![GeoSIG logo - swiss made to measure]

User Manual
AC-73-DH Force Balance Accelerometer

Document Revision

Version	Date	Modification	Prepared	Checked	Released
0	05.11.2013	First issue	SER	MAE	TAB
1	12.11.2013	Pinout correction of iSensor	MAE	SER	TAB
2	31.03.2015	Typo corrections & text improvements	SER	TAB	JOG

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Warnings and Safety

☞ | *The sensor housing provides no protection against explosive atmosphere. It must not be directly operated in an area where explosive gases are present.*
In case of any doubt about the installation, please contact GeoSIG for advice.

1. Introduction

This document describes the steps needed for the installation of GeoSIG AC-7x-DH series down-hole accelerometers, including some guidelines for the borehole drilling.

Such installation procedures / instructions always require to be reviewed according to the local situation and must be used as guidelines only.

The AC-73-DH is an accelerometer sensor that covers the full range for strong-motion measurement over the required amplitude and frequency ranges. For a detailed description of the sensor and its interface, please refer to section 4.

The reasons to have a borehole sensor instead of a sensor at surface can be:

- To measure the acceleration at the rock level without the influence of sediments or soft soil.
- Define site condition to know amplification factor. The acceleration level at surface can be measured with a simple sensor such as AC-73 and with borehole measurement where the amplification factor can be defined. This factor is highly dependant on local conditions and can vary to a great extent from one location to another.
- Avoid human induced noise present at surface.

2. Pre-installation

A good understanding of the installation requirements is the basis for a successful and reliable sensor installation and good quality measurement. As a first requirement, the parameters of the borehole should be well defined. For the requirement related to the sensor itself, the requirements can be simply summarised as below:

- Free borehole diameter of 100 mm as a minimum.
- Water level above the sensor in the borehole should not be more than 100 meters.
- In cases where there is water in the hole, combination of the chemical compositions and temperature should be evaluate for compatibility with the sensor housing material. This usually concerns installation located in areas with hot springs or near volcanoes.
- The choice between putting a casing in the hole or otherwise depends mainly on the kind of rock the hole is made of; this is usually managed / defined by the company which is drilling the hole.
- The selection of the casing type has an influence on how the orientation (angle toward North) of the sensor after insertion in the borehole can be defined. The sensor has an internal compass (toward magnetic North) to define the orientation of its X/Y axis toward the North direction. Its measurement will be only valid if no casing or non-magnetic material is used (plastic, aluminium, fibre glass casing). In case of steel casing, then the orientation of the sensor should be calculated using some recorded earthquakes from borehole sensor data and a reference surface sensor at borehole top.

In the following page, an overview of the layout of a typical installation is provided.

(5) Steel suspension wire

Junction Box

Surface

(1) Borehole with or without casing

(7) Cable clamp to suspension wire

Soft material

Water is usually present in the hole

(9) Sand

(6) Signal cable

(4) Fixation for the suspension wire

Hard rock

(3) Sensor

(8) Concrete

(2) Sand
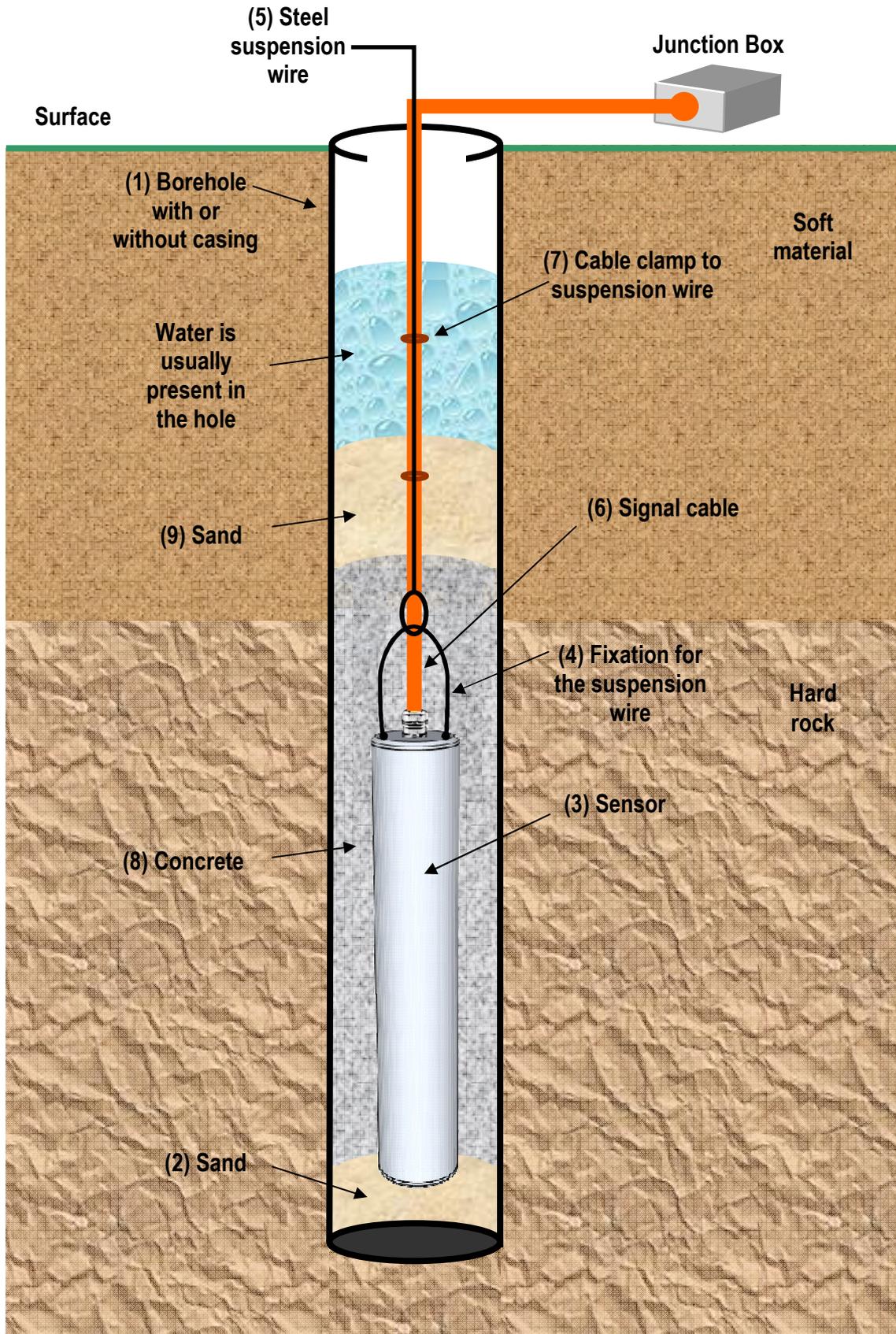
4

Figure 1, Installation overview

2.1. Overview of the installation work

With reference to "Figure 1, Installation overview", the recommended steps are as follows:

(1) A Borehole with or without a casing should be prepared.

