

Digital Inclinometer Pro User Manual





What's this manual about?

This manual tells you about the Digital Inclinator Pro and how to use it to take readings of lateral deflections.

Who does this apply to?

Installers, field engineers and technicians using the Digital Inclinator Pro.

Welcome!

Thank you for choosing the Digital Inclinometer Pro.

This manual has been written to help you utilise all of the functions of the Digital Inclinometer Pro. Please read this manual thoroughly before use to help avoid any problems and keep it handy when using the Digital Inclinometer Pro.

Digital Inclinometer Pro.

The Digital Inclinometer Pro comprises a biaxial probe, cable reel and a rugged Tablet supplied with 'In-Port Pro' application.

The inclinometer probe measures lateral deflections using MEMS sensors, enabling the system to take highly accurate and repeatable readings whilst transferring the measurements via a digital signal for interference-free data transmission.

The system incorporates Bluetooth technology for communicating from the inclinometer reel to the Tablet, offering a complete cable free data transmitting system with no connectors to corrode or break.

The graduated cable is constructed with Kevlar, making it very strong and durable whilst remaining lightweight and consists of a metal cable marker system which, when used in conjunction with the cable gate, provides highly accurate and repeatable depth control.

With all these combined design features, the Digital Inclinometer Pro is a robust, effective and highly accurate system that is light, compact and easy to operate in any site environment.

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OVERVIEW & INTRODUCTION

Important information

The following symbols are used throughout the manual



IMPORTANT
INFORMATION



QUESTION



WARNING



TIP



Failure to observe the warning may result in injury, product malfunction, unexpected readings, loss of data or damage to the product that may invalidate its warranty.



Tips give additional information that may be helpful when using the Digital Inclinometer Pro.


PRODUCT CHANGES

Soil Instruments has an on-going policy of design review and reserves the right to amend the design of their product and this instruction manual without notice.

WARRANTY

Refer to our terms and conditions of sale for warranty information. The batteries are a consumable item and are excluded from the warranty.

DISPOSAL

Products marked with the  symbol are subject to the following disposal rules in European countries:

- This product is designated for separate collection at an appropriate collection point
- Do not dispose of as household waste
- For more information, contact Soil Instruments or the local authority in charge of waste management.

System Description

Things You Need to Know About the Digital Inclinometer Pro

ABOUT INCLINOMETERS

An inclinometer system includes inclinometer casing, a traversing probe, control cable, and tablet.

Inclinometer casing is permanently installed in a near-vertical borehole that passes through a zone of suspected movement. The probe, cable, and tablet are used to survey the casing.

The first survey establishes the baseline profile of the installed casing. Subsequent surveys will reveal changes in the profile if ground movement has occurred. Plotting these changes reveals the rate, depth, and magnitude of ground movement.

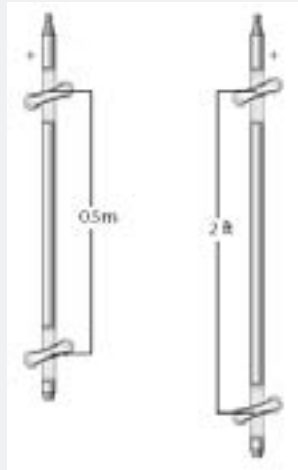
SYSTEM COMPONENTS

The Digital Inclinometer Pro system includes an inclinometer probe, Cable, a Bluetooth reel, a cable gate, and an In-Port Pro app that runs on the supplied Tablet.



THE DIGITAL INCLINOMETER PRO

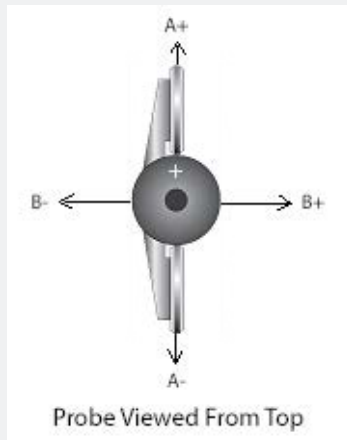
The Digital Inclinometer Pro is supplied in metric and English versions. The metric version has a gauge length of 0.5m. The English version has a gauge length of 2 feet. A + mark is engraved on the body of the probe. This is used to orient the probe during a survey.



MEASUREMENT AXIS

There are two MEMS tilt sensors inside the probe. The A-axis sensor measures tilt in the plane of the wheels. The B-axis sensor measures tilt in the plane perpendicular to the wheels.

When the top of the probe is tilted in the + direction, tilt values are positive, and when the probe is tilted in the - direction, tilt values are negative.



PROBE CABLE

The cable is used to control the depth of the inclinometer probe. It also conducts power and data between probe and reel.

- Metric probe cables have half-meter graduations with labels every meter. The first graduation is 0.5 meters from the top wheels of the probe.
- English probe cables two-foot graduations with labels every four feet. The first graduation is 2 feet from the top wheels of the probe.

HANDLING THE PROBE

The inclinometer probe is a sensitive measuring instrument. handle it with care.

- When you insert the probe into the casing, cup the wheels with your hands to compress the springs and allow a smooth insertion.
- When you lower the probe into the borehole, do not allow it to strike the bottom.
- When you withdraw the probe from the casing, again cup the wheels with your hands to prevent them from snapping out.
- When you rotate the probe, keep it upright and perform the rotation smoothly.
- The probe is rated for temperatures from -20 to 70°C (-4 to 158°F). Avoid using the probe in temperatures outside this range.

CABLE GATE

The cable gate is pushed onto the top of the inclinometer casing to serve as the reference for the depth graduations.

During the survey, successive cable graduations are locked into the cable gate to hold the probe steady for readings.

The cable gate fits three diameters of casing: 85, 70, and 48 mm (3.34, 2.75, and 1.9 inch).

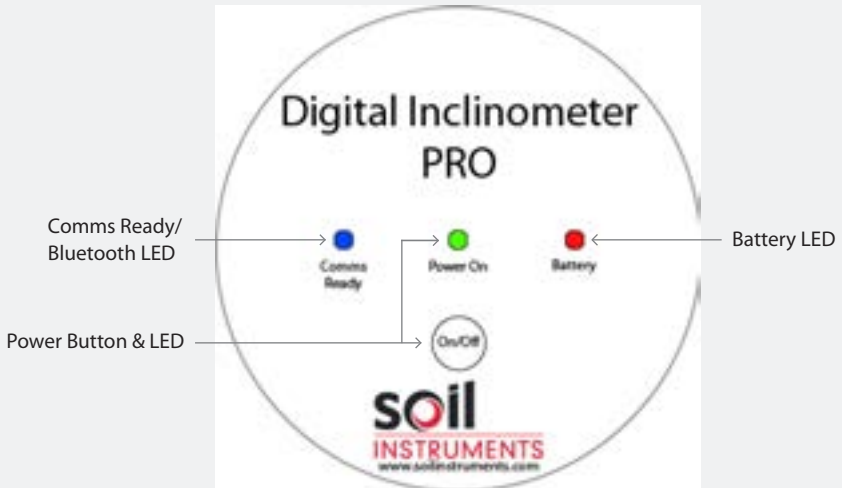


BLUETOOTH REEL

The Bluetooth reel provides a convenient way to carry the probe, control cable, and cable gate. The reel transmits commands and data between the tablet and the probe. A battery pack inside the reel powers both the reel and the probe.

