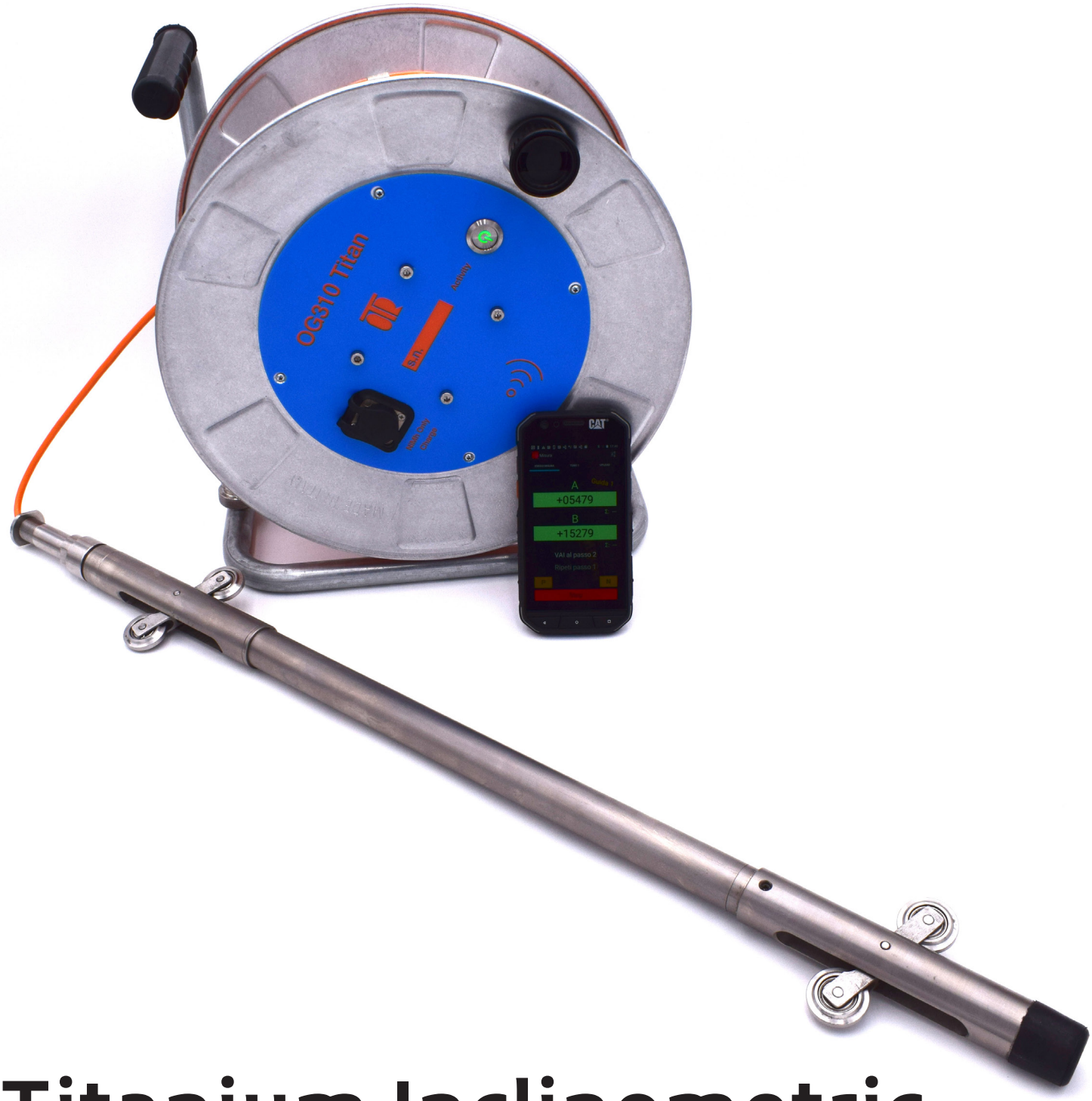

Titanium Inclinometric probe

O.T.R. s.r.l. Via Btg. Susa 36 29122 Piacenza +39 0523 594290
www.otr-geo.it info@otr-geo.it P.IVA 00894610153

Numero 055
Rev. 02 del 27/04/2022

STRUMENTI E MISURE GEOTECNICHE
E STRUTTURALI

O.T.R. s.r.l. Via Btg. Susa 36 29122 Piacenza +39 0523 594290
www.otr-geo.it info@otr-geo.it P.IVA 00894610153

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WARNINGS

This instrument must be utilized only for the application it has been designed for.
OTR declines all responsibility for any improper use.

Do not let this instrument fall into the hole quickly.

Do not put this instrument in flammable liquids or potentially explosive gases.

Do not use this instrument in water where an electric dissipation is in progress

Do not let the cable slide quickly in your hands. Use protective gloves.

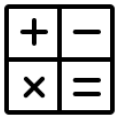
Furthermore

- Do not open this instrument, contact the manufacturer for checks and repairs;
- Keep out of reach of children;
- When recharging, insert protective caps on sensor and connectors;
- When recharging, do not touch the roll with wet hands;
- Do not recharge for more than 12 Hours;
- Use only original power supply unit to recharge the instrument;
- Clean this instrument and its cable with alcohol or water, do not use acetone or aggressive liquids for plastics or labels;

NOTES

Inclinometric measurements, despite the simplicity, needs a minimal preparation. Follow next suggestion:

Have knowledge of basic trigonometric functions;



Be aware of the type of calculation performed by the program (refer to our "Inclinometer Measurements Calculation Scheme").

It is not correct to execute an incliometric measure acquiring just one slide.

Any inclinometric measure needs a minimum of two opposite acquired slides (180°).

It is necessary to have correct angle for slide 1 to obtain charts and results with a correct direction

As a general rule, it is better to have slide 1 in the same direction of the expected movement (e.g. slide 1 directed orthogonal to excavation)

Always use dummy probe in new or deformed installations.

Charge the roll, avoid to completely discharge batteries.

Always use the test probe supplied, particularly in the case of excessively deformed inclinometers in order to avoid foreseeable risks to the instrument

After usage in sea water clean the bearings.

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NOTES

If connector is wet, let it dry up before covering it with its protection caps.

Do not drag the connector

Do not utilize spray or oil on the connectors.

Do not utilize instrument where temperature is more than 50-60 °C. In this case take measures with circling water.

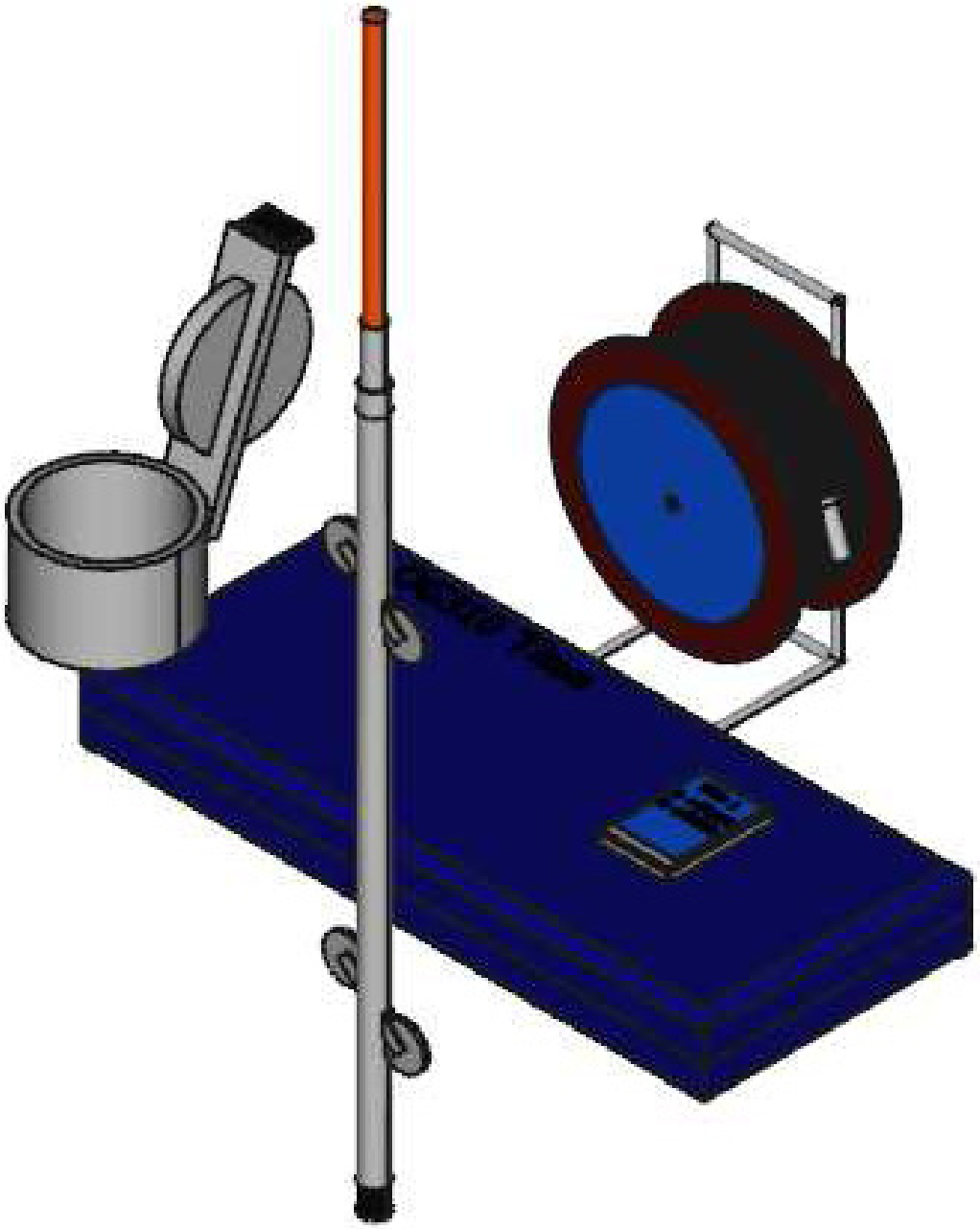
O-rings do not need maintenance.

Do not close app during measurements.

Application

- Inclinometric system OG310T has been designed to execute measurements in inclinometer casings installed underground. Instrument, with differential measurements, can identify and quantify underground movements.

Description



System is composed by:

- Titanium inclinometer probe, 500 mm or 24";
- Inclinometer cable and roll with 500 mm or 24" step;
- Pulley and extension;
- Rugged Mobile Bluetooth;
- Dummy probe on roll;
- Boxes and accessories;

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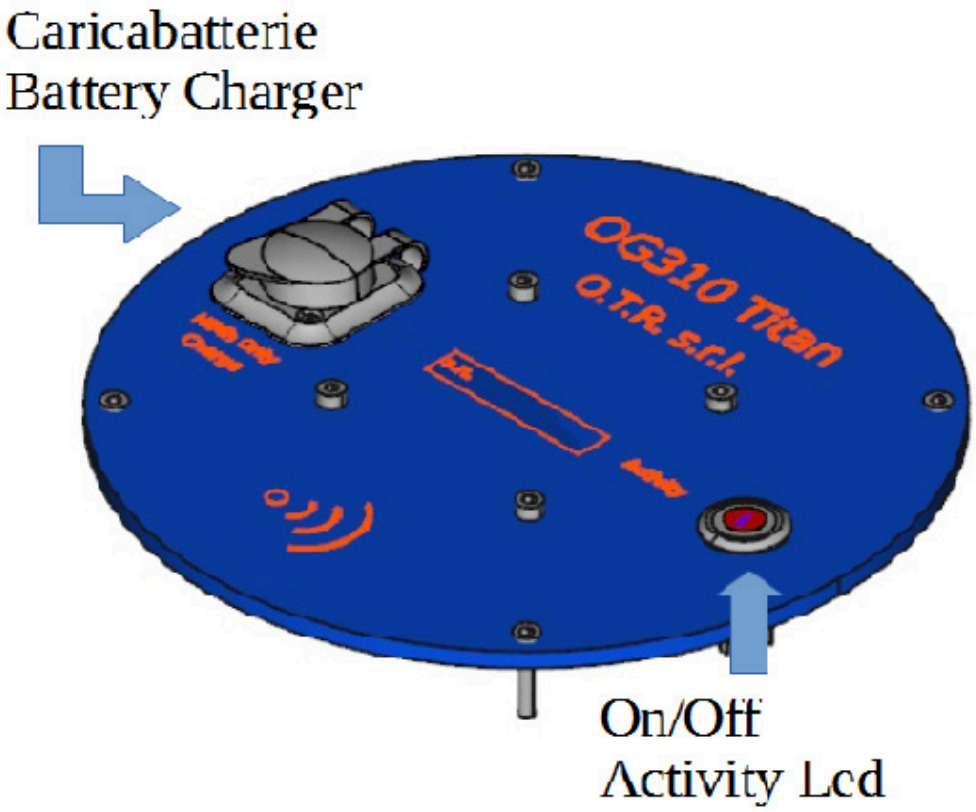
Frontal Panel



On/Off Activity Led

- Led Off: System is completely off;
- Led Blinking: Roll is waiting for connection;
- Led On: Roll is connected to rugged mobile.

Battery Charger

- Plug for the provided battery charger.

Notes:

- Connector has a rubber cap that must be keep closed during measurements;
- It is not possible to charge instrument and make measurements at the same time;
- Use just the provided battery charger.

Identification

Every inclinometric system is identified by:

- Serial number of inclinometric probe;
- Serial number of roll and cable;
- Serial number of PDA, Rugged Mobile;

Calibration parameters are stored onboard each probe. This makes rolls and probes interchangeable. It is recommended anyway to take measures with the same cable, probe and roll combination, when possible.

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Installation

Instrument can be correctly positioned following one of these equivalent rules:

- Placing the first cable notch at the beginning of the tube;
- Placing the second cable notch on the pulley cleats (when using pulley and extension)

Measures can be exectued:

- From the top lowering the probe at every step ;
- From the bottom, lifting the probe at every step..

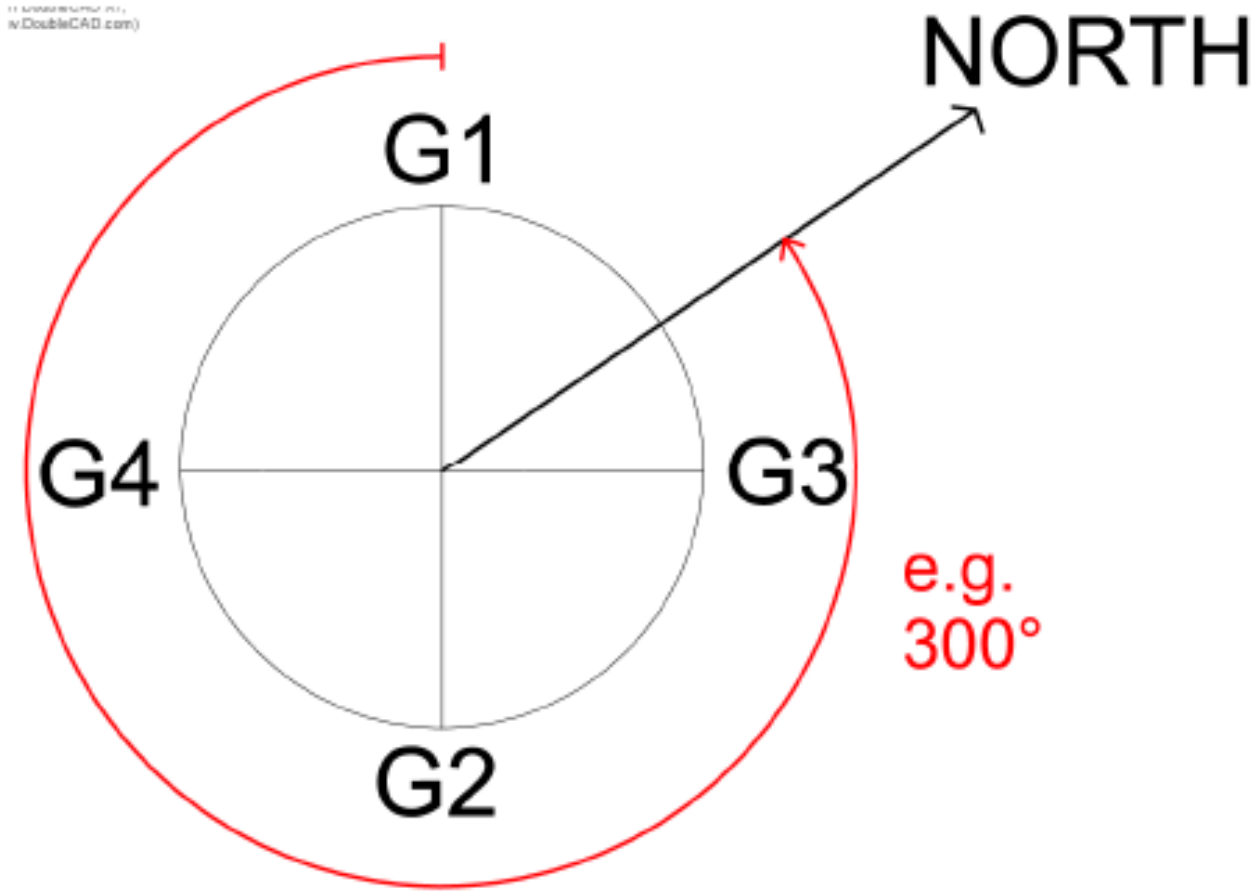
Before starting a measure it is recommended to use a dummy probe. If external temperature is higher than usual, increase thermal stabilization time.
In order to obtain better results, probe wheels should be positioned at the same pipe depth when acquiring corresponding steps in different slides and in different measurements. Measures executed with different cable positioning could not be satisfactory.

Distance between first notch and high wheel pin in O.T.R. systems is 500 mm. Distance between first notch and low wheel pin in O.T.R. systems is 1000 mm. This scheme complies with the polygonal calculation of an inclinometer measurement.

Selecting slide 1

Proceed in the following way:

1. Select slide 1 and mark it with paint or any other durable way;
2. Identify the angle as follows:



Sequence of measures

Inclinometric measures must follow this simple rules to be compatible with OTR inclinometer software conventions:

Slide 1:

- High wheel in the Slide 1. Measures must be executed from top to bottom or from bottom to top with 500 mm steps.

Slide 2:

- High wheel must be inserted in Slide 2 (180° rotation, compared to how the probe was previously insterted in Slide 1).

Slide 3: (if needed)

- High wheel must be inserted in Slide 3 (90° anticlockwise rotation, compared to how the probe was previously insterted in Slide 2)

Slide 4: (if needed)

- High wheel must be inserted in Slide 4 (180° rotation, compared to how the probe was previously insterted in Slide 2).

