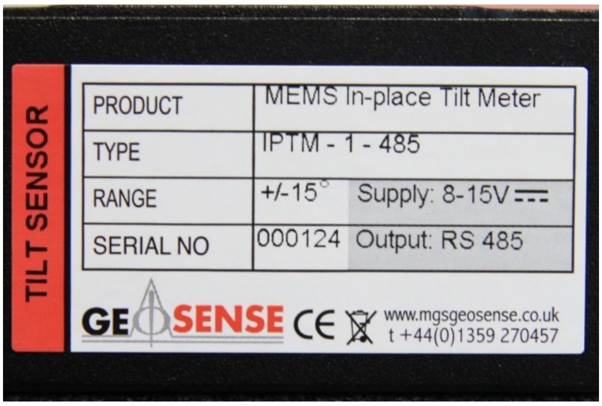
EN 61010 (2010) Safety requirements for electrical equipment for measurement, control, and laboratory use. General requirements.

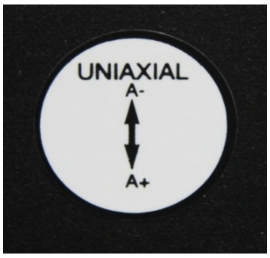
A technical file for this equipment is retained at the above address.

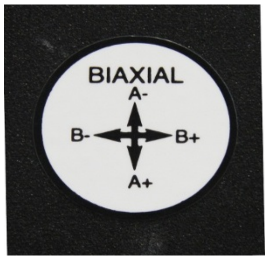
Martin Clegg
Director
Rougham, March 2015

3.0 MARKINGS









A **Geosense® MEMS Tilt Meter** is labelled with the following information:-

Manufacturers telephone number & website address

Product group: Tilt Sensor

Product type: MEMS In-place Tilt Meter

Model: IPTM-1-485 & IPTM-2-485, IPTM-1-485BUS & IPTM-2-485BUS

Range: +/- 15º

Orientation: Uni-axial or biaxial

Input supply: 8-15 Volts DC

Output signal: RS-485

Serial number: XXXXXX

CE mark

WEEE mark

4.0 DELIVERY

This section should be read by ALL users of **Geosense® MEMS Tilt Meters**

4.1 Packaging

Geosense® MEMS In-place Tilt Meters are packed for transportation to site. Packaging is suitably robust to allow normal handling by transportation companies. Inappropriate handling techniques may cause damage to the packaging and the enclosed equipment. The packaging should be carefully inspected upon delivery and any damage MUST be reported to both the transportation company and **Geosense®** .

4.2 Handling

Whilst they are a robust devices, **Geosense® MEMS In-place Tilt Meters** are precision measuring instruments. They and their associated equipment should always be handled with care during transportation, storage and installation.

Once the shipment has been inspected (see below), it is recommended that **Geosense® MEMS In-place Tilt Meters** remain in their original packaging for storage or transportation.

Cable should also be handled with care. Do not allow it to be damaged by sharp edges, rocks for example, and do not pull on the cable as this my damage the internal conductors and could render an installation useless.

DO NOT DROP AS THIS MAY CAUSE DAMAGE TO INTERNAL COMPONENTS

4.3 Inspection

It is important to check all the equipment in the shipment as soon as possible after taking delivery and well before installation is to be carried out. Check that all the components detailed on the documents are included in the shipment. Check that the equipment has not been physically damaged.

Geosense® MEMS In-place Tilt Meters carry a **unique** identification serial number and are supplied with individual calibration sheets that include their serial numbers, which will shipped with the tilt meters.

Calibration Sheets contain VITAL information about the Tilt Meters. They should be stored in a safe place and only copies should be taken to site.

4.4 Storage

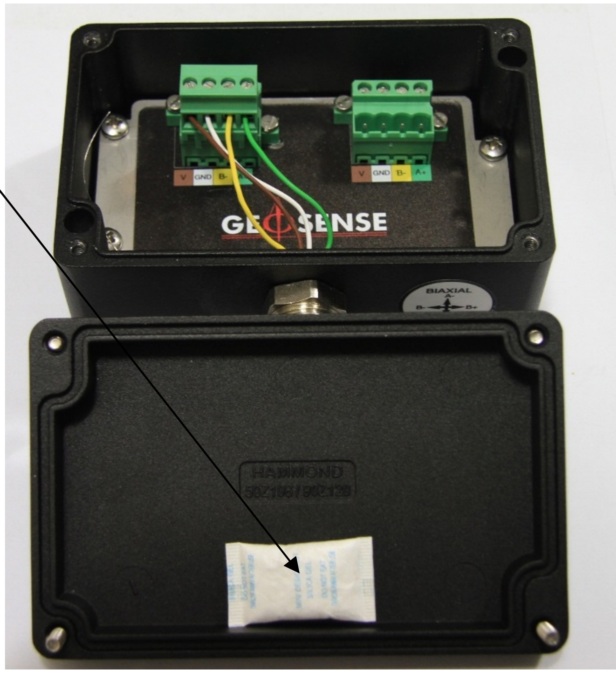
Geosense® MEMS In-place Tilt Meters are precision instruments containing sensitive electronics and whilst they are mounted within a waterproof (IP66) enclosure, the internal circuit board can be affected by excessive moisture.

