Inclinometer probe INCLIS DH
User manual

TERMS OF USE

Version

CODICE		NOTE
Rev. 1.1	**23/07/2014**	First issue
Rev. 2.0	**14/03/2019**	driver for FTDI converter and revision table

SUMMARY

TABLE INDEX

1.   Introduction

The inclinometer measurements are performed by using a probe designed and constructed by SOLGEO, called INCLIS DH. The tool allows to create a three-dimensional detection of the perforations deviation, performing simultaneously one inclination and one orientation relief, in holes having any direction in space.
The probe contains an internal accelerometer tern and a magnetometer tern. The accelerometer tern realizes the reading of the inclination angle and of the rotation relative to the gravitational field measured, the magnetometer tern realizes the reading of the azimuth angle relative to the Earth's magnetic field measured.
The probe is connected to the surface through power cable and data transmission, with a standard length of 60 m and optional up to 200 m. A support and aiming system for driving rods, which allows to maintain the probe in the perforation with a known orientation in the case of metal coated perforations, (in which the magnetic system does not function) is provided. On the surface the probe is connected to a control unit, which allows the real-time communication to the PC via USB connection. A dedicated software provides the real time reading of the orientation parameters and thus their acquisition. By using the same software it is possible to produce measurement reports complete with graphs and tables.

Illustration 1: Probe with **60 m** *cable*

2.   Main characteristics

Intertial Sensors	
Orientation range	360° about all axes (orientation angles); inclination, azimuth, GTF, MTF, Dip Angle
Accelerometer range	24 bits accelerometer; 16 bits magnetometer
Angle resolution	0.02°
Accuracy	± 0.2° inclination ± 0.5° azimuth
Angle measurement repeatability	0.1 °
Digital output rate/logging rate	up to 8 Hz
Output modes	acceleration and magnetic field vectors plus temperature; orientation angles plus temperature
Digital output	RS-422 serial (four-wire full-duplex) standard
Serial data rate	115200 baud
Datalogging capacity	up to 32,768 data records
Supply voltage	+6.0 VDC min, +10.0 VDC max
Supply current	50 mA typical when connected to host 16 mA typical when logging at 8Hz 500 µA typical when logging at 1/4 Hz 50 µA typical in deep sleep mode
Connectors	Souriau 200 bar IP69
Operating temperature	- 40 ℃ to 125 ℃ (-10 ℃ to 125 ℃ with recommended batteries)
Dimensions	100 cm x 40 mm diameter
Weight	4 Kg
Shock limit	500 g
Enclosure material	brass
Software	Windows XP, Vista, 7

Table 1: technical characteristics of the inclinometer sensor

The basic standard kit consists by:
- N. 1 Inclinometer probe (sensor form)
- N. 1 Cable drum of 60 m
- N. 1 Cable connection from roller to control unit from 2 meters
- N. 1 Box interface with PC
- N. 2 Fixed Centering in Teflon
- N. 1 SolClino Software License

Optionals:
- Support for non-oriented guide rods
- Set of PVC rods, not oriented
- Adapter for oriented rods
- Graded support tube head
- Set of aluminum rods oriented
- Variable centering with ranging from 45 to 140 mm

2.1. Range of use

The Inclis DH probe can be used in holes coated or not, with any inclination and direction in space and minimum internal diameter of 45 mm.

- ➢ Inclination : 360 °
- ➢ Orientation : 360 °
- ➢ Hole diameter : from 40 mm to 140 mm with fixed or adjustable centering
- ➢ Hole type: uncoated, coated with nonmagnetic pipe, metal coated.
- ➢ Hole depth: with standard cable 60m, up to 500 m with optional cables

2.2. Holes uncoated or coated with non-magnetic materials

The measurement execution is made with the free probe lowered into the hole, without the use of oriented rods.

For sub-horizontal or upwards inclined holes, it is necessary the use of the support rods and a set of rods in pvc expandable by threading, in order to push the probe into the hole.

Optional Kit in addition to the provided base supply:
- ➢ Support guide rods
- ➢ Set rods in pvc

2.3. Holes coated with iron or steel

The execution of the measurement is made with the probe held driven and directed into the hole through rods which retain an axis of the probe, oriented towards a known direction (conventionally north).