If only 2 slides are measured, they must be at opposite directions (180°). It is not useful to take a single slide measure or a measure with 2 slides at 90°.
An origin set should always have 4 slides. 4 slides are recommended for

---

When measure is finished and the probe is disconnected, it is recommended to protect the connector during cable winding. Do not leave the connector rub on the floor.

Taking Measurements

1. Turn on your inclinometric probe pushing the button on the inclinometric roll.
   After a few seconds the button will blink.

2. Open OTR OG310T app installed on Android device.

At each acquisition step, the app will save two values: A and B. Channel A stores inclination value for the current slide; channel B stores inclination for its perpendicular direction, with a clock-wise rotation of 90° from channel A.
The more your probe leans towards the direction of its higher wheel, the higher the value stored in channel A.

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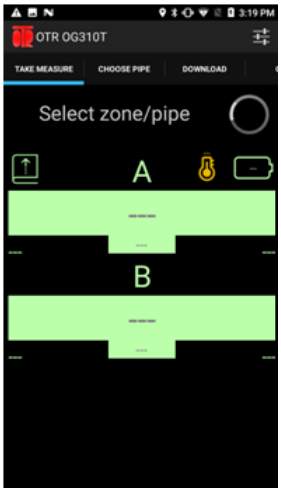
3. Open Settings to establish a Bluetooth connection with your probe.

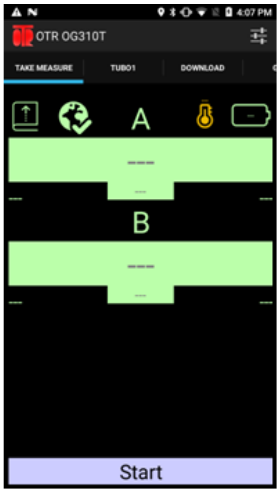
Inclinometric Probe ID is always in the format OG310T SNxxx, where OG310T is the model and SNxxx is probe serial number.
A blue dot next to probe ID indicates that connection between Android device and probe is correctly established.
When connection between Android device and probe is established, the button placed on inclinometric roll will stop blinking.

4. Exit Settings by pressing OTR icon at the top left corner of the screen.
In case you have not selected yet any pipe for the next measure, the warning “Select zone/pipe” will appear.



5. Select zone and pipe for the next measure, tapping on ChoosePipe tab.

6. Select the pipe for the next inclinometric measure.
When pipe is selected, tab Take Measure will open.



7. Tap on battery icon to check probe battery and on thermometer to check its temperature
If probe battery value is low, a warning will appear at the beginning of next inclinometric acquisition.

8. Long press on map save current GPS coordinates for current pipe. Confirm operation to save. If GPS coordinates are available, a message in the lower half of the screen will appear to notify coordinates saving, and a check mark will appear on map icon

A short tap on map icon will open maps app to navigate you to selected pipe.

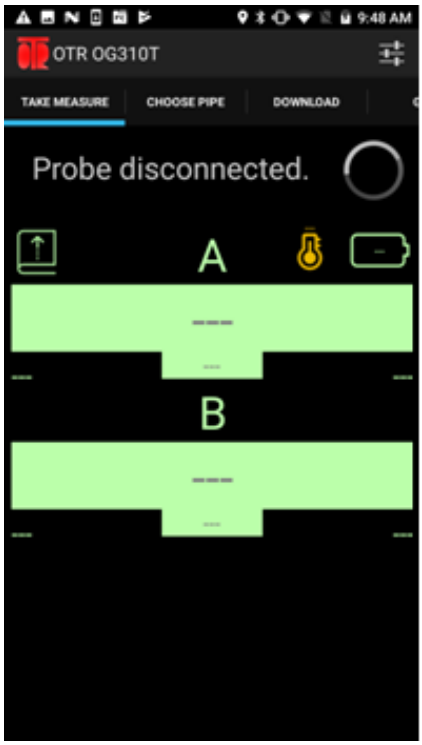
9. Tap on book icon to load an old acquisition into memory.
This function is optional. Use it in case you want to compare values of each step you acquire to value of corresponding step of a previous acquisition you took in the same pipe.

10. Tap on Start to start acquisition.
Start button will change colour. Please wait for some seconds until values of A and B channels appear on screen..

Values of both channels are continuosly updated as they are received from the probe. Values are saved only when you tap on Play button (automatic acquisition) or ACQ button (manual acquisition)

Automatic Acquisition

1. Tap on Play button



As soon as probe reads stable values, first step is acquired.

2. Move probe to the next acquisition step
As soon as probe stabilizes again, next step is acquired..

3. Proceed until you get to the last step of current slide

4. Once you acquire last step of current slide, tap on the Forward button to stop automatic acquisitions and shift to next slide. In order to go back to the previous slide, tap on Back button instead. If you restart acquisition of a previously acquired slide, all steps of that slide will be erased from memory in order to allow new steps acquisition

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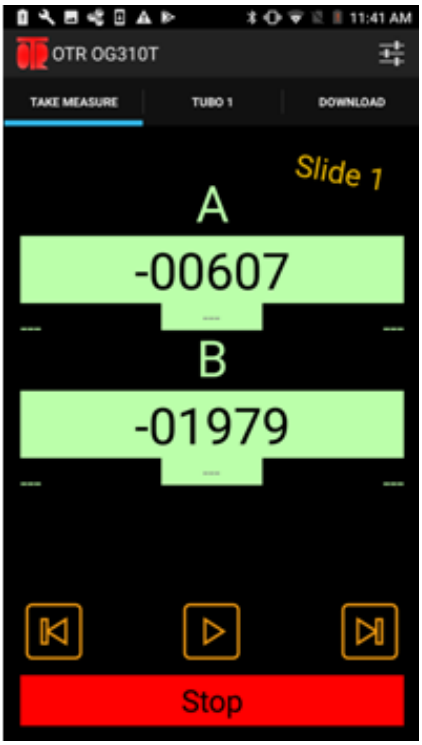
Manual Acquisition

1. Once automatic acquisition is started, tap on Pause to switch to manual acquisition mode.

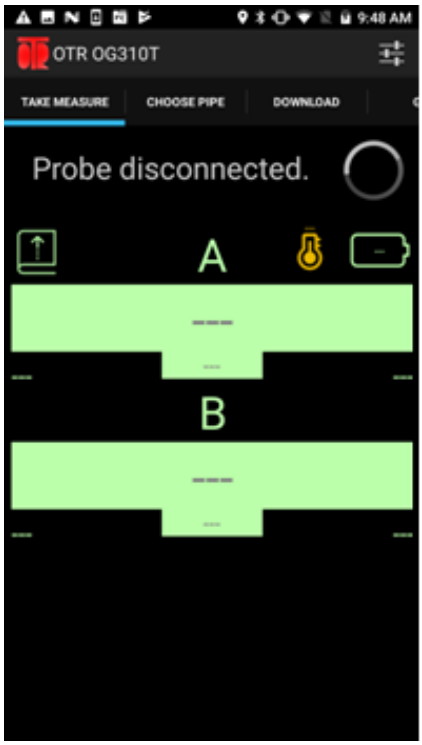


2. Tap on ACQ to acquire a new step.
Once the current step is acquired, you will be taken to the next acquisition step. To overwrite the last saved step, tap on "Back to step". To erase more steps, tap on "Back to step" multiple times until you get to the step you need.

3. Tap on Play button to switch back to automatic acquisition.

Note:
In case OG310T application is suspended during acquisition (i.e. you switch to another application), acquisition will automatically switch to manual mode and will be paused. Tap on Play button to switch back to automatic acquisition.

Measure window



Values of channel A and channel B are continuously updated on screen, as soon as received from probe.

Each time you acquire a step:
- Acquired values of both channels are conveniently displayed under live values (until you acquire a new step).
- Checksum of both channels are displayed on the right under current values (only during acquisition of slides 2 and 4)

Checksum ( ), is the algebric sum of a step value and its correspoding value taken on the opposite slide. Checksums can be calculated only on slides 2 (adding corresponding value of slide 1) and on slide 4 (adding corresponding value of slide 3)
Checksum is useful as a check of acquired values: its value should not vary significantly during acquisition. Bigger Checksum variations can be a symptom of temperature variations of the inclinometric probe during acquisition.

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- In case you loaded a previous acqisition into memory, corresponding values saved in previous acquisition will appear at the left side of the screen.
Values acquired in previous acquisition are shown next to "ex: " for each step.
- The number of the next step to be acquired will appear at the center of the screen
For instance: "Go to step 3"
- A button will appear at the left of "Go to step". Tap it to erase last acquired step, in case you need to remove it from memory.

Each time you change slide:
- You will be prompted to confirm your choice.
Tap on the yellow button that appears on screen for confirmation. If you do not confirm, after a few seconds the yellow button will disappear and operation will be canceled
- New slide number appears on the top rght corner of the screen
- Steps count restart.
If you select an already measured slide (i.e. from slide 3 you go back to slide 2 tapping on the Back button), every step of the selected slide will be erased and you will need to acquire the entire slide once again.

At the end of the inclinometric measure:
- Tap on Stop and confirm your action.
Please wait a few seconds until file is saved. If you do not tap on Stop and confirm, file of full inclinometric measure will not be saved.
Data are saved in temporary files for each slide. After tapping on Stop and confirming, a full measure file is created. Only full measure files can be directly exported to OG390WIN software on a PC.

It may happen that Bluetooth connection between Android device and inclinometric probe gets temporarly down while an inclinometric measure is under way. In this case, a warning appears on screen.

If connection is not automatically restored after a few seconds, please tap the warning message to restore connection, without stopping inclinometric acquisition.
After tapping, please wait for about 20 seconds until Bluetooth connection is restored.
If necessary, press the warning button again and wait for further 20 seconds. In case you can not restore connection repeatedly, turn off and on the inclinometric roll without stopping inclinometric acquisition. Wait for a few seconds until power button on roll panel stops blinking and tap again on the warning button.

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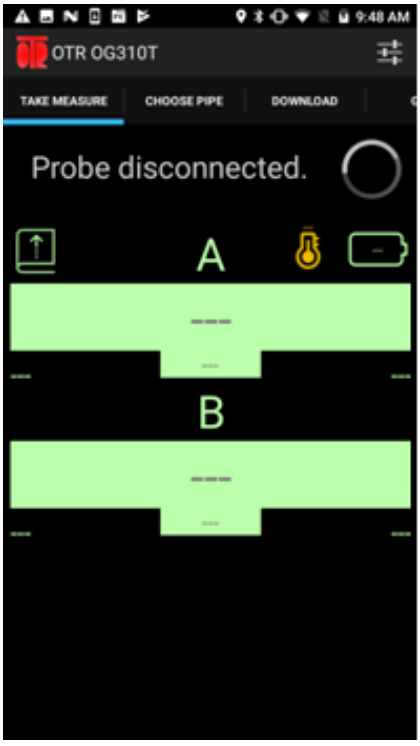
Bluetooth Connection

Bluetooth connections are used to establish communication between your Android device and inclinometric probe, or between your Android device and your PC.
Bluetooth connection between Android device and probe is necessary to acquire new inclinometric data; connection between Android device and PC is necessary to export acquired data to OG390WIN software on your PC.
You can not be connected to probe and PC at the same time.
Do not close or suspend OG310T app while Bluetooth connection is active.
Do not use your Android device to place or receive calls while taking inclinometric measures.

- Setting a Bluetooth connection between Android device and inclinometric probe

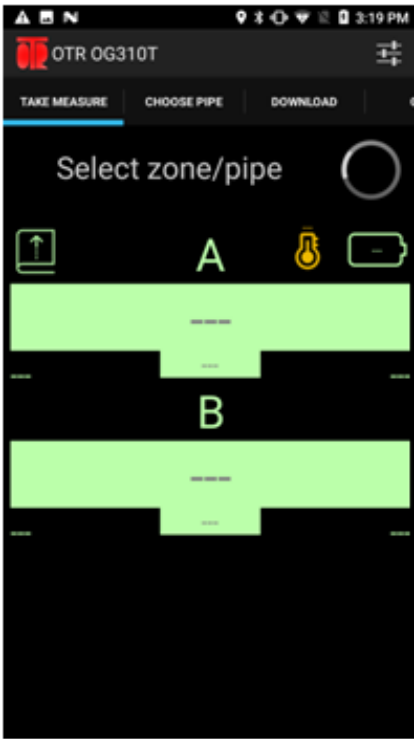
1. Tap Settings icon at the top right corner of the screen
   The following form will open.



2. Select OG310T probe from the list of paired BlueTooth devices.
Inclinometric probe ID has the following format: model (OG310T), followed by Serial Number (in the picture above SN373)

3. Verify that Bluetooth connection between Android device and probe is active: a blue dot will appear next to selected BlueTooth device in the app, and the power button on the inclinometric probe will stop blinking.
In case you can not immediately establish a BlueTooth connection to your probe, please wait for a few seconds and tap again on the probe name in the list. If again you can not establish a connection, please try and come closer to the roll and tap again. You might also turn off and on your inclinometric roll before tapping on the device name in the list.

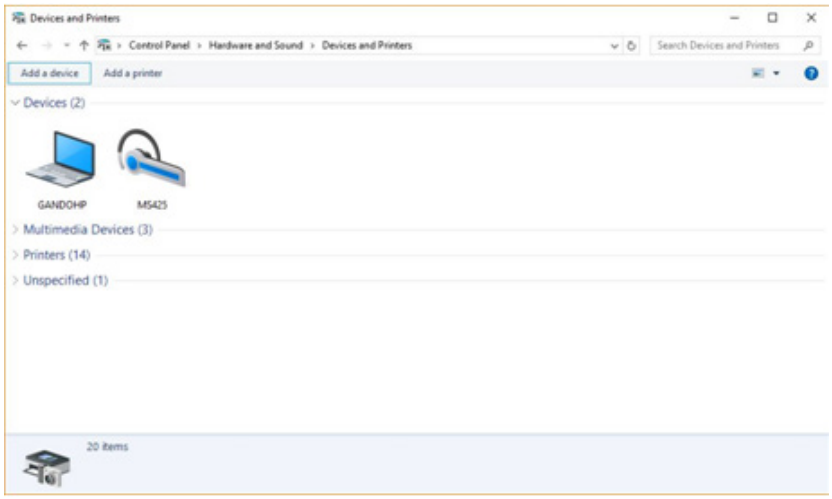
4. Tap on the OTR red icon at the top left corner of the screen, to go back to the Measure tab.
The "Probe disconnected" warning will not be present any more. A new warning reading "Select Zone/Pipe" will be shown instead. Tap on the Choose Pipe Tab to select the pipe you are going to measure. For further details please refer to chapter Taking an inclinometric measure.



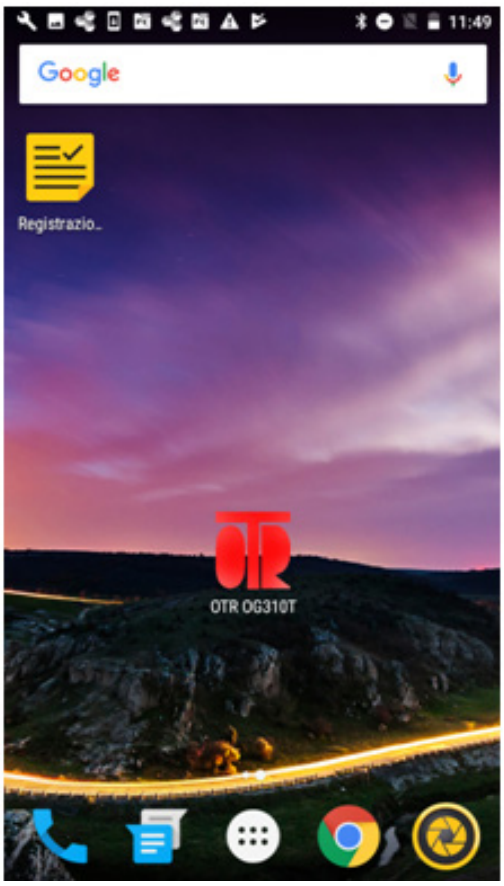
- Setting a Bluetooth connection between Android device and PC.

Bluetooth connection between Android device and PC is needed in order to send acquired data to OG390WIN software.
Android device and PC need to be paired, before establishing a Bluetooth connection for the first time.
Following procedure is based on Windows10.

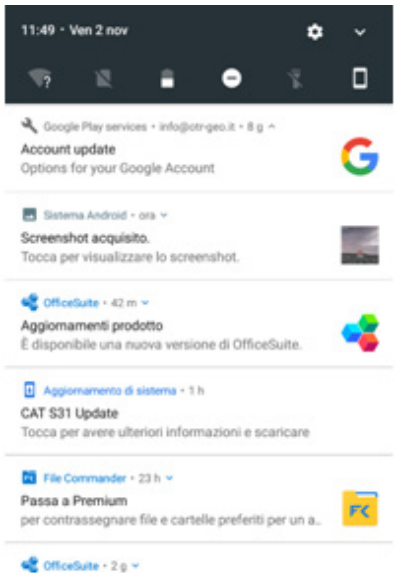
1. Open Control Panel. Select Harwdare and Sound e poi Devices and Printers



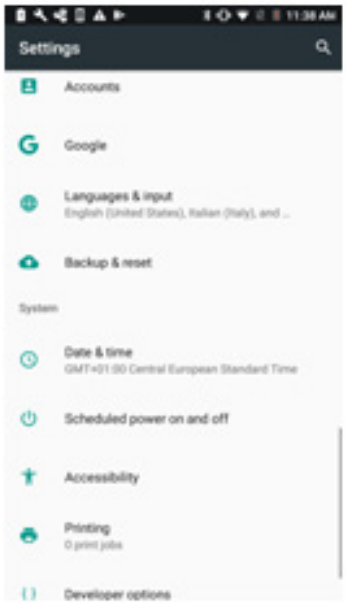
2. Turn on and unlock your Android device.



