



POLARES

ELECTRICAL IMAGING SYSTEM IN ALTERNATE CURRENT

USER MANUAL



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P.A.S.I. srl - via Galliani 5/E - 10125 TORINO - ITALY
Tel.+39 011 650.70.33 Fax +39 011 658.646 E-MAIL sales@pasisrl.it
www.pasigeophysics.com

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POLARES in the minimum configuration with 16 electrodes

ELECTRICAL IMAGING

Electrical Surface Imaging (ESI) is based on the acquisition of a large number of electrical measurements made on a fair number of electrodes placed on the ground along a profile.

The reconstruction of the vertical profile of the investigated soil profile through imaging is made using special processing software that typically uses the Finite Element Method (FEM). With this method, the ground below the electrodes is ideally divided into a finite number of meshes or cells (so-called "FEM"), each with uniform and unknown resistivity. The elements are generally square or rectangular and their sizes are determined by the electrode spacing (half the spacing between two adjacent electrodes). Without going into the mathematical treatment of the problem here, it can however be said that, in reconstruction through imaging, the unknown quantity is the distribution of resistivity in the ground, while the electrical measurements made on the ground are the known quantity.

The Polares device has been studied and designed to eliminate down-time associated with the movement of the electrodes according to the sequence of the acquisitions programmed for the type of spreading chosen (dipole-dipole, Wenner, etc. ...).

In fact, following the procedure for conducting a traditional electrical sounding, the user would have to move the electrodes for each measurement made; with this instrument, the approach is much faster and more effective and can be summarised as follows:

- the electrodes are all fixed in the ground in accordance with the desired spreading before carrying out the sounding and they are connected to the signal distribution units (multiplexer)

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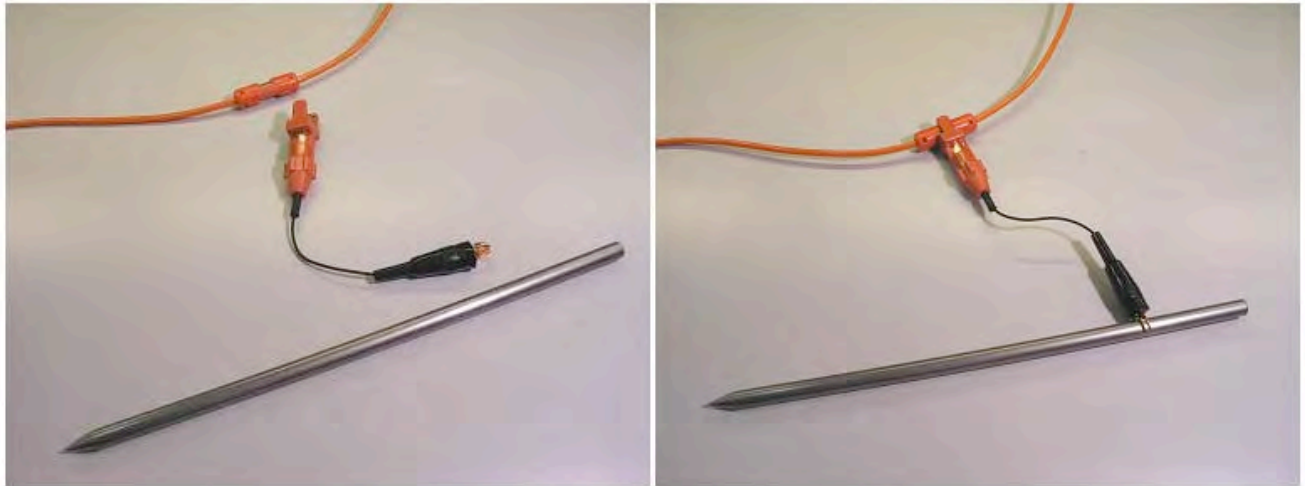
- the most suitable type of spreading for the particular application is selected on the instrument
- start of automatic acquisition

At this point, it is the instrument that takes control of work and communicates continuously with the distribution multiplexers sending them the information necessary to change the function of the various electrodes: each spike driven into the ground is therefore "changed" case by case into **A, M, N, B or disconnected** electrode, depending on the measurement made and the type of spreading chosen. The acquisition cycle programmed by the user is activated by the instrument for each pre-selected configuration. As they are acquired, the values are displayed so the trend of the measurements can be checked immediately and, at the same time, stored in an internal memory

The sounding can be stopped at any time and then resumed without having to start all over again.

The logarithmic or semilog diagram AB/2-Apparent Resistivity diagram (for methods that permit it) or a linear or logarithmic pseudosection can be displayed.

