SYSCAL Pro

Standard & *Switch* (24 - 48 - 72 - 96 - 120) Version

10 channels Resistivity-meter for
Resistivity and Chargeability measurements

User's manual

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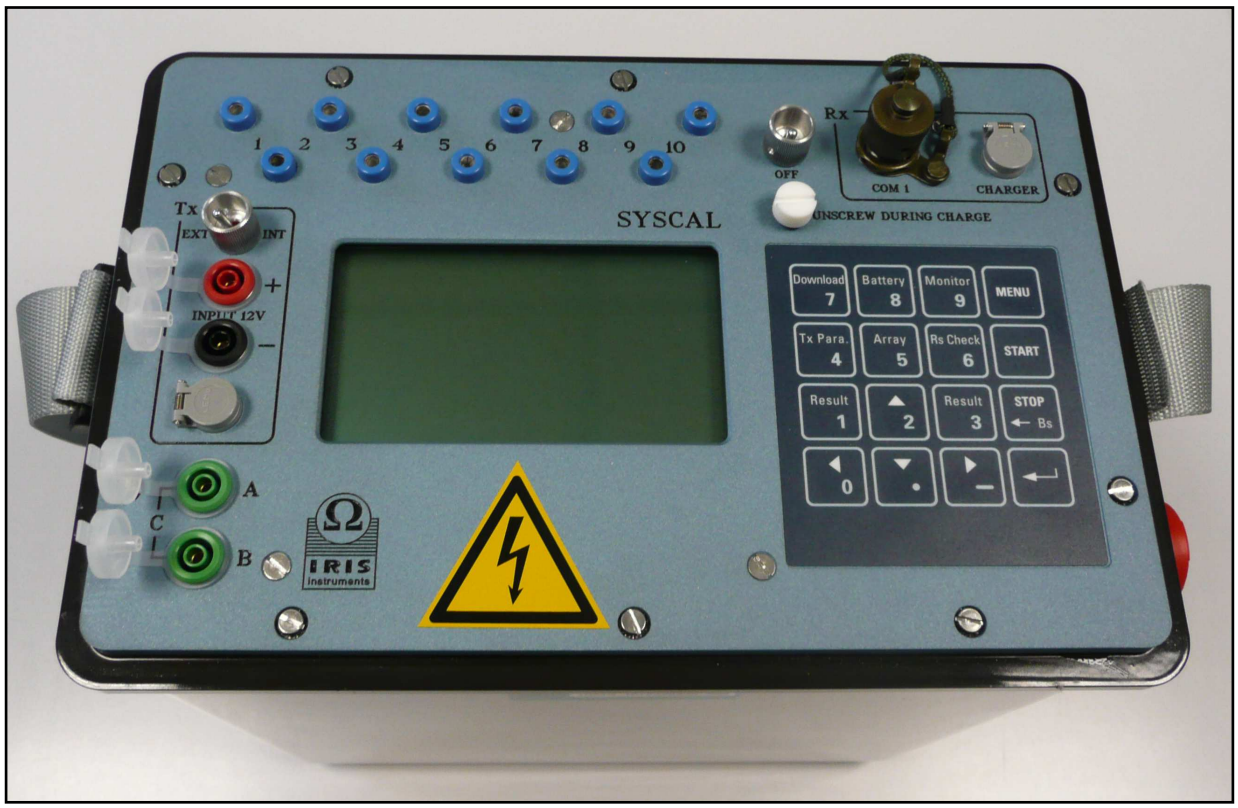
1 2 3 4 5 6 7 8 9 10
Tx
EXT
INT
INPUT 12V
+
–
A
B
C
SYSCAL
OFF
Rx
COM 1
CHARGER
UNSCREW DURING CHARGE
Download 7
Battery 8
Monitor 9
MENU
Tx Para. 4
Array 5
Rs Check 6
START
Result 1
2
Result 3
STOP ← Bs
0
IRIS
instruments

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I. OVERVIEW

I.1. GENERALITIES

The SYSCAL Pro unit is a resistivity-meter designed for high productivity survey.
This all in one unit (containing transmitter – receiver and booster) is a very practical in-the-field tool; an external DC converter for a higher power can be added.
This unit allows to measure primary voltage and decay voltage curve values, giving thus resistivity and chargeability (IP) data.
The main technical characteristics of this unit are the following ones:
- 10 reception dipoles available to carry out some measurements with high productivity in the field
- 20 chargeability slices (automatic or user defined) able to measure the discharge phenomena with a high accuracy
- a 1 μV resolution on the primary voltage allowing to obtain very accurate measurements
- a large graphic LCD screen allowing to visualize the data in real time either numerically or graphically

The SYSCAL Pro unit can be also used in automatic switching mode (thanks to internal switching board(s) or external *Switch* Pro box(es) for intensive measurements in 2D / 3D and boreholes.

I.2. GENERAL SAFETY INSTRUCTIONS

Please, read carefully the operating and safety manual prior to setup. The non-respect of these instructions can lead to people or animals getting hurt or damaged.

These notes warn for things that can lead to people or animals getting hurt or to equipment getting damaged

Read carefully the operating and safety instructions as all labels affixed to the device. Be sure you understand their signification before use. If you do not understand or have doubts about any point of this user's manual, contact IRIS INSTRUMENTS for an explanation or a demonstration.

- Keep the user's manual with the device for future reference. Thus, keep it intact, readable and at the disposable of qualified persons during the entire life of the device. Be sure that all the interveners have read the user's manual and safety instructions.
- The use of a device in accordance with the safety instructions does not guaranty the absence of risks. Proceed carefully. Do not use this device if you have a doubt on the correct and safe way to use it.
- In all circumstances, the user must scrupulously respect the entire instructions of the user's manual. He must also comply with all applicable local and national laws of the jurisdiction of using of the device.
- People under the influence of drugs, alcohol, pharmaceutical products or any other product that might disrupt their reaction should not perform any operation or manipulation of the device.
- This device is designed for industrial use only.
- By principle, electrical methods used in geophysics generate electric and magnetic fields which may eventually interfere with pacemakers. We therefore advise people with implants to consult their physician

According to CISPR 11 norm, this equipment is listed in Group 1, class A.

- Group 1: Equipment has intentionally generated and/or uses conductively-coupled radio frequency energy that is necessary for the internal function of the equipment itself.
- Class A: Equipment is suitable for use in all establishments other than domestic and those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes. There may be potential difficulties in ensuring electromagnetic compatibility in other environments due to conducted and radiated disturbances.

Below is a list of the major risks and precautions to be followed before and during the use of the device:

- Be sure that the equipment is in good working order before leaving on the field.
- Use only cable in good conditions, sufficiently isolated and well adapted, regarding operating current and voltage levels of the device. Replace any worn cable.
- Follow rigorously handling and operation instructions. A wrong plug might be dangerous.
- The device is heavy, be careful when you wear the device. Use your knees, and not your back, to carry the device. When you carry the device by the front face, use either both handles or the carrying strap.
- The device must not fall during its use. Place it down flat, directly on the ground, or slightly elevated to avoid any falls from heights. The power cable can be rigid and create a barrier for the operator.
- The connection of the device to excessive voltage source can cause irreversible damages to the device. Make sure you use the right voltage source.
- The device may in no circumstances be connected to the electricity distribution network.
- Do not modify the jack and unroll totally the power cable. Protect it from sharp pieces. A damaged or twisted power cable increases the overheating risks.
- Wear a face shield, shoes and isolating gloves (class 0, max. 500V for AC and 1500V for DC).

- Be sure that nothing and nobody can touch the cables and electrodes during the functioning of the device.
- Protect the working area using safety cones.
- Use labels and panels "Danger, high voltage" wherever there is people present.

- Use non-metallic objects and tools to avoid any electrical contact with the cables and electrodes (meter tape, hammer, …)
- Be sure to thoroughly clean the area around the injection electrodes. The passage of current in the electrode can produce sparks and cause a fire if the vegetation is abundant.
- Always inform about your presence on the field. Communicate clearly between operators on the field using walkie-talkies that have been checked before the leaving on the field.
- Be careful when using the device in a damp environment. The device is design to work under the rain but not under water. The risk of current leakage is higher in damp environments. Stay at a minimum of 1 m from the electrodes and cables.
- IRIS Instruments products are not designed for use in hazardous environments.
- This device is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments.
- Do not use the device in case of thunderstorm. If a thunderstorm should come up during the measurement, then first stop a possible ongoing measurement process and disconnect the cable from the device without touching any conducting part. Never leave the cables connected to the device overnight unless they are equipped with adequate lightning protections since a thunderstorm may occur.

- Avoid obstructing the ventilation openings of the device. This may generate overheat and stop prematurely the device.
- Protect the batteries during the measurement so that they cannot be touched. Be sure that nobody touch the Tx battery during the measurement. The person that would touch it could be exposed to lethal current and voltages.
- In case of problem, press the emergency push button to stop immediately the injection process. Before releasing the emergency button, make sure that everything is in order and warn all the operator of the power reconnection.

The assembly and maintenance operations must be realized according to the procedure, the preparation conditions and the environment described in the maintenance documentation, by persons with the training and qualifications required to work on electrical equipment

- The input voltage is present in the device even if the general switch is OFF. Before opening the device, ensure that the power source is turned off and is not likely to be turned back again. For more security, disconnect the power source.
- Make sure that the capacitors are discharged. They can maintain high voltages within the device, even when the power is off. The contact could result in death or serious injuries. Wait at least 10 minutes before opening the device.
- Some parts of the device are used to dissipate excess of heat produced by the components. The parts and components remain hot for some time after switching off the device. Be careful not to burn yourself in contact with these parts.
- Use tools in good conditions and suitable for the work to be done. Be careful not to drop any piece of metal into the device (screw, wiring cables, tools…)
- During all life phases of the device, all operation that is not described in the user's manual is strictly prohibited. Always use accessories and spare parts approved by IRIS Instruments.
- Risk of explosion if battery is replaced by an incorrect type. Only use battery recommended by IRIS Instruments.
- It is strictly forbidden to anyone to make mechanical or electrical modifications to the device, to modify the functions or technical documents except those recommended by IRIS INSTRUMENTS.

Note :

To help you, IRIS INSTRUMENTS proposes a Security Pack that feature Safety cones labelled "Danger, High voltages". They allow to minimize the risk of contact with the electrodes, especially if they are distant from the operator and hidden by vegetation. Moreover, considering the voltage levels present, the wearing of personal protective equipment is highly recommended (mainly insulated gloves class 1 and insulating shoes).

Disclaimer:

IRIS INSTRUMENTS sells the Syscal Pro on the understanding that it will be used by qualified geophysicists or geophysical field personnel that are aware of the risks inherent in the use of high voltage and high current Induced Polarization Transmitters.

IRIS INSTRUMENTS cannot be held responsible for any consequential damages of any kind, resulting from the use of the Syscal Pro.

I.3. DESCRIPTION

I.3.1. Front panel

The front panel shows the following features:

- Graphic LCD (128x140 dots) made of 16 lines by 40 characters
- Two plugs for current electrodes connection ("A" and "B") in **Standard** and **Continuous survey** mode (in **Manual switch** - **Manual sequence** - **Automatic sequence** and **High speed sequence** mode, the electrodes are connected to switch cables plugged to the unit; in that modes, the ("A" or "B") plugs can be used only for remote injection electrode, (like in a Pole-Pole or Pole-Dipole sequence).
- Eleven plugs for potential electrodes connection ("1" to "10" dipoles) in **Standard** and **Continuous survey** mode (in **Manual switch** - **Manual sequence** - **Automatic sequence – Sp Sequence** and **High speed sequence** modes, the electrodes are connected to switch cables plugged to the unit; in that modes, the potential plugs can be used only for remote injection electrodes (Pole-Pole or Pole-Dipole sequence)
- Two plugs for internal battery chargers connection ("Charger" for Rx and Tx)