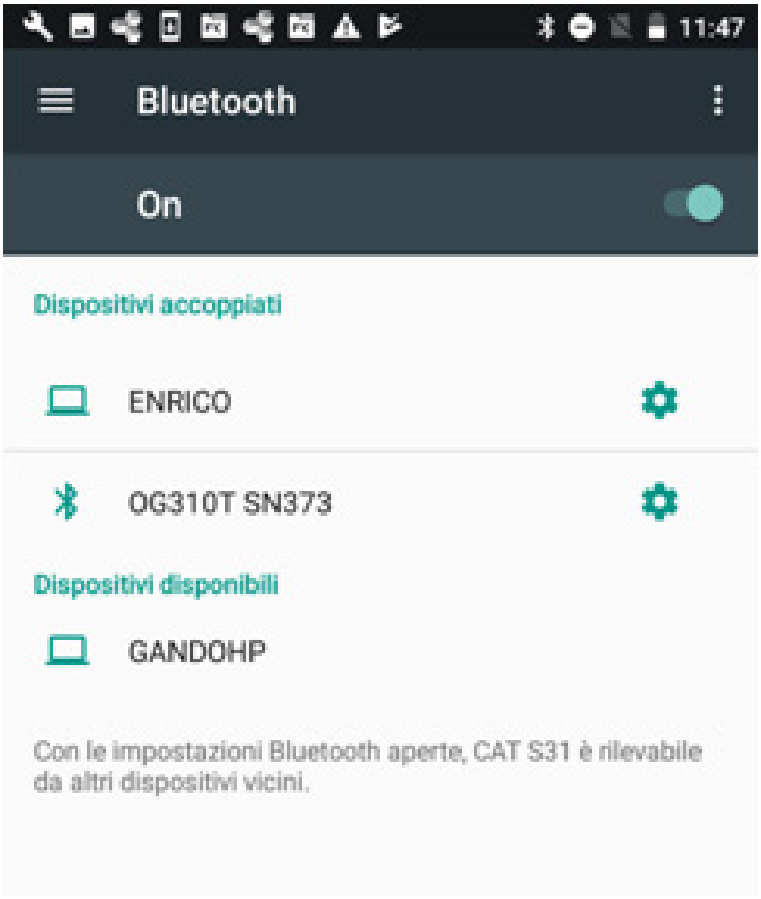
3. On your Android device, swipe down from the top of the screen.



4. Tap on the roller icon at the top right corner of the screen.

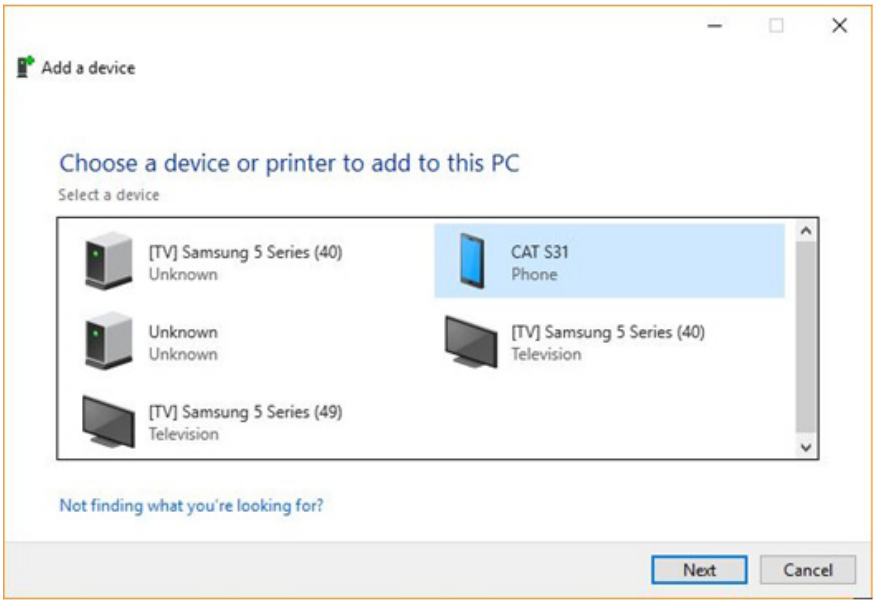


5. Select Bluetooth. The following screen will appear



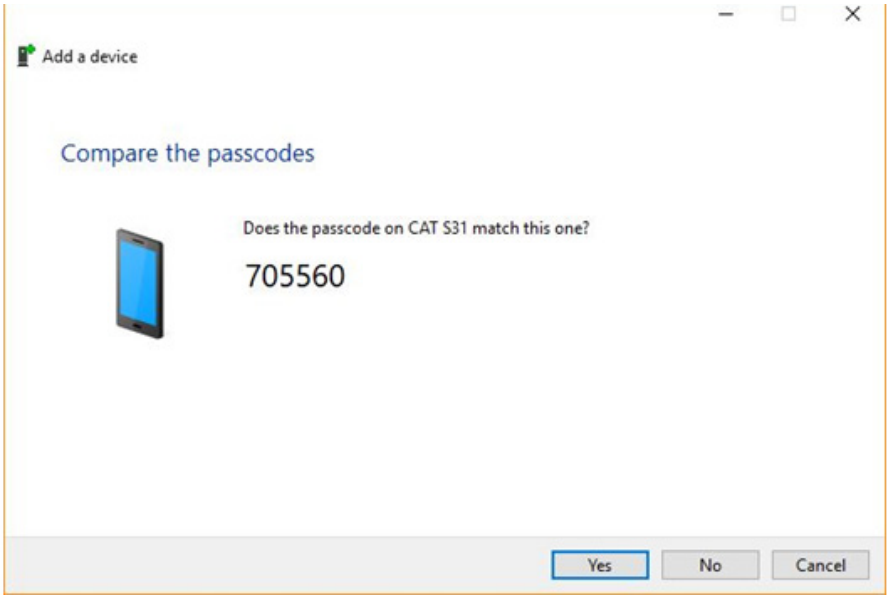
Wait on the screen the connection of Pc and Android device

6. On your PC, click on Add a Device



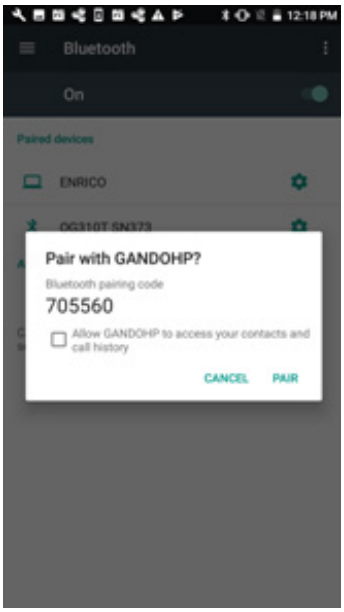
Wait for a few seconds until your device appears in the list of nearby Bluetooth devices.

7. On your PC, select CAT S31 device and click on Next
Wait for a few seconds until a passcode message appears:



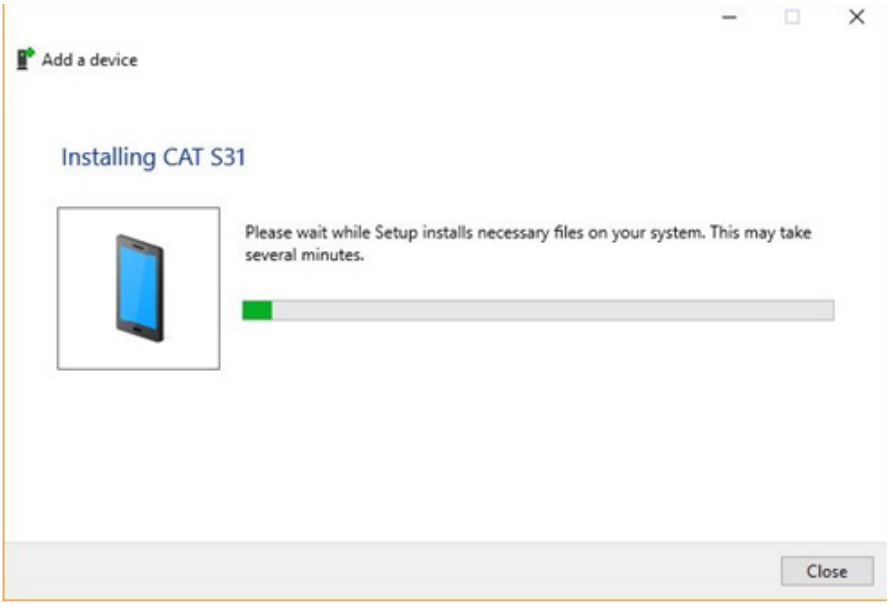
Verify that the same code pops up on your device, and click Yes on your PC.

8. On your Android device, click on Pair

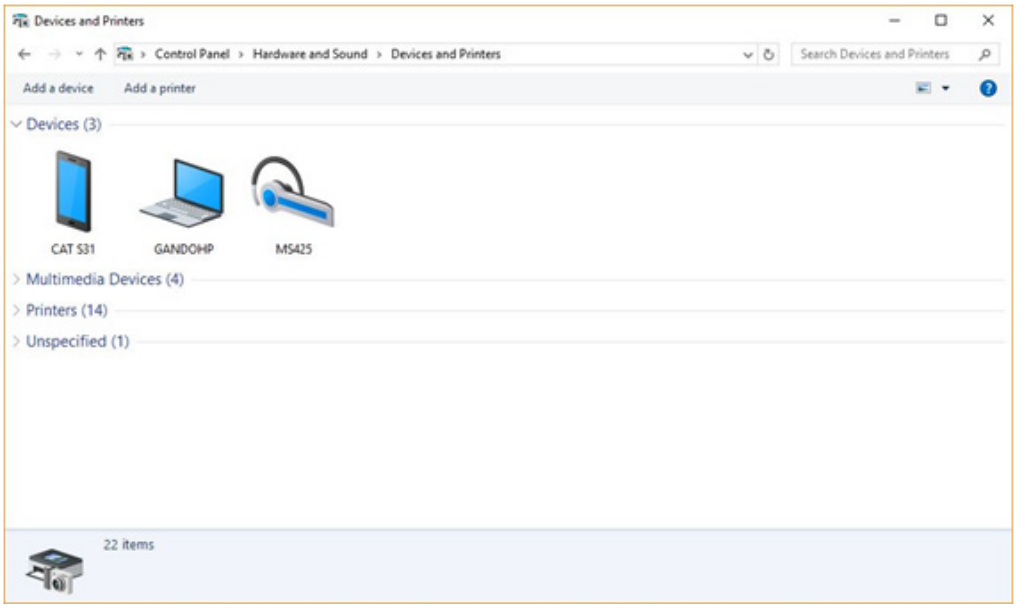


If you fail to accept pairing process in time, click on Cancel on your PC and repeat the procedure from start. Passcode changes at each pairing attempt.

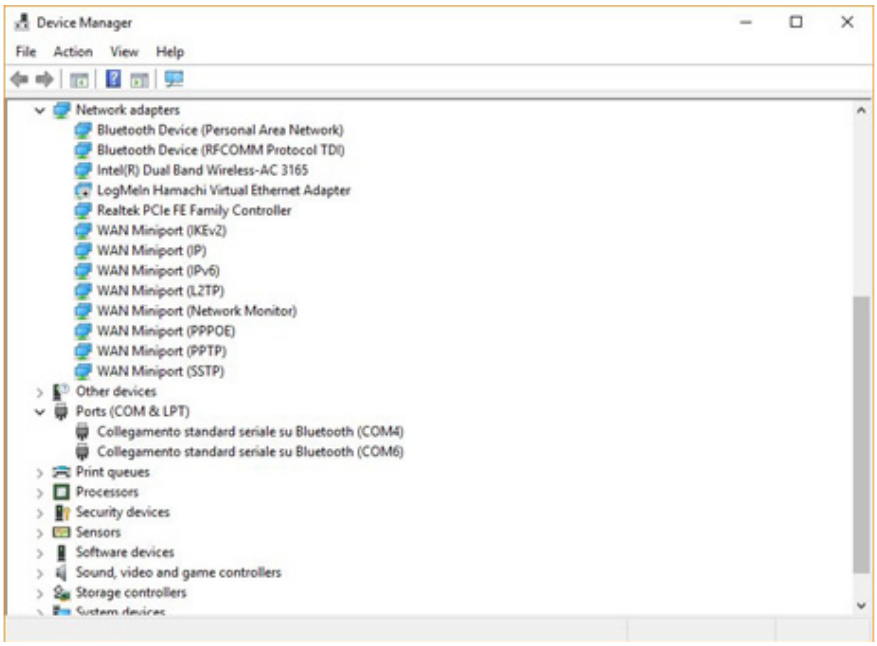
9. Wait for drivers installation on your PC



10. Verify that your Android device now appears in the list of paired Bluetooth devices on your PC



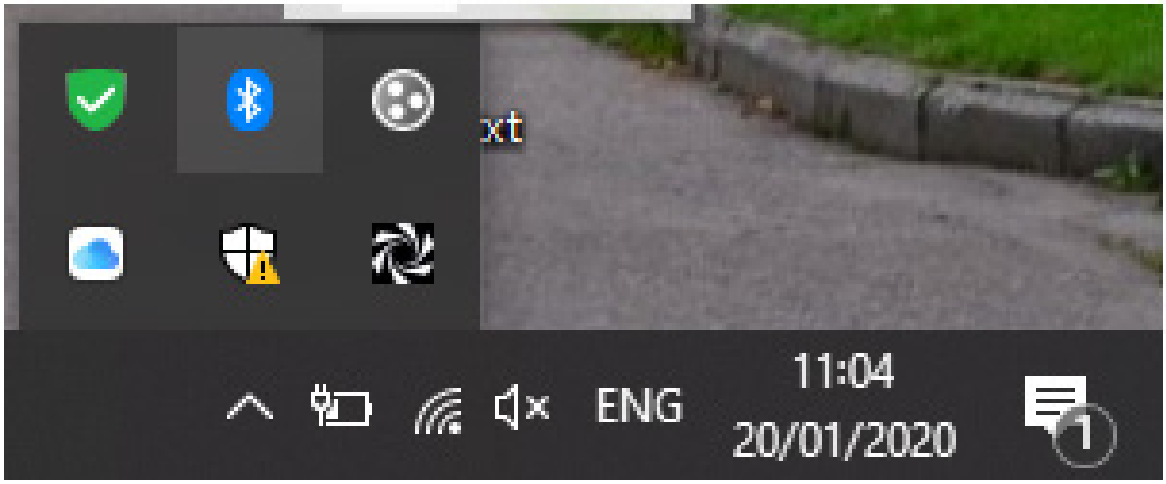
11. Verify which COM port your device is installed on



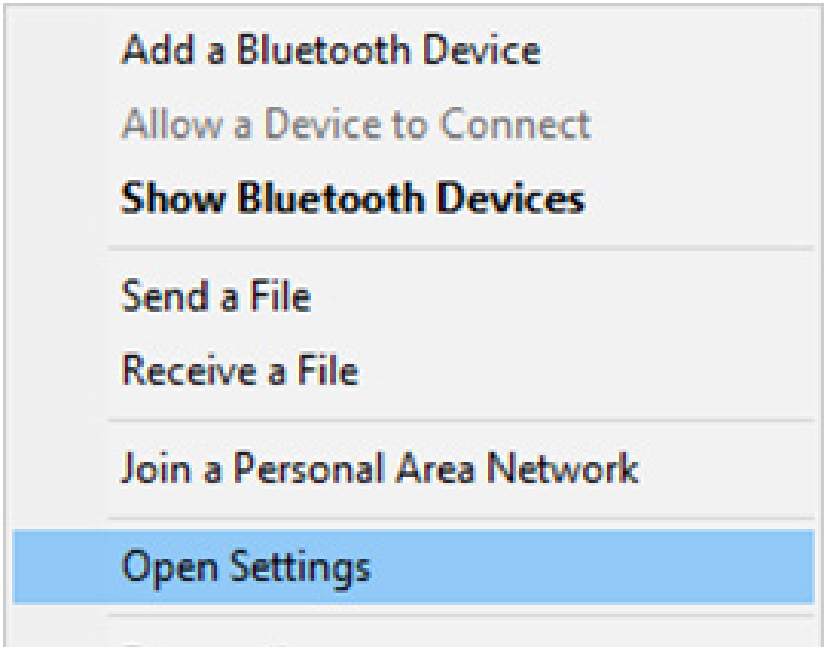
To verify COM port, open Control Panel. Select Hardware and Sound and then Device Manager. In the picture above, Android device is installed on COM4 port. If COM port is more than 4, manually change it and choose one of the first four COM ports .

If COM port is not automatically created, please follow these steps:

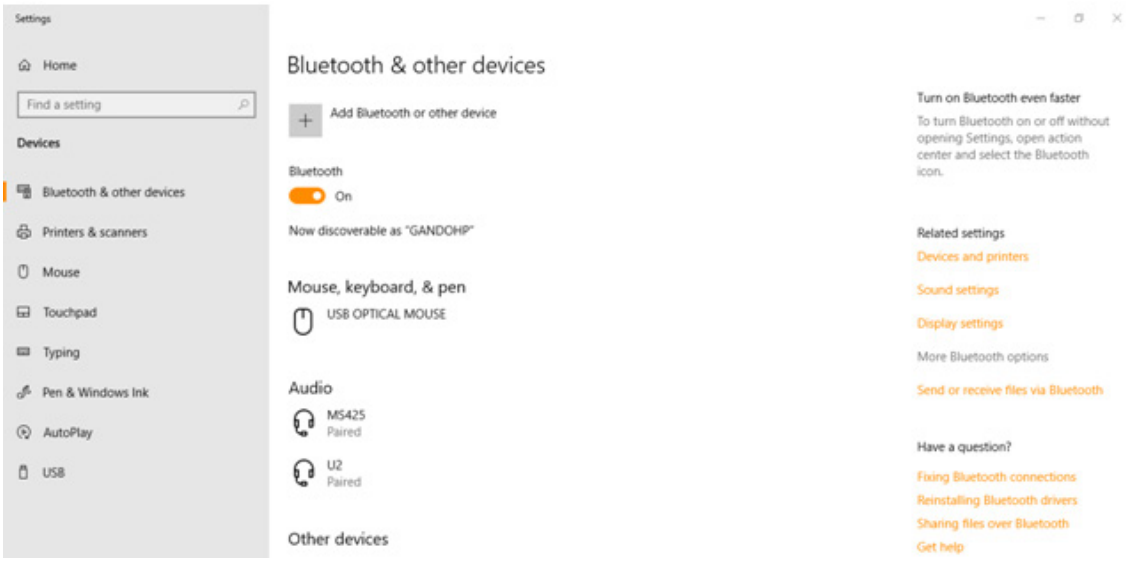
- Locate Bluetooth icon in your Windows applications bar