The following picture shows the connection of a spike to the cable:



For the instrument to work properly, it is important:

- to make sure the battery terminal polarity is correct (red on + terminal and black on – terminal)
- press the button to switch on the instrument only after properly connecting the battery in a fixed position (wait a few seconds for the monitor to show the management program)
- cut off the battery power only when the program is on the main screen (the one that appears at the start)
- pay attention to the alarms that are displayed and act accordingly
- sometimes, due to particularly humidity conditions, or when the connectors accidentally fall into water, major transmission or safety problems may arise. In this case it is recommended to dry all contacts with the help of a compressed air bottle. It is therefore advisable that the instrumentation includes an efficient compressed air bottle suitable for drying the contacts before they are used so that the work can

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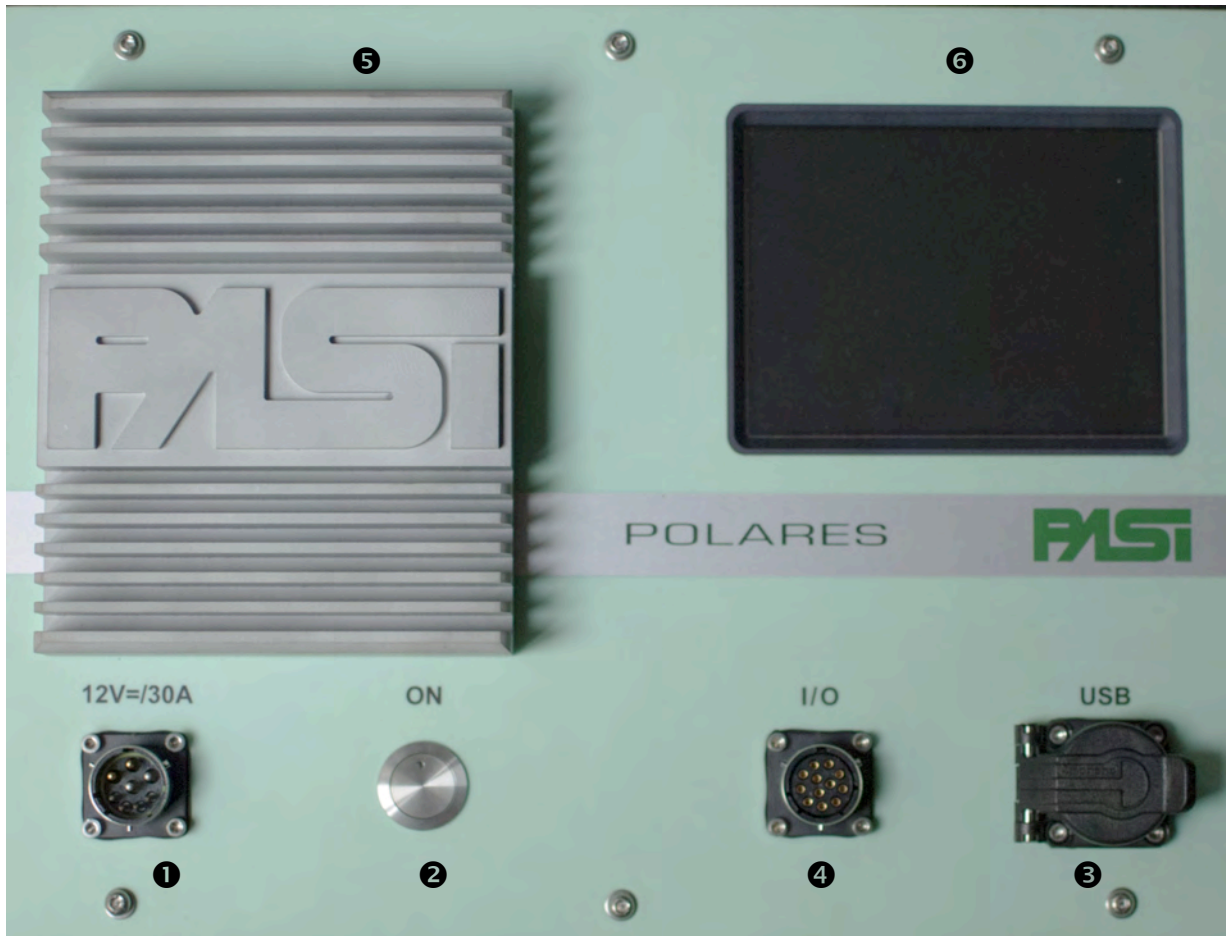
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be performed in perfect safety. If the connector has been immersed in water for several seconds you should not use it and call the Manufacture for advice on what to do

- in case of technical problems, refer to the Appendix.
- read the entire manual at least once and do not improvise when problems arise!

DESCRIPTION OF THE SYSTEM



The front panel of POLARES

1. Power supply connector (12Vbattery)
2. ON button
3. USB socket
4. I/O Connector for the electrodes with the derivation multiplexer (Box)
5. Heat dissipator for the power supply
6. Colour monitor with touch screen

The connections



→ to next
MUX...