The probe is inserted into the hole and thanks to the system of rods it is always maintained oriented toward the same direction of reference. The result of the relief will be constituted by the relief of hole inclination and orientation, with respect to the direction of the initial reference (which in the case is taken Magnetic North corresponds to the azimuth)

Optional Kit in addition to the provided supply :
- ➢ Guide support for oriented rods
- ➢ Set of oriented rods in aluminum
- ➢ Gradable support for tube head

Illustration 2: Support for rods

Illustration 3: Standard centering devices

3. Operation

The inclinometer probe consists by a central form containing the sensors and by an extension that is screwed to the base. The extension has the function to stabilize the probe into the hole.

3.1. Probe hardware connections

- Fit the extension to the probe form.
- Fit the centering devices fixed or adjustable in order to fit them to the hole diameter, In particular for vertical holes. In the case of inclined holes the probe will rest against the hole wall and it will only make necessary the use of the fixed Teflon centering.
- Connect the cable to the probe through the connector. Slightly rotate the connector without forcing it, up to match the inner inserts. Screw the connector manually up to the lock.
- Unroll the amount of cable necessary in order to execute the test (Hole depth + stretch from the tube head to the operator's station)
- Connect the cable between roller and box interface
- Connect the interface to the PC through a USB A-B cable.

Illustration 4: box di interfaccia tra PC e sonda INCLISDH

3.1.1. Precautions

- Check for presence and state of wear of the seal at the probe form base.
- Screw the extension to the probe form
- Insert connector and screw it completely manually. The use of tools is not necessary.
- If using the rods support, insert the cable with the connector before screwing it to the probe and secure it with specific hex keys.

- During the disassembly of extension and connector, be careful in order to avoid unscrewing the part of the probe form (Locked with thread locker)

4. Operation modus

4.1. Free probe (not driven)

After the probe connection the and the SolClino program opening, before proceeding with the measures, place the probe a first time vertically and then horizontally by verifying that the readings of inclination and orientation are correct.

1. Set the acquisition parameters in the SolClino program. Normally the measurements are performed with steps of 3 m, carrying out the relief during the descent phase and telecasts during the ascent phase so as to obtain the mean value and the control of the repeatability of each measure.
2. Insert the probe into the hole until the first measurement corresponding to the set step, for example 3 m. Check the measured values and wait until these are stabilized.
3. Acquire the individual data or carry out of the medium. (this is sometimes necessary for vertical holes with centering, which are not adhering to the hole walls).
4. Set the probe down to the next measure and repeat step 3 until you reach the bottom of the hole.
5. If the last possible measure, with regular step, does not correspond to the bottom of the hole, place the probe close to the bottom making sure that it must be raised, set the corresponding measure manually and capture the data.
6. Start a new file and set the acquisition direction in ascent.
7. Repeat the measurement of point 5.
8. Lift the probe up and repeat all the steps since up to the first measure.
9. Control if the results are coherent and finish the acquisition.

4.2. Driven probe

After support installation for the driven rods on the probe and the graduated support on the tube head, connect the probe and open the SolClino program.

Before proceeding with the measures, place the probe a first time vertically and then horizontally by verifying that the readings of inclination and orientation are correct.

1. Fit two rods oriented on the probe, insert the probe into the hole and lock the probe on the tube head support. Rotate the support up to that the probe is oriented to the North or toward a known point with detected azimuth. Lock the support and do not move until the end of measurement.
2. Set acquisition parameters in the SolClino program (specify the mode of driven acquisition). Normally the measurements are performed with steps of 3 m, carrying out the relief during the descent phase and repeating it during the ascent phase in order to obtain the mean value and the control of the repeatability of each individual measure.
3. Acquire the individual data. Engage two more rods of 1.5 m and drop the probe down till to the next measure and repeat the acquisition until the bottom of the hole. At each assembly of the rods make sure they are properly oriented.
4. If the last possible measure, with regular step does not correspond to the bottom of the hole, place the probe close to the bottom but it must be raised, set the corresponding measure manually and capture the data
5. Start a new file and set the acquisition direction in ascent.

6. Repeat the measurements in ascend by performing the inverse operation.
7. Control if the results are coherent and finish the acquisition.