Geosense® MEMS In-place Tilt Meters are factory fitted with a silica gel moisture adsorbent pouch which should be replaced periodically, especially for any long term storage or operation in environments with a relative humidity above 50%.

DO NOT REMOVE

SILICA GEL ADSORBENT

REPLACE AS REQUIRED



It is also recommended that cables be stored in a dry environment to prevent moisture migrating along inside them in the event of prolonged submersion of exposed ends.

Storage areas should be free from rodents as they commonly damage connecting cables.

5.0 INSTALLATION

This section of the manual is intended for all users of **Geosense® MEMS In-place Tilt Meters** and is intended to provide guidance with respect to their installation.

It must be remembered that no two installations will be the same and it is inevitable that some 'fine tuning' of the following procedures will be required to suit specific site conditions.

5.1 Preliminary Considerations

Prior to installation of **Geosense® MEMS In-place Tilt Meters** it is essential to establish and confirm details of the installation to be carried out. Some of the main considerations are listed below :-

a. Structure / Installation location. The location of the installation can have implications with regard to planning, access and environmental considerations. For example, a city structure installation would demand different considerations than a dam face application.

b. Structure / Installation type. The main consideration is access. The installation of tilt meters on a lift shaft, for example, requires special attention, whereas installation on the face of a low retaining wall requires less consideration, perhaps.

c. Intended Position. This will usually be specified by the monitoring system designer and will be defined by the changes to be measured. However, some 'on-site' adjustments may be necessary but any changes should be approved by the system designer. Considerations such as the proximity of moving plant or other vibrations will also need to be addressed.

d. Mounting requirements. Mounting brackets can be configured for almost any type of structure. This is best discussed and agreed with all interested parties, well before the installation is to be carried out.

e. Connections. The selection of the most suitable and appropriate method of linking the sensors to a convenient readout location will depend upon many factors and should be decided upon prior to ordering the equipment (see section 5.2).

f. Location of readout / data logger (as required). This must take into account the connection method selected, in addition to the EMF generated by adjacent and local equipment and cables.

g. Protection of the Tilt Meters & cables from physical damage.

(Continued on page 13)

5.1.1 Tools & Consumables

The following is a brief list of tools and equipment typically used during the installation:-

- Mounting Brackets and Template
- Electric Drill
- Suitable Drill Bits
- Spirit Level
- Bolts & Fixings or Epoxy Resin
- Set of spanners
- Suitable readout
- Wire cutter / stripper
- Small flat screwdriver
- Pozi-drive #2 Screwdriver

5.1.2 Cables & Wireless Connections

There are 3 main options for connecting a tilt meter to a readout device. Firstly, a readout could be connected directly to the tilt meter locally, using a 'flying lead'; secondly, it could be connected to a remote readout / logger location using cables and lastly, it could be linked to a remote readout location using a wireless communication method.

Local readout connection.

For this type of connection, a cable socket is fitted to the Tilt Meter housing and a 'flying lead' is provided with the handheld readout device. No onsite cabling is required.

Cable connections

Sensors with a digital output (RS485) can be 'bussed' (interconnected) using a single cable between them and a single cable routed to the readout location.

Planning of cable routes is critical as they are easily damaged and can cause an inconvenience. Protection of the cables is also essential in any locations where they could be damaged.

Where cable lengths don't exceed 500m, the length of the cables is not electronically critical, but will have a logistical and economic impact. For 'bussed' installations, cable lengths may have less of an economical impact because the number of sensors does not impact on the cable size.

So as to maintain clarity, cables must be marked with unique codes at both ends and at intermediate points. The codes must be noted in a site record for future reference.

Wireless Connections

In congested locations where wired connections would be difficult, the use of Wireless / Radio Frequency systems may be a more appropriate communication solution. These systems can only be employed when using a data logger for interrogation of the tilt sensors.

Here each tilt sensor is locally wired to an RF transmitter module (‘node’). The RF module becomes a ‘transparent’ link to the matched RF receiver (‘gateway’) which is liked to a data logger.

For wiring details of this option, please refer to the RF Module manual.

5.1.3 Functionality testing

Prior to installation of the **Geosense® MEMS IN-place Tilt Meters** it is recommended that they are always checked for correct operation. Each Tilt Meter is supplied with a calibration sheet which shows the relationship between output signal and inclination. Digital tilt meters produce an angular output (sine of the angle).

Remove the Tilt Meters from packaging & dispose in a responsible way. Connect the cable as in section 5.2 and place the Tilt Meter on approximately horizontal surface and observe the reading. The readings should be close to the factory vertical reading.