FRONT PANEL LED'S

The front panel has three LED indicators and a power button.



POWER BUTTON & POWER LED

Press to switch on. Press again to switch off. The Power LED glows green when power is on. The reel switches off automatically after 5 minutes without a bluetooth connection or after 10 minutes if no commands and data are transmitted between tablet and probe.

COMMS READY/ BLUETOOTH LED

The Comms Ready/Bluetooth LED blinks slowly while the Bluetooth reel waits for a connection, then glows a steady blue when the connection is made.

BATTERY LED

The Battery LED stays off during normal use. A fully-charged battery provides about 40 hours of operation. If the battery charge is very low, the Battery LED blinks red when you first switch on the reel.

QUICK START GUIDE

Using the Digital Inclinometer Pro

BEFORE YOU GO TO SITE

- Unpack the Digital Inclinometer Pro, retaining the packaging for future carriage to Soil Instruments for calibration.
- Charge the Digital Inclinometer Pro by carefully following the charging procedure below;
- Check that there is sufficient battery power in the tablet by tapping on the battery icon located on the top right hand side of the home screen. Ideally the battery should be over 50%; however the tablet will function at a lower level

CHARGING THE BATTERY

Plug the AC adaptor into a wall socket. Insert the barrel-plug into the charge socket on the back side of the reel.

The Battery LED glows a steady red while the battery is charging. When charging is finished, the green Power LED blinks slowly.

You can charge the battery every night. A charging circuit inside the reel limits charge time to 5 hours.

If the battery is fully discharged, a full recharge may take longer than 5 hours. In that case, it is possible to reset the charge timer by disconnecting and then reconnecting the AC adaptor.

The adaptor provides 12 Vdc. Polarity of barrel connector is +ve inside and -ve outside.



Follow the charging procedure outlined in this manual at all times to properly maintain the Digital Inclinometer Pro System. Only use the charger supplied, using other chargers will invalidate the warranty.



Please retain the packaging supplied with the Vertical Digital Inclinometer System to ensure safe carriage when returning to Soil Instruments for future calibration. Soil Instruments will reduce calibration costs if the system is returned in its original packaging.



The Digital Inclinometer System and tablet are fully charged during the manufacturing process, however, Soil Instruments advise you to follow the correct charging procedures before first use.

In-Port Pro App Overview

IN-PORT PRO SOFTWARE

Tap the In-Port Pro icon to open the app.

Survey: Tap to start a survey from the inclinometer list.

Scan: Tap to start a survey from a QR code.

Plot: Tap to show plots and data.

Share: Tap to send new surveys by email or dropbox.

Tablet Hard Buttons: Physical buttons located at the bottom of the tablet

Menu: Press to show options menu.

Home: Press to return to tablet home page.

Back: Press to go back to previous page.

ACTION BAR

The 'Action Bar' contains tap icons that vary depending on the screen.

Add (Inclinometer)

Done

Cancel

Pause (Survey)

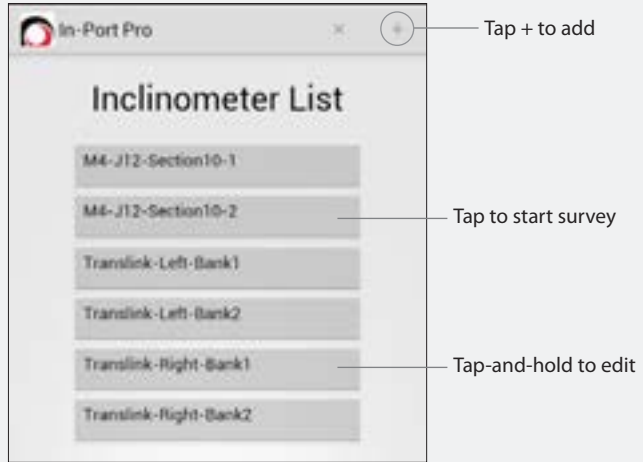
Adding An Inclinometer

THE INCLINOMETER LIST

The App keeps a list of inclinometers along with the survey data for each inclinometer. To see the list, tap the Survey icon (See right).

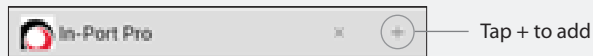


- To add an inclinometer to the list, tap the '+' symbol.
- To start a survey, tap the inclinometer you wish to use.
- To edit an inclinometer, tap-and-hold the inclinometer.



ADDING AN INCLINOMETER

1. Tap "Survey" to display the list of inclinometers.
2. Tap "Add" to display the inclinometer form.



3. Make entries as explained below. If the keyboard hides part of the form, slide the form upwards with your finger.

4. Tap "Done" when the form is complete.

Field	Value
Site	Translink
Inclinometer	Left-Bank 1
Description	Under Manhole 2
A0 Direction	180
Units	Metric
Display Unit	mm
Depth Unit	m
Interval	0.5
Top Depth	0.5
Bottom Depth	25

FIELDS ON THE INCLINOMETER FORM

Site & Inclinometer: These two fields are used together to identify an inclinometer. Each field can contain 12 characters.

Description: Optional. (35 Max Characters)

A0 direction: Optional. Compass heading 0 to 359.
North = 0, South = 180

Units: Tap to switch between metric and English units.

Display Unit: Use mm for metric probe and Inch for English probe.

Depth Unit: Fixed to meters or feet.

Interval: Typically 0.5 for metric and 2 for English.

Top Depth: Typically 0.5 for metric and 2 for English.

Bottom Depth: Enter a multiple of 0.5 for metric systems or a multiple of 2 for English systems.



If the probe is 0.5m gauge length then select metric. Likewise for the imperial probe, if the gauge length is 2ft then select English.



The app turns a field red if it finds an unacceptable entry. Check that you have entered no spaces, punctuation, or special characters. Also check that the top and bottom depths are multiples of the interval.

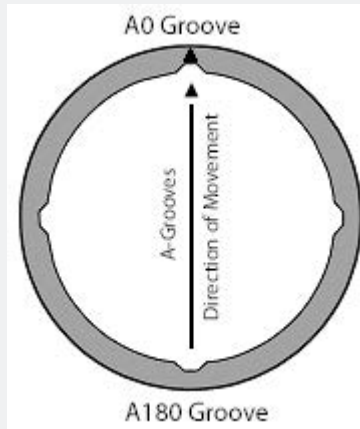
Recording Inclinometer Surveys

During a survey, the probe is drawn from the bottom to the top of the inclinometer casing. This is called a “pass”. A complete survey consists of two passes, a “0 pass” and a “180 pass”.