5. SolClino Program

With the probe INCLISDH comes the SolClino program. This program allows you to view the parameters of the inclinometric relief, to acquire them, export them and save them in a measurement report

5.1. Program features

Once connected to the INCLISDH probe, the program allows to view all the parameters that the probe transmits in real time, viewable in the box located on the left (Illustration 8).
The meaning of these parameters is summarized in Table 2.

Inclinazione	Angle with respect to the vertical: 0° vertical probe, 90° horizontal probe, 180° vertical probe with upward direction.
Azimuth	Immersion angle with respect to North, with clockwise direction: 0° North, 90° East, 180° South, 270° West.
AX, AY, AZ	Restored values by accelerometer tern
HX, HY, HZ	Restored values by magnetometer tern
GTF	Gravity Tool Face: probe rotation angle with respect to the gravitational field
MTF	Magnetic Tool Face: probe rotation angle with respect to the magnetic field
AccelTemp	Temperature accelerometer sensors in degrees °C
MagTemp	Temperature magnetometer sensors in degrees °C
G-TOT	Total gravitational field in g (vector sum of accelerometer tern, must remain near 1g)
M-TOT	Total magnetic field in Gauss (vector sum of magnometer)

Table 2: Parameters measured by the INCLISDH probe

For each measure step, the program provides a calculation of the hole coordinates and deviation with respect to the hypothetical vertical trajectory (useful in controls of verticality of holes).
The displayed data will only be saved by pressing the **"Acquisition"** key. The file * .cli will be saved in binary format and may be then reopened and displayed only with the SolClino program. However, it is possible to save the data enclosed in grid format * .txt: In this case they will be viewable from any text editor or other programs, such as Excel$^©$ or MATLAB$^©$.
The planar graph can be exported in a bitmap format in order to be included, for example, in Word or PDF documents. Finally the SolClino program allows to print a measure report.
It is recommended to previously install a software on your PC software for the printing on file, such as PDFCreator$^©$ or any PostScript printer.

5.2. Program and communication installation

A. In the SolClino CD installation folder double click on the SolClino_setup.exe file and follow the instructions for installing the program. The interface box contains a 422-USB serial adapter.

B. **The first time the PC - interface box - INCLISDH connection is made, it is advisable to connect the PC to the network with Internet access.**
If the recognition of the interface box does not start automatically, verify the correct installation of the configuration drivers that may be available on the www.ftdichip.com site **VCP driver (Virtual COM Port).**

C. connect the box to the PC via USB cable
on the PC, in the "**Device management**" / USB Serial Port / Properties / Port setting / advanced section, configure the COM port number with a number **between 1 and 16**.