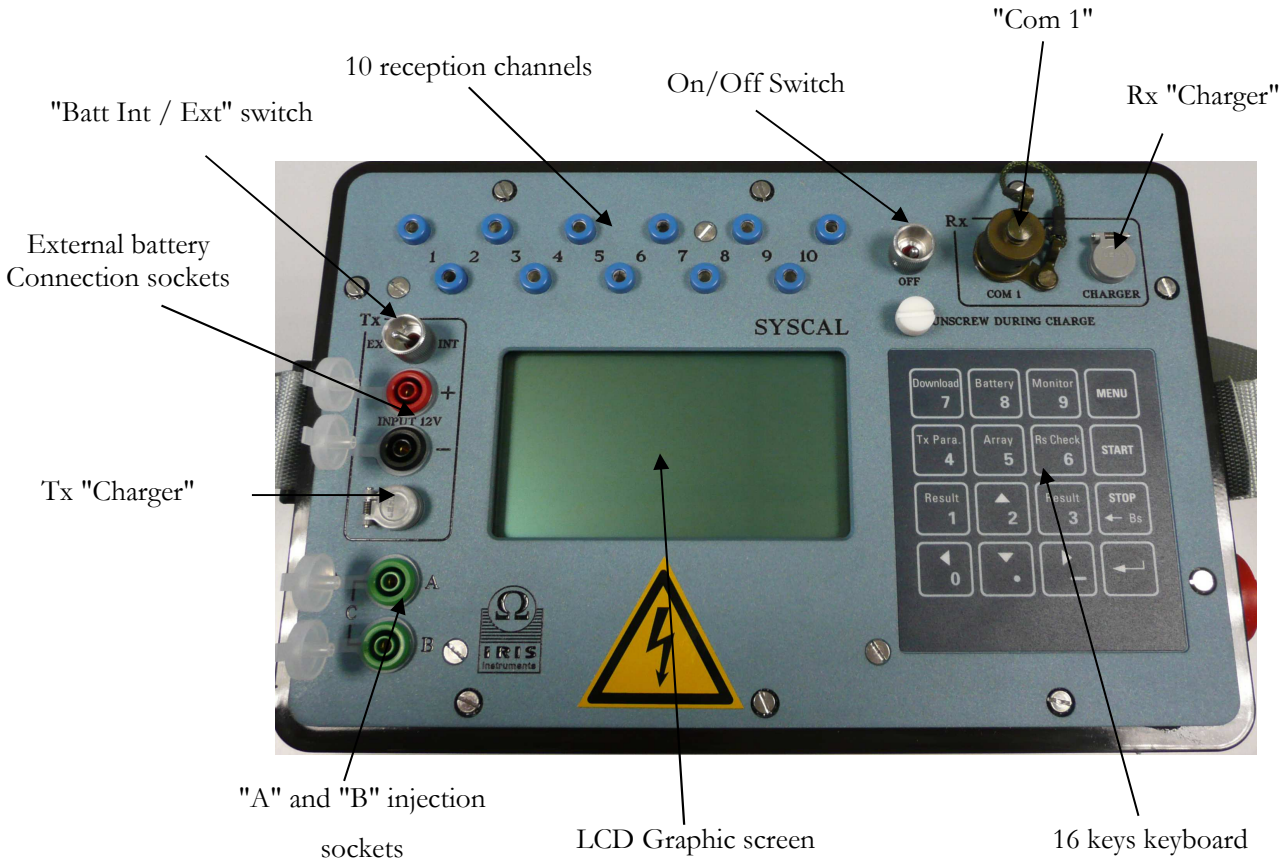
In the "Tx" area:

- "+" and "-" sockets for the connection of an external 12V battery
- "Int / Ext" switch for the selection of the battery used for the injection

In the "Rx" area:

- Three pins plug (RS232 standard port) for the serial or USB link cable connection ("Com 1")

- Keyboard with 16 keys
- Switch On/Off


"Com 1"
10 reception channels
On/Off Switch
Rx "Charger"
"Batt Int / Ext" switch
External battery
Connection sockets
Tx "Charger"
"A" and "B" injection
sockets
LCD Graphic screen
16 keys keyboard
SYSCAL
OFF
Rx
COM 1
CHARGER
Tx
EX
INT
INPUT 12V
MENU
START
STOP

I.3.2. Backside

At the backside of the unit, the SYSCAL Pro has the following plugs:

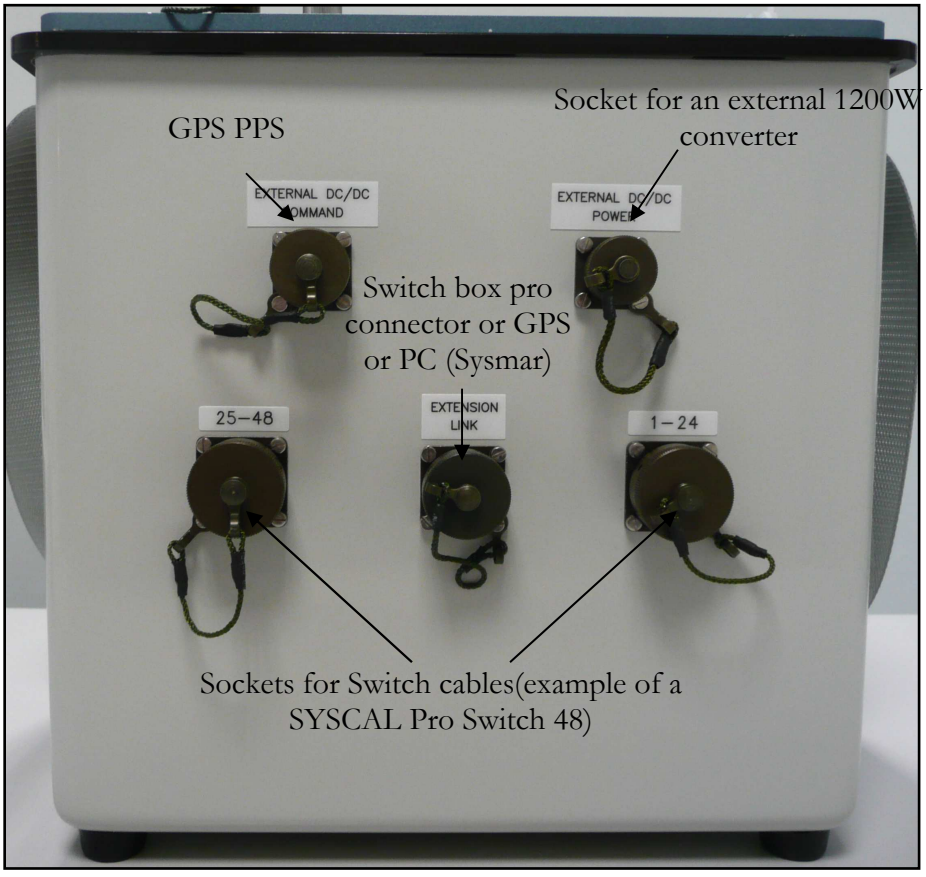
- 1 serial link socket ("**Extension link** ") for external PC connection (useful in **Continuous survey** acquisition where the "**Com 1**" is used for a GPS connection) or for *Switch* Pro box connection

- 1 socket for a connection of a 1200 W AC/DC converter ("External DC/DC Power")

- 1 socket for a connection of a GPS PPS ("External GPS PPS Command") – the GPS Garmin 18 XXLVC will be supplied with its cable.

For the *Switch* version, some more plugs are present (2 in standard) for multi-conductor cables connection.

As an option, an "External Synchro" socket can be installed for the connection of a cable linked to an injection electrode allowing to make quicker the synchronisation process with an external transmitter (in that configuration, the SYSCAL Pro is used as a receiver only ("Rx-Only" operating mode).



I.3.3. Keyboard

The keyboard of the SYSCAL Pro features some keys designed to be used either in the **numeric** or in the **function** mode; no confusion can be done between these modes, as the device knows at any step of the use, in which mode it has to set itself.

The main functions of the SYSCAL Pro are reached either from these keys or from options of the master menu.

- In the numeric mode, the meaning of the keys is obvious.

Each time one has to enter a numeric value, the available range for this value will be indicated in the left bottom part of the screen

- In the function mode, the next table shows the description of these keys:

to transfer the data to the PC

to check the voltage level of the batteries

to check the reception voltage value without injection (ambient noise + Sp)

to select the operating mode and the injection parameters

to select the electrode array and the number of measuring channels

to check, before running a measurement, the grounding resistance value of the electrodes

to visualize the results channel per channel (during and after measurement)

- to scroll up in a menu
- to go up in a range
- to change the result display

to visualize the results of the whole channels (during and after measurement)

- to move to the left in the menu bar
- to move to the left in the alphanumeric bar
- to move in the channel range


- to scroll down in a menu
- to go down in a range
- to change the result display

- to move to the right in the menu bar
- to move to the right in the alphanumeric bar
- to move in the channel range

- to stop the acquisition
- to reach the menu bar (at any step of the process)

to start the acquisition

- to stop the Rs check process
- to rub some letters or numbers
- to go out of any blocked function and go back to the menu bar

- to validate an input or a selected function

I.3.4. Power supply

The electronic of the unit is supplied by two internal rechargeable batteries (12 V – 7.2 Ah), one for the transmission (Tx) and one for the reception (Rx)
To generate the current, one can use the internal rechargeable battery (Tx: 12 V – 7.2 Ah) or an external 12 V battery (standard car battery); so, put the "Int / Ext" switch of the Tx area in correct position.
In switching process (sequence mode), you'll have to use for the transmitter an external 12V fully charged battery (plugs "+" and "-" of Tx) and put the Tx switch in "Ext" position.
If you need to change the Tx switch position during measurement, we recommend to pause the measurement before doing the operation.

In any case, the battery used for the current injection should not drop below 8 V during transmitting. If not, erroneous values will appear (a warning message will appear at 9 V).
Please refer to the Annex 5 to have a view of the behaviour of a battery becoming weak.

• The internal batteries are located at the bottom part of the instrument. In case of the device wouldn't be used for a long time, it can be better to take out the battery in order to prevent any possible leakage of this battery that could damage the casing.
Two specific chargers are supplied with the unit; they have to be connected to the "Charger" plugs of the front panel – it's recommended to let the charger plugged when the Syscal is not in used, so as to avoid that the level of the batteries decreases too much (indeed, in that case, it might be difficult to recharge them correctly).

• The external battery has to be connected to the "+" and "-" plugs of the front panel, using the power cables provided with the instrument.

Always use the specific battery charger supplied by Iris Instruments to charge the device.

Important note:

Internal batteries generate explosive gases during normal battery operation. For security reasons, a valve for an automatic pressure regulation has been installed on the casing (black plastic piece on the right side). This allows an automatic equilibrium of the internal pressure with the atmospheric pressure, and filtering in the same time the air moisture.

Be sure area around battery is well ventilated while batteries are being charged.

Before using the SYSCAL Pro in the field, the first operation to do is to check the voltage level of the batteries by the **"Tools | Battery"** menu or by the 

key (cf. II.2.2.).
The indicator located at the lower right part of the screen allows also to check the level of the two batteries. This indicator is divided in two parts: the upper part is relative to the Tx (transmitter) and the lower to the Rx (Receiver).

I.3.5. Overheating

In case of large sequence of measurements, it's possible that overheating condition appears in the unit. Above 50 °C, an automatic process reducing the output power is automatically run; the injected voltage will be limited but without cutting totally the injection; this will avoid internal damages and won't have any effect on the resistivity measurement.
As soon as the temperature has gone down sufficiently, the unit will recover the original power.

Note:

The SYSCAL Pro can operate up to 70 °C (internal temperature) – above that value, an error message will appear ("Overheat").

I.3.6. Emergency stop button

On the right side of the unit, an emergency stop button (red) allows to switch off the system immediately (switch off time about 20 ms).

Before releasing the Emergency Stop Button, the operator must have full control of the instrument and the entire electrode cable layout, so that people and animals do not get close to the electrodes and electrode take-outs connected to the measurement cables !

Take care that the button is not engaged (which can happen for example during packing or un-packing of the instrument) as in that case the unit won't switch On. One will have then to release the button turning it on of one quarter of turn. Then you'll be able to switch On the unit.

I.3.7. USB port

This device features two communication ports: The usual port COM 1 on the front face and the USB port on the side of the device.

To download the data using the USB port, plug the USB cable on the device and connect it to your computer.

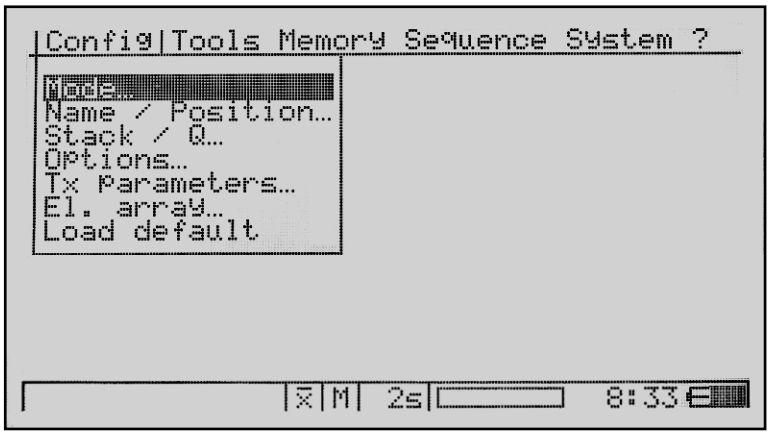
Use the "Data download" function of the PROSYS II software to start the transfer.

Be aware that when using the USB port on the side of the device, you will not be able to use the Port COM 1 of the front face anymore (either for communication, GPS or SD card). So to use it, disconnect the USB port on the side of the device.