Electrode numbering

The Polares imaging system has two forms of electrode numbering: logical and physical.

Logical numbering is the progressive form that is normally used for the definition of the measurement sequences. It is the equivalent of the numbering present in all instruments of the same type. The logical numbers can go from 1 forwards.

Physical numbering is the numbering for the multiplexer outputs: the physical numbers start from 1, corresponding to the first output of the first multiplexer (the one that is connected directly to the instrument), they continue with the electrodes of the first multiplexer, they then go on to those of the second multiplexer (the multiplexer connected to the first multiplexer), and so on until the last electrode of the last multiplexer in the chain.

It is possible to configure the Polares in such a way as to have a bi-univocal correspondence between the logical and the physical numbering (this occurs in the numbering system of other instruments) or, if necessary, it is possible to modify the connection in such a way as to take into account how the electrode cable is made and/or positioned in each application.

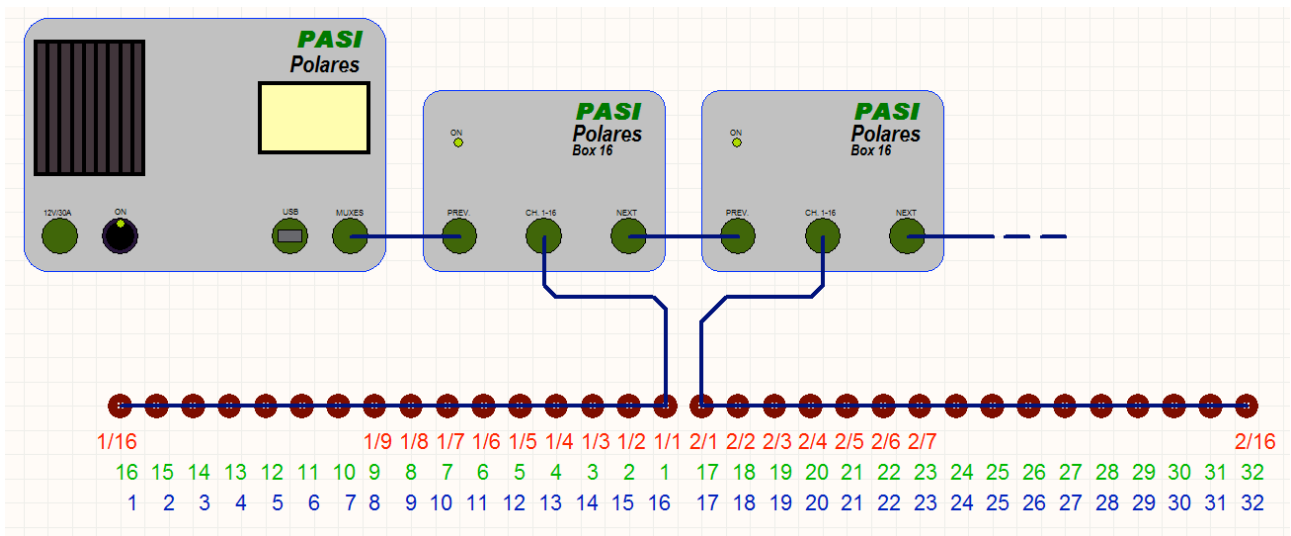
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Example of numbering:

Let us consider a system consisting of a Polares, two multiplexers, two multipolar cables for electrodes where electrode no. 1 is connected to the nearest contact to the connector and electrode no. 16 furthest away. Let us imagine we place the instrument in the middle of the sequence of thirty-two electrodes, in this case the first sixteen electrodes would be connected in reverse thereby altering the sequence required. It is possible to misalign the logical numbering (the numbering used in the sequence) from the physical numbering of the connections so as to solve the problem.

The drawing shows the numbering of the electrodes for the connection to each multiplexer highlighted in red, the physical numbering corresponding to the previous numbering but with a continuous progression from each multiplexer to the next in the chain is shown in green. The required logical numbering is in blue.



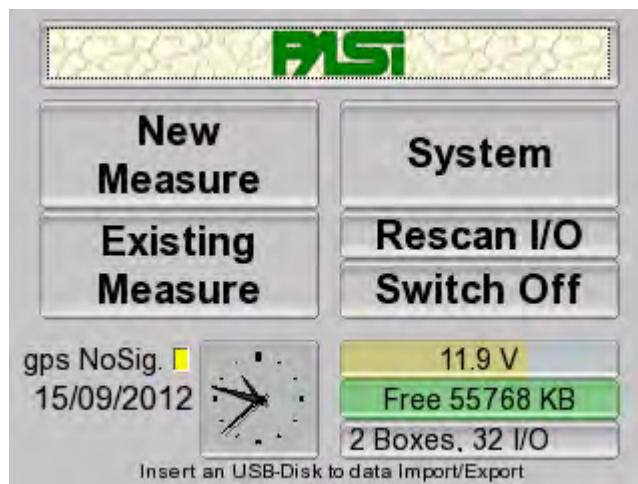
USE OF THE IMAGING SYSTEM

Connect all the multiplexers as described, then connect the battery and switch on the instrument by pressing the appropriate button; on switch on the connected accessories are recognised. The number of the multiplexers and the number of electrodes detected are shown at the bottom of the main screen that appears on the display a few moments after switch on.