(2) Approximately 0.5-1.0 meter of sand to be put in the bottom of the hole. This is to ensure that the sensor doesn't hit a hard part when it reaches the end of the hole.

(3) The AC-73-DH sensor should be prepared and tested before insertion. A computer should be used to retrieve the information from the iSensor module.

(4) Fixation for the suspension wire is included with the sensor.

(5) A suspension steel wire (typically stainless steel wire 3 mm diameter with a capacity of up to 100 kg) should be used to support the weight of the sensor and the cable during the insertion of the sensor.

(6) Signal CABLE

(7) Cable clamp to steel wire

(8) Concrete

(9) Sand

Water is usually present in the hole, it is recommended that the water level above the sensor is only 50 meters high; this is to accommodate for additional water which may be added after a heavy rain.

2.2. Preparation check list

A typical installation requires the following preparation:

- Access permission to the site (if required)

- Drawing of site implementation, including cable length.

- Preparation of the location of any surface sensors.

- Installation of the recording system (without routing cables going to down-hole sensor).

- Drilling of the hole and tubing for the hole if required.

- Verification of the borehole, depth of the water level and the path in the hole is free for the sensor. The deviation from vertical is not an issue for the operation of the sensor itself, but could affect the interpretation of the data. There should be no impact what so ever for up to ±3°. For higher deviations the impact should be checked, as this could affect the interpretation of the recorded data and it could bring difficulty during lowering of the sensor inside the hole until it reaches the required depth.

- Trench for down-hole sensor cables. Under-ground routing is preferred. Steel or plastic tubes (according to the kind of ground and the level the tube is buried) could be directly installed underground and the cable to be routed at a later stage. Ideally a steel wire should be inserted in the tube's hole to simplify the cable routing at a later stage.

If the hole is equipped with cemented tubing, one week delay should be allowed. Otherwise, the next step should be executed as soon as possible to avoid any stones or other material falling into the hole.

It is highly important that the cementation at the bottom of hole is as good as possible to ensure a good coupling near the level of the sensor. So injection should be performed first from the bottom. An injection plastic tube should be routed along the casing when it is inserted in the hole. If the injection cannot be fully performed from the bottom, the rest of injection should be done from the top.

If possible, the cementation should be verified within the next 24 hours using ultrasonic measuring equipment or measuring the temperature profile in the hole. For both methods, water must be present in the hole.

2.3. Requested materials and tools

In addition to some common basic set of tools, the following tools and materials are required:

- Depth probe with water level indicator to know the real depth of the hole.

- Steel wire for sensor suspension with the appropriate lock nut for the depth of the hole plus an additional length of at least 10 meters.

- Injection tube to be fixed along the steel wire and on the side of sensor (provided there is enough space).

- A fixation point at the surface close to the borehole for the steel wire.

- Sensor assembly.

- Recording system for connection to the sensor (including its power supply).

- Laptop (Windows based) to run GeoSIG utility for iSensor interface (iSensorUI.zip, see section 4.5).

- In cases when the use of the compass is required, a serial adapter for RS-485 like MOXA TCC-80I should be utilized to interface the laptop serial port (or through a USB adapter) with the RS-485 interface of the sensor.

Wire 12
Wire 11

Figure 2, MOXA TCC-80I interface for RS-485

2.3.1. Quantities

External hole or casing diameter	Volume between hole and tube[1]	Volume of sensor
cm	dm^3 / meter	dm^3
10	8	
12	11.3	3.2
15	17.7	

It is required to have sand, bentonite and cement. The quantities should be evaluated according to the diameter of the hole, the depth and the mixture requirement outlined in section 3.1.

If there is no casing, It is always needed to have extra reserve for cementation of the sensor inside the drilled hole as there could be some cavities that could required some extra meter cubic of the mixture!!!

---

[1] $Volume = \pi \times \dfrac{Diameter^2}{40}$ With: Volume [dm3], Diameter [cm]

2.4. Casing installation

Note: Drawing not to scale.
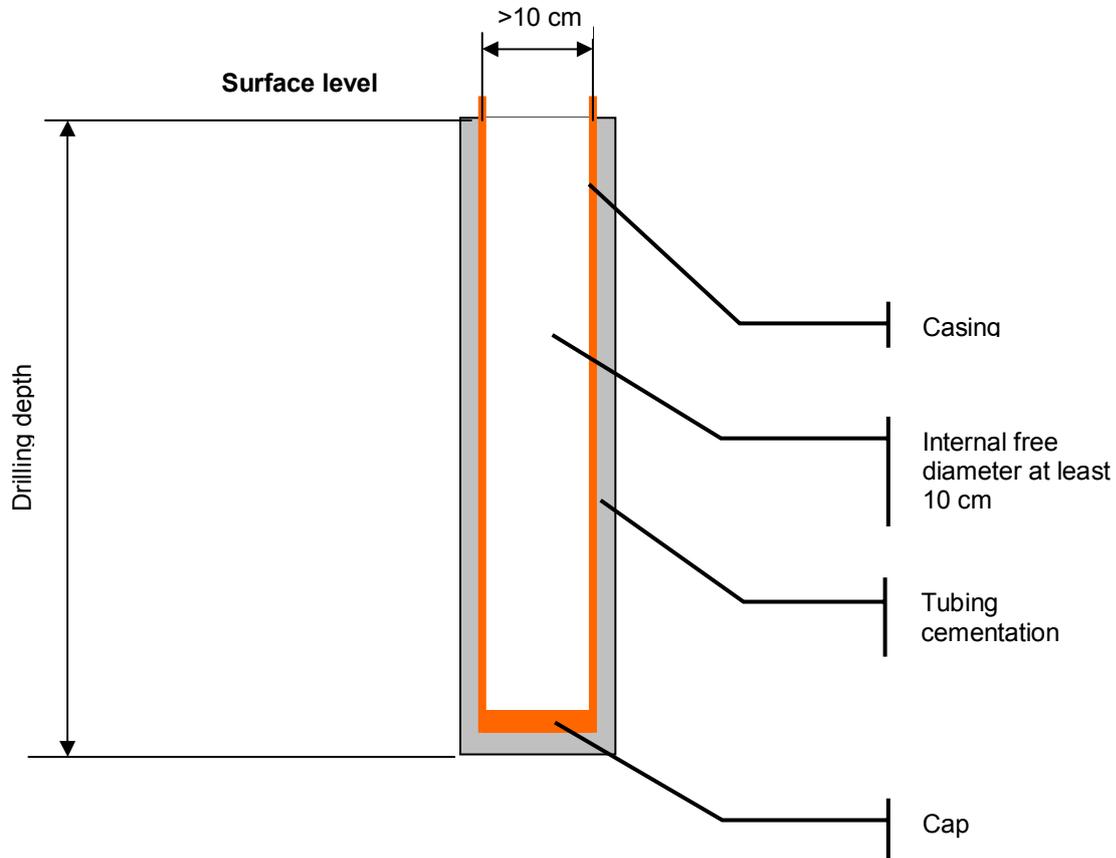
Figure 3, Installation of casing