II. IN-THE-FIELD

II.1. SET-UP

To switch on the equipment, use the On/Off switch: the unit will briefly display the type of the instrument, the version of the firmware and then, the following screen will appear, with the menu bar:



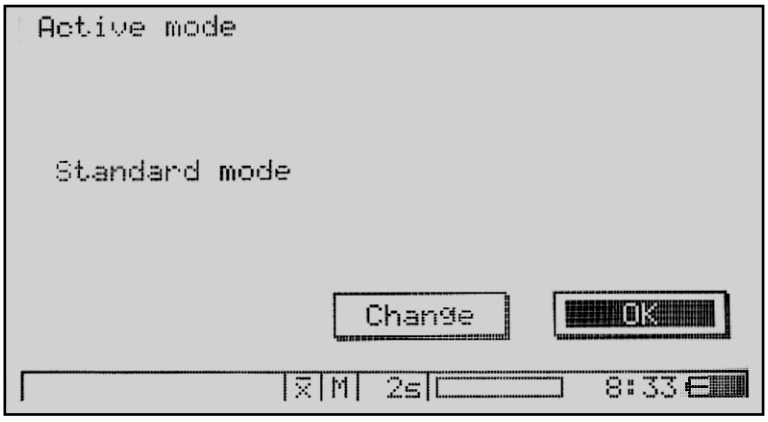
Before performing an acquisition, one has first to introduce the set-up parameters; all the options relative to this set-up can be reached from the "**Config**" menu and some of them, directly from the keyboard.

In case of using a sequence of measurement (*Switch* version), the setup parameters will be entered while the creation of the sequence (cf. II.3.4.).

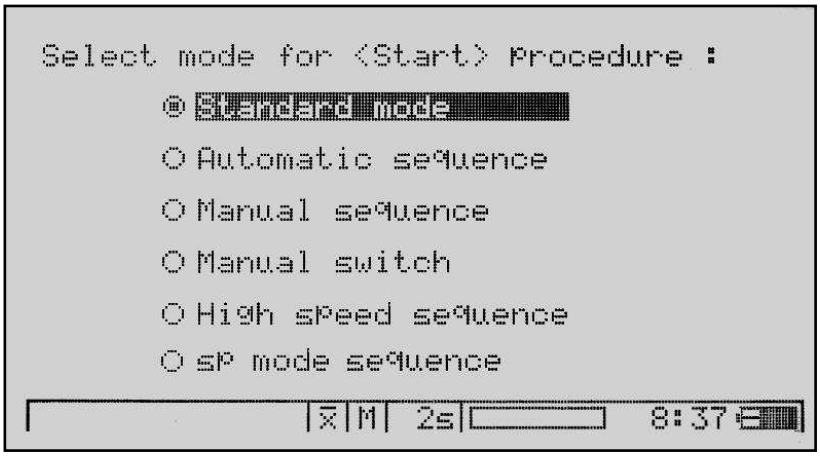
II.1.1. Mode

The SYSCAL Pro unit allows to work in various operating modes.

The selection of the "**Config**|**Mode**" menu will show the following screen:



From that window, one can see the current mode and one has the possibility to change it by the "**Change**" button: the following screen will be displayed:



- **Standard mode**: standard use of the unit (step by step acquisition): this mode requires to move the electrodes and enter the new positions between each location.

- **Automatic sequence**: automatic switching of electrodes according to a preset sequence of measurement: this mode requires the use of a switching system.

- Manual sequence: this mode is equivalent to the previous mode excepted than in that case the sequence will be run in a manual way (necessity to press regularly the START key to continue the sequence).
This mode is useful for the SYSCAL Pro units having the "Rx-Only" option in case of sequences where injection electrodes need to be moved regularly.

- **Manual switch**: test mode allowing to switch manually a set of specific electrodes; this mode requires the use of a switching system.
Remark: this mode can be run in case of doubt with specific electrodes

- **High speed sequence**: quick mode (pulse duration: about 200 ms / 1 positive pulse and 1 negative pulse); this mode requires the use of a switching system.
Remark: this mode can be run for example to get a first idea of the resistivity values of the area.

- Sp mode sequence: automatic switching of electrodes for a Sp measurement (no injection) according to a preset sequence of measurement: this mode requires the use of a switching system – Measurement of the Self potential parameter

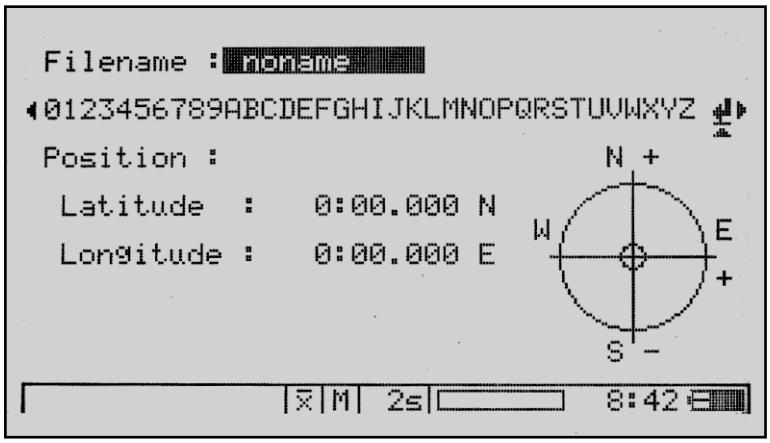
Note:

In **Standard mode** or in **Manual switch** mode, the set up parameters have to be chosen from the options of the "**Config**" menu.

For the other modes requiring a sequence of measurement, the set up parameters have to be specified while the sequence creation (cf. II.3.4.) but can be nevertheless modified from the options of the "**Config**" menu before running the sequence.

II.1.2. Name / Position

The selection of the "**Config|Name/Position**" menu will display the following screen:



So, specify a filename in which the data will be stored (until one enter a new name, all the next data will be stored with this filename).

One can specify also the location of the profile in longitude and latitude positions.

Note:

If you need to perform several profiles (using one of the sequence modes), it can be very useful to enter a filename for each profile, as after the download of the full memory to PROSYS II software, one will have the opportunity to split the file in several files relatively to the various filenames.

Procedure:

- For **Filename**, use the 0 and – keys to move left and right the cursor in the alphanumeric bar and press the ↵ key each time the cursor is located below the letter you wish to enter.

Then, locate the cursor below the "↵" letter to validate the filename.

Automatically, the line **New latitude** will be created and highlighted at the bottom of the screen

- Use the numeric keys to enter the **New latitude** number and validate by the ↵ key; the **Latitude position** will so be updated and the line **New longitude** will be automatically created and highlighted

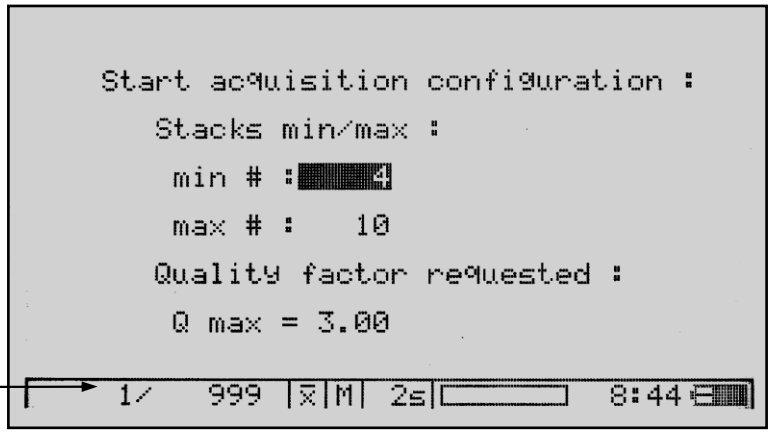
Use the numeric keys to enter the **New longitude** number and validate by the ↵ key: the **longitude position** will so be updated.

Note:

if a GPS is connected to the unit, instead of entering numerically the value, you'll be able to press the START key for a direct introduction of GPS data when **New latitude** and **New longitude** are highlighted (any type of GPS using the *NMEA 0183* norm can be used (cf. Annex 10 for details).

II.1.3. Stacking parameters

The selection of the "**Config**|**Stack/Q**" menu will display the following screen:



Available range

So, enter a value for each parameter (the available range is indicated for each parameter in the bottom left part of the screen):

- **Stack min**: minimum number of stacks (injection cycles)
- **Stack max**: maximum number of stacks (injection cycles)
- **Q max**: quality factor requested (standard deviation in %).

As long as the quality factor is greater than the introduced value, the measurement will run up to the specified stack max. If not, it will stop to the stack min.

The quality factor is computed for each channel but is checked relatively to the results obtained on the triggering channel.

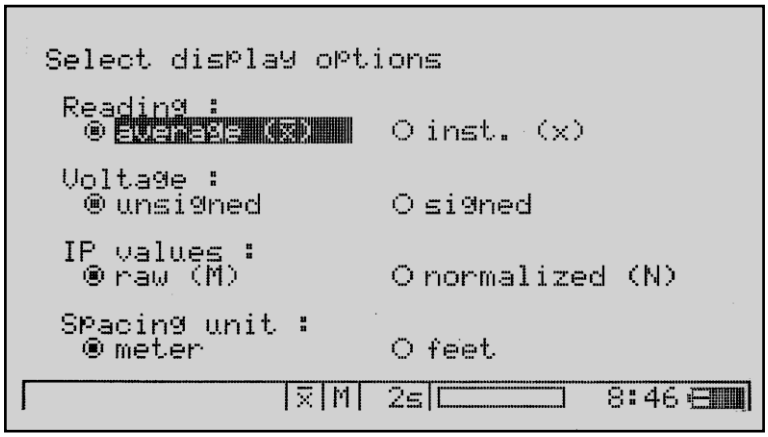
Note that in IP mode, the computation of this factor is made on the global chargeability.

Procedure:

- Use the numeric keys to enter the **min #** number and validate by the  key
- Use the numeric keys to enter the **max #** number and validate by the  key
- Use the numeric keys to enter the **Q max** number and validate by the  key

II.1.4. Display options

The selection of the "**Config|Options**" menu will show the following screen:



So, choose the various options relative to the display:

- **Reading**:

  Average ($\overline{X}$): the displayed values will be the average values of the pulses from the beginning of the measurement.

  Inst. (X): the displayed values will be the average values of the three latest pulses (standard)

- **Voltage**:

  Unsigned: the displayed average values of voltage will be absolute values (standard)

  Signed: the voltage values will have a sign, which depends on the polarity of the measured dipole voltage with respect to the first dipole voltage. Consequently, the resistivity values will be also signed.

- **IP values**:

  Raw: the displayed values will be the true partial chargeability values observed on the decay curve (standard)

Normalized: the displayed values will be values normalized in regards to a reference decay curve (not available for the Cole-Cole and Programmable modes) (cf. Annex 3 for more information)

- **Spacing unit**:

  Meter: the spacing values will be given in meters (standard)

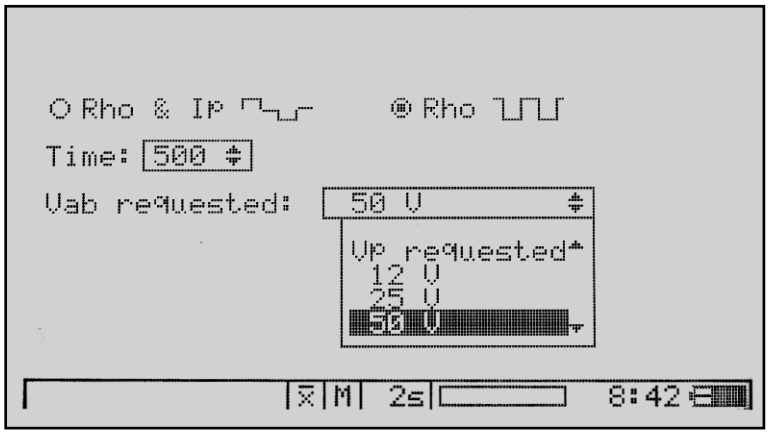
  Feet: the spacing values will be given in feet

Procedure:

Use for each option the 0 and – keys to move left and right the cursor and the ↵ key to validate the option you wish

II.1.5. Tx parameters

The selection of the "**Config**|**Tx parameters**" menu or the Tx Para. 4 key will display the following screen:



- **Rho & Ip** (resistivity and chargeability) or **Rho** (resistivity only) measurement
- **Time**: select the injection pulse duration: *250 ms - 500 ms - 1 s - 2 s - 4 s - 8 s.*
- **Mode** (if **Rho & Ip**): choose the sampling of the partial chargeability slices (Cf. Annex 3 for more information).