Note: The number of the COM Port inserted is then used by the SolClino program to connect to the INCLISDH probe.
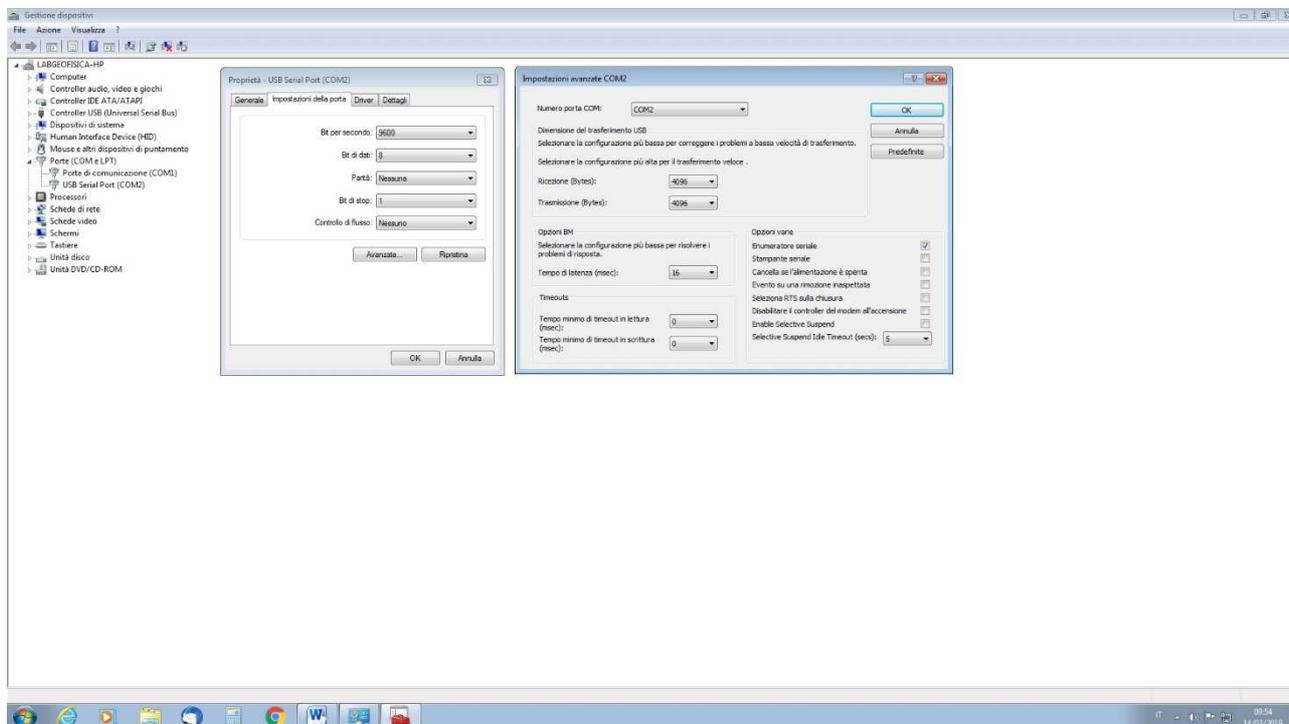

Illustration 5: example of a serial adapter configuration scheme on the COM port
(there may be discrepancies due to operating systems)

5.3. User interface

The program is divided into a window in which all the functions of capture and display data are accessible. The main window, which can be seen in illustration 7, can be ideally divided into an upper toolbar, a control band on the left, a right band and a central form in order to display the results.
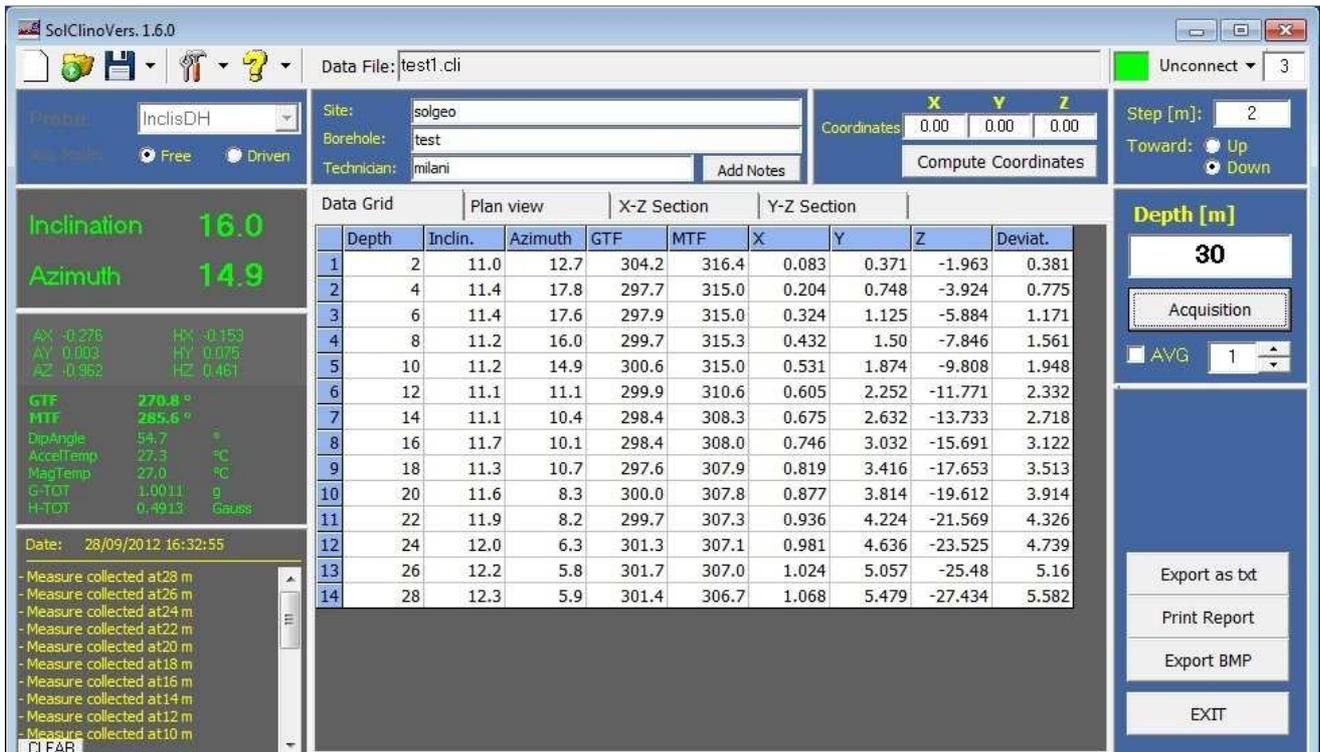
Illustration 6: User interface of the SolClino program