2.4.1. Hole specifications

The hole must either have a casing (steel or PVC) or adequate steps must be taken to avoid ground material falling in the hole before the inclinometer and that the inclinometer tube can be later inserted.

If tubing is of PVC type, some water must be in the hole to sustain water pressure at bottom. Otherwise, there is the risk that the case breaks in case of deep boreholes.

For drilling depths of more than 20 meters, the drill diameter must be at least 12 cm to allow the sensor reaching the correct depth. For holes with less than 20 meters, a drill diameter of 10 cm is sufficient.

In case of using an injection plastic tube (grouting), the minimum diameter has to take in to account the extra space required by the tube.

The deviation of the hole must remain within the following specifications:

- The deviation-drift must remain bellow ±1° / 3 meters

- The deviation at sensor location should be within ±3°, the maximum recommended deviation is ±9° from vertical.

2.5. Variants of installation

For small depths, the sensor can be simply buried in the ground. Care should be taken to ensure a perfect coupling between the soil and the sensor housing is achieved.

2.6. Unpacking and handling of the sensor

The accelerometer is precision measurement equipment and it should be handled with care. Even though the sensor is design and manufactured to be strong for its class, drop shock with hard surfaces should be avoided.

Due to its long cylinder shape, when the sensor is placed on its base, there is a risk that it may fall. It is recommended that it is stored on its side, however care should be taken that it doesn't start rolling and fall from the surface it is placed on.
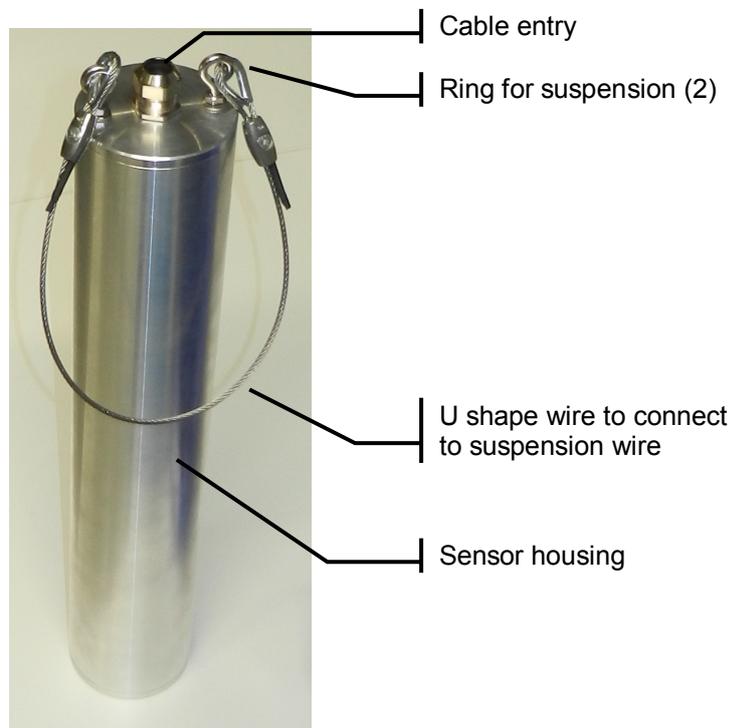
Figure 4, Sensor view

At this stage it is recommended to test the sensor and use the iSensor interface to get information about the sensor condition.

3. Installation

- Make sure the communication with the iSensor is working as described in chapter 4.5.
- Perform a compass calibration as described in chapter 4.5.4.

- Put in the hole the equivalent of 50 cm height of sand (see section 2.3.1 for the volume needed).
- Clamp the cable about every 3 meters to the steel wire and ensure that the cable is not under pressure. The cable is not made to support all the weight of the sensor and cable.
- Lower the sensor in the tube until it reaches the sand at the bottom, this is noticed as a the cable becomes "soft". The movement should be controlled using the steel wire and the sensor cable / injection tube to follow that wire without any tension on them.
- Lift the sensor up by 50 cm (to ensure it is in the vertical position)
- Electrical connection of the cable coming from the hole to any junction box.

☞ | It is not recommended to perform the cementation of the sensor in the hole right after its insertion. The whole installation must be finished and the system must run for some weeks and show correct operation before the final cementation of the sensor inside the hole is performed.

- Route the cables from recording system to the sensor junction boxes and connect the cables to sensor junction boxes.
- Perform a sensor test using the recording system.
- Test the whole system.

- A continuous monitoring of the system must be implemented over some time. Especially, some noise and sensor test measurements must be performed periodically and verified. Clearly as the sensors are not cemented, there could be some records generated by movement of the cables along the hole.

- Final cementation of the sensors in the inclinometer tube.
- When the cementation is done, sand can be put in the hole to avoid that cable and steel wire can move in case of earthquake and create parasitic signals.
- Release of steel wire.

3.1. Grouting

After the sensor has been successfully tested in its place, the cavity between borehole and the sensor can be grouted.

1. Inject a grouting mixture consisting of 100 liters of water, 50 kg of cement, and 10 kg of bentonite. The bentonite percentage may be increased or reduced according to the consistency of the examined soil). Use low pressure and low flow for the expected required amount of the mixture.