  Arithmetic: arithmetic sampling with 3 to 20 partial chargeability slices

  Semi logarithmic: semi logarithmic sampling with 3 to 20 partial chargeability slices

  Logarithmic: logarithmic sampling with 2 to 6 partial chargeability slices

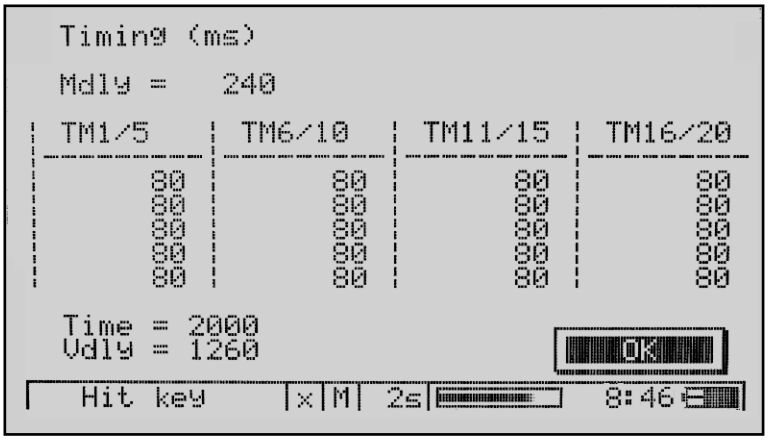
Cole-Cole: specific sampling used to compute the Cole-Cole parameters; the computation will be done by PROSYS II software.
Programmable: 20 fully programmable slices

• **Vp requested** or **Vab requested**: choose either:
- a constant injection value (**Vab requested**) and then select the value among [12V - 25V - 50V - 100V - 200V - 400V - 800V - Vab Maximum - External DC].
If you select "Vab Maximum", you'll have to define the value, in V, of the maximum voltage the unit will inject.
- a constant reception value (**Vp requested**) and then select the value among [Save energy (20 mV) - 50mV - 200mV - 800mV - Max (3V)].
Then, you'll have to define the value, in V, of the maximum voltage that the unit will inject. This option is preferable because it limits the battery consumption (by adjusting automatically the injected current value to the lowest possible level). It also allows to control the voltage for security reasons or in case of local norms on the field site.

Notes:

• The Vp value will be requested for the channel recording the lowest reception signal. If the Vp value requested induces some overvoltage on the first channels, the new channel for the Vp requested will be the previous one, and so on until there's no more overvoltage on channel 1.
The "triggering channel" will be assigned of the character "*" in the results and acquisition displays in front of the corresponding line; it can change during a sequence, due to the organization of the quadrupoles in the sequence and to the reception levels measured.
• In switching process, due to the use of multi-conductor switch cables, the Vab max will be 800V, even if the user has selected a higher injection voltage value.

if **Rho & Ip** has been chosen, then, one will reach the ***IP parameters*** screen allowing to visualize or to modify the values (in regards to the chosen IP mode):



Vdly: delay time (in ms) from which the samples (sampling rate: 10ms) will be taken into account after injection, both for intensity and voltage measurements:

This delay time permits to be sure that all transient effects like IP and EM responses will be vanished and so, won't disturb the measurement.

Mdly: delay time (in ms) from which the voltage samples (sampling: 10ms) will be taken into account after the current cut off.

Note:

The number of chargeability slices depends on the injection pulse duration previously chosen (cf. Annex 3 for more information).

General note about the Rx-Only acquisition mode:

In case of the SYSCAL Pro has the "Rx-only" option, the **Tx parameters** window will be slightly different than the one shown page 14.

Indeed, in that case, we'll have the choice between the two types of acquisition:

- **Tx-Rx** : means the unit is used as a transmitter and a receiver: this is the classical configuration to which we refer in that manual.
- **Rx-only**: means that the unit is used as a receiver.

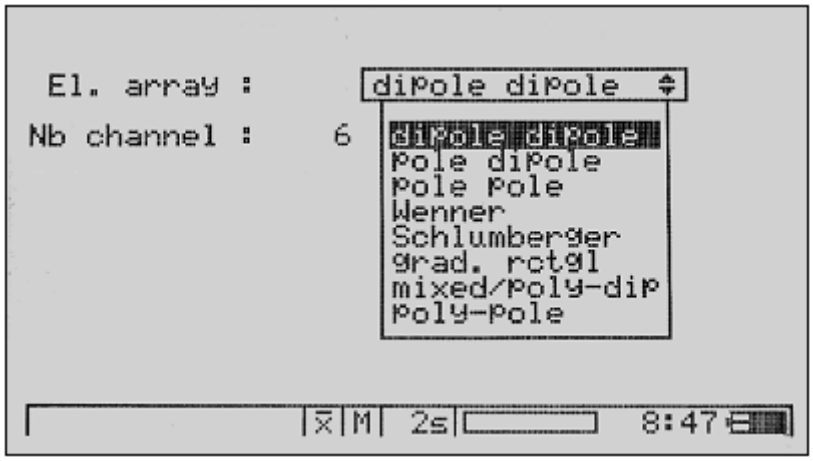
For the transmitter, in that case, it's necessary to use an external unit, like a VIP transmitter.

In that configuration, the SYSCAL Pro unit doesn't drive the transmitter part: the current will be set by the grounding resistances of the electrodes connected to the transmitter, the configuration and the capabilities of this transmitter.

In that measuring mode, which allows running IP acquisition with a high resolution, only the "**Rho & Ip**" mode will be available.

II.1.6. Electrode array

The selection of the "**Config**|**E. array**" menu or the Array 5 key will display the following screen:



So, first, choose the electrode array you wish to use (cf. Annex. 2 for more information).

Then enter the number of channels to be used.

Procedure:

For **El. array**: use the ▲ 2 and ▼ . keys to move up and down the cursor in the list and the ↵ key to select the array you wish

For **Nb channel**: use the numeric keys and validate by the ↵ key.

Note (cf Annex 2 for more information):

The maximum number of channels allowed is 10 except for the following arrays (1 channel max): Pole-Pole - Wenner - Schlumberger.

So for these arrays, by default **Nb channel**: 1.

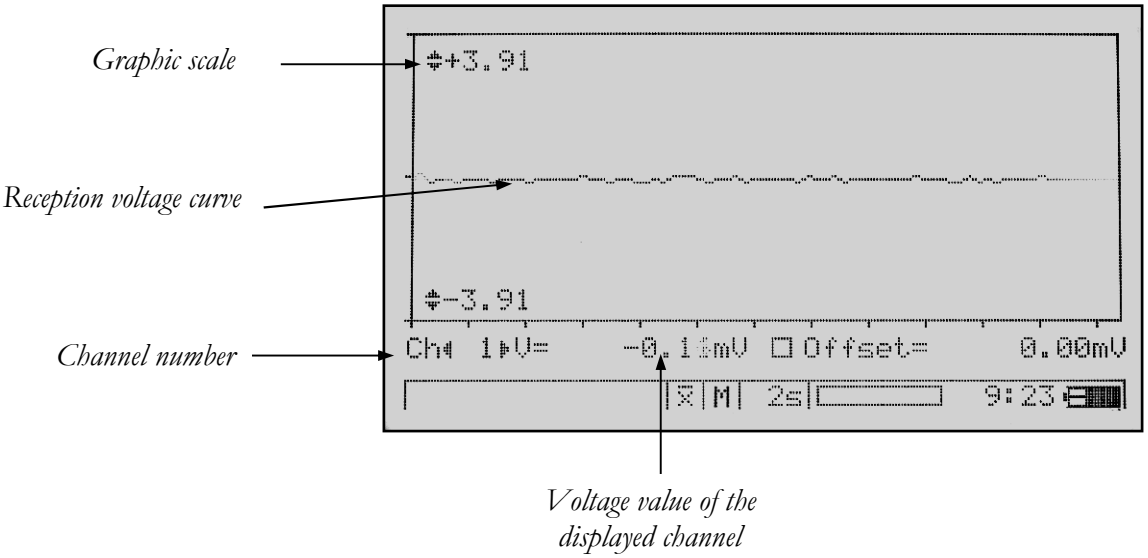
In case of using a mode requiring a sequence of measurement, and if the sequence loaded by ELECTRE Pro (cf. II.3.4.) is a non-standard sequence, the electrode type displayed in the previous screen will be: Mixed/Poly-Dip.

II.2. BEFORE ACQUISITION

Before running the acquisition, some tests have to be done to be sure that the measurement will be performed in the best conditions:

II.2.1. Monitor

The selection of the Monitor 9 key (or the "**Tools**|**Monitor**" menu) will show the following screen:

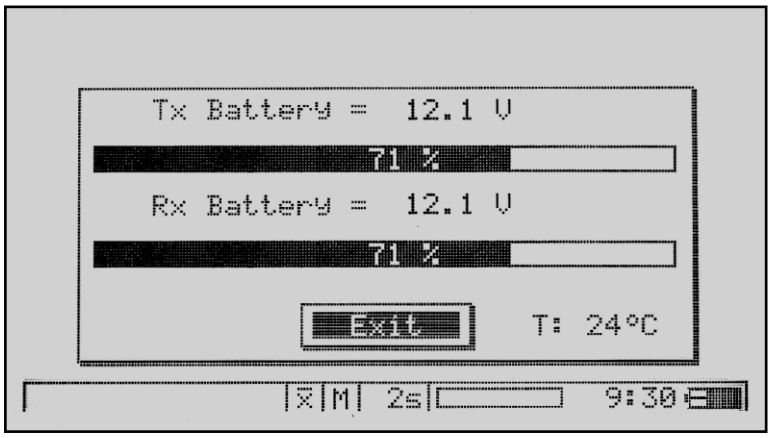


This function allows to visualize in real time the reception voltage value and the corresponding curve, channel per channel. This is just a monitoring of the reception voltages without injection (Sp + ambient noise monitoring)

At this stage, you can change the graphic scale using the 2 and . keys and the channel to be visualized by the 0 and _ keys.
Press the ↵ key to see the DC offset value (SP + noise): automatically, the **Offset** box will be crossed and the voltage value will be indicated.

II.2.2. Battery

The voltage level of the batteries can be displayed by the Battery 8 key or by the "**Tools**|**Battery**" menu; the following screen will appear:



So, one can see the battery voltage value in V and the capacity (10 V means 0 % of capacity) for the Tx (transmission) and the Rx (Reception) part.
Press a key to skip this function.

Note:

From the master screen, the indicator located at the lower right part allows also to have continuously a view of the batteries level.
If one of the battery levels become too low (10 V for the Rx and 9 V for the Tx), a warning message will appear after having pressed the START key or during acquisition.

II.3. ACQUISITION

Before starting a measurement with the Syscal Pro resistivimeter, be sure you read carefully the General Safety Instructions (cf. page 7).

Dangerous voltages and currents are transmitted by the Syscal Pro through the cables and electrodes. During the entire duration of a RS Check or of the measurement session, the operator must always have full control of the entire electrode cable layout, so that people and animals do not get close to the electrodes and electrode take-outs connected to the measurement cables!

The cables delivered by IRIS Instruments are specific cables which can handle 800V. Only use cables delivered by IRIS Instruments and never use cables dedicated to seismic measurements.

Do not use the device in case of thunderstorm. If a thunderstorm should come up during the measurement, first stop a possible ongoing measurement process and disconnect the cable from the device without touching any conducting part. Never leave the cables connected to the device overnight unless they are equipped with adequate lightning protections since a thunderstorm may occur.

II.3.1. In-the-field implementation

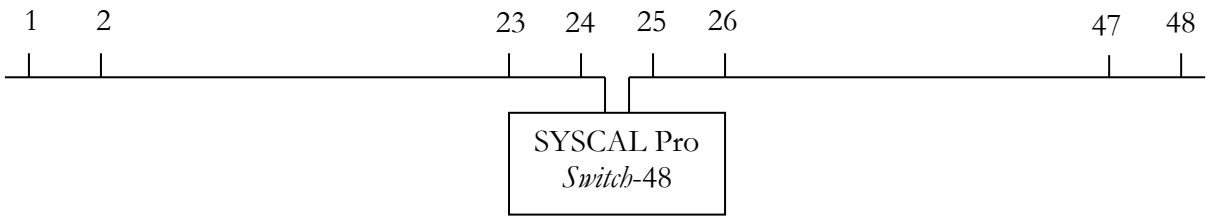
The SYSCAL Pro can be used in various operating modes (cf. II.1.1.)

In regards to that mode, some actions have to be done before running the measurement.

The **Standard** (cf. II.3.2.) and the **Continuous survey** (cf. II.3.5.) modes, requires the electrodes directly connected to the front panel of the unit, on the reception channels (cf. I.2.1).

The **Manual switch** (cf. II.3.3.) - **Manual sequence** (cf. II.4.1.) - **Automatic sequence** (cf. II.3.4.2.) - **High speed sequence** (cf. II.3.4.3.) and **Sp sequence** (cf. Annex 12) modes, require the use of a switching system; the standard switch cables supplied by *IRIS Instruments* are double ended, and so can be reversed for a full flexibility (useful for the Roll along implementation).

In that configuration, the SYSCAL Pro *Switch* unit is located at the centre of the configuration (example given for the SYSCAL Pro *Switch*-48 unit):



The switch cables are supplied in several cable sections, in regards to the electrode spacing and the number of electrodes, to keep a reasonable weight per reel.

II.3.2. Standard mode

Preliminary note:

The screens described below are relative to a Dipole-Dipole array with 5 meters between electrodes and 6 channels of reception.

To run an acquisition in that mode, select the "**Config**|**Mode**" menu; a screen indicating the current mode will appear: if **Standard mode** is displayed, press "**OK**".