For Digital sensors, the following will be required for functionality testing:-

Dedicated data logger with software,RS485 interface module and connecting cables
or
Field PC / notebook computer with a suitable interface module and connecting cables.

5.2 Installation procedures

The intended location of the tilt meters and the material onto which they are to be mounted will define the type of mounting brackets and fixings that should have been ordered. Standard brackets are available for mounting the tilt meters onto vertical and horizontal surfaces using various fixing methods. However, other brackets are produced to suit particular requirements.

Common bracket fixing methods include:

- Drilled type: Through bolts (preferred option)
  Expanding Bolts
  Plugs and Screws
- Adhesives 'Hard' type epoxy resins are commonly used
- Welding Spot welds using ARC systems or gas welding / brazing

The following are brief overviews of some 'typical' installations that serve to highlight the issues and considerations that may need to be addressed.

As no two installations are the same, the methods described below are intended as guidance only.

Uni-axial tilt meter brackets MUST be orientated correctly so that the tilt meter fixes to the bracket in the required direction. Check this prior to fixing the brackets.

It is recommended that, where the sensor is required to operate over its full range (+/- 15 degrees), the tilt meter fixing surface of the bracket will need to be installed close to horizontal . A bubble level can be used to check that this can be achieved. Where only a portion of the operating range is required, the levelling of the mounting plate is not so critical (but is still good practice).

5.2.1 Drilled Fixings - Vertical Surface

Whist the holes in the mounting brackets are 10 mm diameter we recommend that a 6mm fixing is used, together with a washer. The mounting plates are generally fabricated from mild steel and then zinc plated. We, therefore, recommend the use of 'plated' fixings. Stainless steel fixings should only be used with stainless steel mounting brackets.

1. Ensure the mounting surface at the intended location is clean and free of any obstructions that may affect the ease of installation.

2. Apply the tilt meter bracket to the location intended for installation. Take care to ensure that the bracket is orientated correctly, with respect to the tilt meter box fixings and the direction of tilt.

3. Mark the location of the fixing holes and remove the bracket.

4. Using an appropriately sized bit, drill to a depth that will accommodate the selected fixings.

5. Remove any dust from the holes and insert the fixings.

6. Repeat for the second fixing

7. Position the mounting plate and loosely tighten the fixings.

8. Where necessary, adjust the plate to level it and tighten the fixings.

9. Position the tilt meter box on the bracket and orientate it correctly.

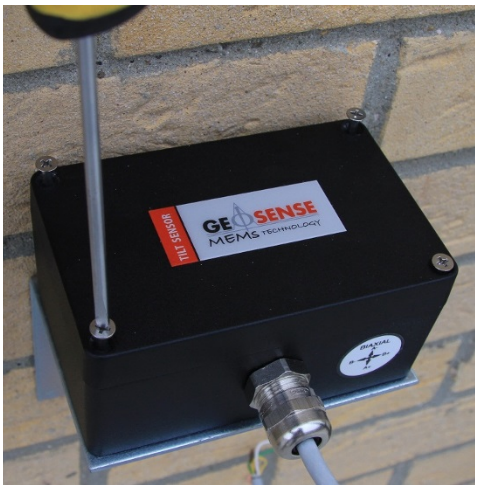
10. Line up the fixing holes on underside of tilt meter box with the holes in the bracket and fit the first screw.

11. Using an 'Allen' key, secure the fixing screw.

12. Locate the other sixing screw and tighten both screws to fix the box to the bracket securely.

13. The box is now ready for wiring. For wiring details see Section 6 of this manual.

14. Once wiring has been completed and the system has been tested the box cover should be replaced and the screws tightened to ensure a waterproof seal.



5.2.2 Bonded - Horizontal Surface

Horizontal mounting plates can be attached a surface using a variety of techniques, such as Bolts, Bonding, Welding, tec. The mounting plates are supplied with 10 mm diameter holes but we recommend that a 6mm fixing is used, together with a washer. The mounting plates are generally fabricated from mild steel and then zinc plated. We, therefore, recommend the use of ‘plated’ fixings. Stainless steel fixings should only be used with stainless steel brackets. Where the plates are to be welded, we suggest that plating be removed locally, prior to welding or ordered in an un-plated condition.

Since tilt meters detect very small movements, any bonding material used to fix the mounting brackets MUST be rigid when it has cured (set). Many, apparently rigid, materials are not actually rigid and can ’creep’ with time. (For example, ARALDITE(TM), a proprietary epoxy resin appears ’hard’ when cured but is, in fact, NOT a rigid fixing material.)

1. Position the bracket on the location intended for installation. The tilt meter fixing surface of the bracket will need to be close to horizontal where the sensor is required to operate over its full range (+/- 15 degrees). A bubble level can be used to check that this can be achieved. Where only a small portion of the operating range is required, the levelling of the mounting plate is less critical. Mark the location of the bracket and remove it.