Toolbar

In the upper part is a toolbar with the following keys, going from left to right, **'New File'**, **'Open'** and **'Save'**, the latter which encloses several submenus: In fact it is possible to save text files as well as Bitmap images or to print a measurement report.

Illustration 7: Toolbar

Always on the left side of the bar, the button with the program options is visible and then the key that activates the on-line help.
In the central part is the name of the file in use and then, on the right side, the toolbar contains the commands for the connection to the controller and then to the inclinometer probe.

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Left window band

Illustration 8: left window band of SolClino

The window band left which is visible at the top, displays the date and the time of the acquisition beginning. Normally it is updated to the PC's clock, double-click to update date and time.

Always on the left, the bounding box of the probe type (usually present only the **InclisDH**) and the measure mode (free or driven).

Furthermore there is displayed the box in which appears all the parameters provided at that moment from the inclinometer probe in real time (if connected): The measures of accelerometer and magneto metric terns as well as GTF and MTF (Gravity and Magneto metric Tool Face), DipAngle, temperatures of accelerometers and magnetometers, total gravitational field and total magnetic field. In the lower left hand corner then is present a panel that displays the log of all operations carried out in sequence.

Right window band

In the upper part of the right band is a panel which displays the step and the measurement direction (ascent or descent along the hole), immediately below is the current acquisition depth. The text panel will be updated at every acquisition by adding or subtracting a measuring step, depending on whether you are, means descent or ascent. The value is still editable at any time, also in case of depth measurements already acquired, which will then be overwritten.

The " **Acquisition** " key allows to save the parameters in the file * .cli, that are at the moment in the receipt phase, or rather everything that is visible in the box seats, left band of the acquisition window.

In the case of strong disorder, or rather vibrations which would lead to an instability in the inclination data, it is possible to operate the medium by activating the check placed immediately below the button, the value acquired at the current depth will be then given by the mean of n values of inclination and azimuth subsequent (the number is editable, it is recommended a number, that is not too high in order to do not slow down the acquisition). In the lower part are enclosed the keys to export the results, as well as the exit key.

Illustration 9: right band SolClino window

Central form of the window

In the upper central part, there is the collecting of the file header, with the indication of the site, the hole and the operator. It is possible to insert notes by pressing the button. The central form of the window is the one, that encloses all of the acquired data. These data can be displayed as Table or as planar projection in order to check the course of the hole (Illustration 10).

In the Table are enclosed main data such as: inclination, Azimuth, GTF, MTF, coordinates for each step of extent and deviation in respect to the vertical.