2. Complete the installation by mounting on the top a plastic cap or if required the lockable top cap.

3. Final cementation is expected within one week.

4. Do noise measurements.

3.2. Layout of the installation

Note: The drawing has no scale.
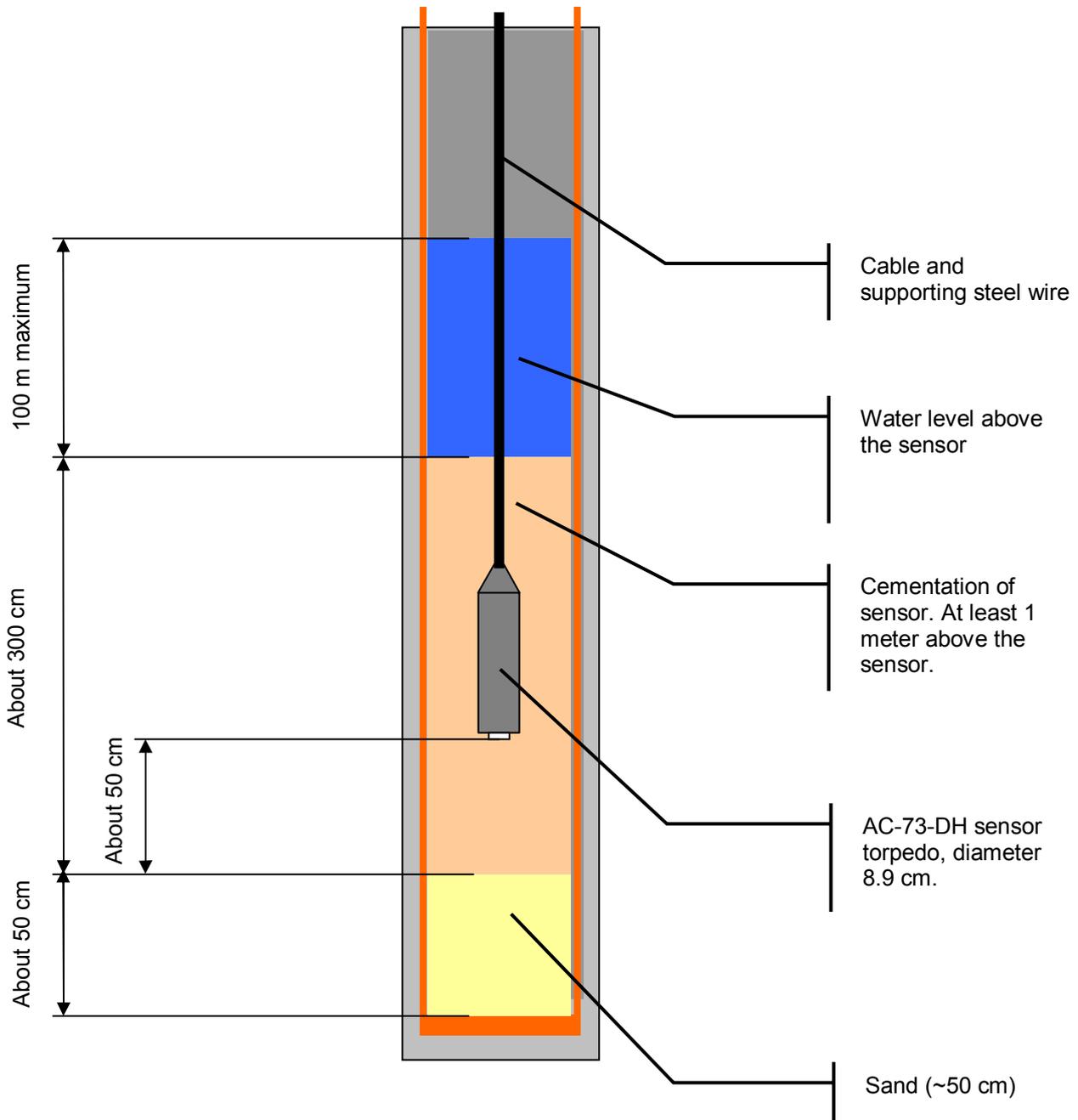
Figure 5, Layout of the installation

Note: It is recommended that at installation, the water level above the sensor is no more than 50 meters; to ensure that during the operating life of the installation the real water level will not exceed the 100 meters limit allowed for the sensor.

4. Reference

The AC-73-DH sensor package is a true electro-mechanical triaxial down-hole accelerometer designed for earthquake monitoring and applications requiring highly sensitive and ruggedized sensors with minimum maintenance and a simple method for periodic testing. The core of this accelerometer is based on the same electronics used in AC-73 or AC-73i with the same performance. The housing for the AC-73-DH is made for insertion into a borehole with a diameter of 100 mm or higher. The orientation of the sensor in the hole can be defined either by the integrated compass (accessible over the iSensor interface) or by calculation using the azimuth of recorded known earthquakes and the borehole location.

4.1. Description

The rugged mass suspension moving coil system improves the signal to noise ratio. The magnetic system and capacitive position sensors offer symmetrical controls for the accurate electronic centring of the mass. At rest the accelerometer mechanism is in balance and no electrical output is generated. Acceleration applied to the AC-73-DH will result in an electrical output proportional to the current used to keep the mass centred. This accelerometer output signal is calibrated to "g" gravity so that the current scale factor of the AC-73-DH is in units of milliamps per g. Because of the symmetrical positioning system incorporated with the force balance servo accelerometer principle, the accelerometer can not arbitrarily change its scaling or drift out of calibration.

The sensor interface to the recording system is based on a differential voltage for each axis over 2 twisted wires (twisted pair) to avoid disturbance over long distance.

The AC-73-DH is equipped with electronic offset adjustment features that keep the offset low and make its installation very user friendly. This powerful feature allows the users to install the AC-73-DH without mechanical offset adjustment, fine levelling and can adapt easily to the usual deviations from vertical found in drilled borehole.

The DC response allows the sensor to be easily repaired, tilt tested or recalibrated in the field. With the help of the test line the AC-73-DH accelerometer can be completely tested assuring proper operation and accurate acceleration measurement. This test line is internally connected to the external world only when a given command is sent to the sensor to avoid any noise pick-up through the test input.

The sensor can be powered from 9.5 to 18 VDC source with the advantage that its power input is insulated from the sensor's electronic ground. This avoids ground loops and reduces noise induced through the power supply.