If not, press "**Change**"; then the screen showing the available modes will appear; then, select **Standard mode.**

Procedure:

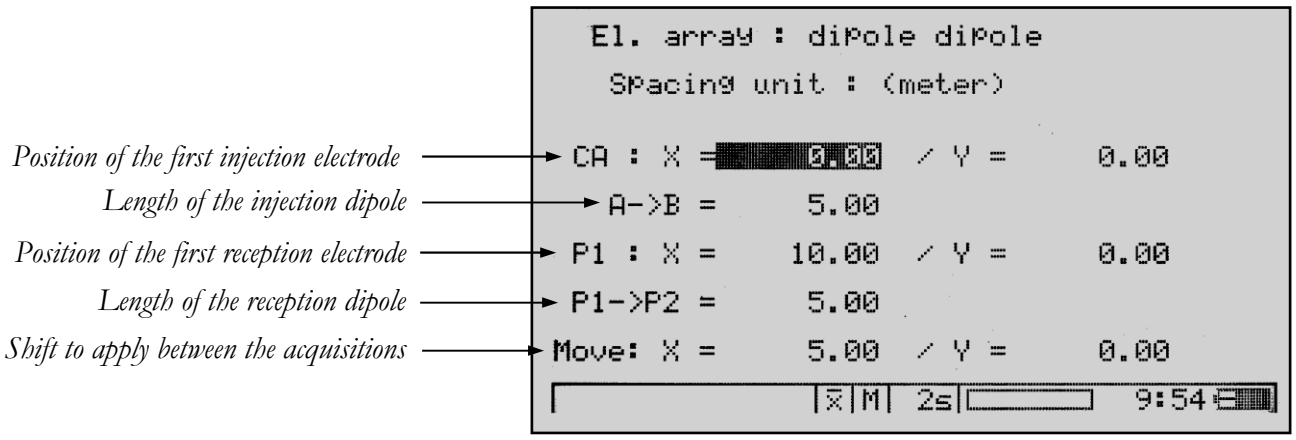
Use the ▲ 2 and ▼ . keys to move up and down the cursor in the list and the ↵ key to select **Standard mode**, then press the ↵ key

Then press the START key or select the "**Tools**|**Start**" menu

At this stage, the program will display the batteries screen if one of the voltage levels is low.

So, in that case, press the "**Continue**" button if you think that it will be sufficient or "**Stop**" button if you want to recharge the batteries or connect an external 12V battery.

Then, the first screen displayed will be the following one:

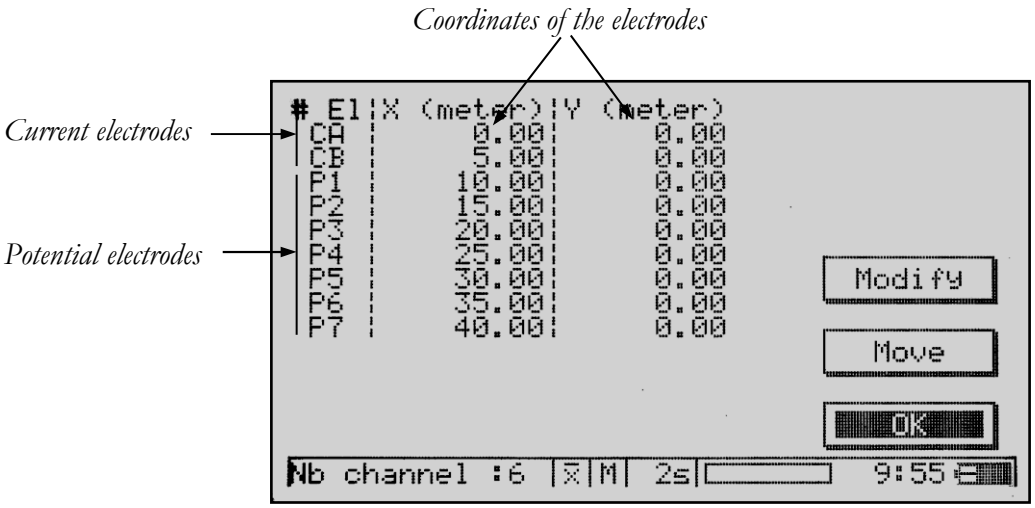


So, enter the spacing parameters (the spacing parameters are relative to the electrode array you previously selected - cf. Annex 2 for more information):

Procedure:

For each spacing: use the numeric keys and validate each input by the ↵ key

Then, the following screen will appear:

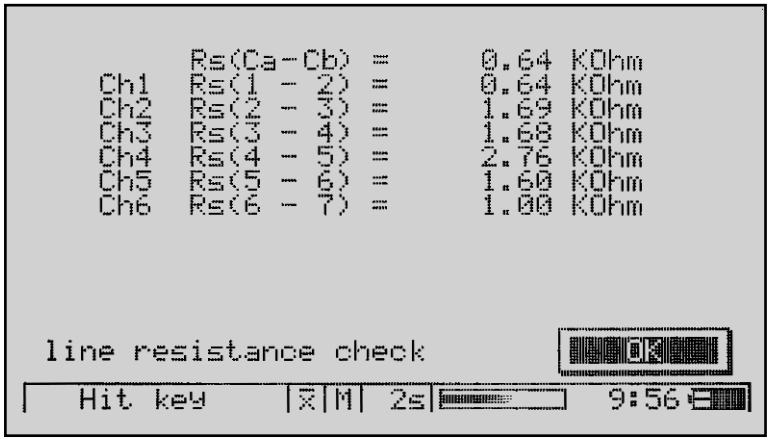


Then, press the ↵ key to run the acquisition.

The next screen is relative to the resistance measurement of the whole dipoles; this allows to check that all the electrodes are correctly connected; if not, check the wires and try to improve the contact with the ground.

Be careful: During the measurement of the contact resistance, elevated currents and voltages are delivered by the unit. To avoid any risk of electrocution, do not touch the electrode during the RS-Check measurement. Shut down the Syscal before touching the electrode to improve the contact resistance.

The following example is given for an SYSCAL Pro used with 6 channels:

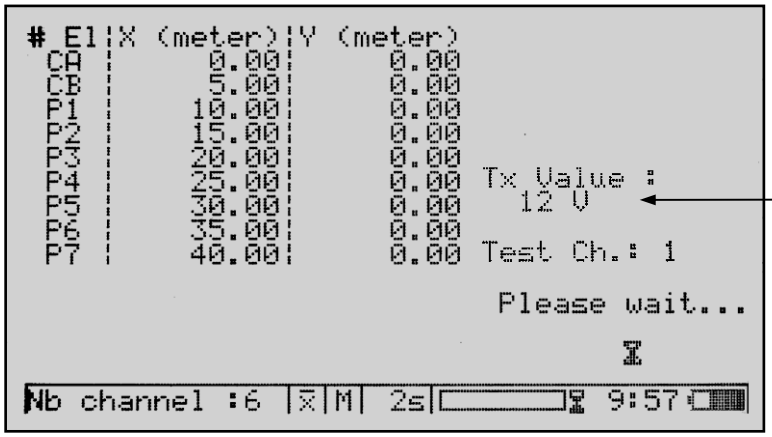


Note:

The value of the grounding resistance is displayed in kOhm.

If the line is open (electrode not correctly connected), the displayed value will be "***999.999***' kΩ and the line will be highlighted. The measurement will continue while the contact resistance will be equal to 999.999 kΩ. Therefore, at this stage, you can reconnect the electrode or improve its contact with the ground. If, however, you want to skip this measurement, press  . The Syscal will measure on the next channel.

Then, the measurement will start automatically with first, a filtering process:

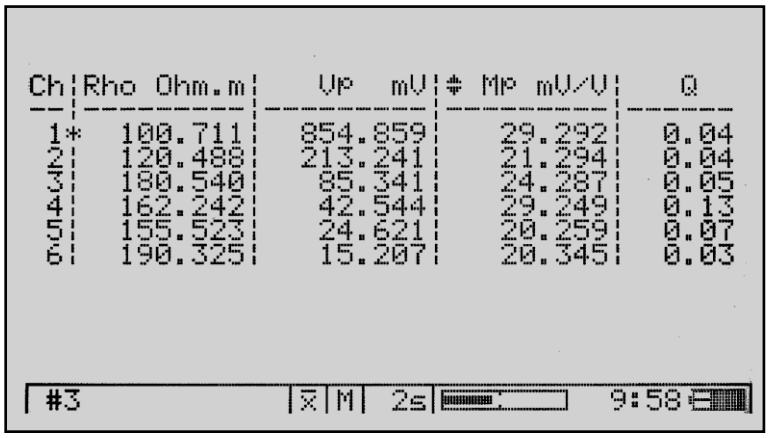


Theoretical injected voltage value

Note:

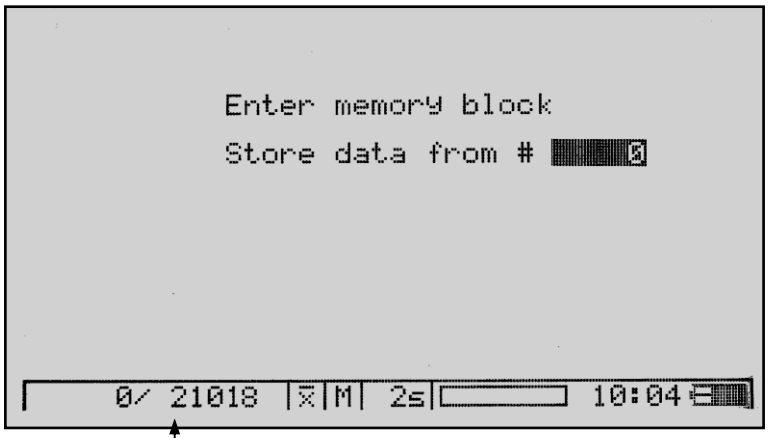
In the previous screen, the **Tx value** displayed is a theoretical value which can be sometimes different from the actual value as a power or voltage limitation can occur in regards to the grounding resistance value.

Then, the results will be displayed in the following screen:



During the measurement, one has the opportunity to see various results and various type of screens: cf § II.3.6. for more information.

At the end of the measurement, for the first acquisition, the program offers automatically to save the data in the first memory area ("0"):



Available range of the memory area

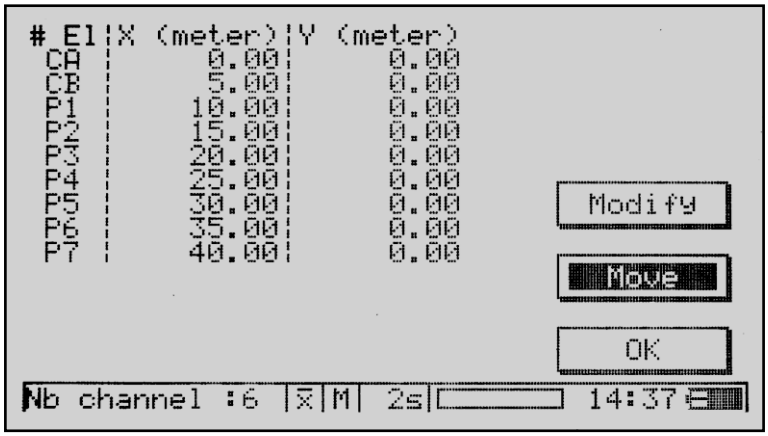
Note that if you want to store the data from a specific memory area, use the numeric keys. Then, press the ↵ key to confirm.

If you don't want to save the data (to check the results beforehand for example), press the MENU key; you'll have the possibility in a second time to store them, thanks to the "**Memory**|**Store**" menu.

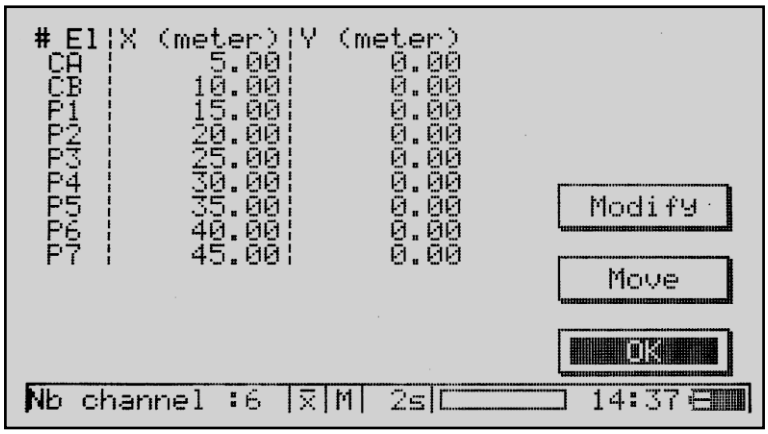
Then to go on the profile, move your electrodes in the field, of the specified **Move** parameter (5 meters in our case) and so, press the START key.

If the data previously acquired has not been saved, a warning message will be displayed; you'll have so the choice to go on the measurement ("**Continue**" button) or to stop it to store the previous data ("**Stop**" button).