The values of origin may be modified at any time, by pressing the button "**Calculate Coordinates**", they will be recalculated over the whole length of the hole. The system of reference is oriented with X-axis toward the East, the Y axis toward the north, and Z-axis toward the top (that is in quota).
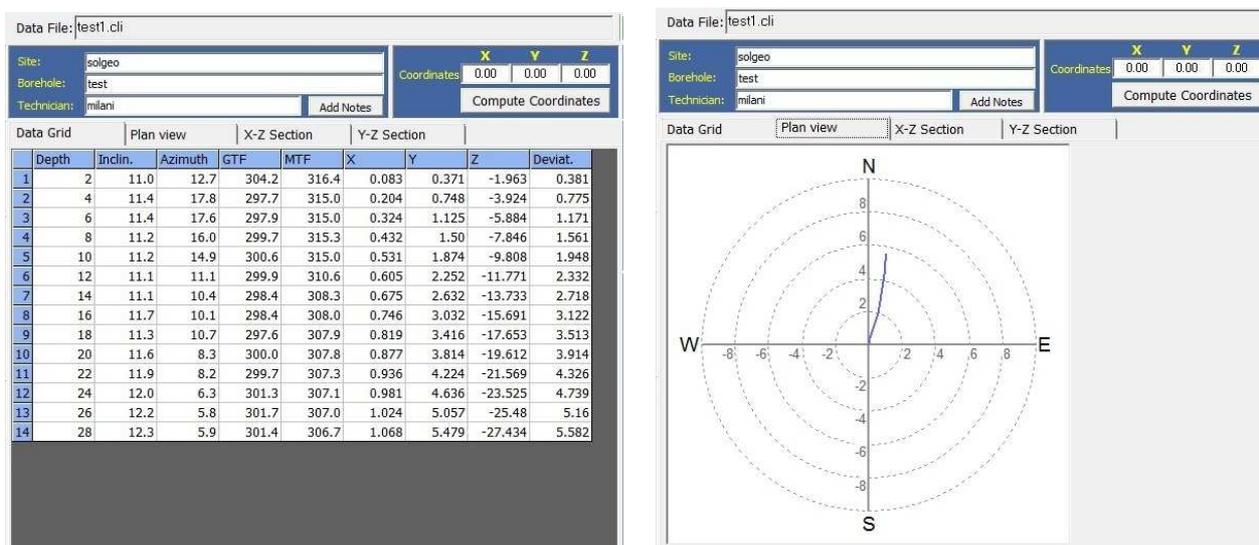

Illustration 10: Central form of window in " Data grid" ore in " Planar projection"

5.4.   Data Acquisition Procedure

The data are acquired simply by setting a few initial parameters and then by pressing the acquisition key every time you want to save the parameters in reception.

The data are referred to a depth value, this is not to understand in an absolute sense, but as the distance travelled along the hole (the absolute share is indicated by Z coordinate, which becomes absolute depth, if the share of the borehole head is set to 0)

Each time a value is acquired, the program updates the depth to a new value, by adding or subtracting the step of measuring set, depending on whether the work is in descent or ascent along the hole.

Consecutively a propose for standard procedure for acquisition:

1. Indicate the name of the file, by pressing the toolbar button "New file" (first one on the left side). If there is no file indication, it will be still prompted at the first acquisition;
2. If it is not automatically selected, then select the probe in use: Normally there is displayed only the INCLISDH;
3. Fill in the fields identifying of the relief: Yard, Hole, Operator, and any notes;
4. Specify the coordinates of hole head, in meters. Commonly 0;0;0;
5. Indicate the measuring step and the acquisition direction: Descent or ascent;
6. Indicate the depth of current measurement.

7. Connect the probe by pressing the "Connect" button on the toolbar (upper right); if the connection ends well (indicator changes from red to green). After a few moments will appear the parameters communicated by the probe (for further details about the connection make reference to paragraph 5.4.1);
8. Wait for the stabilization of the inclination and azimuth values and then press the "Acquisition" key; The data will be saved and displayed on the grid and plotted in planar projection; The depth will be upgraded at the next measurement;
9. Repeat step 8 up to the hole bottom;

In the case you want to repeat the measurements in ascent:
10. From the bottom start a new file, initial depth is that of the hole bottom, the direction must be set as "Ascent";
11. Repeat step 8 up to the surface.