2. Ensure the mounting surface at the intended location is clean and free of any raised areas that may prevent good contact with the underside of the tilt meter bracket. Since this installation uses an adhesive, it is necessary to ensure that the bracket has good contact with the underlying surface. It may be necessary to use a grinder to remove raised areas.

3. Clean the surface under the plate with a wire brush and remove any dust from both surfaces.

4. Any grease or silicon under the plate will prevent the adhesive from making a solid bonded connection so de-greasing the surfacing may be necessary.

5. The selected adhesive should be applied in accordance with the manufacturers instructions. Ensure enough adhesive is applied to bridge any undulations and provide a good bonding surface.

6. Position the plate in line with the markings.

7. Press down firmly on the plate, and where necessary, hold it, or leave it in place, until the bonding agent has cured (set)

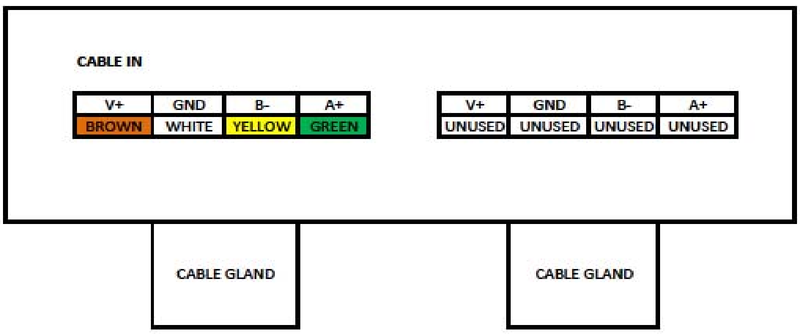
8. After the bond has achieved sufficient strength, the tilt meter should be fitted bracket.

9. Position the tilt meter box on the bracket and orientate it correctly. Line up the fixing holes on underside of tilt meter with the holes in the bracket and fit the screws. Tighten to secure the tilt meter.

10. For wiring details see Section 6 of this manual.

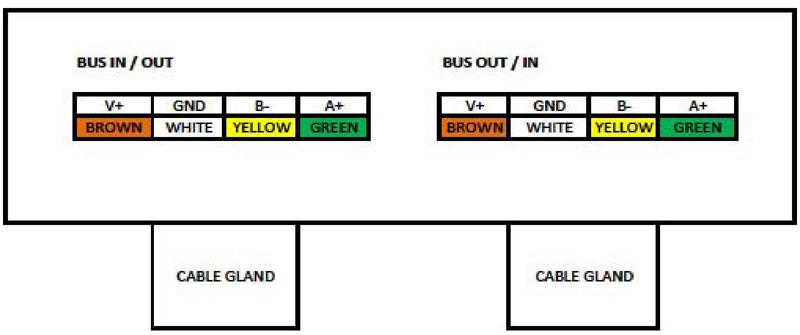
IN-PLACE MEMS TILT METER WIRING DETAILS
DIGITAL RS-485

IN-PLACE MEMS TILT METER WIRING DETAILS
DIGITAL SYSTEM



NOTE: IF AN END OF LINE TERMINATION RESISTOR IS REQUIERED THEN THIS SHOULD BE TERMINATED BETWEEN [A+] & [B-] ON THE UNUSED LINE END CONNECTION

IN-PLACE MEMS TILT METER WIRING DETAILS
DIGITAL BUSSED SYSTEM



5.3 Connections

Where Tilt meters are to be read at a distance from their installed location, a cable can be used to link them to a convenient readout point or to a data logger.

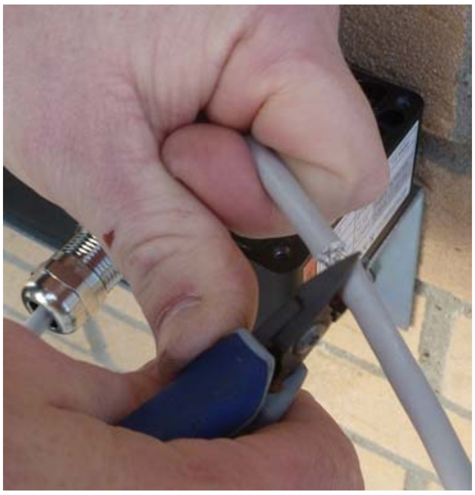
To comply with all the CE and WEE regulations, the type of cable used to link the sensors to a readout location must be selected carefully. Please see the cable specification recommended by Geosense in the Appendix of this manual.

1. Cut the end of the cable to produce a clean, square end. Remove the cover of the Tilt Meter.

2. Insert the cable into the EMC cable gland and push it through until it reaches the back of the box. Mark the cable as shown.