- Click your Bluetooth icon to open menu

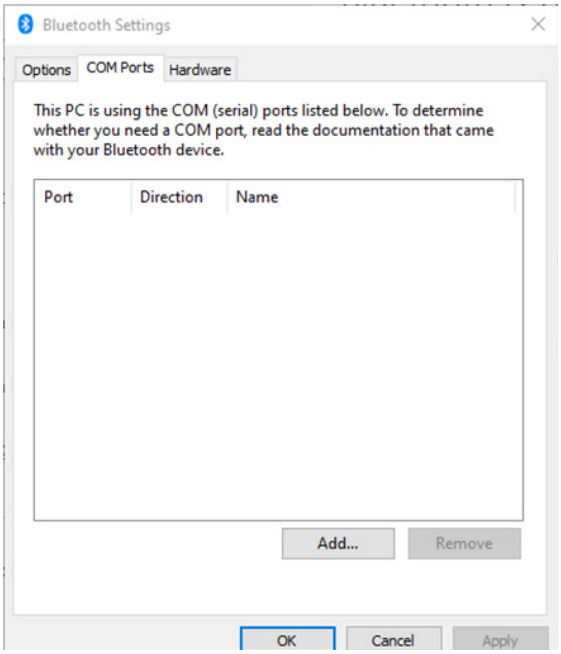


- Click on Open Settings

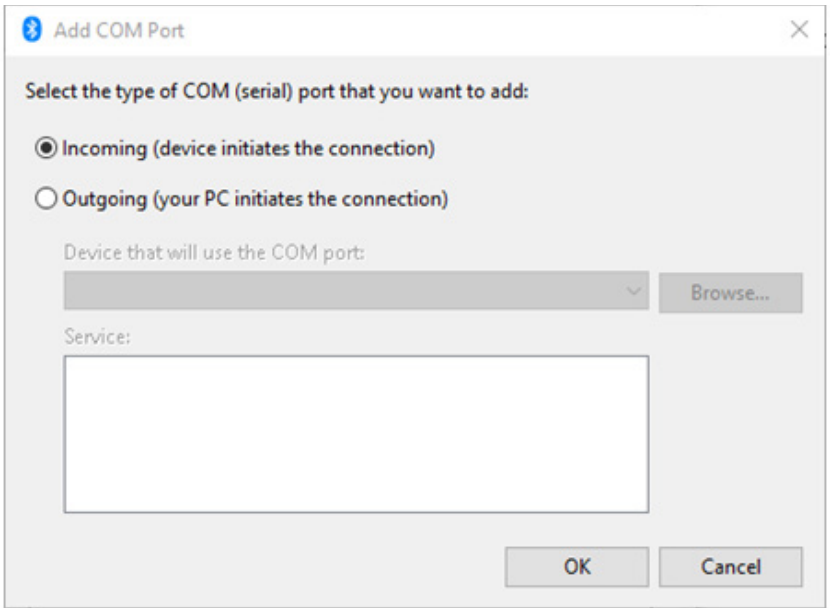


Open full screen, and locate More Bluetooth Options in the right column

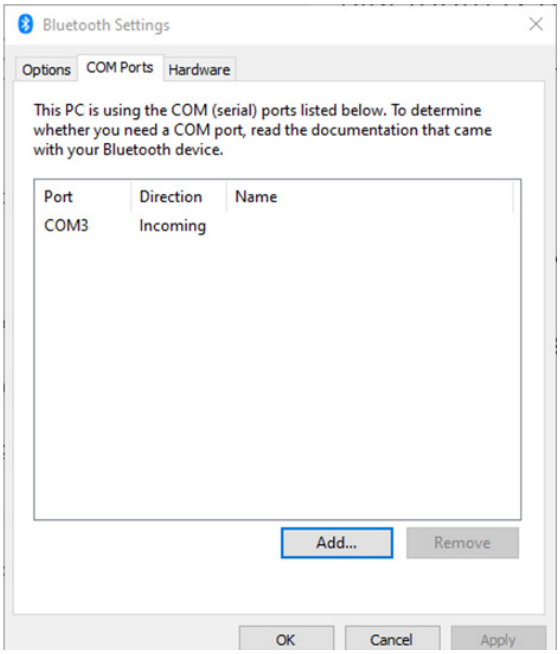
- Click More Bluetooth Options



- Select COM Ports tab and click Add Button



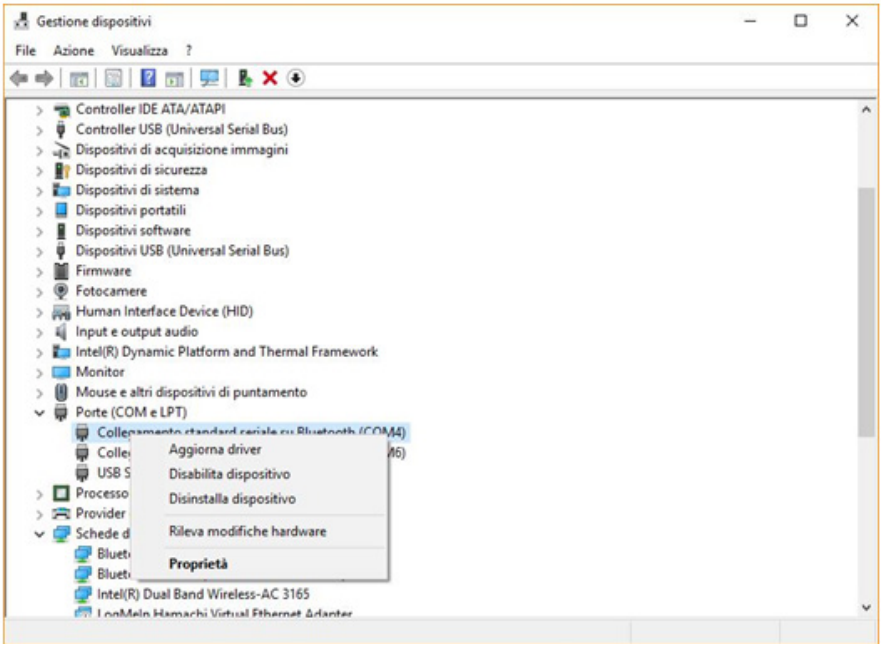
- Select Incoming and click OK



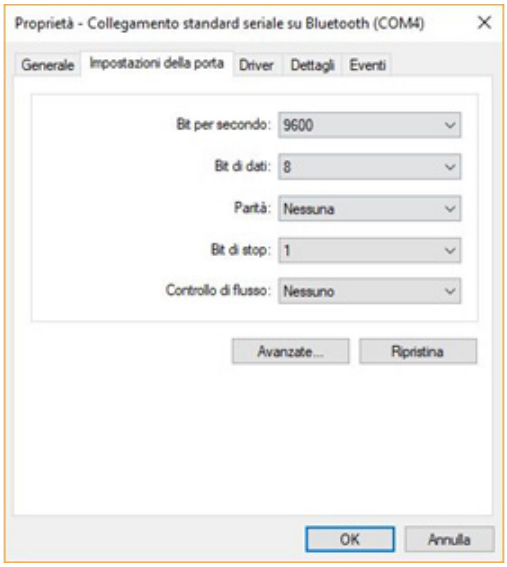
A new COM Port is now created.

- Confirm with OK and then turn off and on Bluetooth connection on your PC

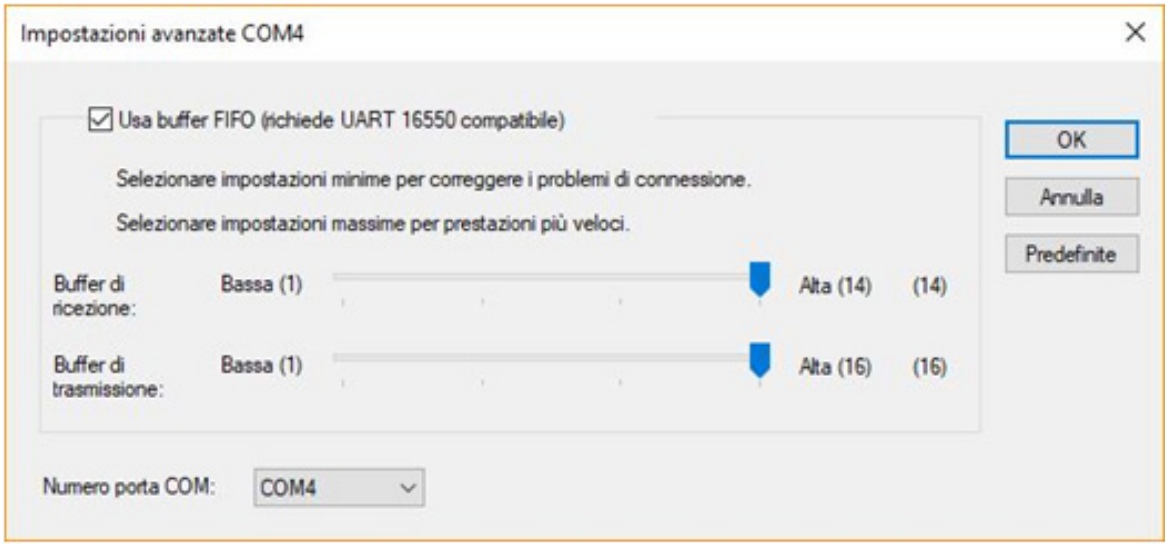
12. If necessary, change COM port number for your Android device, in order to install it on a COM port between 1 and 4.
To change COM port of your device, right click on the COM port and then click on Settings.



In the new window, select Port Settings and click on Advanced settings



Select a COM port between 1 and 4 and then click OK



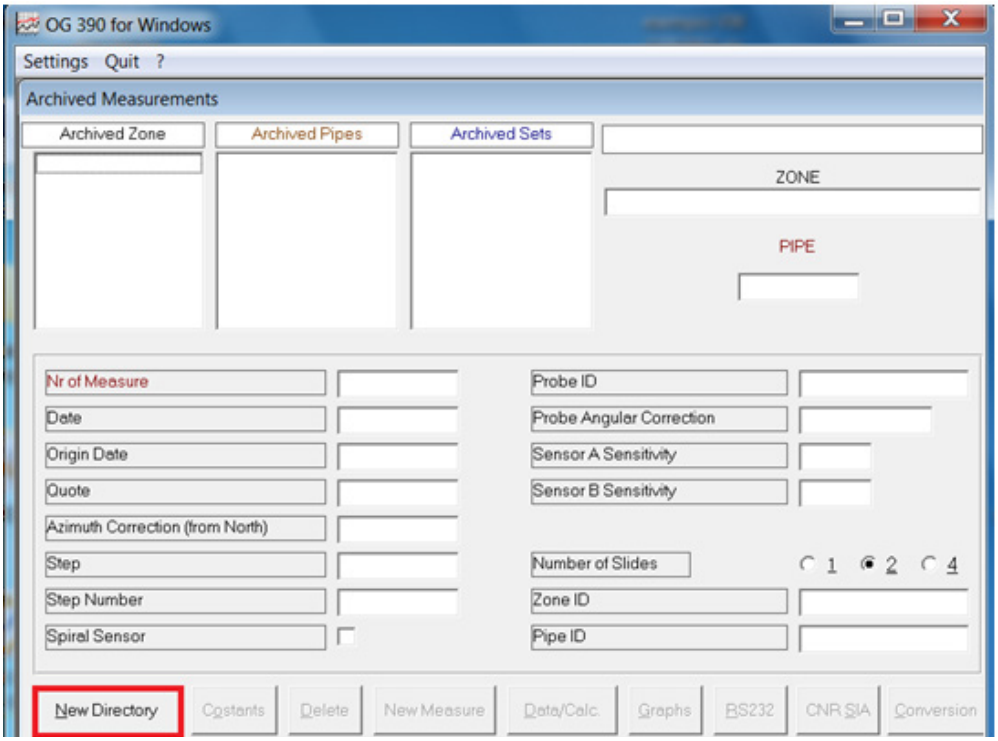
Turn off and on Bluetooth connection on your PC

Data Download to OG390WIN software

1. Open OG390WIN software

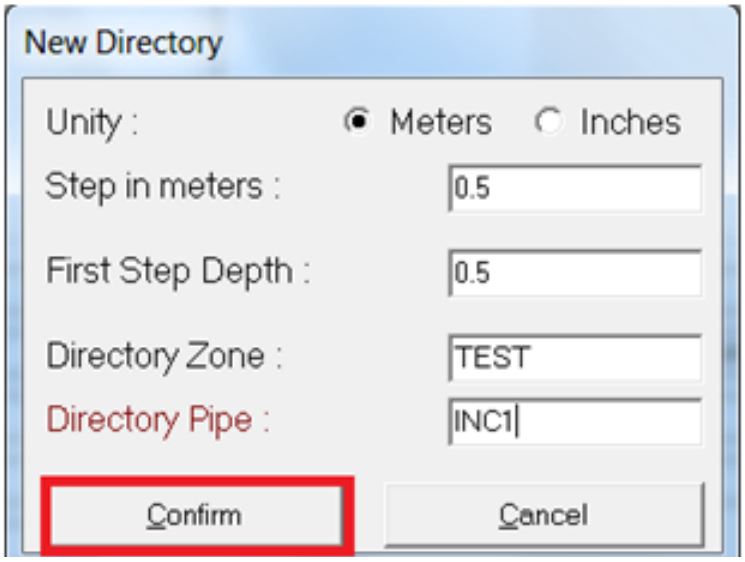
In the following procedure, assumption is that Android device has been paired to PC and correctly set on COM3. To pair a Bluetooth device, please refer to the previous chapter.

2. Once the main form of OG390 is loaded, click on New Directory if you are starting to take measures in a new pipe.
   If you are adding a new measure to an existing pipe, please go directly to step 4)

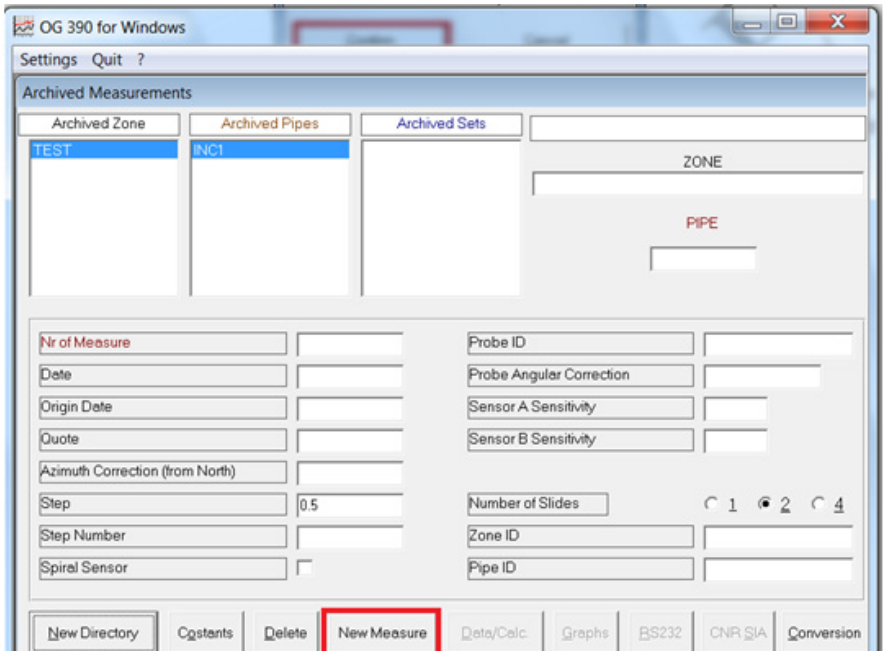


A new folder for the pipe will be created on disk and a window will pop up. Insert the measuring unit (meters or inches), the measuring step, the depth of the first step, the Zone name, the Pipe name and click on confirm. To create a new pipe in an existing zone, type in the existing Directory Zone name and choose a new Directory Pipe name.

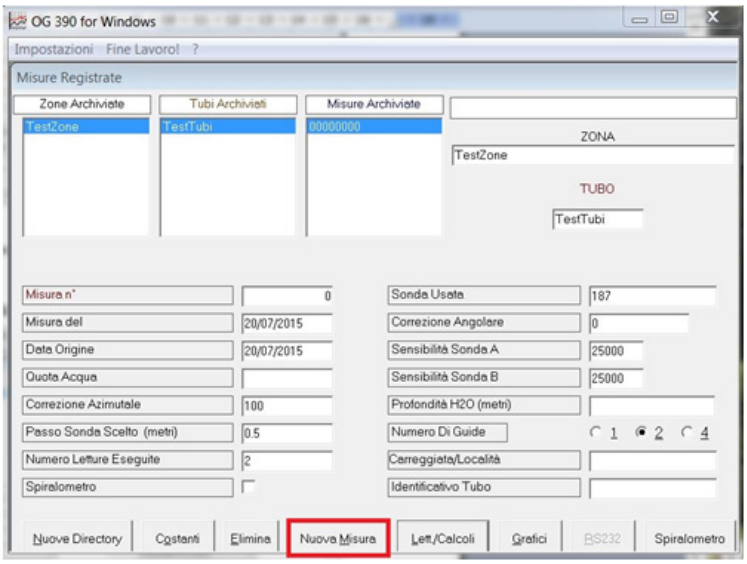
3. Click on Confirm



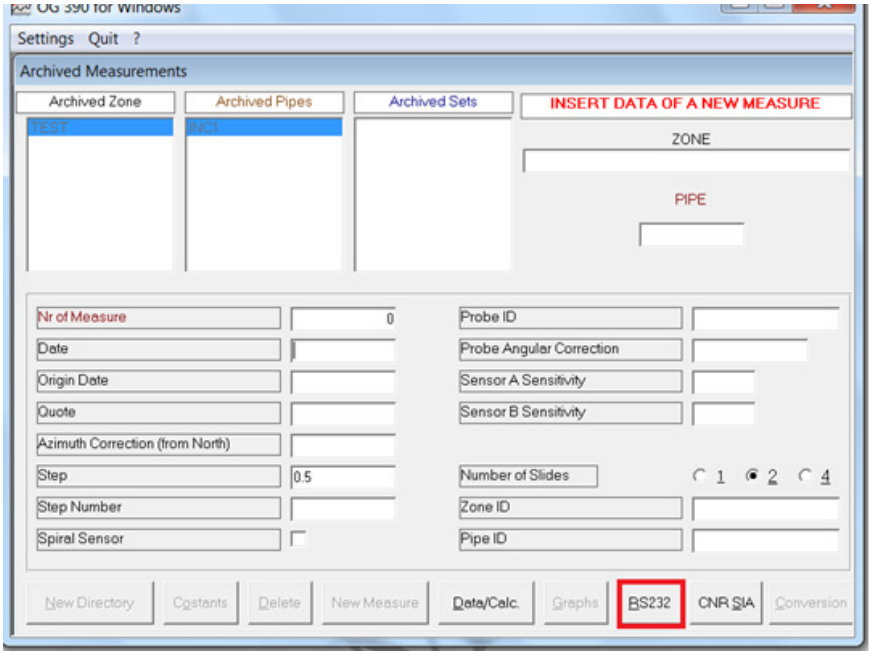
4. In the main window, choose your Zone and your Pipe, then click on New Measure



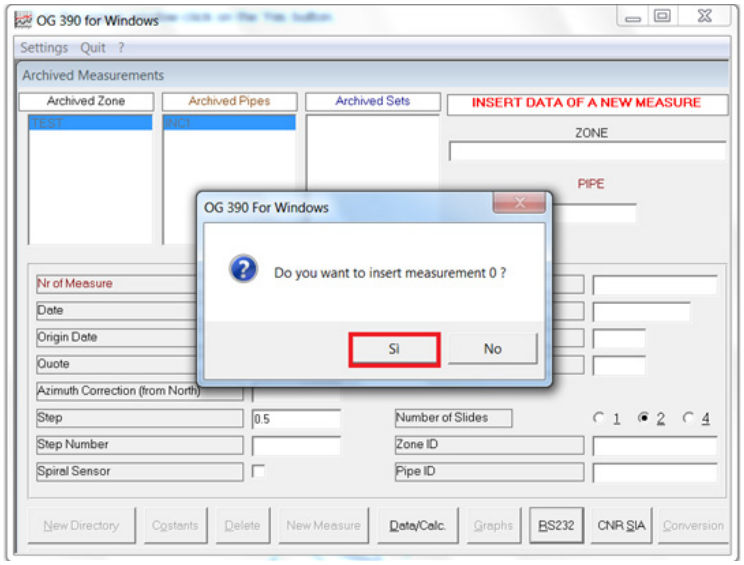
In case of a new measure next the the previous one, click on New Measure skipping all the other steps.