Use of all the software functions is possible via the touch screen: the function of each key drawn is activated by pressing the centre of it with your finger; a line in a list is selected by pressing it with your finger; it is possible to input numeric or alphanumeric data in a field by pressing the field with your finger. This brings up a virtual keyboard that allows you to key in the value required again through the use of the touch screen.

The main screen

The main screen that appears a few moments after switch on looks like this:



The bottom part shows the current date and time, the battery voltage (dependent on the charge status) and under it the number of the multiplexers and the electrodes that the system has detected at switch on.

There are four keys above the indications that make it possible to turn on and access four software functions and yet above that the manufacturer's logo which when pushed leads to the page where the software version is identified. An example might be:



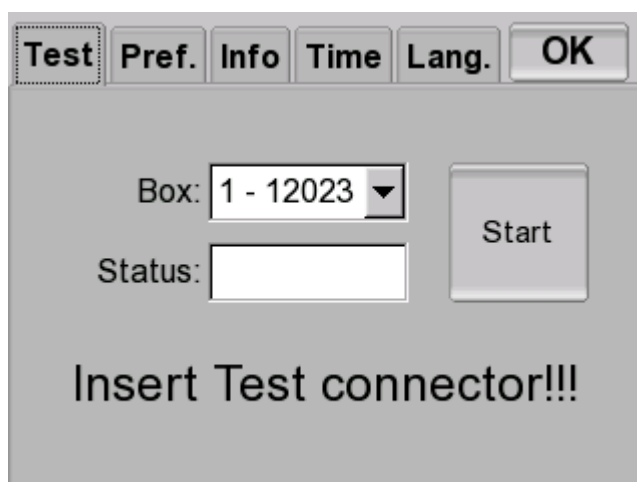
O.S. indicates the version of the Linux operating system that manages the computer that handles the user interface. SW is the software version that it is using, FW is the version of the firmware of the DSP calculation system that deals with the digital processing of the signals in real time. S/N is the serial number of the device.

By pressing “OK” you go back to the main page.

System operations

Pressing the “System” key on the main screen accesses the operations of the system that are gathered into as many tabs on the page that appears; when “OK” is pressed you return to the main screen.

Test:



The aim of this function is check all the connections and the proper functioning of the power generator and the distribution multiplexers. To carry out the test it is necessary to insert the test connector provided with the instrument in the connector of the electrodes of the multiplexer required, temporarily disconnecting any multipolar cable present; then select from the “Box” list the multiplexer in which the test connector has been inserted and press the

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“Start” key. The results of the check are indicated in the “Status” field. If the indication provided is not positive, it is first necessary to recheck all the connections, then rerun the test and finally, if the problem has still not been solved, contact the manufacturer to find out more about it.



How to connect POLARES to a MUX for testing with special test connector



MUX test connector

Preferences:

Test Pref. Info Time Lang. OK

Shown result Exported results

V [Volt] Ascii-Tab
 V/I [Ohm] res2dinv
 Ro [Ohm * m]

Default data file name

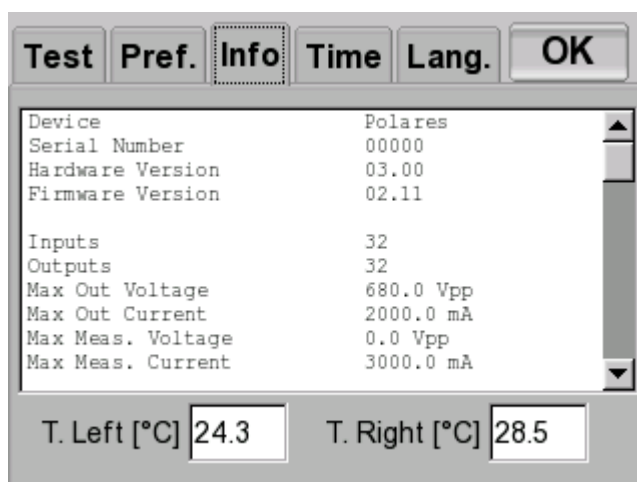
Date/Time
 File Counter:

IP Address:

On this screen it is possible to indicate a number of parameters for customized parameters, at the moment the following can be set:

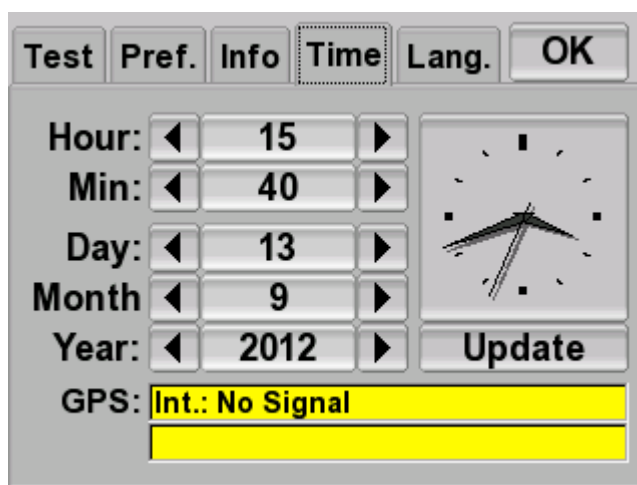
- the type of result required for each scan during the work, to be chosen among the value of the voltage detected between the electrodes M and N, the relationship between these voltages and the current flowing between electrodes A and B or, in conclusion, the resistivity value that also takes into account geometrical factors regarding the layout of the electrodes (not yet implemented)
- the progressive numbering of the measurements that functions like it does in digital cameras: when, at the end of each measurement, an identifying name is proposed to save the results, the system proposes a prefix that can be set (on another screen), followed by the progressive number of the measurement. In this way the possibility of two measurements being saved with the same name (that would results with the elimination of one of the two) is avoided. This numbering of the required value can be set here.

Information:



In the list that appears it is possible to have all the technical information about the instrument: two internal temperatures are shown at the bottom: the right-hand side of the device (the temperature of the display and the left-hand side of the device (the temperature of the heat dissipator)

Date, time and GPS:



With this tab it is possible to set the current date and time; these values are later associated with each measurement taken and they should therefore be accurate.

In addition to the information about the time of each scan of each measurement, information about the positioning detected by an internal GPS receiver (optional) is also associated with each measurement; this information includes the latitude and longitude and the height above sea level of the point the measurement is taken. Associated with each scan is a value that could be useful in the case of measurements taken on the move (field analysis on ground with pulled electrode arrays, bathymetries of rivers and lakes etc.)

Language:

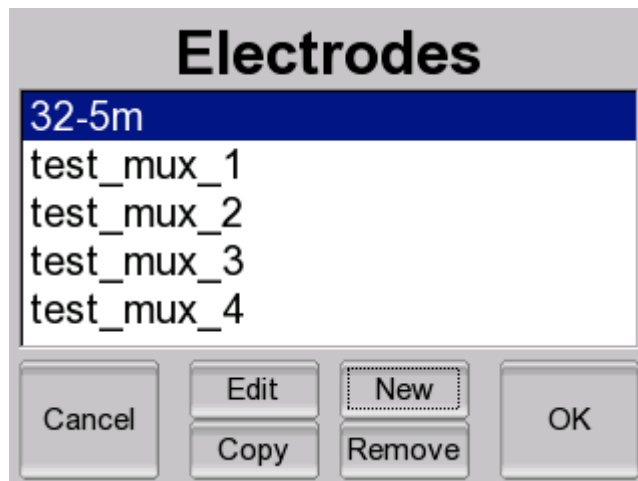


All the management software has been written in multi-language format: this page enables you to choose the language required from those present.

Taking a measurement

To take a measurement, it is necessary to select three configurations: the first is the one that describe the positioning of the electrodes, the second is the one that lists the sequence of the connections of the electrodes and the third defines a number of operating parameters.

The three configurations are chosen on three totally identical pages showing:



- a “Cancel” key to be able to go back to the previous screen
- a list with all the configurations in the system, ordered by those that are the most frequently used to the one that has not been used for some time

- an “OK” key to confirm the choice has been made and to move on to the next screen
- a “Remove” key to remove the currently selected configuration permanently from the list of configurations present
- a “Copy” key that is useful for saving a copy of the selected configuration with a different name (that will be requested)
- an “Edit” key to display the details of the selected configuration and to change one or more of them if necessary
- a “New” key for the rapid creation of a new configuration

When the “New measure” key is pressed on the main screen a new measurement starts and the definition of the electrodes is therefore required (see the electrode numbering section).