The sensor "State Of Health" can be digitally monitored through the so-called "iSensor" interface provided over 2 wires and a RS-485 interface.
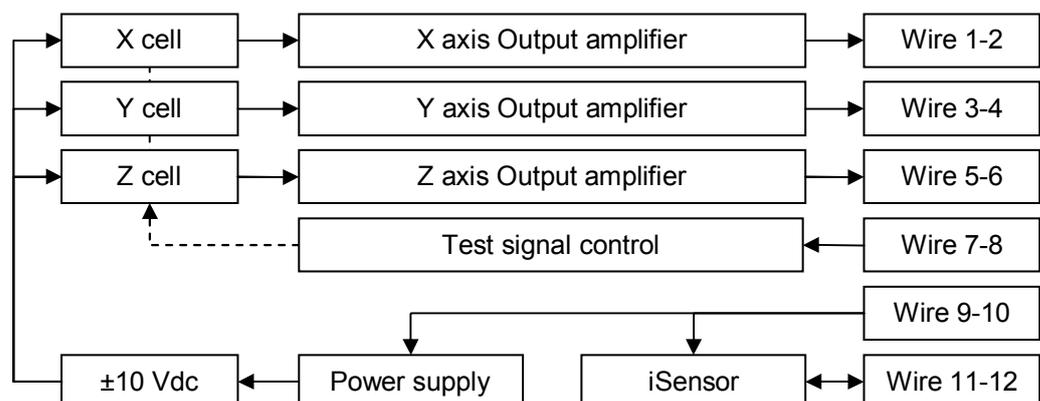
Figure 6, Block diagram

4.2. Sensor physical dimensions
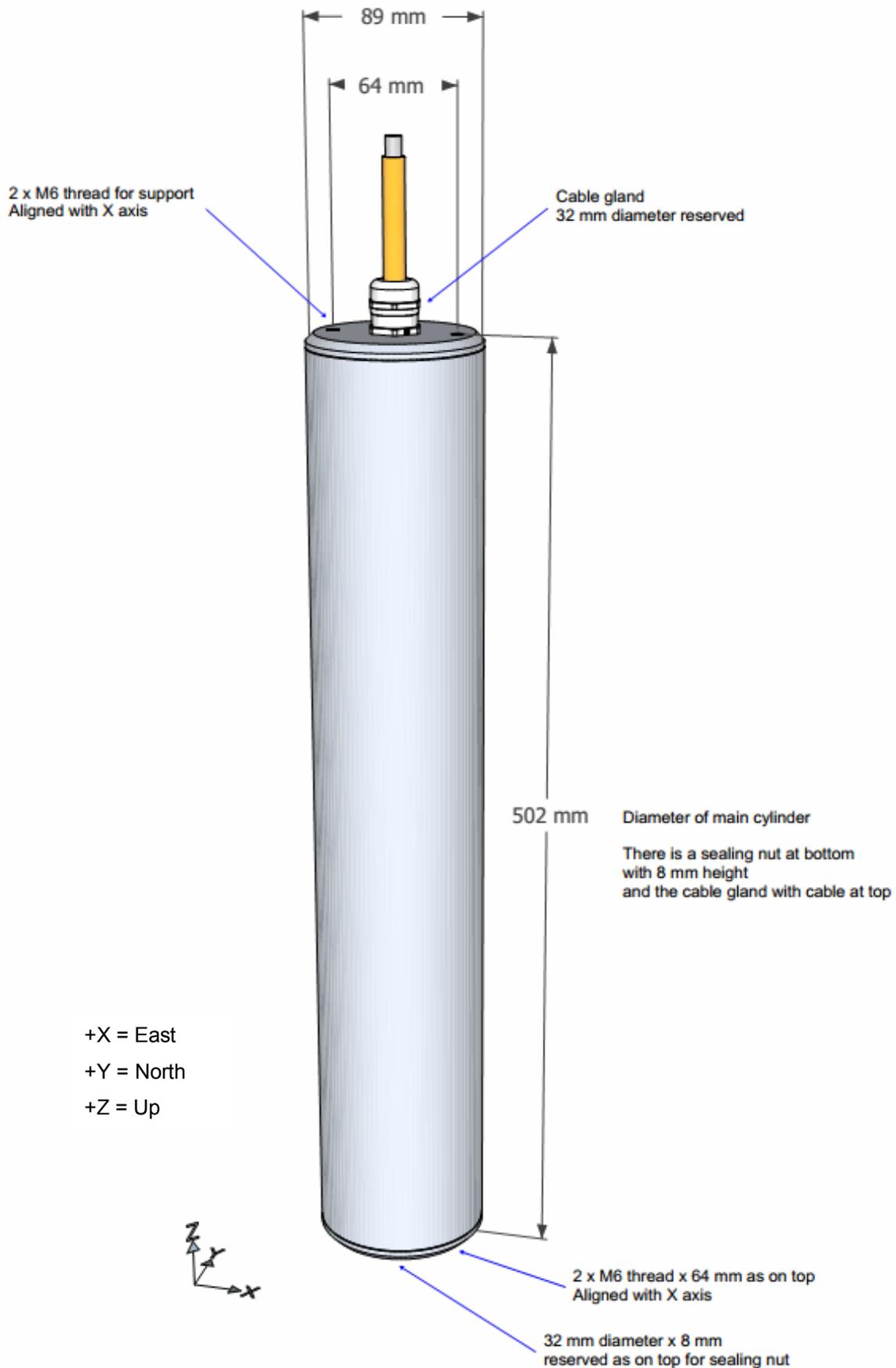
Figure 7, Sensor housing dimensions

4.3. Sensor interface

The sensor interface is the same as other GeoSIG sensors with a differential voltage output for each axis having a ±10 volts range (20 Vpp).

A digital sensor test input is available to create the equivalent of 0.125 g step at output (whatever is the sensor's fullscale).

Power supply input is insulated from the rest of the electronics in the sensor to avoid any ground loop.

Finally a digital interface (RS-485) using MODBUS protocol is provided to retrieve sensor "state of health" (SOH) during installation and maintenance. This digital sensor is named "iSensor". The required software is provided for running on a computer (Running Windows OS). More details can be found in section 4.5.