A-GROOVES

Inclinometer casing is installed with one set of grooves aligned with the expected direction of movement (downhill or towards the excavation). These are the “A” grooves.

Only the A-grooves are used in the survey. The A0 groove is usually marked for easy identification.



To maintain accurate depth control, cut the inclinometer casing as level as possible after installation to ensure the cable gate fits securely over the casing. You must not cut the casing if readings have been taken previously.

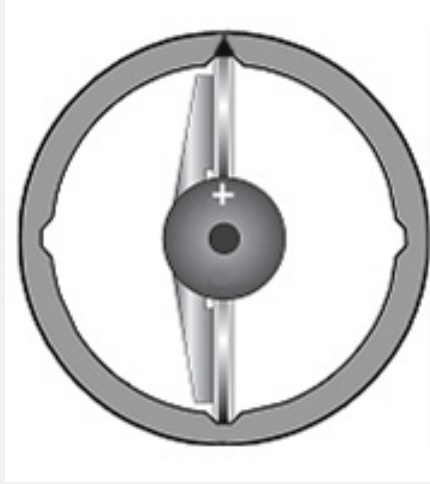


Soil Instruments recommend marking the A0 direction on the inclinometer casing with a permanent marker to make sure the borehole is always read with the correct orientation.

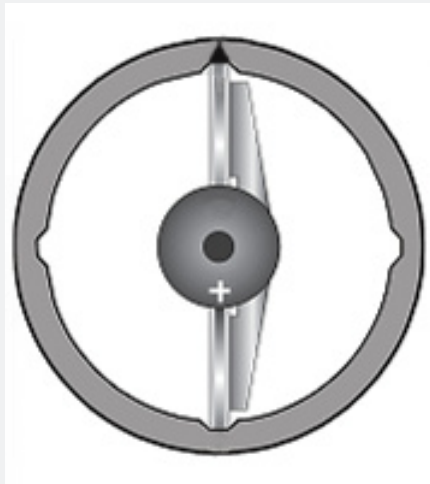
ORIENTATION OF PROBE

0-Pass Readings: For the 0 pass, insert the probe with the + mark facing the A0 direction.

The + mark appears on the body of the probe above the top wheel set.



180-Pass Readings: For the 180 pass, remove the probe, rotate it 180°, and insert it with the + mark facing the A180 groove.



THE SURVEY SCREEN

The survey screen guides you through the survey.

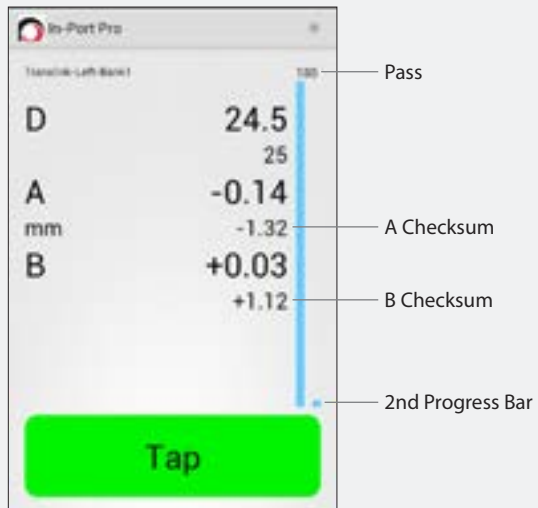
0-PASS SCREEN

The elements of the survey screen are explained below.



180-PASS SCREEN

The 180-Pass screen adds checksums and a second progress bar.



SURVEY BUTTONS The record button is yellow when readings are not stable. The record button is green when readings are stable and ready to record. If the button stays yellow or flickers between green and yellow, tap to record the reading anyway.



Wait for stable readings



Readings are stable.
Tap to record

The record button is orange at the beginning and end of each pass. Tap "Start" to enable recording. Tap "End" to disable recording. This prevents accidental recording of readings while you position the probe.



Tap to start recording



Tap to end recording

CHANGING THE ACTIVE DEPTH

If cable depth and "active depth" get out of sync, tap & hold the active depth until arrows appear. Tap the arrow to change the depth. Then move the probe to the new depth and tap OK to resume the survey. The new "in-sync" readings overwrite the previous "out-of-sync" readings.



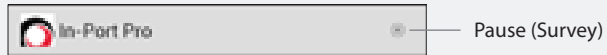
Tap & hold the active depth

Tap arrow to change the depth

Move the probe to the new depth,
then tap 'OK' to resume the survey

HALTING A SURVEY

1. Tap Pause to halt the survey for any reason.



2. Make a choice, then tap OK. Or tap Cancel to resume the survey.



Abandon: Deletes the current survey.

Bookmark: Sets a bookmark at the last recorded reading.

Done: Saves the current survey as is. This is useful if you are correcting a few readings and then want to stop.

RESUMING AN INTERRUPTED SURVEY

The app automatically stores a "bookmark" with each recorded reading. If the survey is interrupted, you can resume the survey from the last recorded depth.

1. Tap the inclinometer to start a survey in the normal way.
2. Tap OK to start the survey from the bookmark. To abandon the bookmarked survey and start a new survey, choose New.



RECORDING THE SURVEY

1. Switch on Reel and Reader. Tap the In-Port Pro icon to start the app. Wait for a steady blue glow from the Bluetooth LED to show that a connection has been made.



2. Tap "Survey"



3. Tap the inclinometer to survey.



4. The reader displays the start depth for the survey. Insert the probe, with + mark facing the A0 groove, and lower it to the start depth.



Do not allow the inclinometer probe to drop to the bottom of the borehole of its own accord as this will result in damage to the inclinometer probe components and calibration.



Pay special attention to ensure that the inclinometer cable markers are never dropped into the cable gate. Always make sure that the cable markers are placed into the cable gate at each depth to avoid the risk of causing cable damage or marker slippage.

5. Place the cable gate onto the casing and lock in the cable.

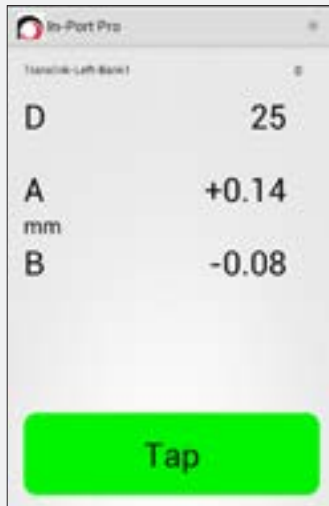
6. Wait ten minutes for temperature adjustment. You can switch off the tablet while you wait.