Then the next screen will be automatically displayed:

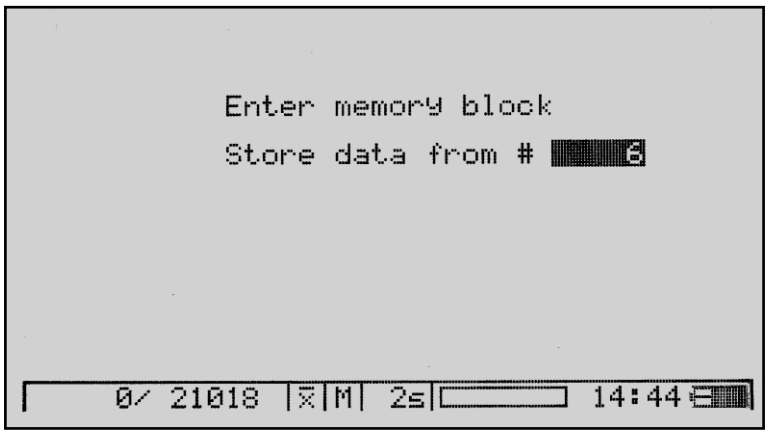


Then, from this window, choose the "**Move**" button.
The following screen will be then displayed:



Note that all the electrodes have been shifted of 5 meters.
Then, press the ↵ key to run the acquisition: the measurement will start automatically with the same screen as previously.

Then, after acquisition of this second data set, the program offers for saving the data from the next memory area ("6" in that case as the previously data have been stored in memory area from "0" to "5"):



Note that if you want to store the data from a specific memory area, use the numeric keys.
So, press the ↵ key to confirm.
If you don't want to save the data to check the results beforehand, press the MENU key; you'll have the possibility in a second time to store them, thanks to the "**Memory**|**Store**" menu.

Note:
If you want to store the data from a full memory area, the following warning message will be displayed:

So, press "**Yes**" to confirm, and "**Abort**" to skip this function without overwriting the data.
If you press "**No**", the program will check automatically the first free memory area and will offer to save the data from this one; then, press ↵ to validate.

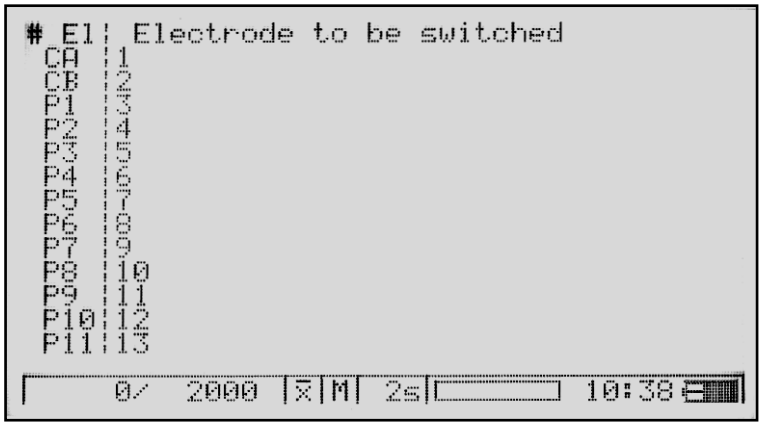
II.3.3. Manual switch

To run an acquisition in that mode, select the "**Config**|**Mode**" menu; a screen indicating the current mode will appear: if **Manual switch** is displayed, press "**OK**".
If not, press "**Change**"; then the screen showing the available modes will appear; then, select **Manual switch.**

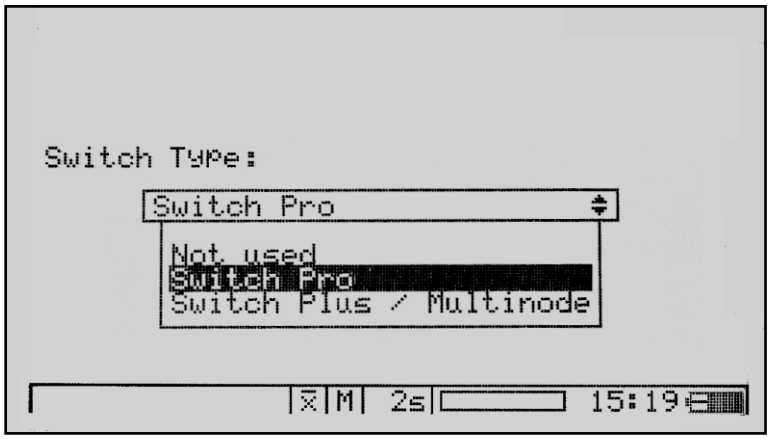
Procedure:
use the ▲ 2 and ▼ . keys to move up and down the cursor in the list and the ↵ key to select **Manual switch**, then press the ↵ key

Then press the START key or select the "**Tools**|**Start**" menu

At this stage, the program will display the batteries screen if one of the voltage levels is low.
So, in that case, press the "**Continue**" button if you think that it will be sufficient or "**Stop**" button if you want to recharge the batteries or connect an external 12V battery.
Then, the first screen displayed will be the following one after having entered the electrodes to be switched:



Then, press  key to validate: the following screen will appear:



Then, specify the configuration of the system:

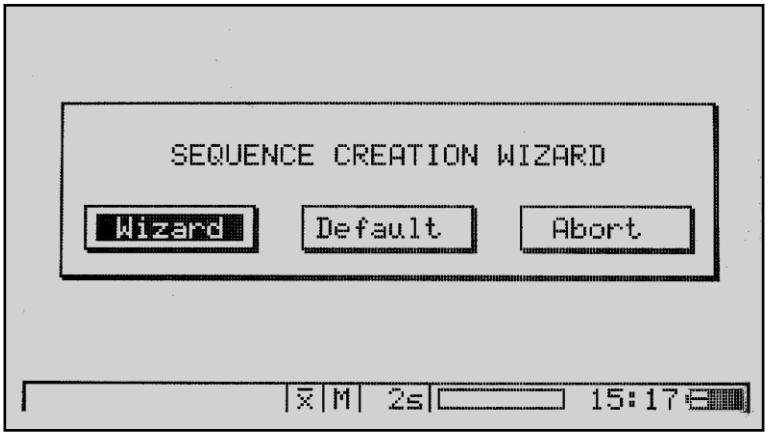
- **Not used** (no switching capability: 10 channels standard using): no meaning in that mode.
- **Switch Pro** (internal or external 10 channels switching capability)
- **Switch Plus / Multinode** (external 1 channel switching capability)

Then press the  key or select the **"Tools|Start"** menu.
Then, one will reach exactly the same screens than in **Standard mode** (cf. II.3.2.), from which one will have to specify the coordinates of the electrodes.

Note:
No Rs check process and no data storage will be done in the **Manual switch** mode.

II.3.4. Sequence creation

For the other modes of measurement (**Manual sequence** - **Automatic sequence – Sp sequence** and **High speed sequence**), before running the acquisition, one has first to create a sequence of measurement (i.e. a list of quadrupoles with the definition of the geometrical parameters); this can be done by the **"Sequence|Create"** menu; the following screen will appear:

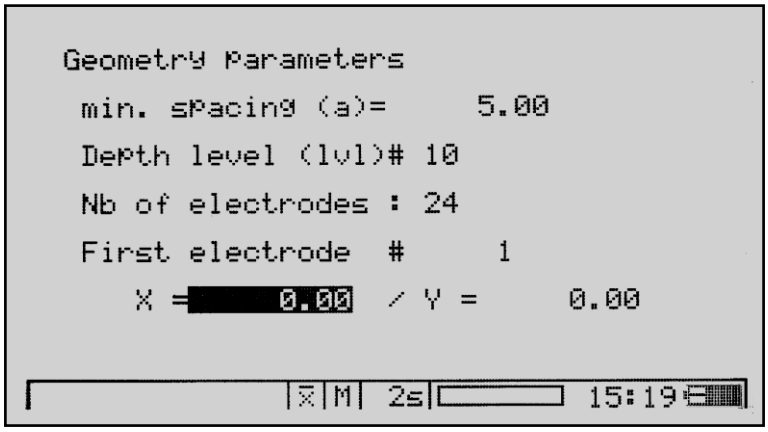


Then, from this window, you have the opportunity to press the "**Wizard**" button if you want to create the sequence step-by-step, from the beginning.
If the set up parameters have been defined from the "**Config**" menu, you can press directly the "**Default**" button.
Press "**Abort**" button to skip this function and reach the master menu

From the **Wizard** creation, you'll reach successively the screen of the following **Config** parameters:
- Name / Position (cf. II.1.2.)
- Tx parameters (cf. II.1.5.) (note that the "**Vp requested / Vab requested**" selection has no meaning for the **Sp sequence** mode as no injection is done in that case)
- Stacking parameters (cf. II.1.3.)
- Electrode array (cf. II.1.6.)

Note:
In "Vp requested" mode, we advise to choose a number of channels in relation with the number of depth levels of the sequence.
For example, if 16 depth levels are programmed, a number of channels of 8 will allow to optimize the measurement. Indeed, in that case, the unit will perform a first set of measurements of 8 channels and then another set of 8 channels: so, this will allow to get higher voltage levels in reception than in the 10 channels configuration, as in that case a first set of measurements of 10 channels would be performed followed by a set of measurements of 6 channels).

Then, one will reach the ***geometry parameters*** screen:



From the "**Default**" button of the ***Sequence creation*** screen, you'll have only access to the ***Filename*** screen and then you'll reach directly the ***geometry parameters*** screen:

Then, enter the following parameters:

- Min. spacing (a): minimum spacing between the electrodes (in meters)

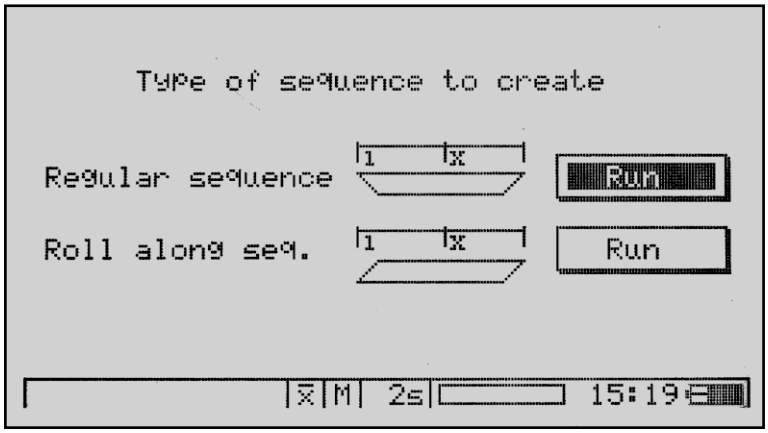
- Depth level (lvl): number of levels of investigation (max:16)

- Nb of electrodes: total number of electrodes (linked to the length of the profile you wish to explore and the spacing between electrodes)

- First electrode: first electrode to be used

- Position of the first electrode in **X**, **Y** coordinates

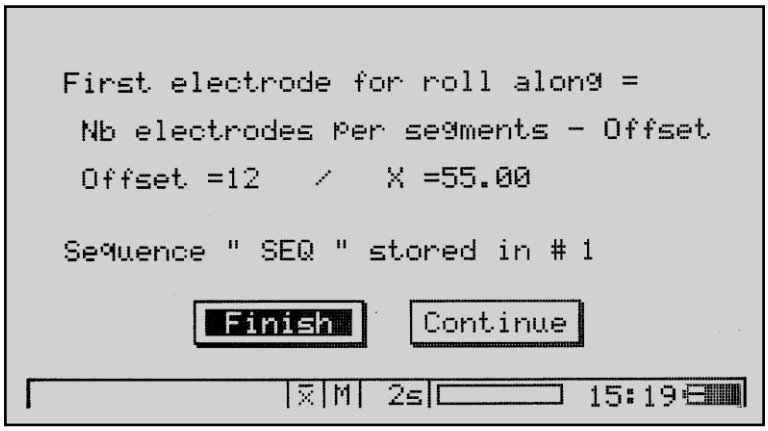
Then, the following screen will appear:



Choose **Regular sequence** to run a standard sequence and the **Roll along seq.** to run a roll along sequence.

The selection of the **Roll along seq.** requires that you have previously entered the correct spacing for the first electrode; this spacing is given at the end of the creation of the regular sequence (for the first roll along).

Indeed, at the end of the creation of a regular sequence, one will reach the following screen:

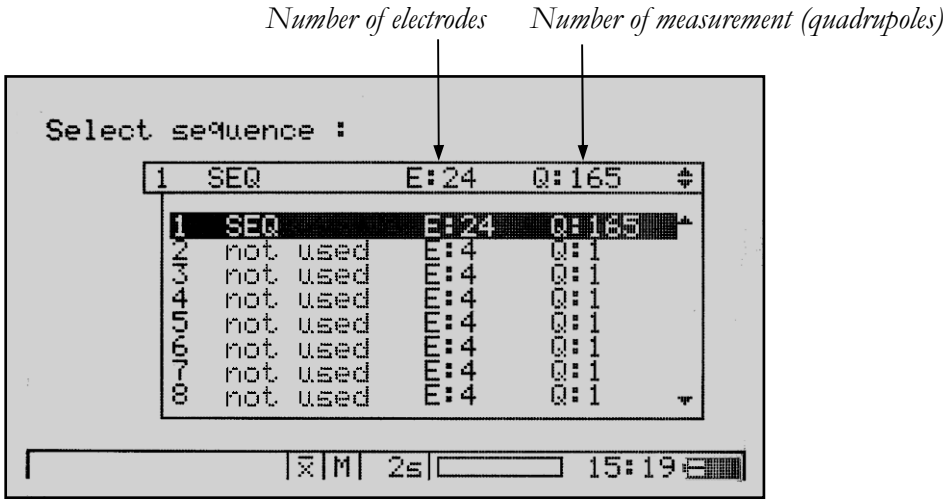


So, press "**Finish**" to validate the sequence creation or "**Continue**" if you want to modify the sequence.