Electrode configuration:

When you press the “Edit” key on the screen for the selection of a configuration of the electrodes, the following page is accessed:

Logical	Hw	Box/IO	x	y	z
0001	0016	(01/16)	0.00	0.00	0.00
0002	0015	(01/15)	5.00	0.00	0.00
0003	0014	(01/14)	10.00	0.00	0.00
0004	0013	(01/13)	15.00	0.00	0.00
0005	0012	(01/12)	20.00	0.00	0.00
0006	0011	(01/11)	25.00	0.00	0.00
0007	0010	(01/10)	30.00	0.00	0.00
0008	0009	(01/09)	35.00	0.00	0.00
0009	0008	(01/08)	40.00	0.00	0.00
0010	0007	(01/07)	45.00	0.00	0.00

Cancel
Add
Edit
Up
OK

Remove
Down

For each logical electrode defined, the corresponding physical electrode (also called Hw from Hardware), the multiplexer and the electrode of the multiplexer to which it corresponds as well as the electrode position coordinates in metres are shown in the list.

After selecting an electrode from the list, various operations are possible using the keys underneath. With “Edit”, it is possible to change its parameters, with “Remove” the electrode can be removed, with “Add” a new electrode can be added right above it and with “Up” and “Down” you can scroll up and down the items on the list. The “OK” key is used to confirm any modifications made and, by pressing Cancel, the modifications are abandoned. In both of the last two cases the device returns to the configuration selection display.

Pressing the “New” key on the request for the configuration of the electrodes, an automatic generation function is accessed that can create the new definition required with the insertion of just a few parameters.

For example , the figure below shows the parameters that generate a useful sequence for the configuration of the example given in the section that explains the numbering of the electrodes: the total number of electrodes (32), the first physical electrode (1),the number of

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electrodes connected backwards(16), the co-ordinate X and Z of the first electrode (0 and 0), the electrode spacing in X (5 m) and in Z (0 m).

Once the configuration has been generated a descriptive name with which to save it for later use is requested; when it has been saved it will appear in the list of available configurations and it can be selected.

Configuration of the sequence:

Selecting an electrode configuration and pressing “OK”, you pass to the following menu dedicated to the sequence configuration; you can operate exactly in the same way as before. What was described above regarding the functionality of the various keys also applies to the sequences; the differences are obviously in the display/modification screen (“Edit” key) and in the automatic generation screen(“New” key).

Scan	A	B	M	N
00001	1	9	2	3
00002	1	9	2	4
00003	1	9	2	5
00004	1	9	2	6
00005	1	9	2	7
00006	1	9	2	8
00007	1	9	16	15
00008	1	9	16	14

Each sequence configuration is nothing but the indication of how many acquisitions must be made to carry out a measurement and which is the layout of the A,B,M and N connections compared with the electrodes on the ground.

The functioning of the keys under the list is the same as what is specified for the electrodes. The three keys on the right serve to change the display method: when the “Logic”

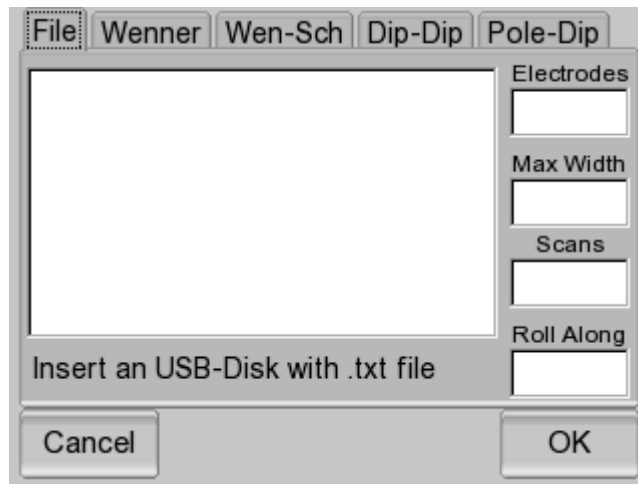
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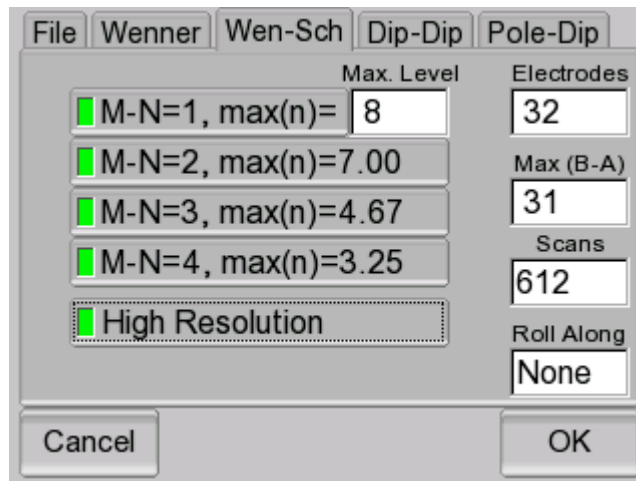
key is active , the numbers of the electrodes shown on the list are to be considered Logical; if the key showing “Hw Ch.” is active, the numbers of the electrodes shown on the list must be considered physical and, finally, when the key selected is “Box/IO” the corresponding multiplexer and multiplexer electrode is indicated for each of the four connections. If the different numbering of the electrodes is not clear, refer to the appropriate section at the beginning of this manual.