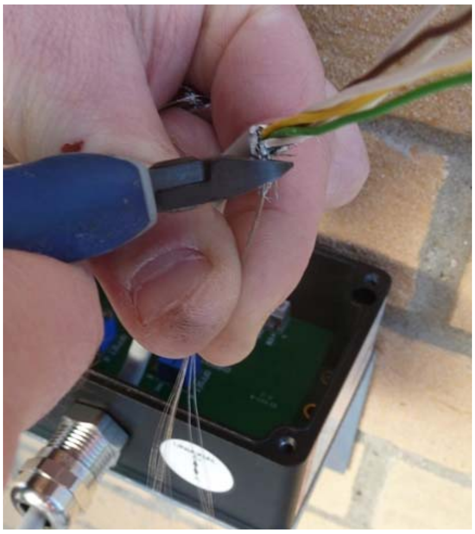
3. Draw the cable through the gland until the mark is clearly visible.

4. Cut the outer sheath at the mark. Take care not to cut into the braided shield.

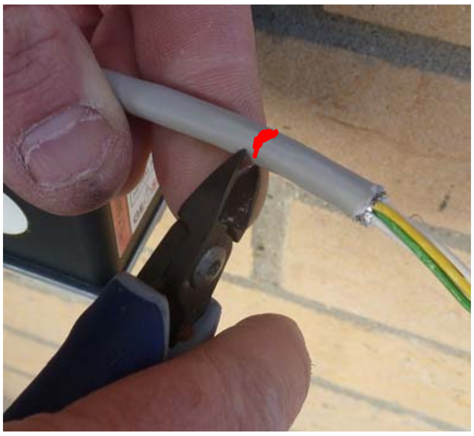


5. Remove the sheath to expose the braided shield.

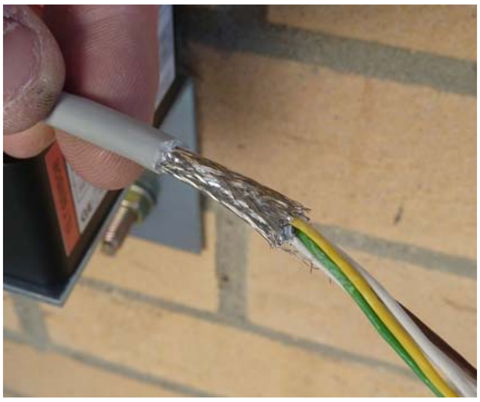
6. Carefully cut and remove the braided sheath. Then cut the inner 'drain' conductors (the fine inner conductors that are not sheathed) as shown in the photograph.



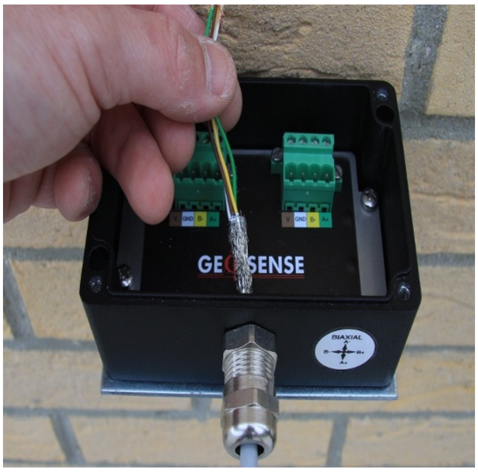
7. Measure 30mm back from the end of the sheath and carefully cut the sheath using either cutters or a sharp knife. Take care not to cut the braided shield.



8. Remove the sheath to expose the braided shield.



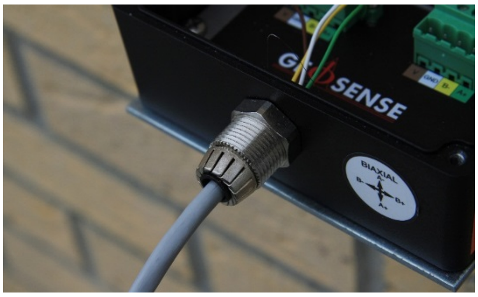
9. Draw the cable back into the box so that the braided section is just inside the gland.



10. Trim out any ‘fillers’. These are solid plastic cores used to fill the voids in the cable. They have no conductors within them and are white in colour.
TAKE CARE not to cut the white wire.

11. Carefully draw the wire back out of the gland until the braided section is just visible.

12. Now push the cable back in through the gland so that the braided section is within the gland but the rubber seal in the outer section of the gland is over the outer sheath of the cable.

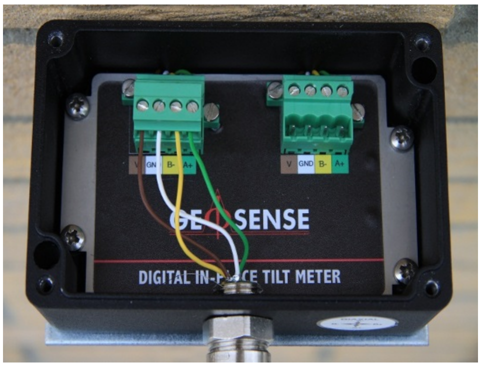


13. Hold the cable in position and carefully tighten the gland nut to complete the seal onto the cable and the 'sheath to gland' connection.