**RECORDING THE
0-PASS**

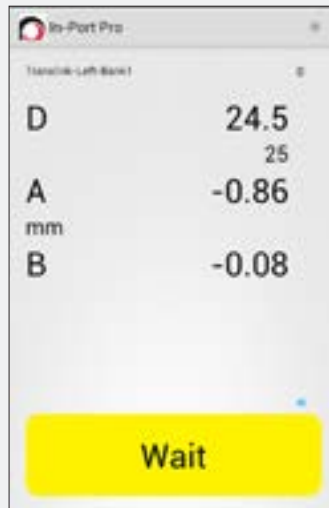
1. Switch on In-Port Pro and tap “Start 0 Pass”



2. The A and B readings appear. The probe has been immobile, so readings are stable. Tap to record.



3. The tablet displays the next active depth. Raise the probe to this depth and wait for stable readings. The last recorded depth appears just below the new active depth.



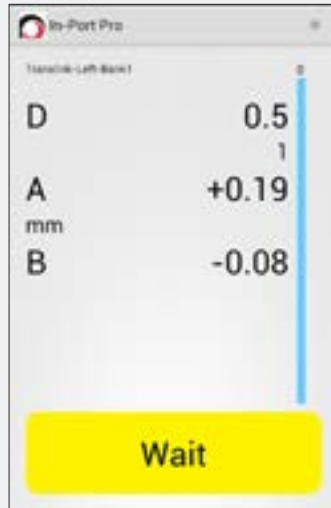
4. Tap the record button when it is green.

5. The tablet displays the next active depth. Raise the probe to this depth, wait for stable readings, and then tap the record button.

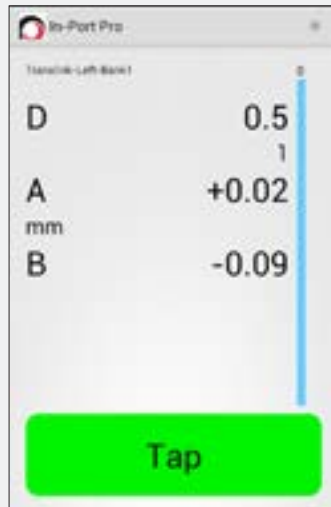
6. Repeat these operations until the probe reaches the top depth.



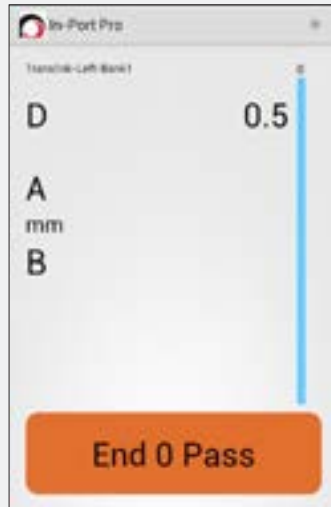
Now the tablet displays the top depth. Raise the probe to this depth and wait for a stable reading.



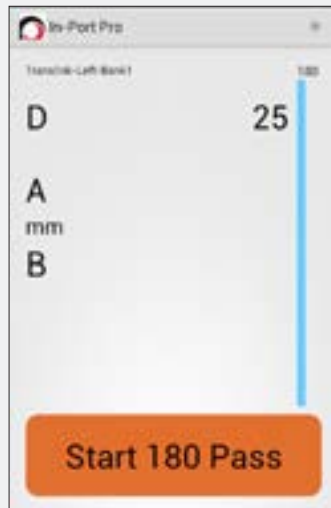
7. Tap when the record button is green.



8. Tap "End 0 Pass". This disables recording so you can handle the probe.

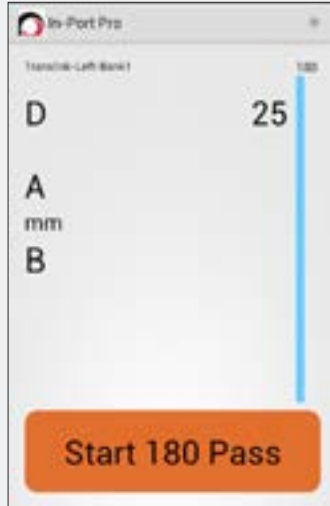


9. Now the tablet displays the start depth for the 180-Pass. Recording is still disabled. Remove the probe, rotate it 180 degrees, and insert it with the + mark facing the A180 groove. Lower it to the start depth.

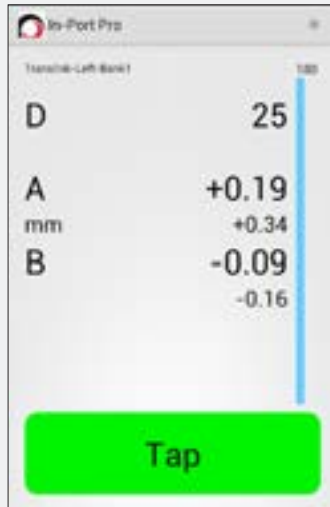


RECORDING THE 180 PASS

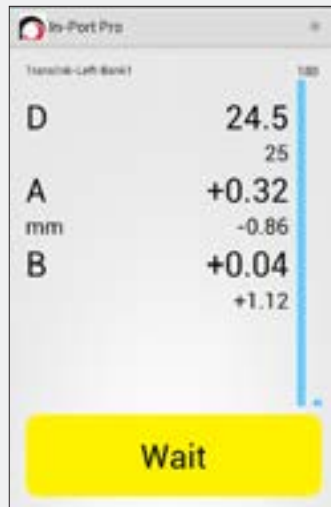
1. Tap "Start 180 Pass". This enables recording.



2. Tap the record button when it is green. You can see checksums now.

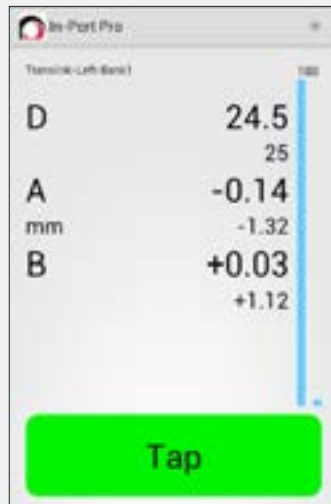


3. The tablet displays the next active depth. Raise the probe to this depth and wait for a stable reading.

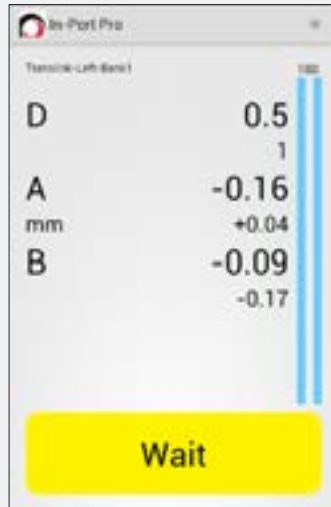


4. Tap the record button when it is green.

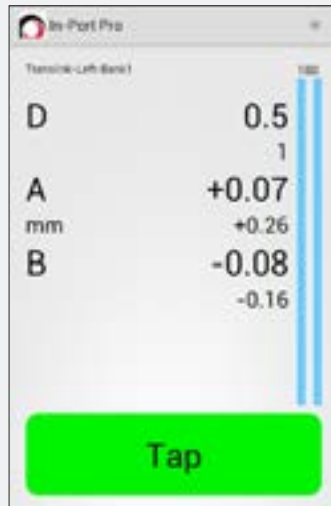
5. The tablet displays the next active depth. Raise the Probe to this depth, wait for stable readings, and then tap the record button. Repeat these operations until the probe reaches the top depth.