At the end of these operations you have all the data that can be exported in a text format or printed in a report. If measurements were carried out in two directions it is recommended to compare the two acquisitions and then check the reliability of the survey carried out.
The data in text format, as well as the report or the image in bitmap can be exported at any time by re-opening the file

5.4.1.   Connection PC - INCLISDH probe

The probe transmits the data to your PC via a cable type RS422 (serial). The equipped box control contains a serial to USB adaptor that is needed to communicate with the PC, in addition to providing power to the sensors included in the probe.
On the toolbar, right upper part, is placed the connect command. The colored indicator shows the connection status: green is connected, red is not connected. The number in the illustration represents the COM port in use.
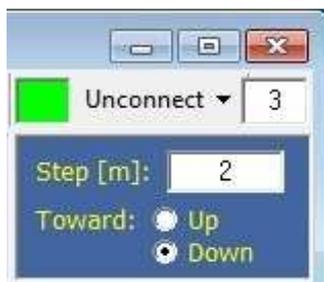

Illustration 11: Connection check

By pressing the button "Connect" will be activated the connection through the COM port whose number is indicated in the box adjacent (In the example in the illustration 12 you see the port number). This number is set in the configuration of the serial USB communication port (as described in paragraph 5.2). In the case you do not know the port number, you can use the menu "**Auto COM Port Configuration**" (Submenu of "Connect" key).
The function performs a port scan until finding the active Com port. If the process ends good, value of the port will be mentioned and then the program will connect to the probe.
Once connected the colored indicator should be green and a confirmation message appears in the log window. The COM port number is automatically stored for subsequent software uses.

5.5. Display and export of the results

During acquisition, it is possible to see all the acquired data, collected in a grid of values in order of increasing depth, at any time.

For the reopening of a file, it is sufficient to press the second button from left on the toolbar "Open File" and select the desired file. While rereading, the data will be written in the grid of the central window panel.

The data displayed are: Inclination, Azimuth, GTF, MTF, coordinates and deviation with respect to the vertical.

In the file * .cli however are all the other parameters provided by the inclinometer probe acquired (as in table 2: The measures of accelerometer and magnetometric terns, DipAngle, temperatures of accelerometers and magnetometers, total gravitational field and total magnetic field).

The Parameters related to each acquisition depth are recharged by double-clicking on the corresponding row of the grid data. If the probe is connected to a PC and is communicating, these values will remain visible for 5 seconds, then the program will go back to data receive mode.

The way to export the results are many: In the first place, it is possible to convert the data into text format (right button below or menu save in the toolbar). A file will be saved as * .txt file with the file header and everything written to the data grid. Is it possible to export the graph of the planar projection: by pressing the below button to the right, or from the menu save of the toolbar, will be saved an illustration with the same name as the file. A further possibility is to send a full report, thus creating a standard export module containing the inclinometer reliefs. This procedure is better described in paragraph **Errore. L'origine riferimento non è stata trovata.**.

5.5.1. Print a Measurement Report

Through the button "Print Report" (present as submenu, "save" key on the toolbar) will be opened the window, in order to print a complete measuring report. The report window displays a preview of what should be the final printing result. It is possible to customize the header of the page by inserting a logo. To do this, before all make active the corresponding check box, located to the left of the preview. Once activated, it is possible to upload a logo in a common image format (* .bmp or * .jpg) in the upper left. To search for the logo file, double click on the report preview, in the portion designed to the logo, or rather in the upper left. The header of the page is proposed with the file parameters. However, it is possible to change the title and all the header writing, simply by writing in the specific spaces. A check box allows you to enter or not the planar projection of the hole, by activating it will be inserted the same visible image in the main window.

The true report is then returned in Table form, containing all inclination, azimuth, GTF, MTF, coordinates and deviation data. The positions of graph and table can be changed: By tending pressed the left mouse button on the illustration and dragging up or down what you want to move.

The logo, the title and the positions of illustration and Table are stored by the program so as to have a layout that can be reproduced in the subsequent prints.

By pressing the "Print Report" button, the one represented in the preview, will be sent for printing.