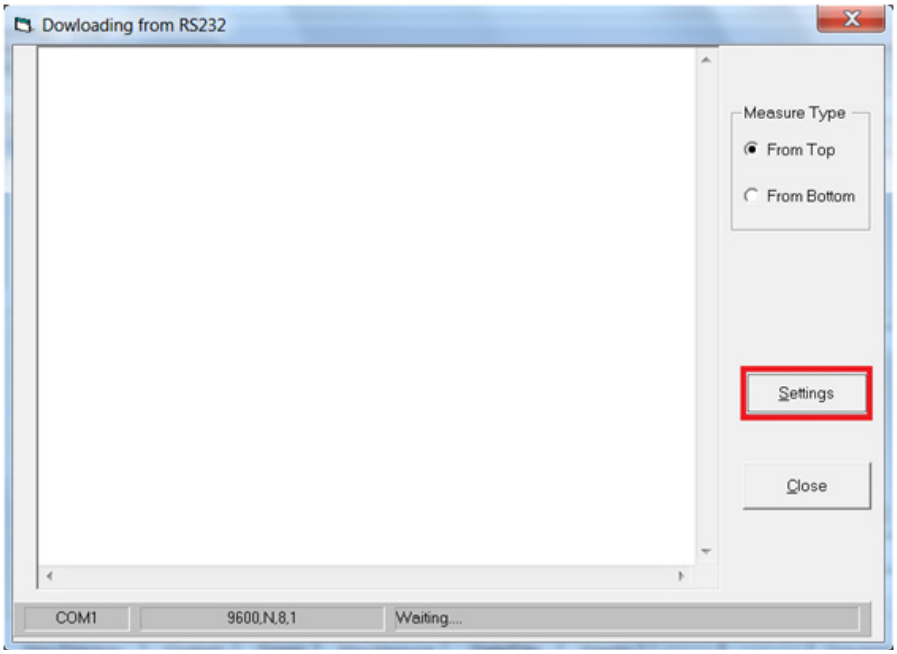
5. Click on RS232



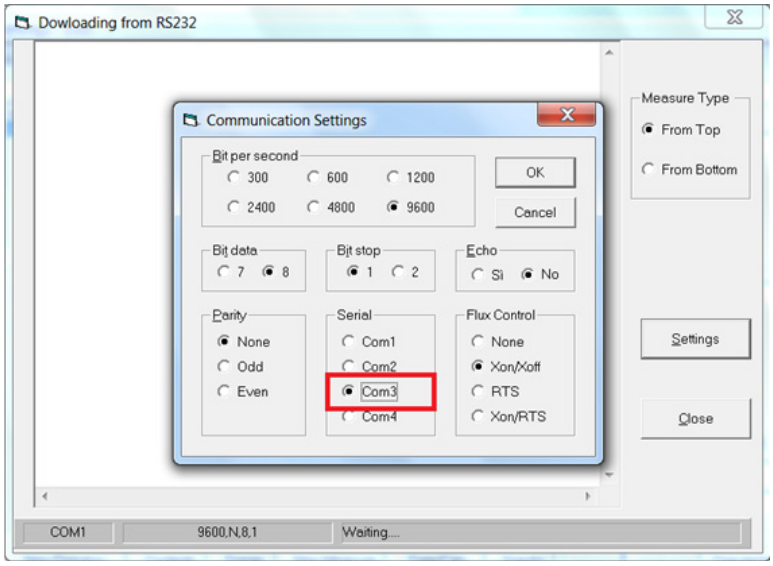
6. In the pop-up window, click on Yes.



7. A new window will open. Click on Settings

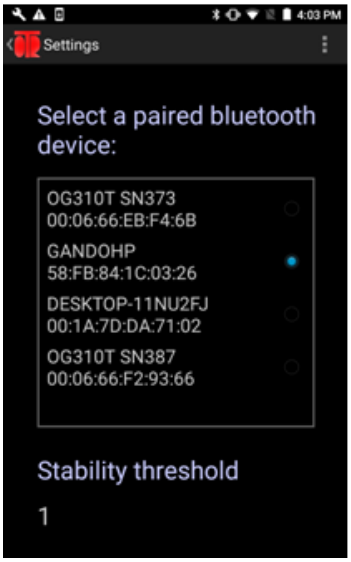


8. Selelect the COM port the Datalogger is connected to. Then, confirm your choice by clicking on OK



9. On your Android device, tap on the Settings icon at the top right cornen of the screen, to open Settings window in the app OG310T

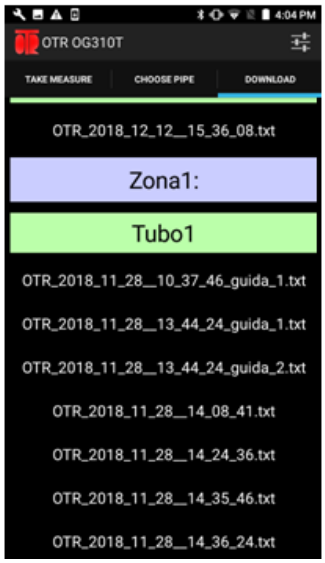
10. Select your computer



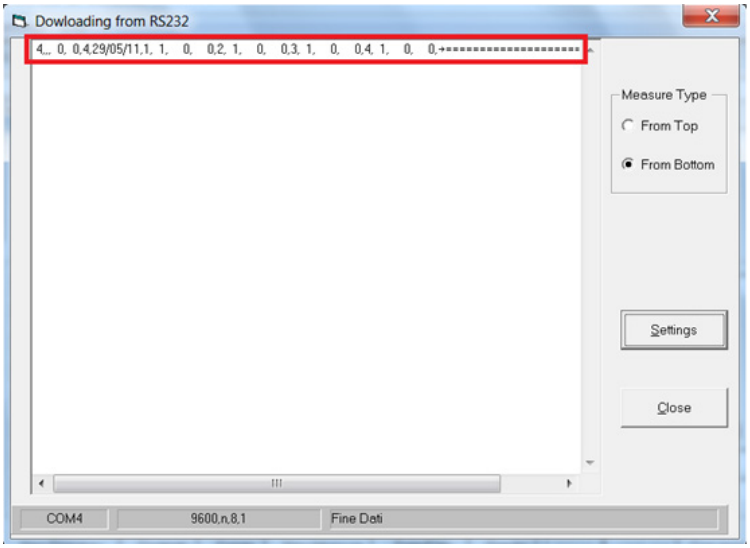
In the picture above, computer name is GANDOHP. When Bluetooth connection is correctly established, a blue dot will appear next to computer name

11. Tap on OTR icon at the top left corner of the screen.
App will take you to the Download tab directly.

12. Tap on the file name you want to download



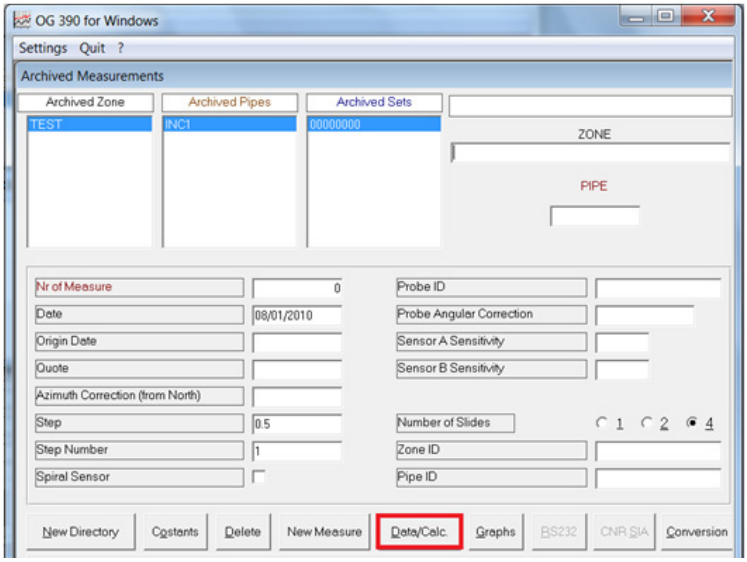
Data are exported to OG390WIN software for further elaboration:



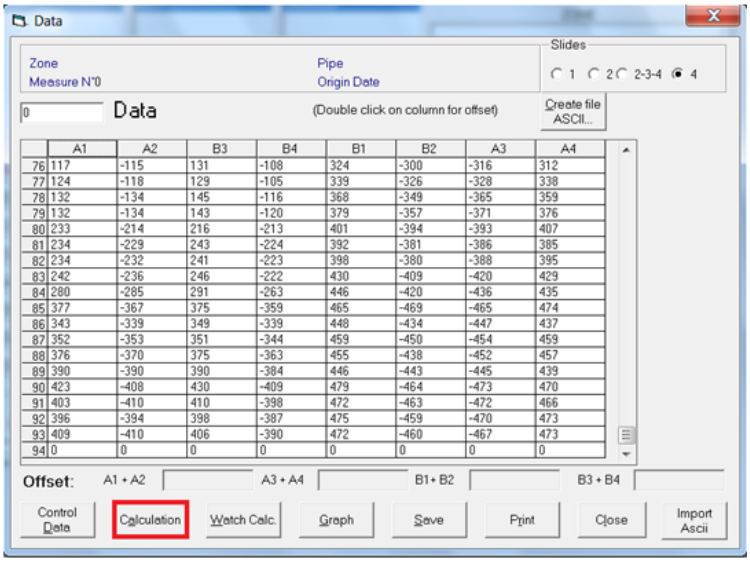
13. Click on Close button in the window of OG390 software

14. Fill in every field you need :
Origin date
Azimuth correction
Zone
Pipe
Probe angular correction :0
Sensor A sensitivity: 25000 (*)
Sensor B sensitivity: 25000 (*)
Click on Data/Calc

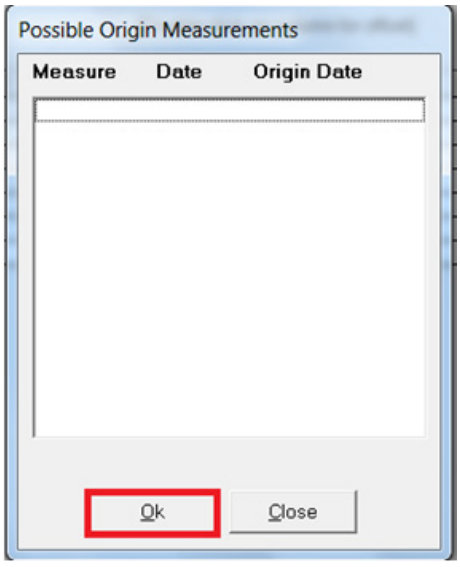
* Please refer to probe calibration chart.



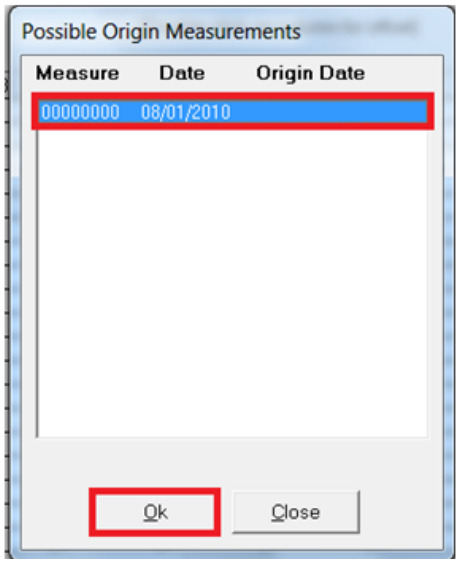
15. Click on Calculation



	A1	A2	B3	B4	B1	B2	A3	A4
76	117	-115	131	-108	324	-300	-316	312
77	124	-118	129	-105	339	-326	-328	338
78	132	-134	145	-116	368	-349	-365	359
79	132	-134	143	-120	379	-357	-371	376
80	233	-214	216	-213	401	-394	-393	407
81	234	-229	243	-224	392	-381	-386	385
82	234	-232	241	-223	398	-380	-388	395
83	242	-236	246	-222	430	-409	-420	429
84	280	-285	291	-263	446	-420	-436	435
85	377	-367	375	-359	465	-469	-465	474
86	343	-339	349	-339	448	-434	-447	437
87	352	-353	351	-344	459	-450	-454	459
88	376	-370	375	-363	455	-438	-452	457
89	390	-390	390	-384	446	-443	-445	439
90	423	-408	430	-409	479	-464	-473	470
91	403	-410	410	-398	472	-463	-472	466
92	396	-394	398	-387	475	-459	-470	473
93	409	-410	406	-390	472	-460	-467	473
94	0	0	0	0	0	0	0	0



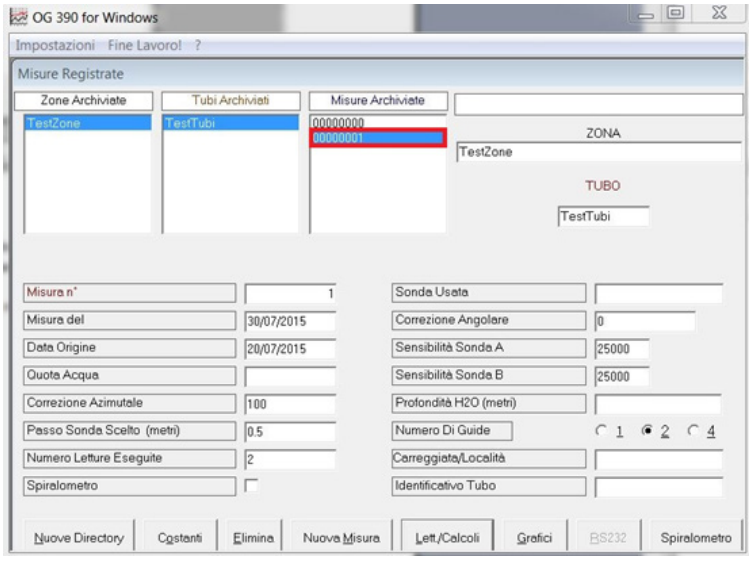
16. If you are not creating the Origin Measurement, select the Origin from the list and then click Ok



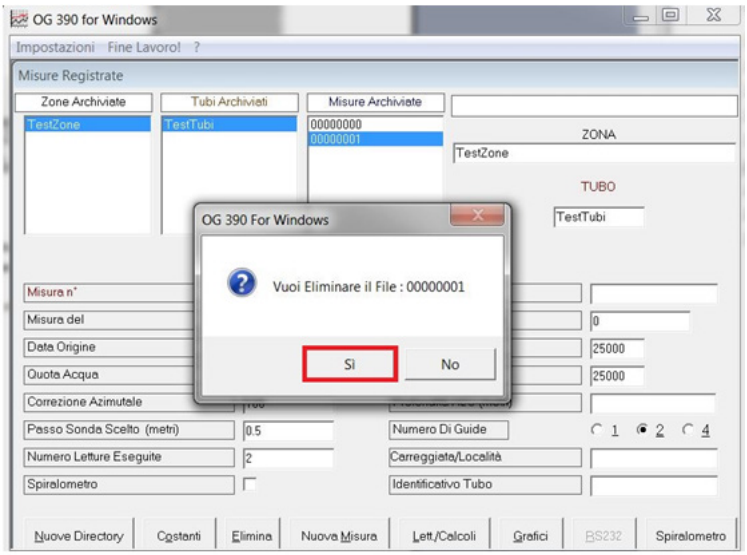
17. Data are now processed:

- In case you are creating an origin measure (misura 00000) only verticality and azimuth charts will be available.
- Following measures allow creation of all remaining charts.

18. In case you incorrectly add a new measure that needs to be erased, remove it from the list with a double click



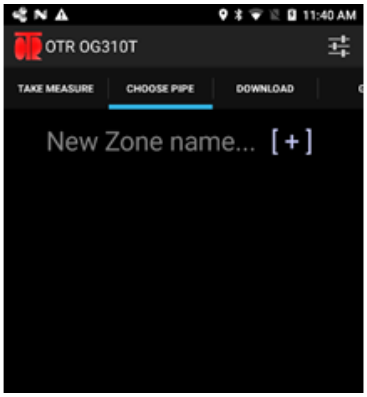
Click Yes to confirm

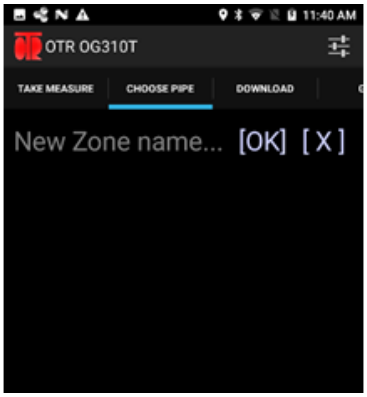


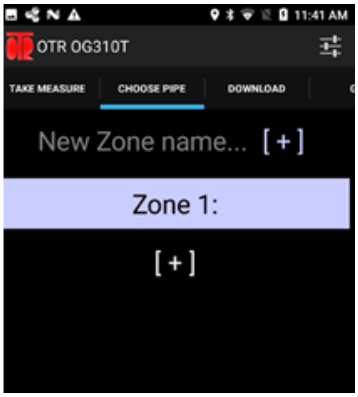
Create Zones and Pipes on Android device

Zones and Pipes can be created in the app, tapping on the CHOOSE PIPE tab

1. To create a new Zone: tap on [+] next to New Zone. Tap on New Zone Name and a keyboard will allow you to enter the name for your new Zone.
Confirm with a tap on [OK] or cancel with [X]

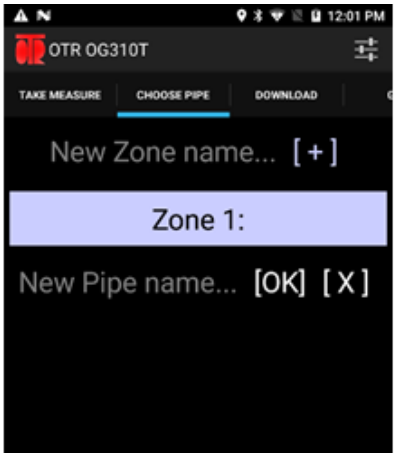






2. To create a new Pipe: tap on [+] in a Zone. Tap on New Pipe name and a keyboard will allow you to enter the name for your new Pipe.