6. Now the tablet displays the top depth. Wait for a stable reading.

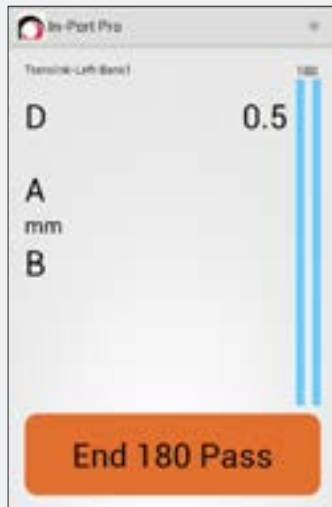


7. Tap the record button when it is green.



6. Tap "End 180 Pass". The survey is complete.

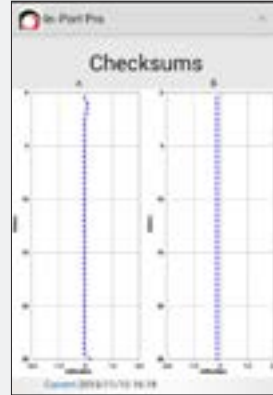
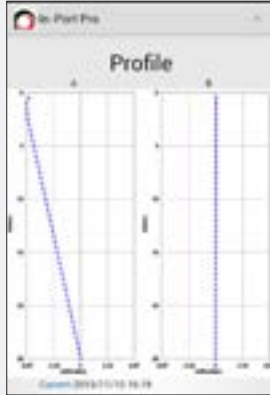
The app saved readings during the survey so there is no need to save anything now. When you tap the "End" button, the app takes you to the "Plot" screen.



DETAILED SOFTWARE GUIDE

Plotting Inclinometer Surveys

INTRODUCTION The In-Port Pro app can display four types of plots. These are useful for validating the survey. These plots cannot be printed directly, but if necessary, you can take screen shots, transfer them to a PC, and print them using Word. For more control of plots and printing, we suggest using the In-Profile software.



CHECKSUMS Checksums are the sum of the 0 and 180 reading at each depth. The ideal checksum is 0. In practice, checksums are typically some small non-zero value. Checksum plots are displayed in the reading units used in the survey.

CHANGE FROM INITIAL 'Change in initial' shows the change in profile (cumulative displacement). There are three profiles shown: current-initial, last-initial, and initial-initial (which plots on the 0 line).

CHANGE FROM LAST This plot shows also shows cumulative displacement, but in this case, the change in profile is plotted as current - last, and last-last (which plots on the 0 line).

PROFILE This plot shows cumulative deviation, the profile of the casing.

VIEW DATA This shows a table of data. If your checksum plot shows a bad reading, look at the data table to identify the depth and pass (0 or 180) of the bad reading. If you are still on site, you can reopen the survey and make the correction with the inclinometer probe. The steps are:

1. Tap and hold the depth the the bad reading.
2. Choose 0 or 180.
3. The Reader displays that depth and a live reading. Orient the probe for 0 or 180, insert it into the casing, and lower it to the depth displayed on the Reader.
4. Click OK to enable recording. Tap the record button to record a replacement reading. Continue upwards as needed, or tap the "Pause" button to exit the survey.

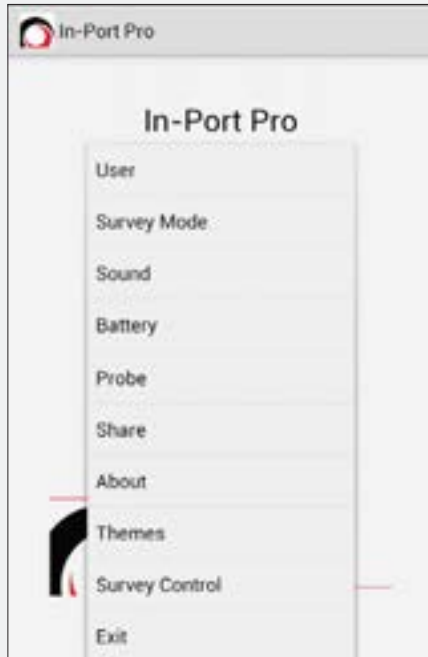
Advanced Borehole Features

AUTORUN (HANDS-FREE MODE)

As well as manually recording the readings the system can automatically record readings with nothing more than a pull on the cable.

You can switch between the two methods of readings whenever you like, even if you are already partway through a run.

Press the 'Menu' hard button on the tablet. Then select "Survey Mode"



Select "Tap" for manual survey or "Hands-Free" for the Autorun survey.



When performing the run this way, the prompt buttons at the bottom of the screen will change in the following way.



"Pull" will appear to inform you to pull the cable up to the next depth marker, this will initiate the saving process.



"Save" will appear once you have pulled the cable to the next depth to inform you the readings are being saved.



"Wait" appears when the readings are not within the predetermined stability range. The prompt will disappear once the unit is stable.

QR CODE FEATURE

Once a borehole has been completed and imported to the evaluation software, you can then print a QR code for that specific borehole. This QR code can then be stuck to your borehole to help you initiate a run in the future.



Tap the Scan icon (See right). This will take you to a QR scanner.



The scanner will read the QR code and take you straight to the readings page. This his method will allow you to initiate the run even if you are using another tablet that doesn't have the borehole programmed. It uses the data in the QR code to create the borehole so you don't have to.

Sending Data Files to a PC

There are three ways to transfer inclinometer files (.dux files) from the Reader to a PC.

1. USB (Completely manual, requires USB connection cable).
2. Email (Partially automated, requires internet access).
3. Dropbox (More automated, requires internet access).

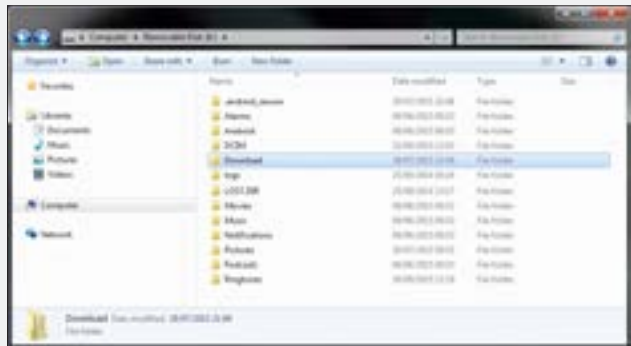
USB TRANSFERS

This method requires the USB cable supplied with your Reader device and the Windows file manager (Windows Explorer).