The installation of a printing device to a file, is strongly recommended: For example a PostScript printer or a software for direct printing on * .pdf files (Printer Emulator). In this regard it is recommended to install the PDFCreator software, if not present in the installation package, it can be found on-line, free of charge from the following site: http://sourceforge.net/projects/pdfcreator/
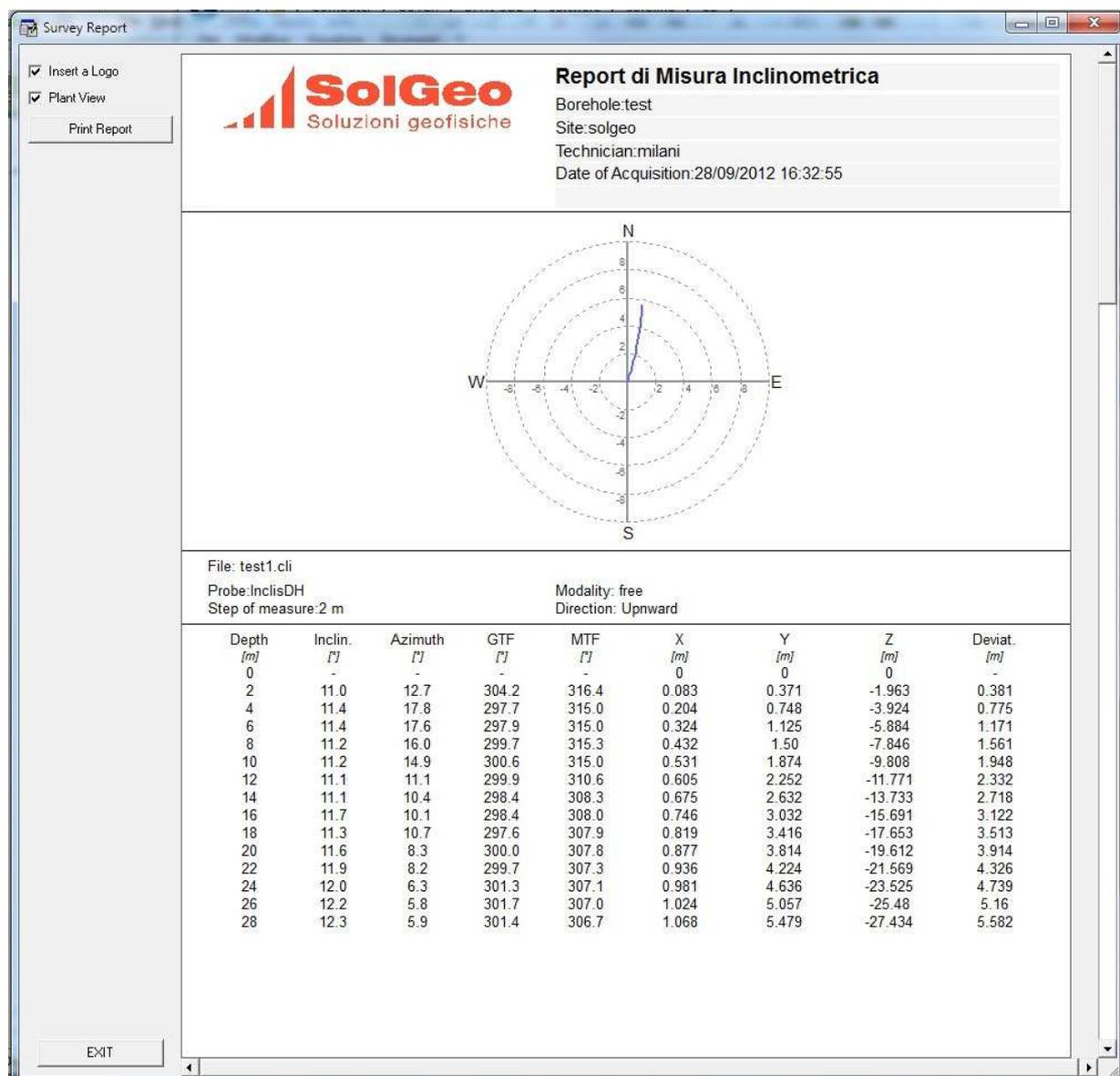
Illustration 12: Print window for Measurement Reports

App. 1. Diagram of the control box connector

Female panel socket SOURIAU UTS710E7S connector pole male from panel

Pin	Label	Description
A	+9V	Input **Power POSITIVE**
B	GND-	Input **Power NEGATIVE**
F	TX-	pin 4. White wire
E	TX+	pin 3. Blu wire
C	RX+	pin 2. Green wire
D	RX-	pin1. White wire

Table 3: connections control box