Confirm with a tap on [OK] or cancel with [X]



3. To delete a new Pipe: Lon press on Pipe's name.

You can not delete pipes containing inclinometric files. Only unse piped can be deleted..

4. To delete a new Zone: Lon press on Zone's name.

You can not delete zones containing pipes. Only empty zones can be deleted.

Manage Zones and Pipes from your PC

1. Connect Android device to PC with USB cable.

USB connection to PC allows battery recharge as default option.

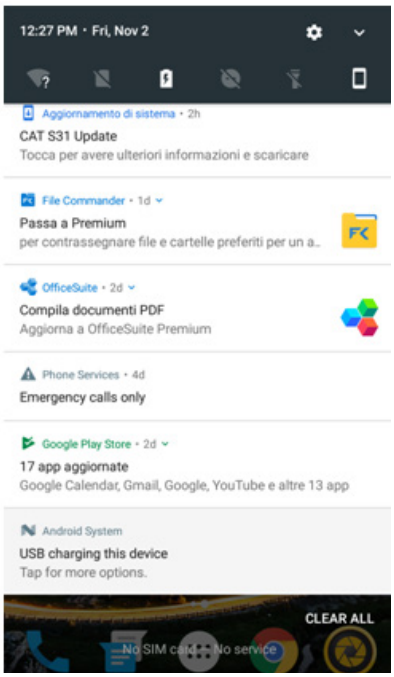
2. Enable USB file transfers on your Android device.

To enable file transfer to PC via USB connection::

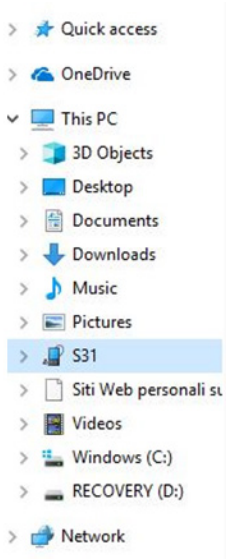
- Unlock your Android device

- Swipe down from the top of the screen to show Android notifications.

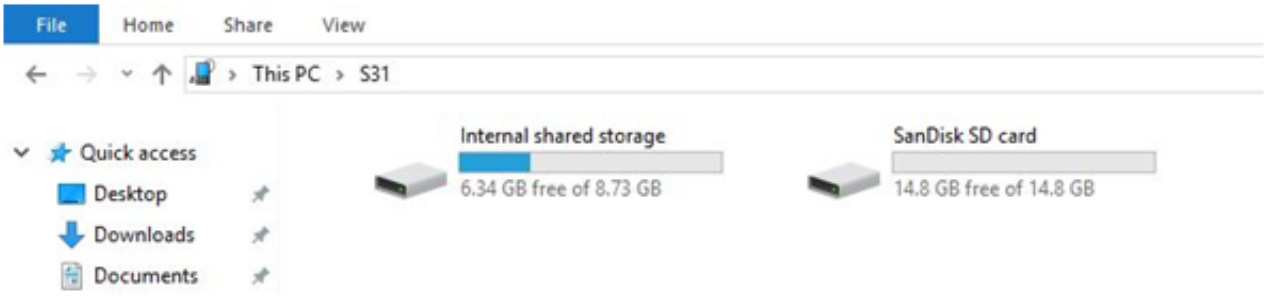
- Veew the notifications
- Select Charging Device



3. On your PC, browse to This PC and open your Android folder (S31)

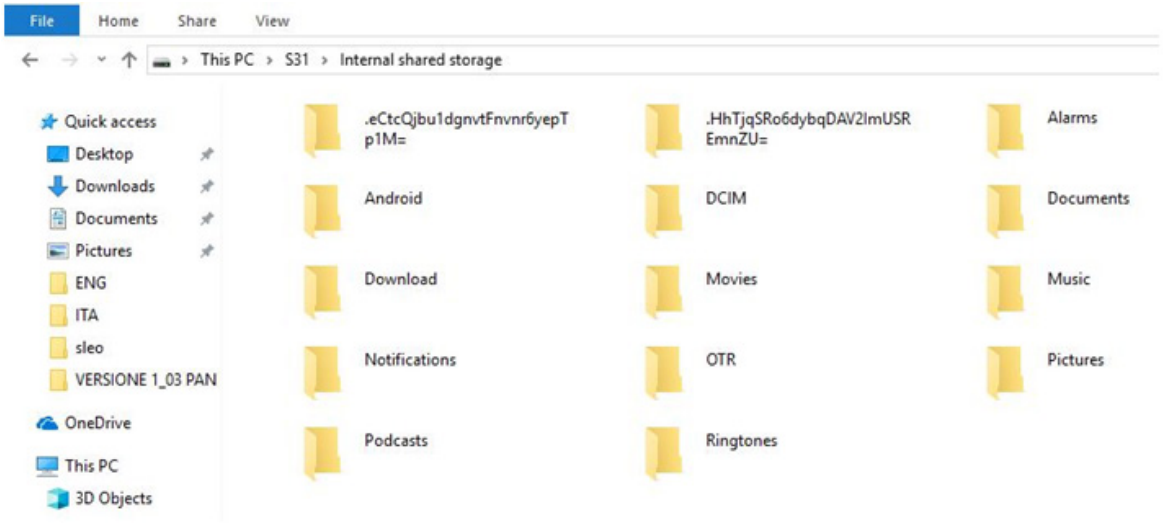


Android device S31 is listed in computer folders

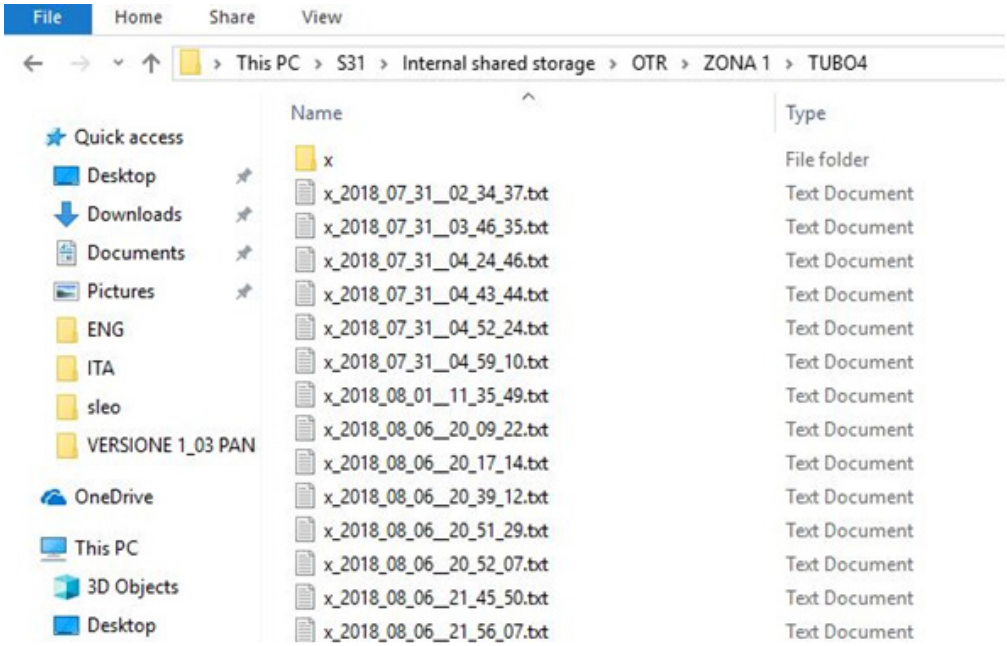


You can now access internal archive of your Android device

4. Open OTR folder in device internal shared storage.

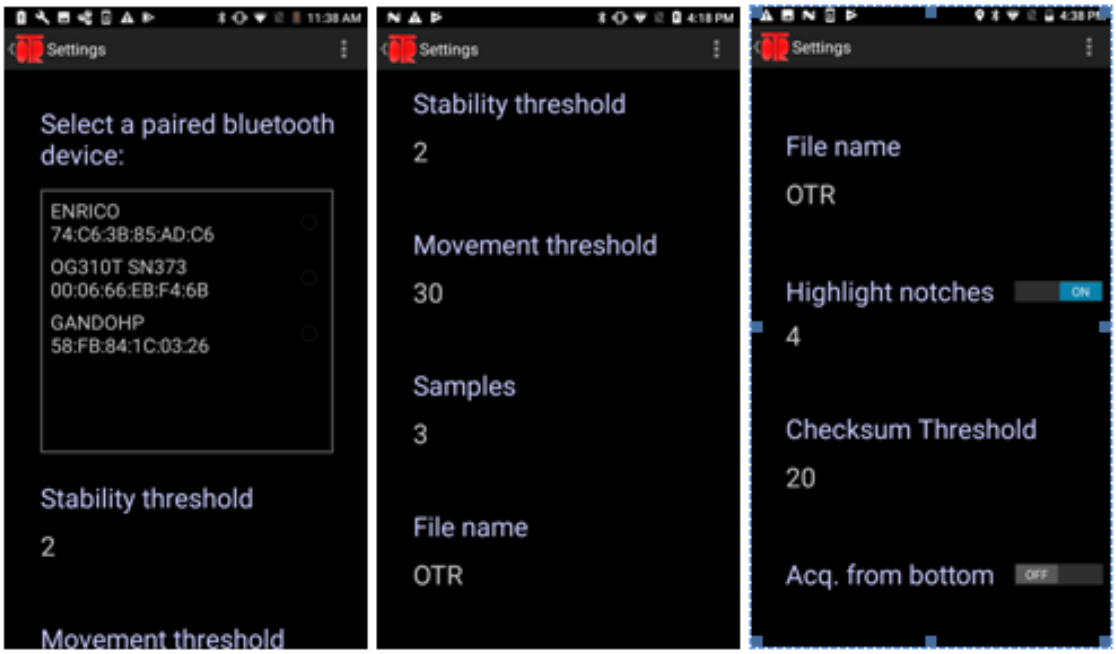


5. In OTR folder, create a new folder for each Zone you want to list in the app.
6. In any new Zone folder, create a Pipe subfolder for each Pipe you need in that Zone.
   Inclinometric measures will be saved in these Pipes subfolders.



Inclinometric measure files are named as follows: prefix_date_time.txt (you can change prefix inthe Settings screen of the app. For instance, it can be changed to operator's name. Date and time refer to date and time of file creation. Zone folders and Pipes subfolders structure will be listed in the app after you close and reopen it. To modify name and/or number of Zones and Pipes, modify name and/or number of folders and subfolders.
Measure text files can be exported to OG390WIN software through data download procedure in the app.
For further instructions about downloading inclinometric measures to OG390WIN software, please refer to chapter Data Download to OG390WIN.

OG310T app Settings



In the Settings screen are listed the following settings:

- Select Bluetooth Device

List of Bluetooth devices paired to Android device.
In this list you can find one or more inclinometric probes, each one identifiable by its Serial Number, and one or more PCs for data download.

This is a read-only list.
For further details about how pairing Bluetooth devices, please refer to chapter Bluetooth Connection.

- Stability Threshold

Variation threshold for channels A and B, below which probe is considered stabilized during automatic acquisition.
Default value: 2
In case inclinometric pipe is poorly embedded in concrete, probe might not get stabilized due to undesidered small pipe vibrations. It might be necessary to increase stability thershold value, or switch to manual acquisition mode.

- Movement Threshold

Variation threshold for channels A and B, above which probe is considered voluntarly moved between two steps of measures, during automatic acquisition.
Default value: 30

- Samples

Number of samples used to evaluate probe stabilization
Default value: 3

- File name

Prefix for saved files.
Default value: OTR
Prefix can be useful, in case you have more inclinometric systems or more Android devices, to identify measures acquired by different operators.

- Highlight notches

Activates/disactivates sound effect and visual notification for acquisition of colored notch steps.
Enter number of first colored notch on your inclinometric cable
Default value: Off

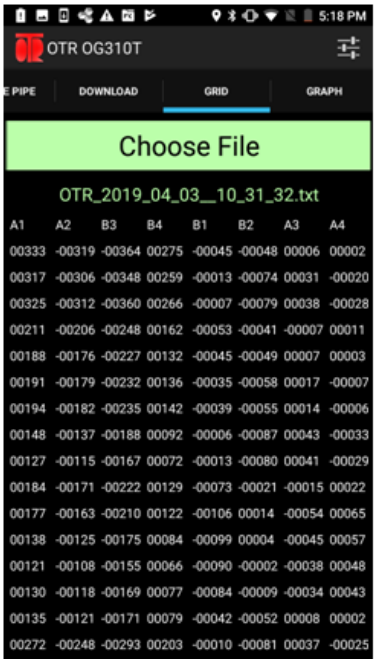
- Checksum Threshold

Threshold for checksums when loading file in Table view.
Checksum average is computed for each acquired slide. Steps are highlighted whenever their own checksum differs from slide average more than this threshold.
Default value: 40

- Acq. from bottom

Steps acquisitions order. Select ON in case you acquire steps from bottom up. Select OFF in case you acquire steps from top.
Affects in-app charts visualization only.
Default value: Off

Data Grid



1. Tap on Choose File button
2. Select file to load
3. Swipe down to check all steps.

Steps are checked as soon as they are loaded into table. Steps whose checksum differs from checksums average of their slide will be highlighted.. Threshold for checking checksum can be changed in app Settings. Please refer to previus chapter.

Charts

1. Tap on Choose File button
2. Select acquisition to show
3. Tap on Choose Origin button
4. Select origin file.
5. Tap on chart to change chart type

Charts are computed against selected origine measure .
In-app charts are indicative of quality of acquired measure. Please refer to OG390WIN software for an accurate elaboration of acquired data.

Measurement Specifications

1 – PURPOSE

The aim of inclinometer measures is to find out with precision, in a probably instable side, possible sliding planes; to control during time the entity, the speed and direction of the movements, so gaining valid data on danger. The same data can be used also in planning a stabilizing process.
Measures are carried out with proper devices in inclinometer tubes, properly installed in the ground, in time interval established by the Customer.

2 - EQUIPMENT USED AND REQUISITE

2.1 - Inclinometer probe
The inclinometer probe must be biaxial, use servo-inclinometers with FS of 14.5, 30 o 45 degrees.
The probe step, i.e. the distance between the wheels of the higher and lower part, must be 500 mm. (for probes with metrical steps) or 24 inches (for probes with English step).
Sensitivity of the oblique axis must not exceed the 0.015% of the FS, per degree.
Temperature variation of sensitivity must not exceed the 0.015% of the reading, per Celsius degree.
Temperature variation of zero must not exceed the 0.01% of the FS per Celsius degree.
Reading sensitivity must not be lower that 20,000 x sin (= angle of inclination in respect to vertical line)

2.2 - Control cable
Control cable, i.e. the cable with electrical conductors and the little strengthening cable to which is fastened the probe, must quote the notches of measure every 500 mm for metrical system or 24 inches for English measuring system.
The cable must guarantee no variation in the distance between the notches.

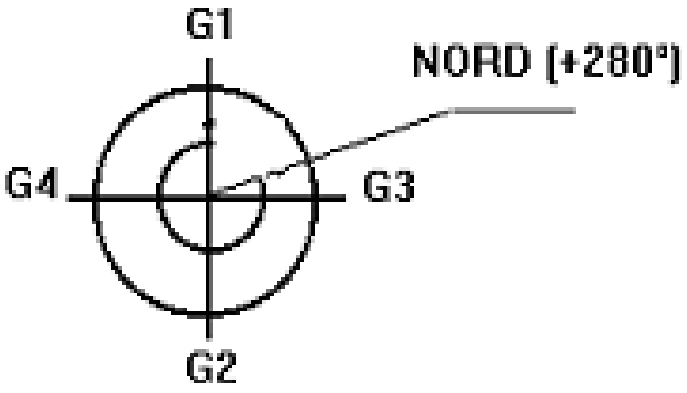
2.3 - Spiralometrical probe .
In some cases, when data elaboration gives movement directions hard to interpret or physically improbable, the use of a particular probe, "spiralometrical probe", can be requested to reveal the spiral deformation of the guides of the inclinometer tube, so that it is possible to adjust elaboration.
The spiralometrical probe can be :
- completely electronic with magnetic North sensor (flux gate);
- with rotating edges and electronic angular sensor (analogical or digital angle meter);
- completely mechanical with rods and goniometer.

In all cases the system of spiralometrical measure must allow to verify and measure spira¬l deformation of the guides with a minimal sensitivity of 0.1 degrees per meter of inclinometer tube.

2.4 - Reading unit (Data Logger).
Reading unit can be manual, with one or two displays, or automatic (data acquisition).
In both cases the unit must be able to operate in a range of temperature from -5 to + 40 °C and respect the specifications of temperature variation, see 1.2a.

3 - HOW TO EXECUTE MEASURES.

3.1 - Original measures
3.1.1 - Find on the inclinometer tube, among the four ones, the guide that more comes near to the direction of a probable movement (guide towards the max slope), name it "1" with a permanent marker.
3.1.2 Measure the height of the edge of the tube (or the depth, in the case of tubes in wells) in respect to the ground and take note of it on the proper module



3.1.3 - Write on the parameter of walls the position and the name of the tube, when this is possible.

3.1.4 - Read on a compass the angle between the magnetic North and the joining line between guide "1" and "2", guide "2" is the guide opposite to "1", and take note of it in a proper module with all data of the measured zone, inclinometer data of the tube (number, id.)
The lines joining guides "1"-"2", and guides "3"-"4", form a system of Cartesian axis, X-Y as in fig. 1.
For OG390WIN in the case of fig. 1 the correction of Azimuth must be entered with positive sign (the angle is positive if read in an anti-clockwise direction from Guide 1 to North).

3.1.5 - Prepare the devices of measures for starting the measure itself.

3.1.6 - Insert the inclinometer probe with the wheel of reference in the guide "1" (the wheel of reference for probes OG 310 is the higher wheel).

3.1.7 - Lower the inclinometer probe until it reaches the bottom of the tube; wait some minutes for a correct thermal acclimatization and until the values read on the display of the unit are stable.