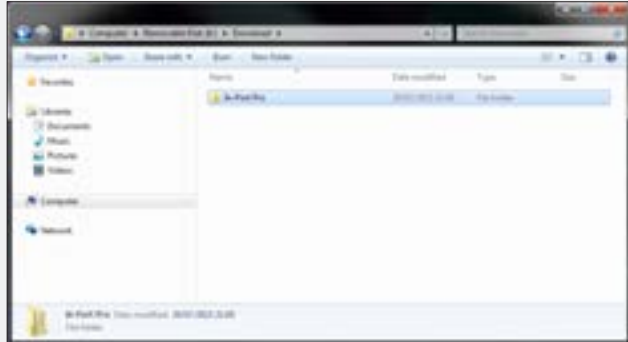
1. Connect the tablet to the PC using the USB cable. Open 'My Computer' and select the device. It should appear as a removable disk drive.



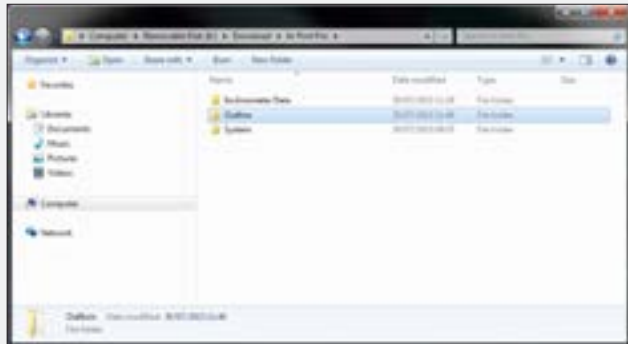
2. The app can be located inside the 'Download' folder.



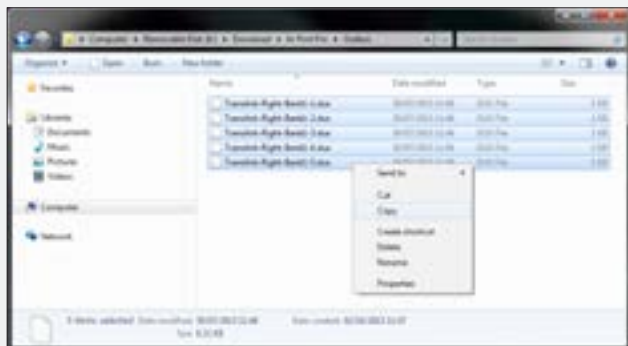
3. Click on the In-Port Pro folder.



4. Click on the "Outbox" folder. This folder holds any updated inclinometer files.



5. Copy all the .dux files in the Outbox and paste them into a folder on your PC.

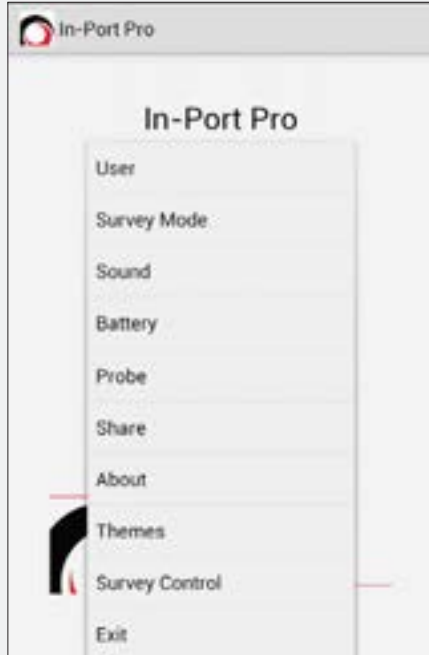


6. (Optional) Verify that the .dux files are on your PC, then delete the files in the Outbox. This has no effect on the "real" inclinometer files in the tablets Inclinometer Data folder.

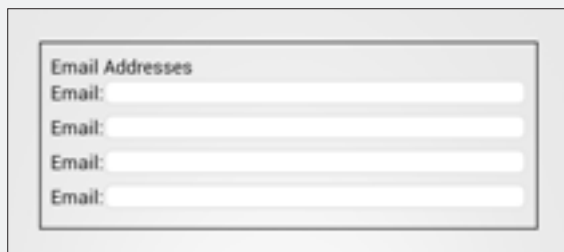
EMAIL TRANSFERS This method sends the inclinometer files as email attachments and requires an internet connection. You can use Gmail or an email client configured for your company's exchange server.

**SETTING UP
EMAIL RECIPIENTS**

1. Setup is a one-time task. Press the 'Menu' hard button, then "Share".



2. Enter one or more email addresses. Then tap Done.



EMAILING FILES

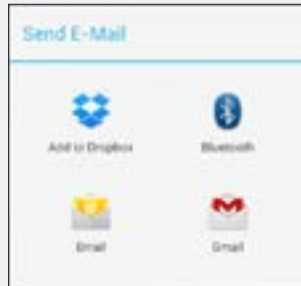
1. Tap the 'Share' icon.



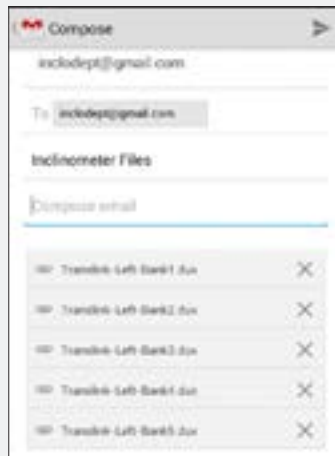
2. Tap Share.



3. Tap Gmail. If your Reader has been setup for exchange server, you can also tap the E-mail icon.



4. The Reader attaches files automatically. Tap Send.



5. When the email arrives, the recipient saves the attached files into a folder on the PC.

DROPBOX TRANSFERS

Dropbox is a “cloud storage” service that you can use for file transfers. The process explained here should also work with services offered by other companies, so long as they support Windows and Android devices.

1. Download the Windows Dropbox program from Dropbox.com. After you run the setup program, create a Dropbox account. Accounts are free or paid. Log in to the account and create a folder to hold inclinometer data.
2. Download the Android Dropbox app from the Google Playstore.
3. Run the Dropbox app on your tablet and log in to your new account. The tablet stays linked to Dropbox, so you don't have to do this often. Now you're ready to transfer files.

SENDING FILES TO DROPBOX

1. Tap the 'Share' icon.



2. Tap Share.



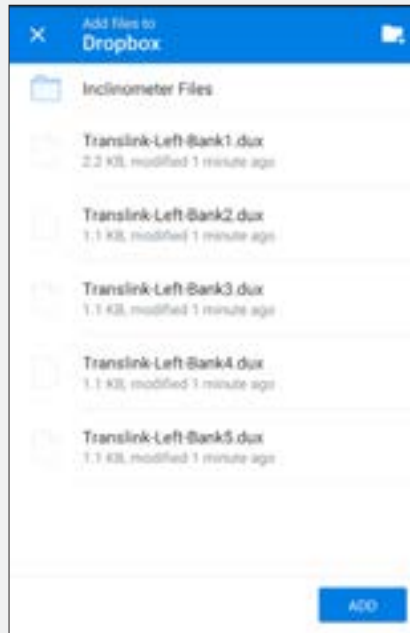
3. Tap Dropbox (or any other cloud storage service).