4.4. Connection

The AC-7x-DH accelerometer is supplied with a cable mounted at factory. It uses 12 wires for the full signal interface. The connector pin assignment and cable colour code is as per DIN47100:

Pin	SIGNAL	Comment	Color	
1	OUTPUT X (+)	0 V ± 5 V voltage output, 100 Ω output impedance	White	
2	OUTPUT X (-)	0 V ± 5 V voltage output inverted, 100 Ω output impedance	Brown	
3	OUTPUT Y (+)	0 V ± 5 V voltage output, 100 Ω output impedance	Green	
4	OUTPUT Y (-)	0 V ± 5 V voltage output inverted, 100 Ω output impedance	Yellow	
5	OUTPUT Z (+)	0 V ± 5 V voltage output, 100 Ω output impedance	Grey	
6	OUTPUT Z (-)	0 V ± 5 V voltage output inverted, 100 Ω output impedance	Pink	
7	TEST INPUT	Test input, each axis output will have the equivalent of a 0.125 g step when activated high (+8 to +18 V toward GND)	Blue	
8	GND	Electrical ground reference, connected to recorder's ground signal	Red	
9	+12 VDC power	Power input, +9.5 to +18 VDC range, 80 mA @ +12 VDC	Black	
10	0 VDC power	Power return	Violet	
11	RS-485 D-	iSensor interface, RS-485, "DATA-" wire	-	
12	RS-485 D+	iSensor interface, RS-485, "DATA+" wire	-	

Table1. AC-7x-DH Cable wire Assignment and Colour Code

When a GeoSIG connector is mounted at the cable end, the pin number is show in the first column. In case of a custom connector, please refer to the separate document which will be included with the sensor.

4.5. iSensor interface

The AC-73-DH sensor is an intelligent sensor (iSensor) containing the following additional sensors to simplify the installation.

- Temperature sensor
- Humidity sensor
- Tilt sensors
- Magnetic compass

The humidity sensor can be used for the verification of the water tightness of the sensor after its installation. The tilt sensors give a feedback if the sensor is aligned vertically in the down-hole and the magnetic compass helps to align the sensor axes.

> The communication with the iSensor should be checked before the sensor is installed in the down-hole.

4.5.1. Preparation

For the communication with the iSensor AC-73-DH, the followings are required:

- AC-73-DH sensor
- Computer with serial port and *iSensorUI* software
- RS-485 to RS-232 converter (not required in case the computer provides an RS-485 port)
- 15 VDC power supply
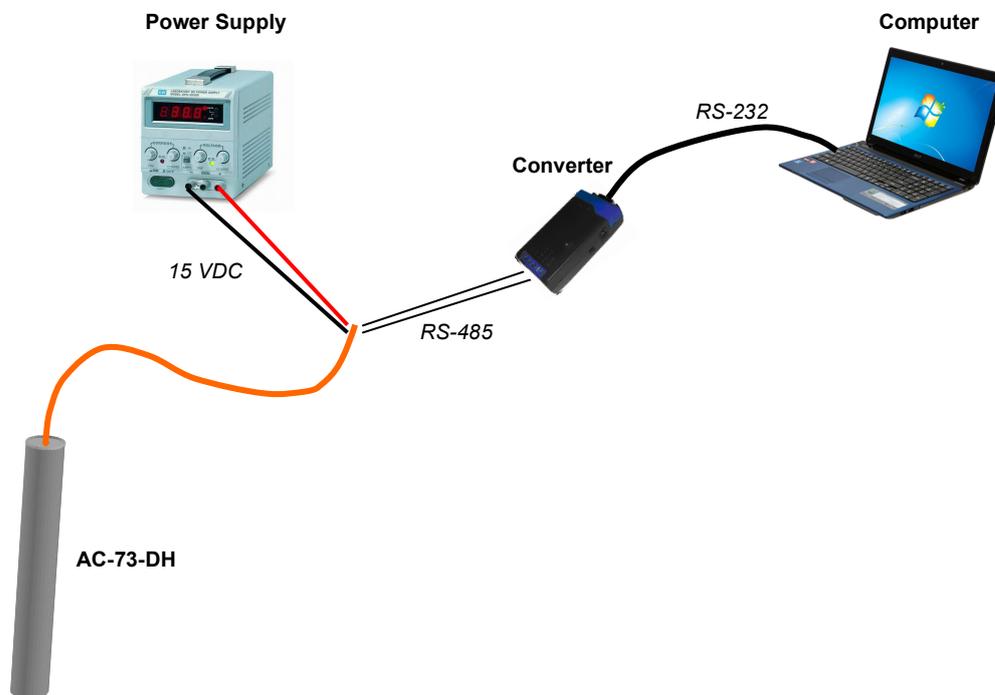
Figure 8, Overview of cabling
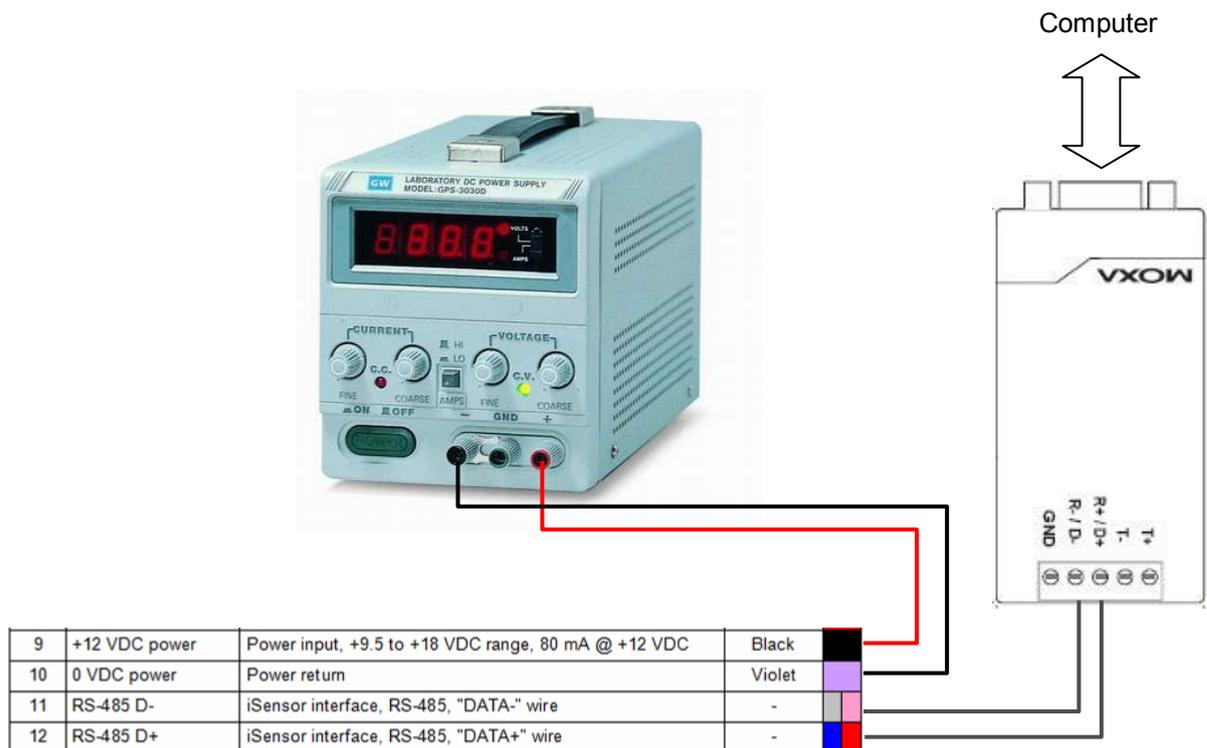
Figure 9, Detailed cabling