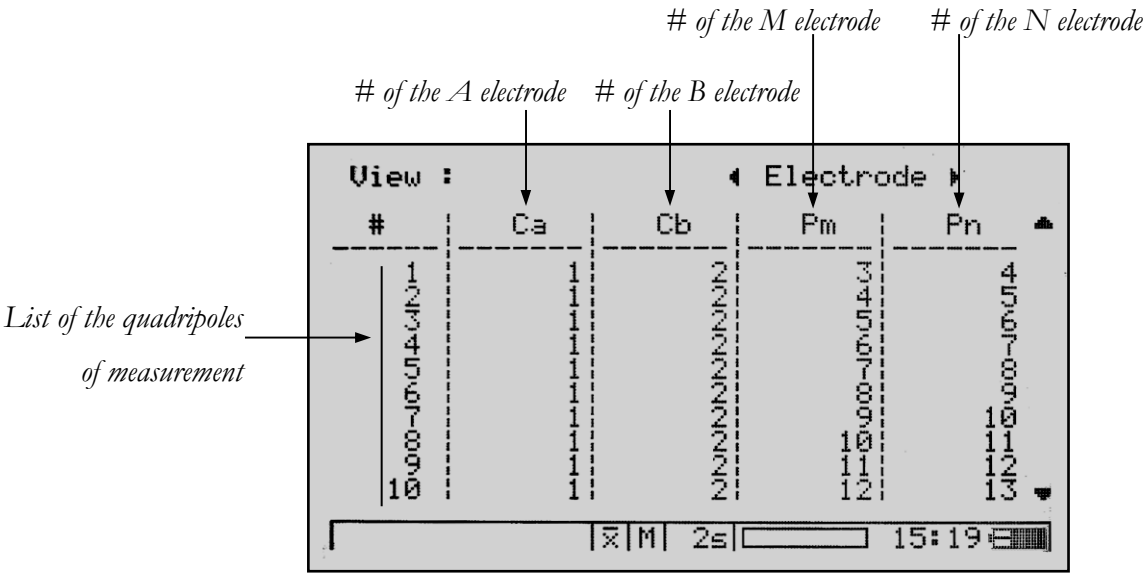
Notes:

- After creation of the sequence, the modification of the parameters from the options of the "**Config**" menu will be taken into account.
- Up to 12 sequences can be stored into the SYSCAL Pro memory

Once the sequence has been created, it's possible to visualize it from the "**Sequence|View**" menu: the list of sequences present in the memory will so be displayed:



So choose from this list, by the [2] and [.] keys, the sequence you wish to visualize and validate by the [↵] key: the following screen will appear:



From this window, use the [2] and [.] keys to scroll up and down in the list and the [0] and [_] keys to visualize the set up parameters of the sequence.

Note:

It's also possible to use some sequences created by the ELECTRE Pro software, in case of the sequences generated internally wouldn't match your requirement (cf. IV.4.1.).

In such a sequence:

- The number of measuring has not been defined; by default, the number of channel is "10"; you can change it just before starting the sequence from the "Config|E. array" menu (cf. II.1.6.).

- No "Vab maximum" value has been entered: by default, this will be the highest one ("800 V"); you can change it just before starting the sequence from the "Config|TX parameters" menu (cf. II.1.5.).

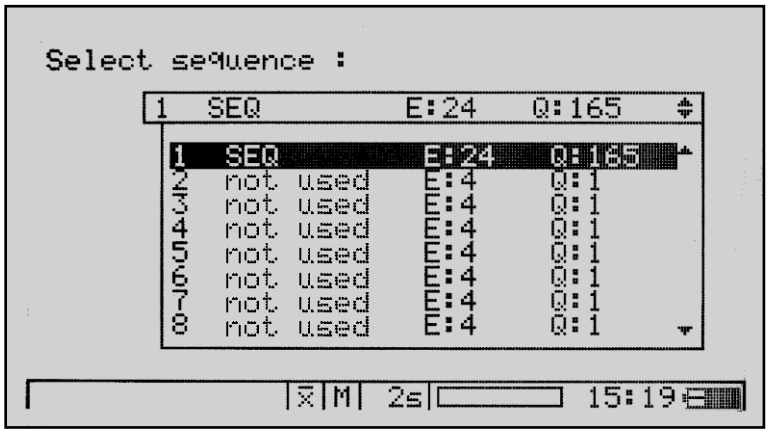
II.3.4.1. Manual sequence

This mode is useful for the units having the "Rx-only" option.
Indeed, in configuration where it's necessary to move regularly the A-B electrodes, (like dipole-dipole), this type of acquisition allows to work in multi-electrodes using a sequence, but that is run manually (to permit the user in the field to move physically the A-B electrodes).

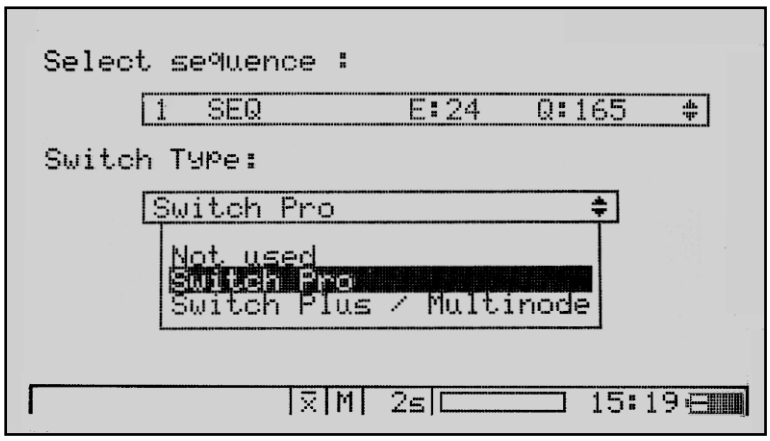
In that process, after having created a sequence (cf. II.3.4.), one has to specify that the acquisition has to be performed in **Manual sequence** mode.
Then select the "**Config|Mode**" menu; a screen indicating the current mode will appear; so if **Manual sequence** mode is selected, then press "**OK**".
If not, press "**Change**": the screen showing the available modes will appear; so, select the **Manual sequence** mode**.**

Procedure:
use the 2 and . keys to move up and down the cursor in the list and the ↵ key to select **Manual sequence**, then press the ↵ key

The list of sequences present in the memory will so be displayed:



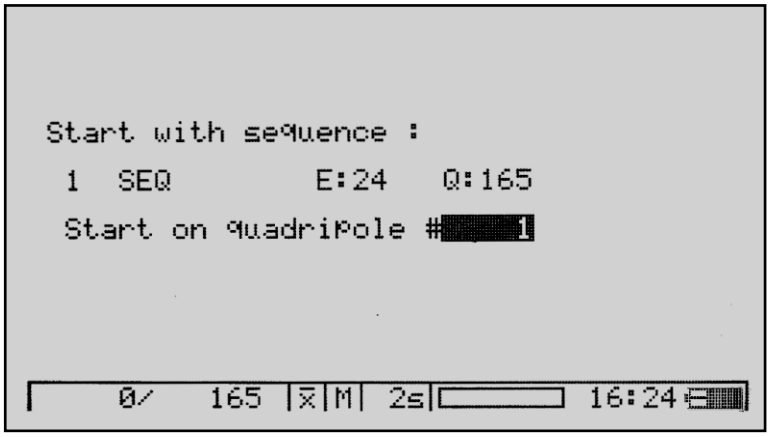
So choose from this list, by the 2 and . keys, the sequence you wish to run and validate by the ↵ key: the following screen will appear:



Then, specify the configuration of the system:

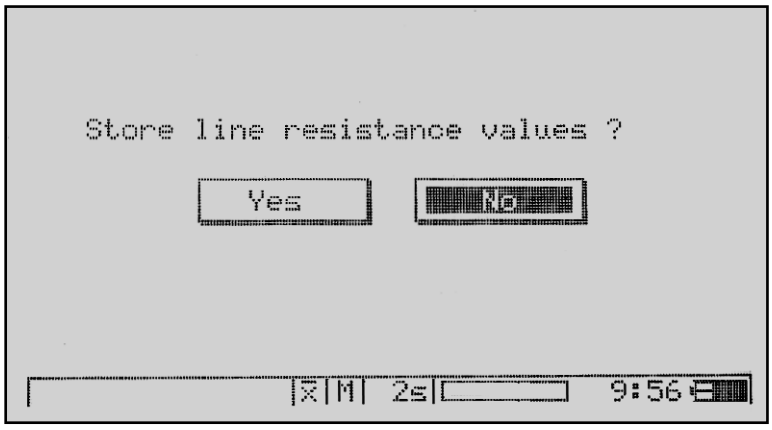
- **Not used** (no switching capability: 10 channels standard using): no meaning in that mode.
- **Switch Pro** (internal or external 10 channels switching capability)
- **Switch Plus / Multinode** (external 1 channel switching capability)

Then press the START key or select the "**Tools**|**Start**" menu.
The first screen will be relative to the filename, which you can change at this stage; then press the key: ↵ following screen will appear:



So, to start the measurement at the first quadrupole, then press the ↵ key (if you want to start the measurement from another quadrupole, enter its number and validate):

Then, the program will offer to store the resistance values of the dipoles:

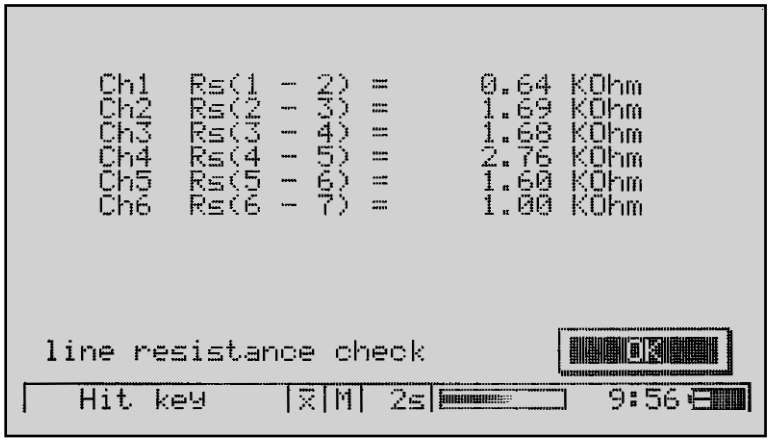


So, if you choose "**Yes**", the Rs check process will be run first displaying the resistance of the dipoles in the cable; and then, between each set of measurements, the Rs check on the next measuring dipoles will be run and the resistance value of these dipoles will be stored.

Note:
Keep in mind that this option is time consuming (acquisition time will be multiplied about by 2)

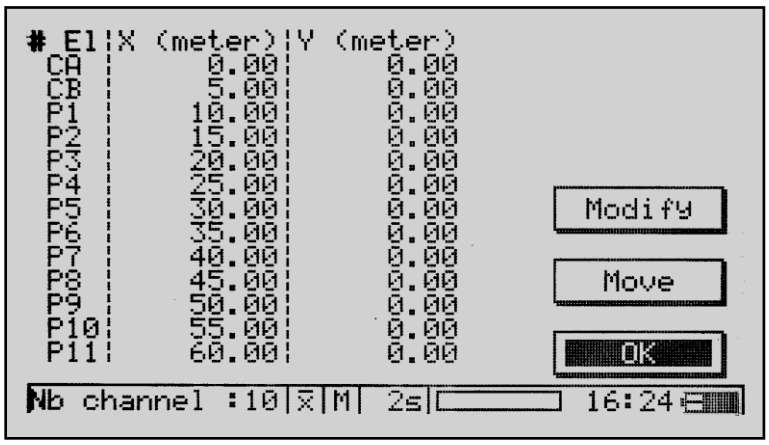
Be careful: During the measurement of the contact resistance, elevated currents and voltages are delivered by the unit. To avoid any risk of electrocution, do not touch the electrode during the RS-Check measurement. Shut down the Syscal before touching the electrode to improve the contact resistance.

If "**No**" has been selected, the Rs check process will be run but values won't be stored.