3.1.8 - Raise the inclinometer probe at the edge of the tube and lower it again until the wheels of the higher trolley are at a probe step (50 cm or 24 inches) from the edge of the inclinometer tube. Take note of the values read on the display in the proper module if you are using a manual reading unit or acquire data if the measuring unit is automatic.

3.1.9 - Lower the inclinometer probe until you it reaches a probe step, taking note for each reached depth the values read on the display or acquiring them with the reading unit if it is automatic.

3.1.10 - When the probe reaches the bottom of the tube, control that the last measure is carried out in a way that the inclinometer probe doesn't touch the bottom, also the last measure must be executed for an entire probe step.

3.1.11 - Recover the inclinometer probe, insert it in guide "2" (opposite to "1") and follow the same instructions as in points from 1.3h to 1.3n.

3.1.12 - Finished the measures on guide "2", it's the turn of guide "3", i.e. the guide placed 90 degrees in a clockwise direction in respect to "1", and then of guide "4" (opposite to "3").

At the end of the measure you will have 4 values of inclination on axis X (G3-G4) and 4 values of inclination on axis Y (G1-G2) for each probe step, this is because you have carried out a 4 guide precision measure.
Example: for an inclinometer tube, 20 meters long, measured with a probe with steps of 500mm, you will have 160 values of inclination along axis X and 160 values of inclination along axis Y, that is 320 collected number in total.

Measures of control.
Control measures must be executed in the same way than the original measures. In particular, you have to follow instructions form points 3.1.4 d to 3.1.11.

In the case that, during a control measure, you are no more able to carry out reading as far as the depth of origin, you will place the probe on the point of maximum reachable depth and you will accurately take note of the inclination data and of the distance in centimetres form the last complete reading (a probe step).

In the case that you find hard to interpret of physically improbable directions of movement in the elaboration of the previous measures, spiralometrical measures will be requested. These ones must be executed with a proper probe described at point 3.1.3. The way to measure with spiralometrical probe will be suggested by the Producers.

4 - CALCULATION PROGRAM.

A lot of programs are traded for datas inclinometric's elaboration; some of them, allows the user to correct angular arrangement and instrument sensitivity. Sensibility is the ratio between the physical quantities, angles' sine and readouts, if it's authomatical, of the measurement control unit; other programs can't allows the user to do that.
The time variations, angular arrangement or sensitività variations, are small compared to nominal values about: angular arrangement: at first on "Zero" nominal value just a few sexagesimal; for the sensibility at first 20000 or 25000 times the angle's sine so percentages lower than 1%.
In many cases this little variations should distort results of the alaborations making the necessity to offset, using a file, the datas and/or keeping the measurement's equipment perfectly calibrated.
Calibrations' checking and re-checks of the equipments should be repeeted periodicaly to the construction company or inside the qualified shops; the working procedure will be sent to the client.
Client, in case of abnormal returns and/or not very reliable, may in every time ask for checks abd calibrations of the measuring equipment used.

4.1 Calculation program with correction possibilities.

When correction programs are used to correct angular arrangement and sensitivity, during the elaboration the values correct and adepted in the printouts have to be highlights.
Corrections accepted for the previous parameters mustn't overcome ± 2° sexaggesimal (not more than 2° sexaggesimals respect to the original measure) for the angular arrangement; and ± 1% of the nominal sensibility's of the measurents equipment. Any superior corrections to these values should be justified and specificated to the clients. The reasons: equipment change, periodic calibration and methods to make corrections; will be sent to client too.

4.2 - No-correction programs.

When no-correction programs are used, besides the periodical calibration checks, should be necessary re-calibrate of the measurement equipments or replecements of the same one and warn the client.

4.3 - Common features of calculation programs.

The program have to be able to evaluate the "out of zero" difference, between a readout and his combine, and allows to print correctly his average with plainness, to enabe a rapid evaluation of the status of the measure. The same file have to execute elaborations both by summathory and by local inclination variation ("by points" and "by displacements"), to report the azimut to the nord pole; performing an axial rotation; in order to make every worksite a single coordinate system. Produced charts should be scaled and reported. And possibly the deepness scale should be the same in the same place.
Program have to be furthermore able to provide the datas in Ascii files like previously told.

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5 - FILES DELIVERED TO THE CUSTOMER .

The files to be delivered to the customer will be numerical (tables) and graphical (graphs).

5.1 - Tables for original measures.
Tables must have all data for the identification of the interested zone, Zone, place of the inclinometer tube measured, given name, direction in respect to the magnetic North of the guide "1"; data on sensitivity of the inclinometer probe expressed through the sine of the angle in respect to vertical line multiplied for the value of "sensitivity" and the date when the measure took place; then must be reported the data of the campaign, the reading on axis X and Y (8 values for each probe step) taken at various depths and the correspondent spiralometer reading, if requested.
Then, you have to report polar co-ordinates calculated (deviation in respect to the vertical line in mm. And direction in degrees) at various depths, in a system of axis which has the bottom of the inclinometer tube as origin and oriented according to the magnetic North.

5.2 - Graphs for the original measures .
The graphs for the original measures will be the following ones:
- depth-deviation from vertical line graph through "summation from the lower part", with zero point at the bottom of the inclinometer tube (maximum reading depth) and points calculated for each probe;
- graph of direction at various depths reporting the angle in respect to a Cardinal point of the deviation from the vertical line at various depths;
In the graphs will be reported all data concerning the zone and the inclinometer tube and the numerical values of the maximum shifting from the vertical line, of the shifting of the edge of the tube from the vertical line, in mm., of the relative direction in degrees and of the depth in meters from the edge of the tube of the point in which you have the maximum shifting from the vertical line.

5.3 - Tables for control measures.
These tables must report all data concerning zone, inclinometer tube, sensitivity of the system of measure, direction of the magnetic North in respect to guide "1", campaign data, as well as the movements calculated from the origin for each probe step, in polar co-ordinates through summation (vectorial summation of the movements starting from the bottom of the tube ("summation from the lower part") expressing the values in meters for the depth, in mm. for the distance and in degrees for the direction); the values of the "variation of local inclination", expressing them in mm./meter, reporting also the direction in degrees in respect to a cardinal point and the depths from the edge.

5.4 - Graphs for control measures. .

- depth-movement graph through "summation from the lower part" (vectorial summation), with zero point at the bottom of the inclinometer tube (maximum reading depth) and points calculated for each probe step, reporting the movement in respect to origin through summation from the lower part in 2:1 scale if possible;
- graph of the direction calculated at various depths, reporting the angle from the magnetic North of the movement from the origin.
- Graph of the "variation of the local inclination – depth" reporting the variation at various depths (every probe step) of the local inclination expressed in mm./m in 10:1 scale if possible;

In the graphs will be reported at least two previous curves (if they exist) besides the one under elaboration.
In the graphs will be accurately reported all data for the identification of the measure: Zone, place, name of the inclinometer tube, date of measure, date of the origin, etc.
You will report in numerical form:

- the maximum shifting expressed in mm. or mm./meter, the relative direction in degrees and the depth from the edge of the tube in meters of the maximum shifting.
- the shifting from the edge of the tube expressed in mm. or in mm./ meter and the relative direction in the same way that has been described many times.

Both for original measure and for control measure is useful that the documents, (tables and graphs) are reported in A4 sheets, for comfortable reading and filing.

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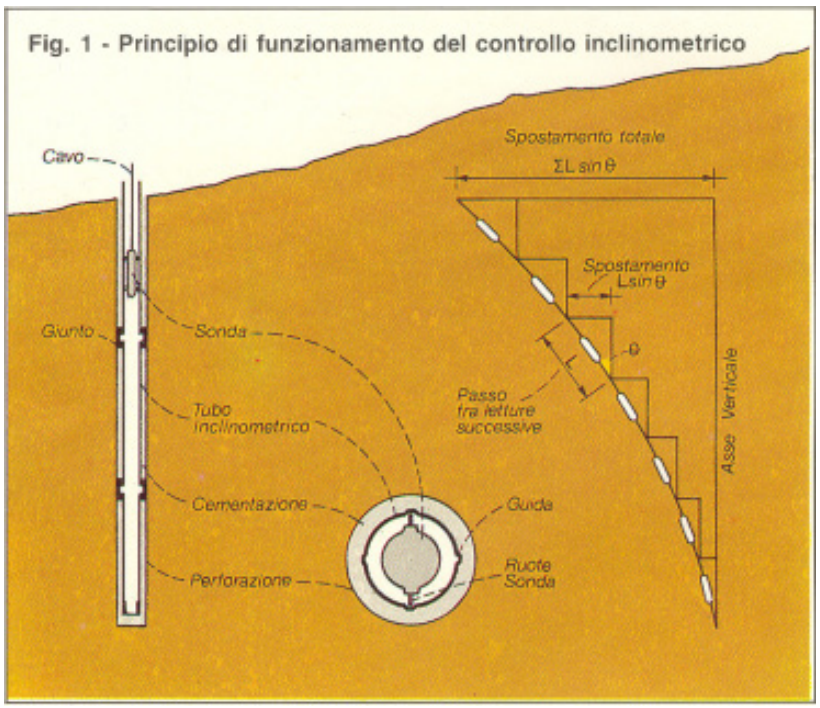
Measurements' calculation scheme

The following document is drown up to be a simple description of the calculations executed of the vertical inclinometric measurements, differential and absolute.

Calculation scheme



Calculation, if it's not explicitly demand, are executed starting from the bottom of the inclinometer;
In the calculation is presupposed that the bottom is a fixed point;
In OTR's software is calculated the real deepness (not the lenght of the case).
The cable have to guarantee during the time the constancy of the measurement mark' distance.

ABSOLUTE POSITION CALCULATION SCHEME

Proceed as follows to calculate the absolute position of the inclinometer tube:

- Average the measures on 2 guides or on 4 guides for every inclination (A and B):

$$A_i = \frac{A1_i + (-A2_i)}{2}$$

- Change the data in sine's angle measured (refer to probe's sensibility);
- Considerare il passo sonda L;
- And run the following summation for every axis (A and B)

$$= \sum L \times sen(\theta_i^A)$$

$$_{.} = \sum L \times sen(\theta_i^B)$$

- Every step execute the following calc

$$\text{Vertical displacement} = \sqrt{A_i^2 + B_i^2}$$

Execute the angle's calculation of the X component vector anticlockwise and run the rotation, following the instrument's conventions, using guide reference direction to obtain Norn and Est datas' expression (according to our Y and X convertions) .

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RELATIVE/DIFFERENTIAL POSITION CALCULATION SCHEME

Procede in the following way:

- Make the differential between Aì (exercise readout) and Ai (0 readout), Bi (exercise readout) and Bi (lettura 0);
- Calculate the differential sommathory on the two axes and the complessive movement;
- Turn referal system according to the direction of guide 1 to obtain the datas expresed in Nord and Est (according to our Y and X convertions).

Printouts

Campaign data printouts:
Collected instrument datas in 25000 sen a.
Number sequence is:

- 4 guides: A1 A2 B3 B4 B1 B2 A3 A4;
- 2 guides: A1 A2 B1 B2;

Processing table:
Absolut processing: elaboration of the datas from the bottom, indicated step with absolute position of the case inside the soil compared to the bottom point;
Differential sommathory eleborations: case position compared to the seleted origin treating the bottom step like a fixed point;
Diffential "by points"/local elaboration: case position compared to the selected position considered for every step.

Calculation program OG390WIN allows the user to see the lenght of the step. The deepness isn't the number of steps multiplied the lenght of the step (ex. 40x0.5m). Inside the software is considered the angle in its individual steps. Infact, if you measure a non-linear inclinometric case, the diffence of the tube's lenght and his deepness should be cospicuous.
OG390WIN allows to execute the elaboration (differential or absolute) in different ways (usefull to evaluate the datas in different way sto confirm or exclude measurements problems):

- On 4 guides (4 guides option in the printouts screen only for 4 guides set);
- On the guides A3/A4/B3/B4 (option 2-3-4 guides in the printouts screen only for 4 guide set);
- On A1/B1, mono guide (not racommended)(option 1 guide on the printouts screen);
- Using only A accellerometer (only 4 guides set) placing the sensitivity to A=25000 and B=0;
- Using only B accellerometer (only 4 guides set) placing the sensitivity to B=25000 and A=0;

N° numero del passo (1 valori di testa)

A1 e B1 misure asse A e B 1° calata
A2 e B2 misure asse A e B 2° calata
A3 e B3 misure asse A e B 3° calata
A4 e B4 misure asse A e B 4° calata

Passo

Inclinazione direzione scelta come G1

Inclinazione direzione ortogonale alla G1

N°	A1	A2	B3	B4	B1	B2	A3	A4	Spira.	
1	164	-170	-165	160	42	-52	44	-63	0	
2	177	-175	-177	178	8	-15	12	-19	0	
3	205	-232	-221	214	-17	5	-19	-8	0	
4	248	-249	-249	248	18	-22	26	-24	0	
5	244	-244	-244	239	45	-48	44	-45	0	
6	231	-231	-232	230	57	-54	55	-52	0	
7	217	-219	-216	220	64	-58	63	-62	0	
8	207	-204	-207	199	51	-54	52	-56	0	
9	154	-158	-157	157	52	-56	47	-54	0	
10	134	-139	-128	137	69	-64	71	-66	0	
11	159	-158	-163	154	60	-63	62	-65	0	
12	171	-172	-173	176	74	-75	73	-72	0	
13	186	-189	-184	188	76	-70	81	-75	0	
14	206	-205	-208	204	80	-83	82	-81	0	
15	215	-232	-214	212	44	-48	44	-62	0	
16	218	-221	-219	222	17	-9	15	-8	0	
17	217	-211	-216	214	0	-3	4	-3	0	Eventuali dati di spiralatura
18	219	-217	-222	221	-13	7	-9	8	0	
19	216	-217	-216	216	-17	26	-16	22	0	
20	220	-221	-219	220	-35	29	-28	31	0	
21	171	-193	-197	178	8	-19	7	-37	0	
22	191	-191	-189	188	27	-26	34	-28	0	
23	194	-193	-192	199	30	-30	33	-31	0	
24	197	-193	-196	193	32	-41	34	-38	0	
25	215	-218	-215	212	44	-37	44	-39	0	
26	228	-223	-219	229	43	-38	44	-41	0	
27	254	-253	-259	252	141	-146	144	-147	0	
28	246	-247	-250	249	135	-134	137	-130	0	
29	257	-258	-255	252	126	-129	131	-132	0	
30	258	-255	-260	257	131	-134	130	-132	0	
31	258	-261	-258	261	126	-116	127	-122	0	
32	290	-288	-277	294	137	-136	142	-137	0	
33	364	-358	-371	366	290	-293	293	-294	0	
34	358	-358	-358	364	289	-283	289	-286	0	
35	0	0	0	0	0	0	0		0	Zeri di fondo

Plots

- Absolut plots: inclinometric case position compared to the bottom place (entity and direction);
- Differential plot using summathory: inclinometric case position compared to the origin (bottom place is fixed. Calculation of entity and direction);
- Differential plot "by points": Local differential of the inclinometric tube compared to the origin (entity and direction);
- Polar plot: entity and direction of the movement in polar coordinates.

To correctly understand a displacement of the soil is needed to evaluate the differential summathory plot, "by points" and the end the direction of the movement using summathory. It helps to execute the printouts of the side by side plots and relative direction.

The polar graphic doesn't show the deepness of the movement, if the movement isn't clear look like a doodle. So isn't raccomended using it to complete under stand datas
Movement direction is given like an Est anticlockwise angle. If azimuthal correction isn't introduced Y is the first guide and X is the third guide.

If the movement quantity is near the instrumental error or null the relative direction is random (Just like in a wind meter that measure direction and speed of wind: the direction of the wind hasn't any sense if ther isn't that)