14. VERY carefully remove approximately 10mm of the conductor sheaths to expose the copper conductors.

15. Twist the copper conductors together and them fold them back onto themselves to create a good contact surface.

16. Using a small flat screwdriver, connect the conductors into the terminal on the circuit board. The number and colours of the conductors and the connectors used will depend upon the type of output selected.



ONCE INSTALLED TAKE BASE READINGS

To see how to take readings using a portable readout see next section 6.

6.0 READOUTS

Sensors with a single or 'bussed' **Digital** output are intended for direct connection to a data logger but can also be interrogated using a field PC or notebook computer, using a suitable interface.

The following demonstrates the use of the Field PC PDA:-

The above digital interface's will be required to operate the digital tilt meters. The interface on the left is for USB and is used with the PDA. The interface on the right is used to wire RS 232 to a data logger system.

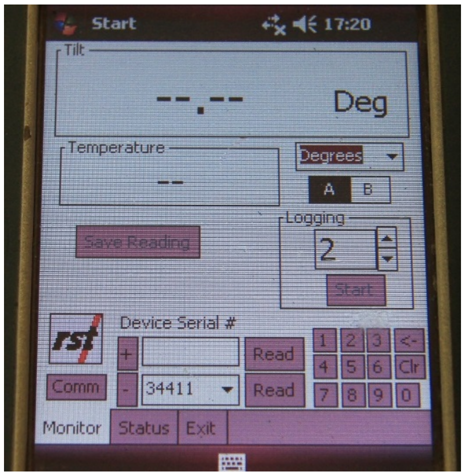
Press the start button on the keypad to turn on the field PC.

From the welcome screen using the stylus provided from the pocket to the rear of the PDA tap the start icon in the upper left of screen.

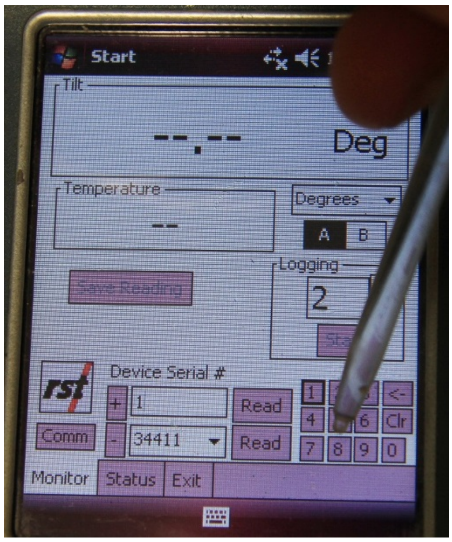
6.0 READOUTS contd...

Choose the option Digital Bus Tilt Mobile.

The tilt programme screen will now load



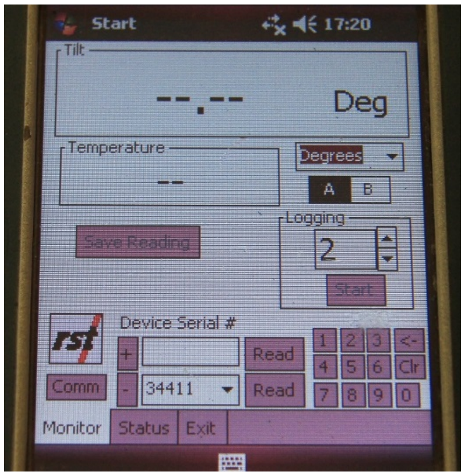
Using the numeric touchpad key in the serial number of the device



6.0 READOUTS contd...

After inputting the serial number touch the read button to begin live data stream.

The tilt programme screen will now load



Data should now be seen on the PDA screen.

6.2 Data loggers

Data loggers have the ability to automatically excite and interrogate a number of sensors together with the ability to store large numbers of readings that might be associated with tilt monitoring.

This is the preferred and most common method of monitoring tilt meter installations and is the recommended method of interrogating multiple installations of **Geosense® MEMS In-place Tilt Meters.**

The following are 'industry standard' data loggers that are typically used for connection to **Geosense® MEMS In-place Tilt Meters:-**

- Campbell Scientific loggers
- DataTaker loggers

Since +5 to –5 Volts and 4 - 20 mA's are common instrument outputs, it is possible to use a wide variety of data logging devices to record their readings. However, only those manufactured by the above companies are currently supported by **Geosense® .**

Connection to Data loggers

Campbell and DataTaker based data loggers and their associated components are configured and programmed to suit a sites' particular requirements, reflecting site conditions, instrument numbers and the required monitoring regime.