9	+12 VDC power	Power input, +9.5 to +18 VDC range, 80 mA @ +12 VDC	Black
10	0 VDC power	Power return	Violet
11	RS-485 D-	iSensor interface, RS-485, "DATA-" wire	-
12	RS-485 D+	iSensor interface, RS-485, "DATA+" wire	-

☞ Make sure no shortcuts are made between all the other wires of the cable.

4.5.2. Installation of the Software

To install the user interface, extract the content of the file *iSensorUI.zip* to any folder on your computer (e.g. C:\iSensorUI\). The following files should be present in the folder after extraction:

- iSensorUI.exe
- libmodbus-5.dll
- iSensor_Expert.bat
- iSensor_Start.bat

4.5.3. Simple User Interface

Make sure that the sensor is powered and the setup is wired according to the Figure 8 and Figure 9. Then double-click on *iSensor_Start.bat*.

The following command prompt appears

```
Enter COM Port Number:
```

Enter the number of the serial port that the sensor is connected to. In case of COM1, just type '1', in case of COM2, type '2', etc... If you are unsure about the serial port, please check in Windows under Start → Control Panel → System → Device Manager.

☞ Only serial port numbers COM1 to COM9 are supported.

The following screen should appear, plotting every second the readings from the internal sensors.

```
Enter COM Port Number: 1
Time                    T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 18:23:33     26.5     38.4    0.5         -0.5        203.0
2013/11/07 18:23:34     26.5     38.4    0.5         -0.5        203.0
2013/11/07 18:23:35     26.5     38.4    0.5         -0.5        202.4
2013/11/07 18:23:36     26.5     38.4    0.5         -0.5        203.0
2013/11/07 18:23:37     26.5     38.4    0.5         -0.5        203.2
2013/11/07 18:23:38     26.5     38.4    0.5         -0.5        203.5
2013/11/07 18:23:39     26.5     38.4    0.5         -1.0        202.9
2013/11/07 18:23:41     26.5     38.4    0.5         -1.0        202.8
2013/11/07 18:23:42     26.5     38.4    0.5         -1.0        202.5
2013/11/07 18:23:43     26.5     38.4    0.5         -1.0        202.9
```

Time: Time of the reading

T: Temperature inside the AC-73-DH down-hole sensor in °C

RH: Relative humidity inside the AC-73-DH down-hole sensor in %

TiltX: Tilt of the AC-73-DH sensor tube in direction of the X axis in °

TiltX: Tilt of the AC-73-DH sensor tube in direction of the Y axis in °

MH: Magnetic heading of the Y axis. When the MH is showing 0°, then the Y-axis points to the direction north. In case of 90°, the Y-axis points east, 180° for south and 270° for west.

At the same time, the values are logged into the file *iSensor_Output_YYYYMMDD_HHMMSS.csv*, whereas

YYYYMMDD_ HHMMSS stands for the year (YYYY), month (MM), day (DD), hour (HH), minute (MM) and second (SS) when the measurement has started. For example the filename could be: *iSensor_Output_20131107_182333.csv*

The program measurement can be stopped by closing the command prompt window or pressing **<CTR>** + **'C'**.

The CSV file can be opened by any text editor or the Microsoft Excel for further analyse.
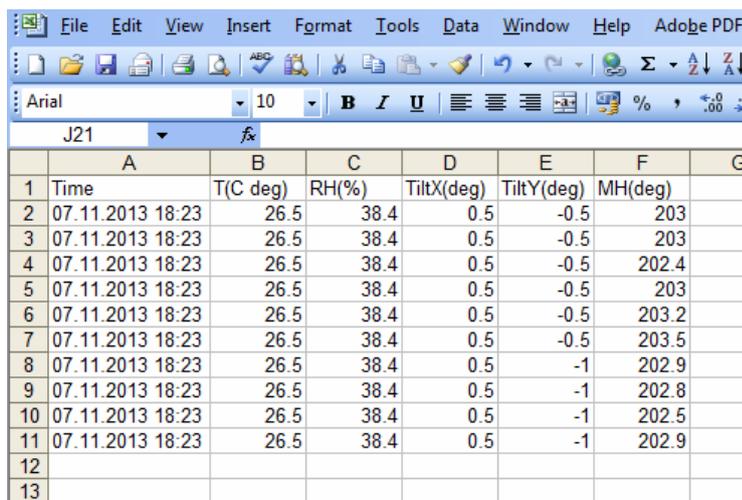
Figure 10, CSV file opened in the Microsoft Excel

4.5.4. Compass Calibration

👉 | Compass calibration shall be done before the installation of the AC-73-DH sensor.

Make sure that the sensor is powered and the setup is wired according to the Figure 8 and Figure 9. Then double-click on *iSensor_Compass_Calibration.bat*.

The following command prompt appears

```
        Enter COM Port Number:
```

Enter the number of the serial port that the sensor is connected to. In case of COM1, just type '1', in case of COM2, type '2', etc... If you are unsure about the serial port, please check in Windows under Start → Control Panel → System → Device Manager.

👉 | Only serial port numbers COM1 to COM9 are supported.

Then follow the instructions on the screen. After the calibration is finished, the correction factors are stored into the iSensor.

4.5.5. Expert Mode

A double-click on *iSensor_Expert.bat* starts the expert mode of the iSensorUI software. The help content will be shown immediately.