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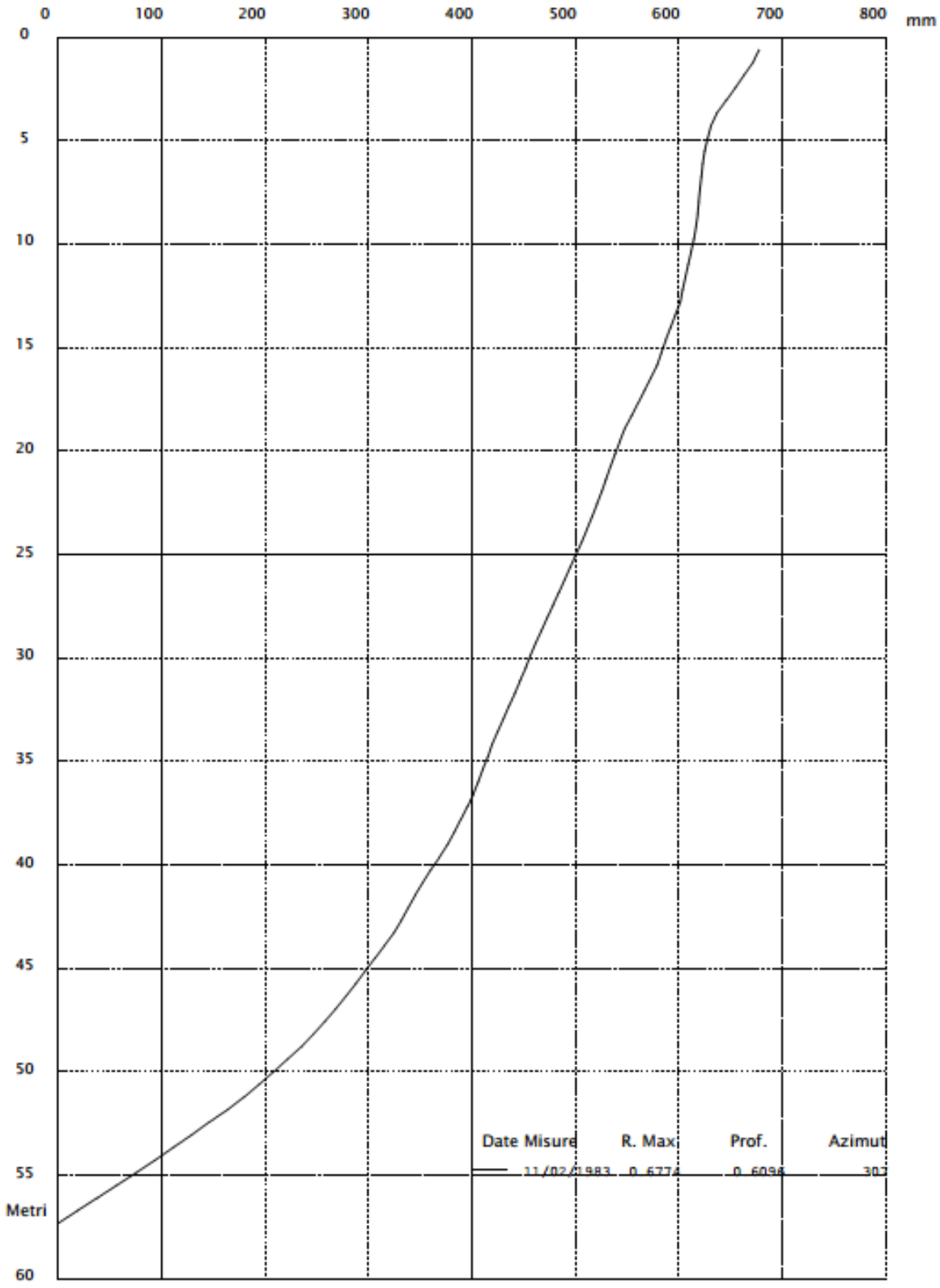
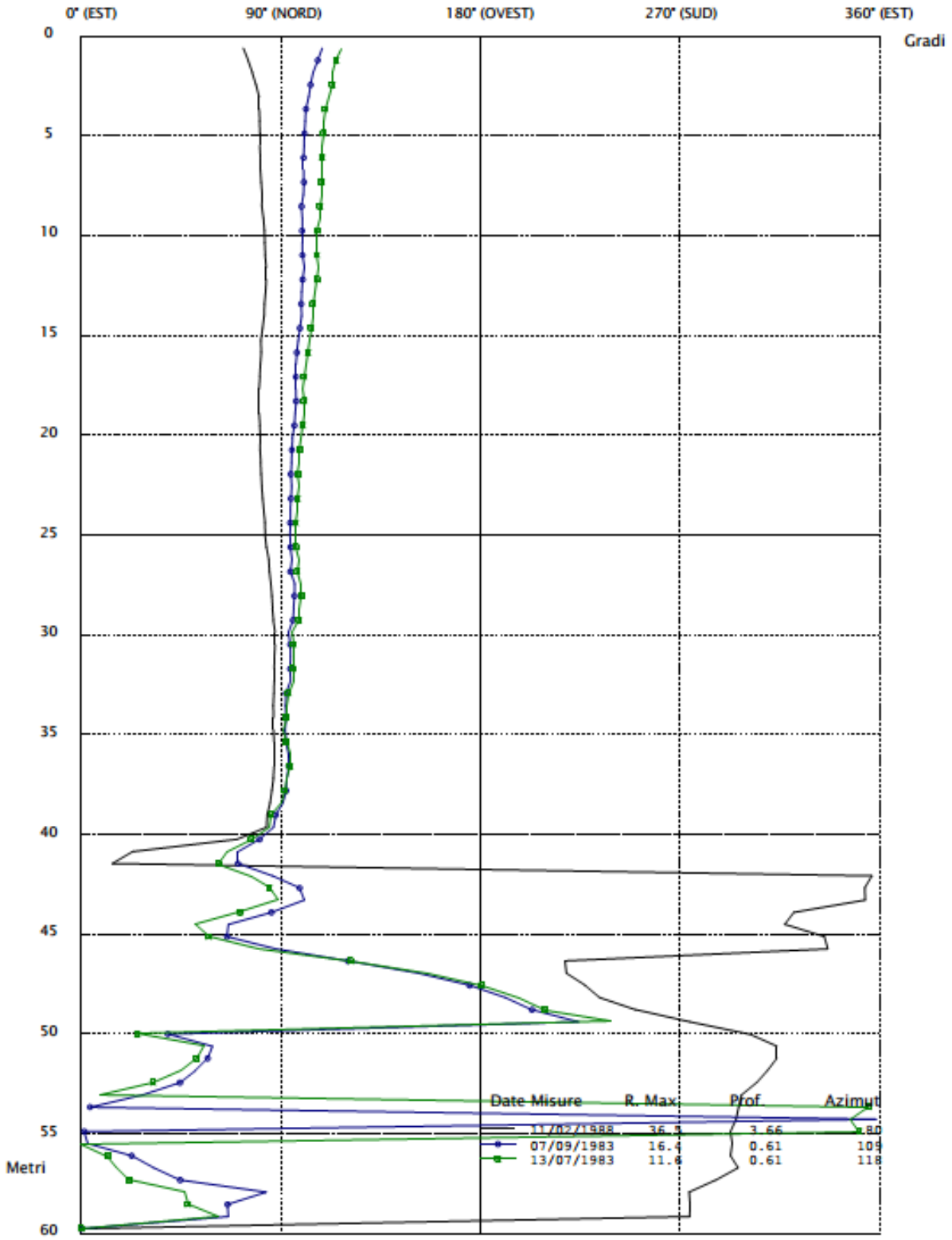
Verticality exemple (non-linearity) from the bottom.



Movement direction exemple, angles from Est anticlockwise.



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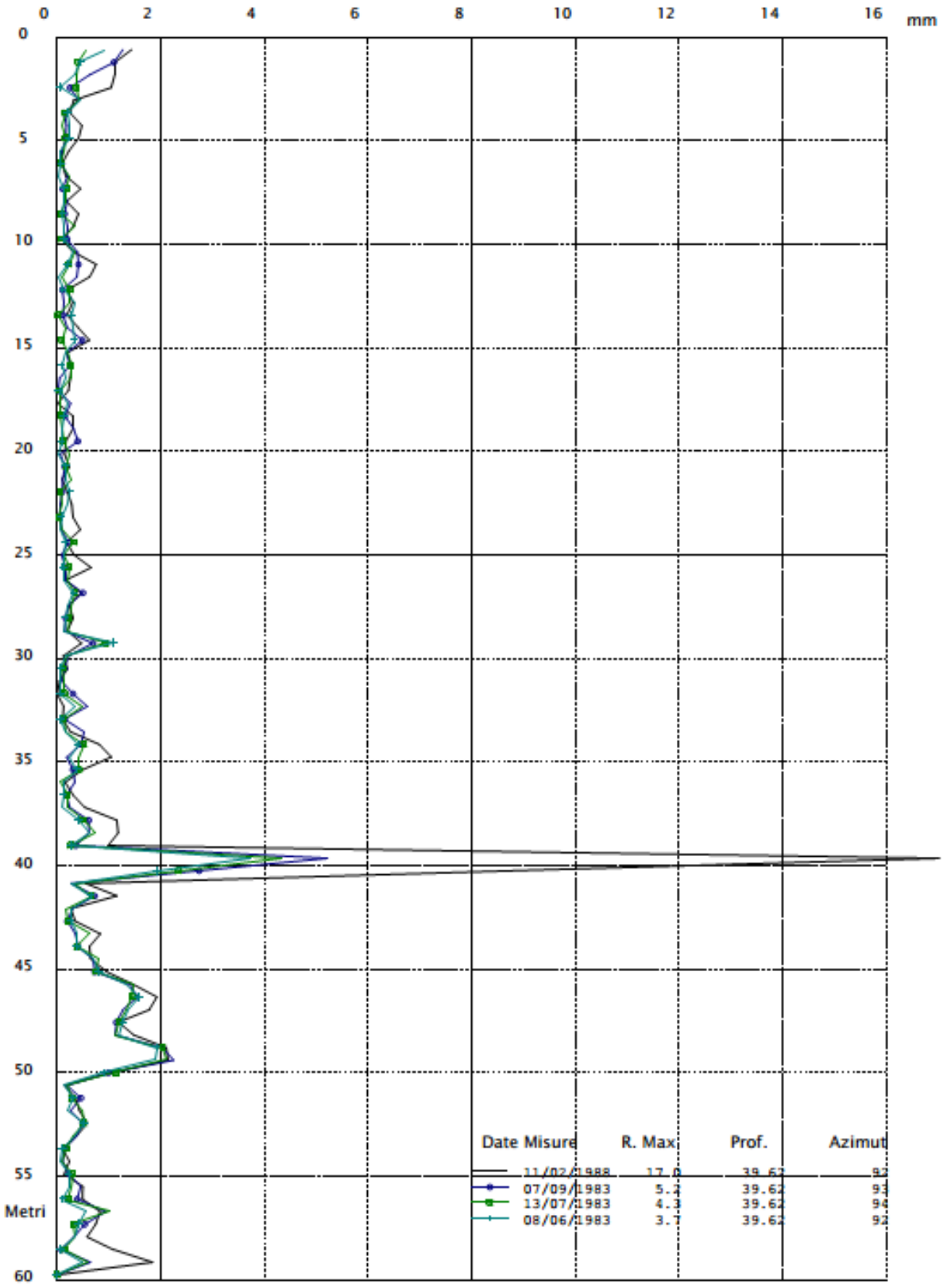
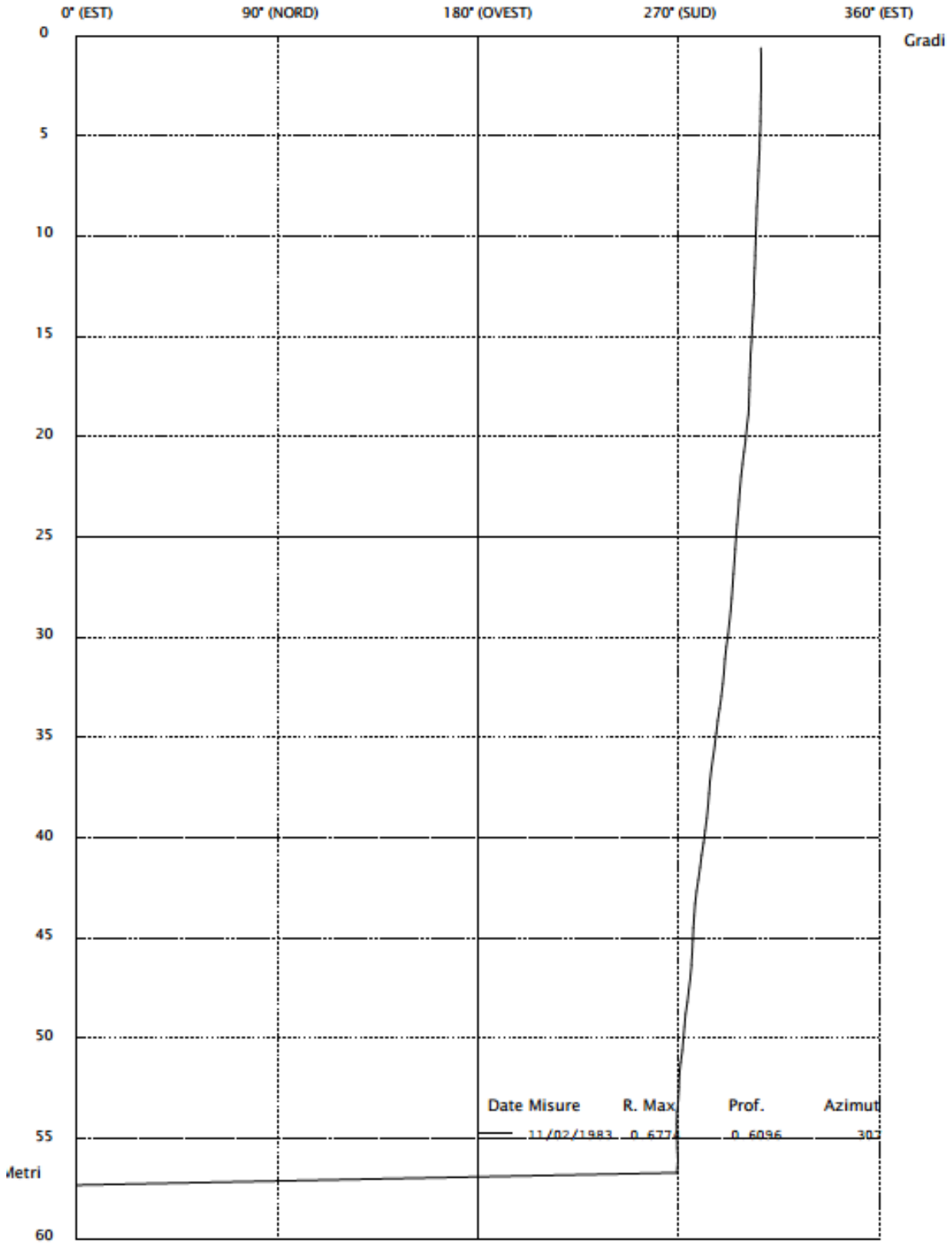
Differential/movement local/by points exemple.



Verticality direction, from the bottom, bottom fixed point exemple



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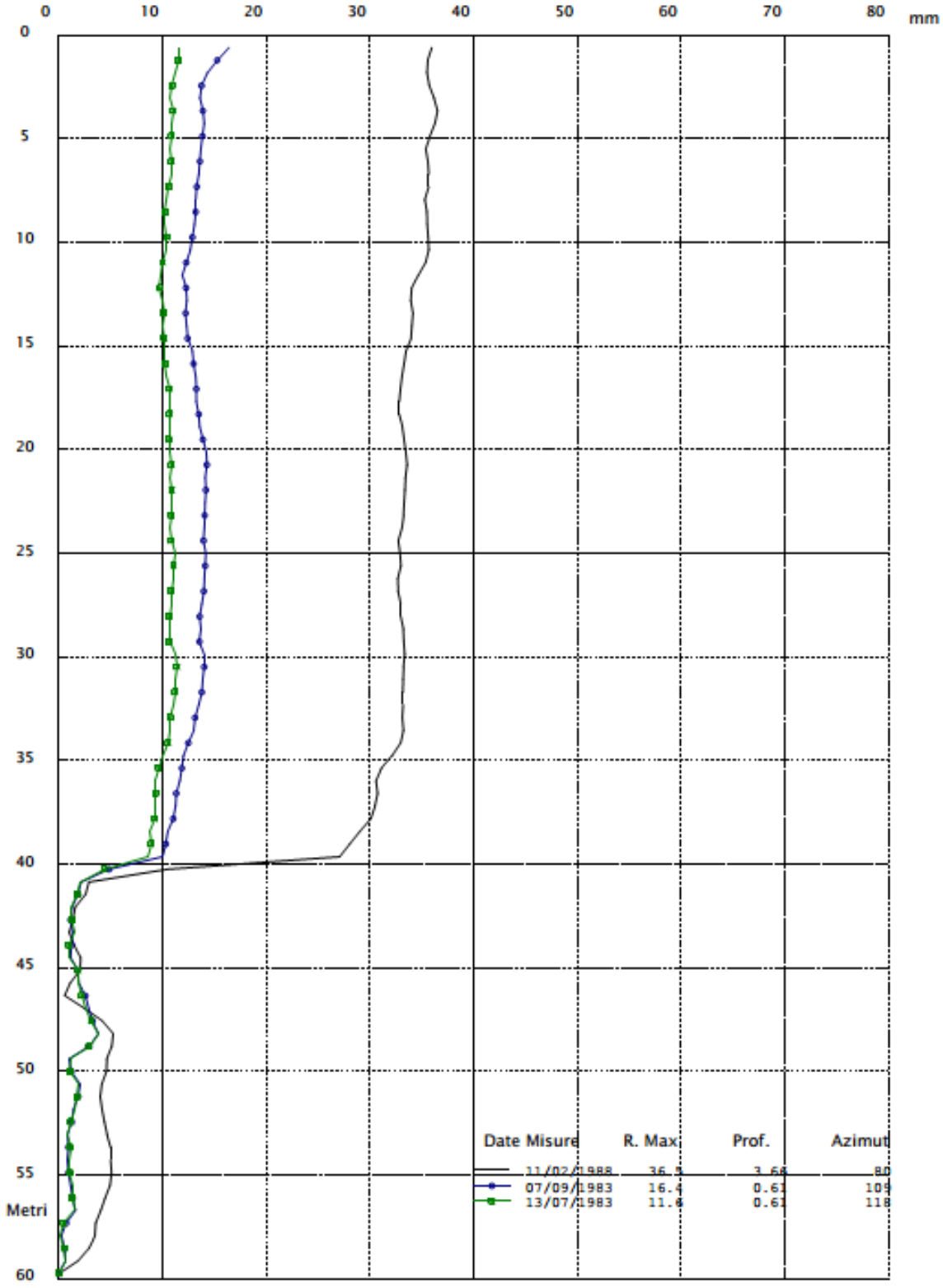
Differential summathory (displacement) from the bottom.



Procede in the following way:

- Make the differential between Aì (exercise readout) and Ai (0 readout), Bi (exercise readout) and Bi (lettura 0);
- Calculate the differential sommathory on the two axes and the complessive movement;
- Turn referal system according to the direction of guide 1 to obtain the datas expresed in Nord and Est (according to our Y and X convertions).

Measurement execution specifications

Sensibility *A* and B axes

Allows to execute a rotation of the floor where the inclinometers are placed.

Nominal parameters are:

- Sensibility A axis->25000;
- Sensibility B axis->25000;
- Angolar correction->0

This parameters mustn't be modified if it isn't extremly needed (manteinence, sensor or trolley replacement).
Precision and repeatability of the instrument are influenced from the inclinometric status of the inclinometric case, keep on your mind:

- Shape and depth of the guides;
- Problems during the installation;
- Cementation status (if the tube isn't cemented the measure won't stabilize);
- Non-linearity overall installation.

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File exportation:

OG390WIN allows the user to export files in ASCII's format:

- Placing in the main menù on the readout that has to be export;
- Press readings/calculations;
- Press "Create ASCII File";
- Set the importing file's name like <Name-File>.txt;
- It'll be created a resettable and importable file on excel that will contain:
- Compaign datas, steps, depth, measure's dates, elaborated datas in different ways.

Import of campaign data

Import from an ASCII file in Excel, the datas should be introduced inside OG390 software;
Place the following datas in the following way:

2 Guides:
- A1 / A2 / B1 / B2 following OTR convertions;

4 Guides:
- A1 / A2 / B1 / B2 / B3 /B4 / A3/ A4 following OTR conventions:
- Excel folder should contain the datas from A1 box (with out heading);
- Create the new measurement that should be import in OG390WIN and enter in Readings/Calculation;
- Press "Import ASCII" and introduce the name of the work sheet (Nome of file). The sheet name hasn't any extention;
- Press import and elaborate the datas with the nominal sensibility of the probe which has collected the measures.

In the datas importation and exportation procedure is usefull to keep on your mind to:

- Respect OTR conventions during the importation (direction;sequence of guides, etc.)
-
- The created files has an UK english format during the exportation: decimal seperator (point);
-
- It isn't possible to compare measurement executed with different steps (Ex. 0.500 m / 1.000 m / 24" ...);
-
- It isn't satisfing compare measurements with different placements (Ex: probe's wheels beating in different case position of 10-20cm);

Possible comparison of two different probes, besides respecting the measure and placament convention, need further insights on the sensibility compensation and angle but they aren't subject of this manual.