The automatic generation of a measurement sequence is obtained with the “New” key on the sequence selection screen, this operation leads to the following screen where five different methods of generating the sequence can be seen. :



The first creation method is that of importing a list written in ASCII format on a file contained in a USB key. The format consists of a first line containing four symbols “A”, “B”, “M” and “N” separated by spaces or tabs, every number corresponding with the logical electrode to be connected to the generation of the current (electrodes A and B) or the measurement of the potential (electrodes M and N). When a USB key has been inserted all the files that have the ".txt" extension are shown on the list. When one of them is highlighted, the number of the electrodes necessary and the number of sequences detected, as well as the maximum aperture required are indicated next to it (if you don't have enough physical electrodes in the field, the roll-along function will be activated).

It is also possible to generate sequences using the classical Wenner, Wenner-Schlumberger, Dipole.Dipole and Pole-Dipole (not yet implemented) spreading pressing the relative tab on the screen.

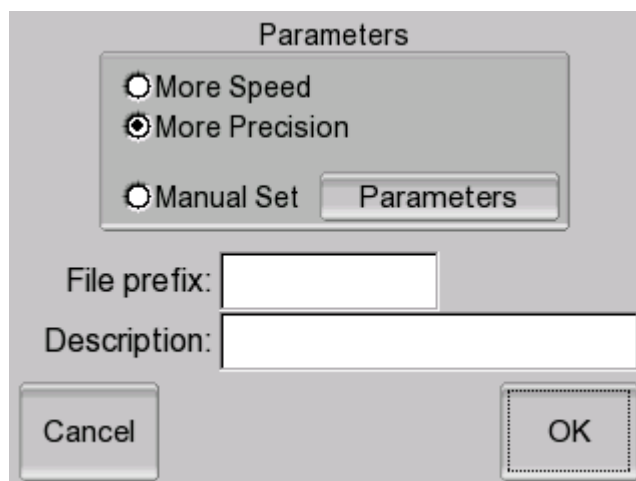


For example, to generate a Wenner-Schlumberger sequence it is necessary to indicate the related parameters.

Here too, once the sequence has been defined it is necessary to save it with a proper name in the list, where it will be possible to select it and to continue.

Parameter configuration:

After selecting a sequence configuration and pressing the “OK” key, a configuration of the parameters is requested exactly the same way as before; both the pressing of the “Edit” key and the “New” key lead to the following screen where it is possible to input a few simple parameters that will govern the performance of the measurements:



It is enough to indicate whether a fast measurement is preferred or a measurement that is slightly slower but more precise (the system calculates a mean from several measurements). It is also possible to define a prefix for the name with which each measurement will be saved: the full name will consist of the prefix followed by a progressive number (see the measurement counter in the system functions).

If a more complete check is required, the following screen appears when the "Parameters" key is pressed:

Here it is possible to indicate whether the acquisition must be obtained from the mean of 2, 4 or 8 measurements and whether the maximum acceptable phase delay between the current generated and the voltage measured is 5, 20 or 45 degrees. It is also possible to set the frequency at which the current is generated.

It is been provided the possibility to have more measures automatically to monitor phenomena that evolving in the time. You can choose between have a measure every n seconds or leaving a pause of n seconds between one measure and the following.

Taking of a measurement:

After selecting the parameter configuration the system goes to the following screen:

Scan	A	B	M	N	I [mA]	AB [Ko]	V [V]
00001	1	9	2	3			
00002	1	9	2	4			
00003	1	9	2	5			
00004	1	9	2	6			
00005	1	9	2	7			
00006	1	9	2	8			
00007	1	9	16	15			
00008	1	9	16	14			
00009	1	9	16	13			
00010	1	9	16	12			
00011	1	9	16	11			

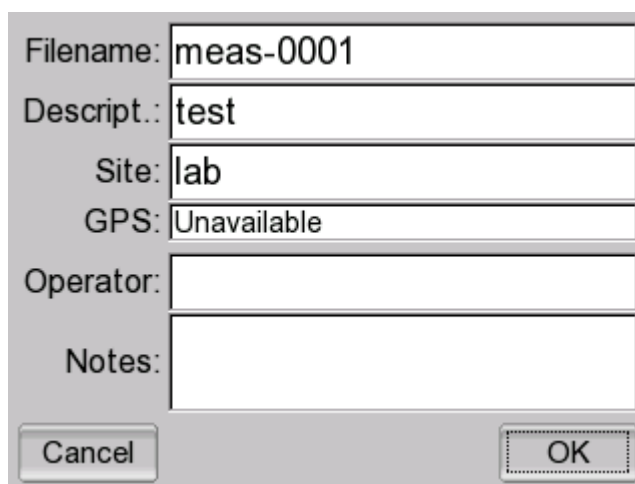
At this point, the instrument is ready for measurement; before starting it is still possible to carry out a check of the correct connection of the electrodes to the ground by pressing the “Check” key; in this case, after just a few seconds the impedance of contact with the ground or the indication of no connection is displayed.