4. Dropbox will open up showing your list of folders and files. This should be empty when you first open the program. To upload the files, simply tap the "Add" button. The program will then start the upload to your Dropbox.

Note: This process will vary with other cloud based storage services.

5. Soon afterwards, the files appear in the Dropbox folder on your PC. (Look for the folder in My Documents).



Options Menu

OPTIONS LIST

Press the 'Menu' hard button on the tablet.

User: Change the user name. The user name is recorded with each survey.

Survey Mode: Choose "Tap" or "Hands-Free". In Hands-Free mode, the record button says "Pull" when the readings are stable. When you pull the cable, the app records the most recent stable reading.

Sound: Choose the sound that the reader makes when you record a reading.

Battery: Displays battery level of the Reader. Does not display the battery level of the Reel.

Probe: Displays "live readings" from the probe. Tap the units label to specify different units (Keep in mind that metric units should be used with metric probes and English units should be used with English probes).

Share: Enter email addresses for sending data files by email.

About: Displays embedded serial number and firmware versions.

Themes: Light theme shows black text on a light background. Dark theme shows white text on a black background. If visibility is a problem, try changing the theme. The theme takes effect when you display a different screen.

User
Survey Mode
Sound
Battery
Probe
Share
About
Themes
Survey Control

SURVEY CONTROL These settings can improve your surveys.

Stability: This is the variation allowed for stable readings. The default value is 6 sine units, equivalent to 0.03mm or .001 inch. If your readings take a long time to stabilise, consider using a value up to 12.

Motion: When a reading exceeds this number the app assumes the probe is in motion. Used for hands-free mode. If the app fails to detect your pulls, try setting a lower number. Users who pull slowly need a lower number and users who pull quickly need a higher number. Normal values are 80 to 100.

If there is a lot of vibration at the site, tap mode may be your only choice, but you could try setting "motion" to a higher number and then make your pulls quick, rather than slow. The higher number decreases sensitivity to the ground vibration, but you must accelerate the probe faster so that a pull can be detected.

Tap Lockout: This tells the app how long to display the "saved" message. During that time, the app will not accept new input. The default is 2 seconds.

Pull Lockout: Same as above, but used for hands free mode. Lockout is more important for hands-free mode. Experiment to find the right lockout timing. New users may be more comfortable with a lockout of 3 seconds or more. Expert users who develop a rhythm may prefer a 2 second lockout.

Exit: Turns off the bluetooth connection and closes the app.

Technical Details

READING UNITS The Digital Inclinometer Pro records tilt readings as $100000 \times \sin(\theta)$, where θ is the angle of tilt. During the survey, the Reader app displays the following units:

Metric Units: mm of deviation, assuming a 500mm gauge length.

English Units: Inches of deviation, assuming a 24 inch gauge length.

FILES AND FOLDERS

The In-Port Pro app creates a .dux text file for each inclinometer. The .dux file contains inclinometer parameters and all surveys for that inclinometer. New surveys are appended to the end of the file. Transferring inclinometers and data is a matter of copying these .dux files from one location to another location.

The In-Port Pro app creates the following folders:

In-Port Pro: Top Level folder.

Inclinometer Data: This folder holds all the inclinometer (.dux) files. The Reader app scans the Inclinometer Data folder to create its list of inclinometers.

Outbox: This folder holds a copy of any .dux inclinometer file that has been updated with a new survey. All the file transfer methods use files in this folder.

System: Holds system files. It contains the bookmark file which allows any interrupted survey to be restarted with no loss of data. Most files are machine-readable, not human-readable.

FILE MANAGEMENT

The final repository for your inclinometer data should be a database on your PC or network. The .dux files on the Reader should be regarded as temporary, not long term.

Inclinometer Data: This folder holds the “original” files. As mentioned above, the app scans the inclinometer folder to create its list of inclinometers.

- If you want two readers to have the same list of inclinometers, copy the .dux files from one Reader to the other.
- If you want to remove an inclinometer from the list, delete its .dux file in the inclinometer data folder.

Outbox: After you transfer the files from the tablet to the PC, you can delete the files in the Outbox, either with the “Empty Outbox” button on the Reader or via a file manager.

MAINTENANCE GUIDE

Maintaining the Digital Inclinometer Pro System

ROUTINE MAINTENANCE

Although the Digital Inclinometer Pro System is a robust unit, it still needs to be treated with care and properly maintained.

The Digital Inclinometer Pro System is supplied with a cloth for removing moisture and dirt and an oil pen for maintaining the moving parts, such as the wheel assemblies. It is important that these components are kept clean and regularly oiled to preserve the quality of the parts.

The Digital Inclinometer Pro System and all its components should be wiped clean and the wheel assemblies oiled after each use.

CABLE MAINTENANCE

When using the inclinometer on site, the cable needs to be well maintained and kept away from all sharp or abrasive objects that could cause cable damage. For this purpose, we recommend that after the cable has been fully extended to the bottom of the borehole and the A0 reading process has started, that the inclinometer's cable is either wound back onto the inclinometer hub or placed in a suitable container. If multiple data sets on one borehole are required, it may be more appropriate to have a dedicated container on site to place the inclinometer cable into. The cable should be placed in an orderly fashion, ensuring no kinks and twists are present.

It is important to pay attention to how the inclinometer is used in conjunction with the cable gate. The inclinometer cable markers should never be dropped into the cable gate. You must ensure that at each depth the cable markers are placed into the gate; if this is not adhered to you risk the possibility of applying additional stresses into the cable. If the cable markers are dropped into the cable gate, depending on the height at which they are dropped, there is the risk of causing cable marker slippage. If this were to occur, the readings would be offset at each depth and would not align with previous readings taken on the same borehole.

It is essential that any twist on the cable is reversed immediately. This may only be noticed when the inclinometer is replaced in its cradle on the reel, however all that is required to reverse the twist is that the probe is rotated, as required, until there is no more twist in the cable. This twisting may not always be obvious; to ensure that you can see any twisting that is occurring, we recommend that the cable is cleaned and inspected regularly.

Probe Inspection

WHEEL BRACKET **Bracket does not return to fully extended position:**
If the bracket is dirty, clean it. If the problem persists the spring may be broken or weak.

WHEEL **Wheel does not run/spin freely:**
Lubricate the wheel bearings with light machine oil.

Probe Maintenance

MOISTURE MANAGEMENT Wipe off the instrument cable and probe when you finish the days final survey. Do not store wet cloth with the probe.

Lubricate the wheels. This helps displace moisture.

WHEELS Lubricate the wheels by applying drops of a light machine oil on the wheel bearings. Do *not use* WD-40 or any other lubricant spray that contains chlorinated solvents. Wheels should be lubricated at the end of each day of usage, prior to storage of the probe.