Connections to each logger will, therefore, vary. Details of specific connections will be included with each logger supplied.

7.0 DATA HANDLING

The readings from digital tilt sensors are already converted to engineering units within the board and are provided in the form of Sine of the angle of tilt. Consequently no additional calibration factors need be applied.

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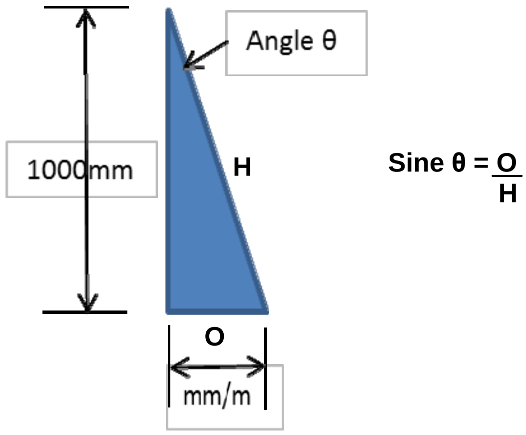
7.1 Data Conversion

- *Range is* : -0.2588 sin-1 to +0.2588 sin-1

  The tilt meter is supplied with 8 - 15 volts to power the internal processor and sensors via the RS485 ‘bus’ cable. Each sensor has a unique identification or ‘address’. The interrogating logger or readout ‘requests’ a reading from a particular ‘address’. The value returned from the processor is a value in $\sin^{-1}$ (the sine of the angle with respect to vertical) which can then be easily converted into a reading in degrees or other engineering units.



Whilst calibration records are provided for all sensors as a record but are not needed for any data conversion they are only there to provide a reference if required.

YOU SHOULD ENSURE THAT YOU ALWAYS HAVE A BASE READING AS EVERYTHING IS MEASURED RELATIVE TO THIS. IT IS THE CHANGE IN READING THAT IS IMPORTANT

READINGS FROM THE TILT METER WILL BE IN THE SINE OF THE ANGLE

7.1 Data Conversion contd...

To convert from one engineering unit to another (degrees or mm/m) only a simple calculation is required as shown below:-

- **The Sine of the angle into the angle**

  To convert from the Sine of an angle to an angle it is necessary to use the Arc Sin or Sin^{-1} mathematical function:-

  Y = Value from tilt meter (Sine of the angle) - for example 0.08716

  Angle in degrees = **Y** (0.08716) Sin^{-1}

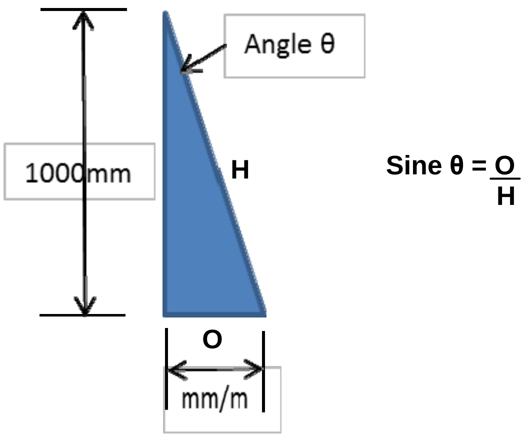
  Angle in degrees = 5.000º

- **Sine of angle to mm/m**

  Y = Value from tilt meter (Sine of the angle) - for example 0.08716

  mm/m = **Y** (0.08716) x 1000

  = 87.16mm/m



8.0 MAINTENANCE

Geosense® MEMS In-place Tilt Meters are maintenance free devices, for most applications. However should the unit be subjected to an impact, be producing "un-expected" readings or have been moved to another project after an extended period, it is recommended that they be returned to **Geosense®** for re-calibration.

9.0 TROUBLESHOOTING

If after all of the above checks have been carried out and the Tilt Meter still does not operate correctly, please contact **Geosense®** for advice, or return unit for inspection.

PROBLEM	READOUT	REMEDY
NAN displayed	Logger	Check for loose cable connections
NAN displayed	Logger	Check polarity of supply voltage connections
NAN displayed	Logger	Verify the 'address' of the sensor(s)
NAN displayed	Logger	Check cables, glands, logger box for EMC

IF A "**NAN**" IS DISPLAYED IN A LOGGER DATA STRING, IT MEANS THAT THE DEVICE IS NOT CONNECTED OR IS NOT FUNCTIONING CORRECTLY
IT SHOULD IMMEDIATELY BE INSPECTED TO RECTIFY THE FAULT