The iSensorUI software can be started with several parameters.

```
    isensorui -parameter value
```

Parameter	Value	Description
-h	-	Shows the help text
-a	show-sensors	Shows the measurements of the iSensor
	Show-fw-ver	Shows the firmware version of the iSensorUI
	calibrate-compass	Starts the calibration of the compass
-p	COM1, COM2, COM3, ...	Serial port for the communication with the sensor
-b	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	Baudrate of the serial port (default is 9600)
-s	1, 2, 3, ...	Slave address of the AC-73-DH iSensor (default is 1)
-t	1 ... 3600	Delay in seconds between the measurements (default is 1)
-l	1, 2, 3, ...	Limit the read values by the specified value. Program stops when the specified measurements have been done
-o	filename.csv	Print the sensor values to the selected CSV file
-V	-	Show the version of the software

4.5.5.1. Example 1

The sensor is connected to **COM1** and **iSensor values shall be plotted**.

```
    isensorui -p COM1 -a show-sensors
```

Then the sensor sends the measurements as shown below to the screen.

```
Time                       T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 16:39:35        26.5     38.1    0.5         -0.5        203.0
2013/11/07 16:39:36        26.5     38.1    0.5         -1.0        203.0
2013/11/07 16:39:37        26.5     38.1    0.5         -1.0        202.4
2013/11/07 16:39:38        26.5     38.1    0.5         -1.0        203.0
2013/11/07 16:39:39        26.5     38.1    0.5         -1.0        203.2
```

4.5.5.2. Example 2

The sensor is connected to **COM4** and **iSensor values shall be plotted** **and saved to the file** *installation.csv* **every 5 seconds**.

```
isensorui -p COM4 -a show-sensors -o installation.csv -t 5
```

Then the sensor sends the measurements as shown below to the screen.

```
Time                       T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 16:39:35        26.5     38.1    0.5         -0.5        203.0
2013/11/07 16:39:40        26.5     38.1    0.5         -1.0        203.5
2013/11/07 16:39:45        26.5     38.1    0.5         -0.5        202.8
2013/11/07 16:39:50        26.5     38.1    0.5         -0.5        202.4
2013/11/07 16:39:55        26.5     38.1    0.5         -1.0        203.0
```

Additionally the data are stored in the CSV file *installation.csv*
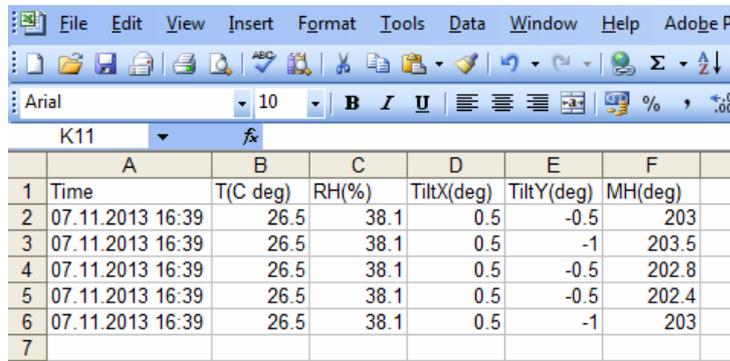
4.5.5.3. Example 3

The sensor is connected to **COM2** and only **3 measurements** with **an interval of 20 seconds** **shall be read out from the iSensor**.

```
isensorui -p COM2 -a show-sensors -l 3 -t 20
```

The reading stops after 3 measurements.

```
Time                       T(deg C) RH (%)  TiltX(deg)  TiltY(deg)  MH,(deg)
2013/11/07 16:40:00        26.5     38.1    0.5         -0.5        203.0
2013/11/07 16:40:20        26.5     38.1    0.5         -0.5        202.4
2013/11/07 16:40:40        26.5     38.1    0.5         -0.5        202.8
```

4.6. Specifications

The key specifications of the sensor are in the table below. For more detailed specifications, please refer to the AC-73-DH leaflet.

Sensor P/N	AC-7x-DH
Input range	Acceleration, ±0.5, ±1.0, ±2.0, ±3.0 or ±4.0 g
Output range	0 ± 10 Volt differential output (20 Vpp)
Frequency range	DC to 200 Hz
iSensor	Digital monitoring of sensor condition accessible through RS-485 interface, it provides the following information: • Temperature inside sensor • Humidity inside sensor • Tilt along X and Y axis • Orientation to magnetic North
Protections	All connectors pins are over voltage protected by double stage circuit
Power supply	9.5 – 18 VDC
Current drain	Typical 80 mA @ 12 VDC
Dimensions	Diameter 89 mm x 502 mm (excluding screws and cable entry)
Volume	3.2 dm^3
Weight	4.2 kg
Density	1.3 kg/dm^3 (No additional weight needed for insertion in borehole with water)

Table 2. AC-7x-DH Basic Specifications

5. Maintenance

Maintenance should be periodically performed to insure, the recorded data is valid and can be correctly interpreted. The issue with any strong-motion borehole sensor is that it cannot usually be retrieved after installation and that maintenance capability is therefore limited. Consequently reliability of the sensor is vitally important for its long term maintenance free operation.

The sensor should be opened for maintenance only by a qualified technician that has been trained by GeoSIG and has the required special tools. During the normal life of the sensor, there will be no need to open the sensor casing.

5.1. Testing

The tests outlined in this section can be performed remotely over the sensor cable without having physical access to the sensor itself. Such tests should be performed at intervals of one month to one year.

5.1.1. Test input

Basic testing is mainly done using the test input provided by applying a voltage in the range of 7 to 18 V_{DC} on wire 7 toward ground wire 8 (GND).

It should be verified that the step created at sensor output is the equivalent of 0.125 g ±10% acceleration.

5.1.2. Power

The second test is related to the power consumption and should establish that a current of ~80 mA_{DC} (could change according to sensor model) is drawn from a 12.0 V_{DC} power supply when sensor is in normal position. The sensor uses a DC/DC device to convert the input power voltage and this result is typically constant electrical power consumption and the input current will be dependent on the input voltage.

5.1.3. Offset

When used with GeoSIG recorders, offset can be compensated without loosing signal range for up to ±10% of the output range. This corresponds to an offset of ±100 mV for the ±10 V output range. Therefore it should be checked that the voltage offset at output remains within ±100 mV.

5.1.4. Gain

Gain can only indirectly be verified through the test input (section 5.1.1). Absolute gain verification would require taking the sensor out of the borehole, which is usually not practical and requires a tilt or shaker calibration.

5.1.5. Noise

Specific noise measurement is not usually required during a maintenance period. It is normally the recorded data which is used to evaluate the noise performance. This naturally requires knowing clearly, what is the real seismic or human induced noise which is present at the installation location.

5.2. Calibration

Calibration can be performed before installation by doing tilt (rotation of sensor toward earth acceleration) to apply on the sensor up to ±1g on horizontal axes and 0 to -2 g on the vertical axes.