At the end of the check you can start with the real measurement by pressing “Start”.

During the execution of the various acquisitions are indicated on the displayed list: the current delivered, the impedance in KOhm seen between electrodes A and B and the final result, that is indicated as voltage, resistance or resistivity as selected. Displayed under the list is the percentage of acquisitions made with the indication of the estimated time to the end of the measurement. Under the percentage bar, a second red bar indicates the number of acquisitions not carried out because of the bad positioning of the electrodes or a bad contact between the electrodes and the ground.

Below that indication it is also possible to keep the battery voltage and its charge status under control.

After a period of time depending on the number of scans and on the operating parameters set, the measurement is completed and it is possible to save it by pressing “Save” that appears in the place of the “Check” key.



The image shows a dialog box for saving measurement data. It contains the following fields and values:

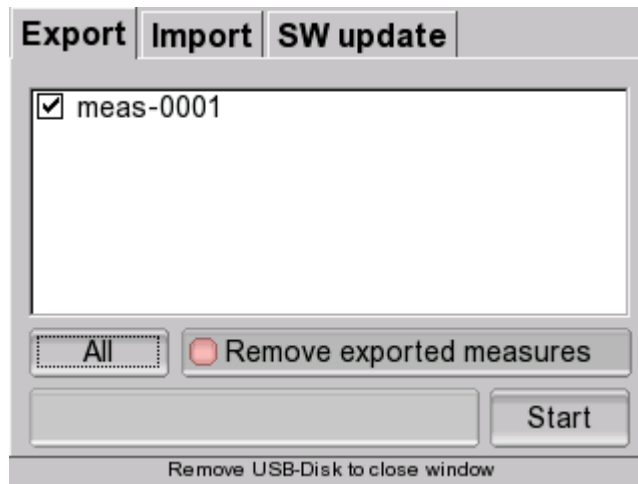
Filename:	meas-0001
Descript.:	test
Site:	lab
GPS:	Unavailable
Operator:	
Notes:	

At the bottom of the dialog box, there are two buttons: "Cancel" on the left and "OK" on the right.

The fundamental field is “Filename” that has to contain the name with which it is intended to save the measurement made. The other fields are only descriptive and their content can be attached within the file together with the results obtained.

Exporting the data of the measurements

To export the files of the done measurements, insert a USB key when you are in the main screen. After a few moments the specific window will appear in which it will be possible to carry out the operation by pressing “Start”.



The saved files will be located in the USB pendrive inside the folder “Polares/Measures” in binary format and inside “Polares/Export” in the export formats set in the preferences.

Activating then “Remove exported measures” instead a copy operation you will have a move operation with the deleting of the data in the instrument.

When the key is removed at the end of the operation, it automatically returns to the main screen.

Technical Data

CPU	Arm 9 32 bit
Operating system	Linux
Display	QVGA 5.7" with LED background lighting
Touch Screen	4 wire resistive
Data storage	Solid state flash memory
External data ports	USB host 1.1
Connectivity	USB key
Optional connectivity	Ethernet, Wi-Fi, Bluetooth, RS232, RS485, USB client, GPS, etc.
GPS	Integrated receiver for georeference of measures
DSP	Freescale (Motorola) 120 MIPS
Converters	A/D 16 bit SAR and D/A to 16 bit
Voltage measurement range	300V, 30V, 3V
Current measurement range	3A, 300mA, 30mA
Frequencies that can be generated	114Hz, 28.6Hz, 7.15Hz, 1.79Hz, 0.45Hz, 0.11Hz
Measurement soundness check	DC component, distortion, background noise, phase excess, module sigma, phase sigma
Maximum number of spikes	Unlimited
Maximum number of scans per measurement	> 40,000
Results that can be stored to memory (scan)	> 200,000
Scan velocity	Up to 6 scan/sec
Peak voltage that can be generated	700 Vpp
Peak current that can be generated	2 A
Peak power output that can be generated	200 W
Thermal protections	Heatsink and inside case alarms and system shutdown
Power supply	8.5V= / 15V= lead or lithium batteries, 30 A internal fuse, protection against polarity inversions
Operating temperature	-20°C / +50 °C outside
Storage temperature	-40°C / +80°C
Dimensions and weight	410x300x170mm; 6kg

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Tel.+39 011 650.70.33 (r.a.) Fax +39 011 658.646 E-MAIL info@pasigeophysics.com

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