10.0 SPECIFICATION

TILT METERS

ITEM	IPTM-1-485	IPTM-2-485	IPTM-1-485BUS	IPTM-2-485BUS
Range	±15°	±15°	±15°	±15°
Axis	Uniaxial	Biaxial	Uniaxial	Biaxial
Output	RS-485	RS-485	RS-485	RS-485
Resolution	±2 arc sec	±2 arc sec	±2 arc sec	±2 arc sec
Non linearity	±0.0125% FS	±0.0125% FS	±0.0125% FS	±0.0125% FS
Repeatability	±0.0125% FS	±0.0125% FS	±0.0125% FS	±0.0125% FS
Sensor	MEMS	MEMS	MEMS	MEMS
Excitation	8-15 V DC	8-15 V DC	8-15 V DC	8-15 V DC
Operating Temp	-40 to +85°C	-40 to +85°C	-40 to +85°C	-40 to +85°C
Dimensions	125x80x60mm	125x80x60mm	125x80x60mm	125x80x60mm

NOTE: THE BUS VERSION CAN BE LINKED TOGETHER IN A BUSSED CHAIN SIGNIFICANTLY REDUCING THE AMOUNT OF CABLE REQUIRED

CABLES

Standard

TILT METER MODEL	CABLE	PART NUMBER
Digital uniaxial RS-485	2 twisted pair	Q10-151
Digital bi-axial RS-485	2 twisted pair	Q10-151

Low smoke halogen free (LSHF)

TILT METER MODEL	CABLE	PART NUMBER
Digital uniaxial RS-485	2 twisted pair	Q10-161
Digital bi-axial RS-485	2 twisted pair	Q10-161

LUL Approved

TILT METER MODEL	CABLE	PART NUMBER
Digital uniaxial RS-485	2 twisted pair	Q10-171
Digital bi-axial RS-485	2 twisted pair	Q10-171

11.0 SPARE PARTS

There are no spares parts available for **Geosense® MEMS In-place Tilt Meters.**
In the case of damage to the connectors on the readout unit or the tilt meter, Geosense can provide the replacement parts and a service to attach the connectors.

12.0 RETURN OF GOODS

12.1 Returns procedure

If goods are to be returned for either service/repair or warranty, the customer should contact **Geosense®** for a **Returns Authorisation Number,** request a **Returned Equipment Report Form QF034** and, prior to shipment. Numbers must be clearly marked on the outside of the shipment.

Complete the **Returned Equipment Report Form QF034**, including as much detail as possible, and enclose it with the returned goods and a copy of the form should be faxed or emailed in advance to the factory.

12.2 Chargeable Service or Repairs (Inspection & Estimate)

It is the policy of **Geosense®** that an estimate is provided to the customer prior to any repair being carried out. A set charge for inspecting the equipment and providing an estimate is also chargeable.

12.3 Warranty Claim (See Limited Warranty Conditions)

This covers defects which arise as a result of a failure in design or manufacturing. It is a condition of the warranty that the **Geosense® MEMS In-place Tilt Meters** must be installed and used in accordance with the manufacturer's instructions and has not been subject to misuse.

In order to make a warranty claim, contact **Geosense®** and request a **Returned Equipment Report Form QF034.** Tick the warranty claim box and return the form with the goods as above. You will then be contacted and informed whether your warranty claim is valid.

12.4 Packaging and Carriage

All used goods shipped to the factory **must** be sealed inside a clean plastic bag and packed in a suitable carton. If the original packaging is not available, **Geosense®** should be contacted for advice. **Geosense®** will not be responsible for damage resulting from inadequate returns packaging or contamination under any circumstances.

12.5 Transport & Storage

All goods should be adequately packaged to prevent damage in transit or intermediate storage.

13.0 LIMITED WARRANTY

The manufacturer, (Geosense Ltd), warrants the **Geosense® MEMS Tilt Meter** manufactured by it, under normal use and service, to be free from defects in material and workmanship under the following terms and conditions:-

Sufficient site data has been provided to **Geosense®** by the purchaser as regards the nature of the installation to allow **Geosense®** to select the correct type and range of **MEMS In-place Tilt Meter** and other component parts.

The **Geosense® MEMS In-place Tilt Meter** shall be installed in accordance with the manufacturer's recommendations.

The equipment is warranted for 1 year from the date of shipment from the manufacturer to the purchaser.

The warranty is limited to replacement of part or parts which, are determined to be defective upon inspection at the factory. Shipment of defective part or parts to the factory shall be at the expense of the Purchaser. Return shipment of repaired/ replaced part or parts covered by this warranty shall be at the expense of the Manufacturer.

Unauthorised alteration and/or repair by anyone which, causes failure of the unit or associated components will void this **LIMITED WARRANTY** in its entirety.

The Purchaser warrants through the purchase of the Geosense® MEMS In-place Tilt Meter equipment that he is familiar with the equipment and its proper use. In no event shall the manufacturer be liable for any injury, loss or damage, direct or consequential, special, incidental, indirect or punitive, arising out of the use of or inability to use the equipment sold to the Purchaser by the Manufacturer.

The Purchaser assumes all risks and liability whatsoever in connection with the **Geosense® MEMS In-place Tilt Meter** equipment from the time of delivery to Purchaser.

Geosense Ltd

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