Cable Inspection

CABLE **Twists:**
Twists indicate a poor coiling technique. Change practice - do not pull the cable over the side of the reel - reel off and reel on.

Work markings:
The user is dragging the cable through the cable gate. Change practice - pull cable out then up.

Kinks and/or gouges:
If the kinks do not straighten, there is probably internal damage and likelihood of intermittent reading failures. If there are any deep gouges, water can enter the cable. In both cases the bad section of cable must be removed, either by shortening the cable or replacing the cable.

Cable Maintenance

MOISTURE MANAGEMENT Wipe off the instrument cable as you draw the probe up on the last run of the day.

CABLE When necessary, rinse cable in clean water or wash the cable in a detergent.

Do not use solvents to clean the cable. Do not submerge the reel.

APPENDICES

Appendix A - Data Download Format and Manual Data Reduction

Soil Instruments have designed and developed a powerful data interpretation software package called 'In-Profile' to analyse Digital Inclinometer System data. If a user chooses to manually reduce the inclinometer data outside of this software, they should only do so providing they have full competency. Soil Instruments cannot be held liable for incorrectly manually reduced data. We offer the following guidelines to reduce Soil Instruments Digital Inclinometer System data:

DATA REDUCTION VARIABLES

Inc =	Displacement over the probe length
G =	Gauge constant for probe (Metric = 0.01, Imperial = 0.001)
A+ =	Commonly referred to as A0 results. A axis results from first run in direction of expected movement, leading wheel direction
A- =	Commonly referred to as A180 results. A axis second runs results 180° from direction of expected movement, trailing wheel direction
B+ =	Commonly referred to as B0 results. B axis results from first run in direction of expected movement, leading wheel direction
B- =	Commonly referred to as B180 results. B axis second runs results 180° from direction of expected movement, trailing wheel direction

DATA REDUCTION TO INCREMENTAL DATA

A axis Inc =	$((A+) - (A-)) / 2 * G$
B axis Inc =	$((B+) - (B-)) / 2 * G$

DATA REDUCTION, ABSOLUTE PROFILE

Accumulate Inc results at each depth to obtain the absolute profile

DATA REDUCTION, CUMULATIVE PROFILE

Subtract the previous absolute profile from the current absolute profile to get the change in deflection

Appendix B

CHECKSUMS

The readings screen on the tablet shows two checksum boxes. The checksum is the 0° direction reading (e.g. A0) at each depth added to the 180 degree reading (e.g. A180).

In an ideal situation, these two readings would be exact opposites of each other and cancel each other out, giving a checksum of zero, however, checksums are rarely zero due to manufacturing tolerances in the probe and very small differences in both the 0° and 180° position of the probe wheels; in other words, the probe is never exactly in the same place, so the readings are never exactly opposite.

The checksum is still of use to you as a check that all depths have been correctly read for the A0 and A180 directions; if a depth is missed, the checksums from this point onwards would be very large. It is also useful for checking that the probe is not showing any sign of deterioration as the checksums at each depth should be;

- **Approximately the same**
- **Consistent along the length of the borehole**

Checksums should only be of concern, no matter what their actual numeric value, if they fall outside the parameters above. It is worth remembering that if the readings are taken near a casing joint, the checksums for these readings may present a false error. If all of the other checksums are consistent, then this also is quite normal.

CALIBRATION

Any inclinometer system should be regularly calibrated to ensure that the readings taken with the system are accurate. Soil Instruments recommends that the Digital Inclinometer System is calibrated on a yearly basis.

Appendix C – Frequently Asked Questions



Q: What is the advantage of measuring cable marks from the top wheels?

A: The Digital Inclinometer Pro system displays readings as mm or inches of tilt, and this reading applies at the depth of the top wheels. The Soil Standard Systems cable markers are measured from the middle of the probe, but this has some unexpected effects when the readings are plotted:

Metric Plots:

Digital Inclinometer Pro system: A reading taken at 10 m is correctly plotted at 10 m, as you would expect.

Soil Standard System: A reading taken at 10 m is correctly plotted at 9.75 m, which you would not expect.

Imperial Plots:

Digital Inclinometer Pro system: A reading taken at 30 feet is correctly plotted at 30 feet, as you would expect.

Soil Standard System: A reading taken at 30 feet is correctly plotted at 29 feet, which you would not expect.

The drawing shows a probe in tilted casing. We can overlay the probe with a right triangle. The vertical side of the triangle is the gravity vector. The hypotenuse of the triangle is the gauge length - the distance between the top and bottom wheels of the probe. You can see the tilt angle at the bottom of the triangle.



The tilt angle applies anywhere along the length of L . The tablet displays readings in sine units (the sine of the angle of tilt), which also apply anywhere along the length of L .

The tablet records sine units, but when it displays a reading, it multiplies the sine value by L , the gauge length of the sensor (500mm or 24 inches) to display a reading in mm or inches. This value applies only at the top of the triangle, as in the illustration, which is the elevation of the top wheels of the probe. Thus we measure cable marks from the top wheels of the probe, so that the reading is shown at the proper depth.



EC Declaration of Conformity

Soil Instruments Ltd., located at 34 Bell Lane, Uckfield, East Sussex, TN22, 1QL, United Kingdom.

We hereby declare that the devices described below are in conformity with the directives listed. In the event of unauthorised modification of any devices listed below, this declaration becomes invalid.

Type: DIGITAL INCLINOMETER PRO
Product Model: C17-PRO series

Relevant EC Directives and Harmonized Standards:

With Radio equipment (Class 1) for data transmission (built in Bluetooth module), the product to which this declaration relates, is in conformity with the essential protection requirements of **R&TTE Directive 1999/5/EC 2004/108/EC** Electromagnetic Compatibility directive, as amended by **EN61326-1, ed3**

The product(s) to which this declaration relates is in conformity with the essential protection requirements of 2004/108/EC Electromagnetic Compatibility directive, as amended by EN61326-1, ed3. The products are in conformity with the following standards and/or other normative documents:

EMC Harmonized Standards: EN 61326-1:2006 Lab Equipment, EMC

- IEC61000-6-3:2007 Emission standard for residential, commercial and light-industrial environments
- IEC61000-4-2:2008 Electrostatic discharge immunity test
- IEC61000-4-3:2006 Radiated, radio-frequency, electromagnetic field immunity test
- IEC61000-4-4:2012 Electrical fast transient/burst immunity test
- IEC61000-4-5:2005 Surge immunity test
- IEC61000-4-6: 2008 Immunity to conducted disturbances, induced by radio-frequency fields
- IEC61000-4-11:2004 Voltage dips, short interruptions and voltage variations immunity tests

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The items comply with all applicable Essential Requirements of the Directives.

Philip Day

Date: 07 January 2016

A handwritten signature in black ink, appearing to read "Philip Day", is written over a horizontal line.

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