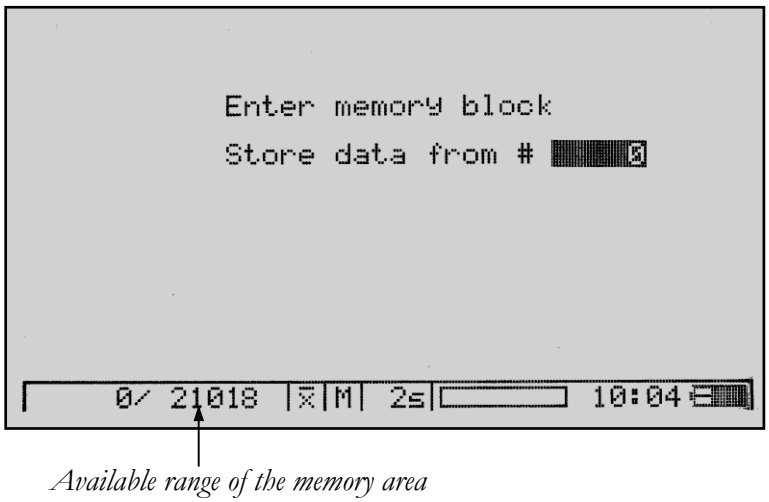
Then, if you selected previously "**Yes**", a screen with the "**Rs check**" message in the lower left part of the screen, will appear briefly.

Then, the next display will be:



Then, press the ↵ key to run the acquisition.
During the measurement, one has the opportunity to see various results and various type of screens: cf § II.3.6. for more information.

At the end the measurement, for the first acquisition, the program offers automatically to save the data from the first memory area ("0"):

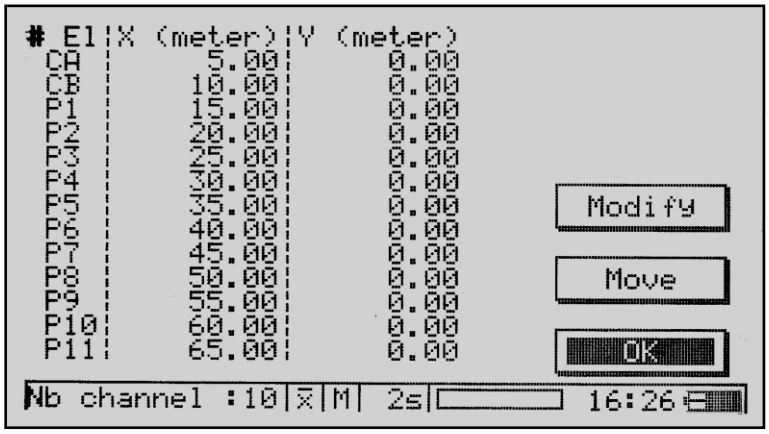


Available range of the memory area

Note that if you want to store the data from a specific memory area, use the numeric keys.
Then, press the ↵ key to confirm.

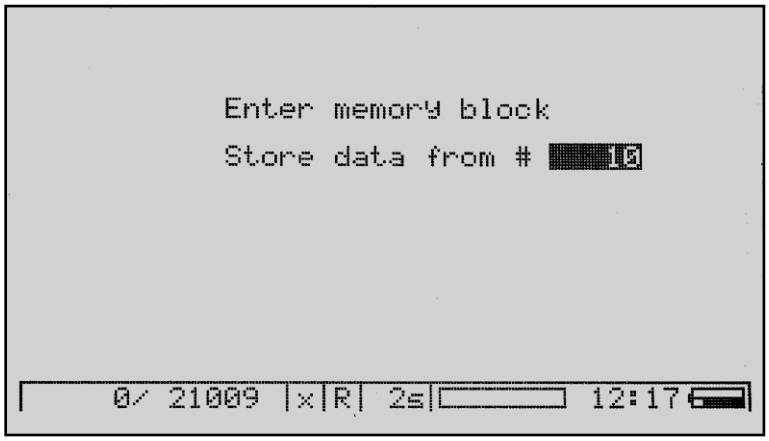
If you don't want to save the data (to check the results beforehand for example), press the MENU key; you'll have the possibility in a second time to store them, thanks to the "**Memory**|**Store**" menu.

Then the next screen will be automatically displayed:



Note that all the electrode positions have been shifted of 5 meters (as the min. spacing parameter defined in the sequence is "5" (cf. II.3.4.). In **Manual sequence** mode, the unit computes automatically the new spacing parameters; so, you don't have to use the "**Move**" or the "**Modify**" button between the acquisitions: then, one has just to move the electrodes and press the key ↵ to continue the sequence.

Then, after acquisition of this second data set, the program offers for saving the data from the next memory area ("10" in that case as the previously data have been stored in memory area from "0" to "9"):



Note that if you want to store the data from a specific memory area, use the numeric keys.

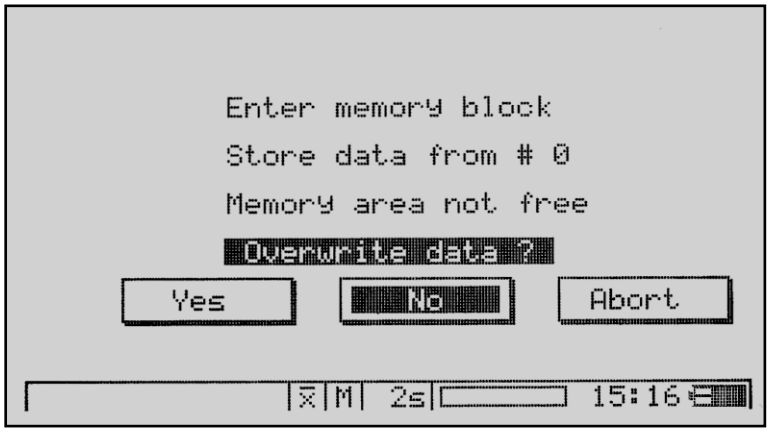
So, press the ↵ key to confirm.

MENU

If you don't want to save the data to check the results beforehand, press the key; you'll have the possibility in a second time to store them, thanks to the "**Memory|Store**" menu.

Note:

If you want to store the data from a full memory area, the following warning message will be displayed:



So, press "**Yes**" to confirm, and "**Abort**" to skip this function without overwriting the data.

If you press "**No**", the program will check automatically the first free memory area and will offer to save the data from this one; then, press ↵ to validate.

II.3.4.2. Automatic sequence

In that process, after having created a sequence (cf. II.3.4.), one has to specify that the acquisition has to be performed in **Automatic sequence** mode.

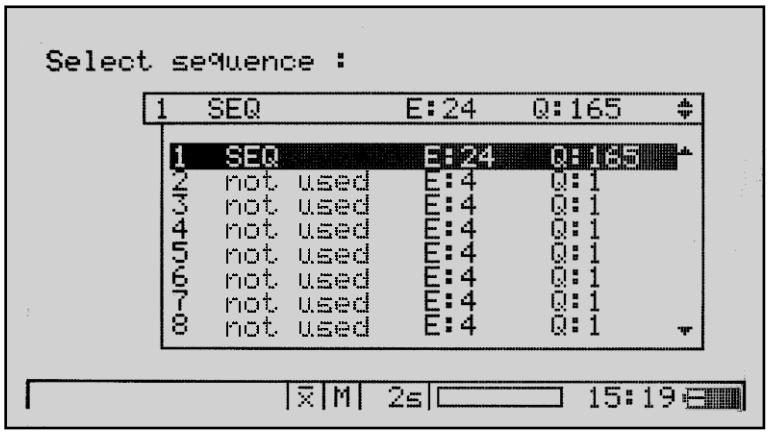
Then select the "**Config|Mode**" menu; a screen indicating the current mode will appear; so if **Automatic sequence** mode is selected, then press "**OK**".

If not, press "**Change**": the screen showing the available modes will appear; so, select the **Automatic sequence** mode**.**

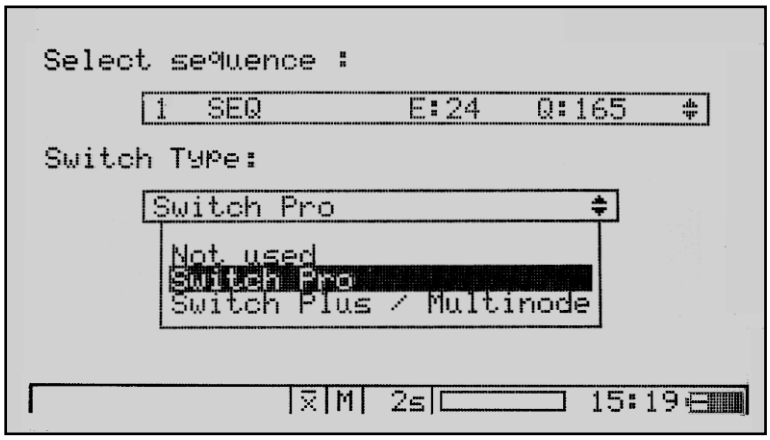
Procedure:

use the ▲ 2 and ▼ . keys to move up and down the cursor in the list and the ↵ key to select **Automatic sequence**, then press the ↵ key

The list of sequences present in the memory will so be displayed:



So choose from this list, by the  and  keys, the sequence you wish to run and validate by the  key: the following screen appear:



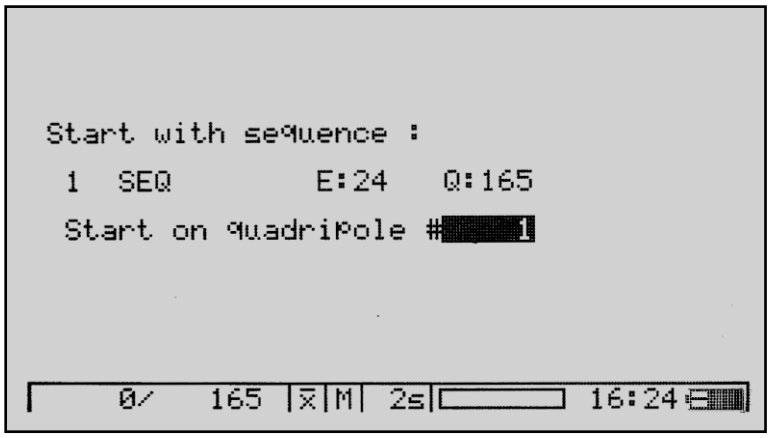
Then, specify the configuration of the system:

- **Not used** (no switching capability: 10 channels standard using): no meaning in that mode.
- **Switch Pro** (internal or external 10 channels switching capability)
- **Switch Plus / Multinode** (external 1 channel switching capability)

Press  to validate

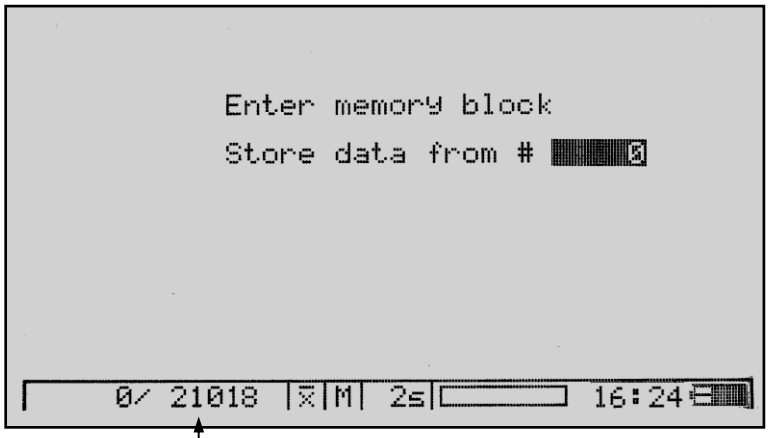
Then press the  key or select the **"Tools|Start"** menu.

The first screen will be relative to the filename, which you can change at this stage; then press the key:  the following screen will appear:



So, to start the measurement at the first quadrupole, then press the ↵ key (if you want to start the measurement from another quadrupole, enter its number and validate):

Before running the measurement, for the first acquisition, the program offers automatically to save the data from the first memory area ("0"):



Available range of the memory area

Note that if you want to store the data from a specific memory area, use the numeric keys.

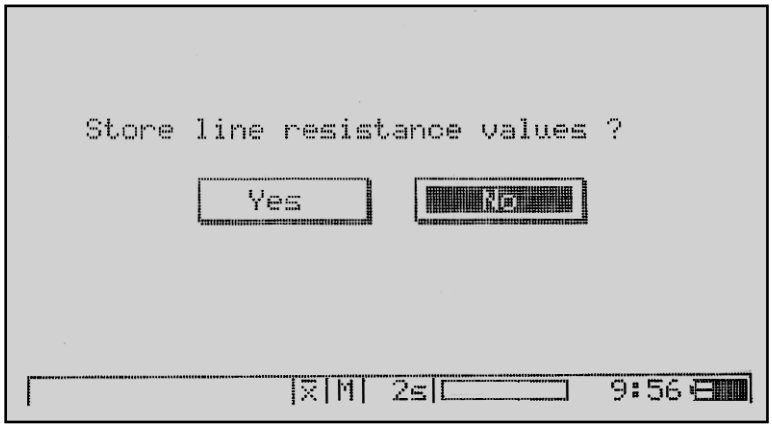
Then, press the ↵ key to confirm.

Note:

If you want to store the data from a full memory area, the following warning message will be displayed:

So, press "**Yes**" to confirm, and "**Abort**" to skip this function without overwriting the data.
If you press "**No**", the program will check automatically the first free memory area and will offer to save the data from this one; then, press ↵ to validate.

Then, after selection of the memory area, the program will offer to store the resistance values of the dipoles:

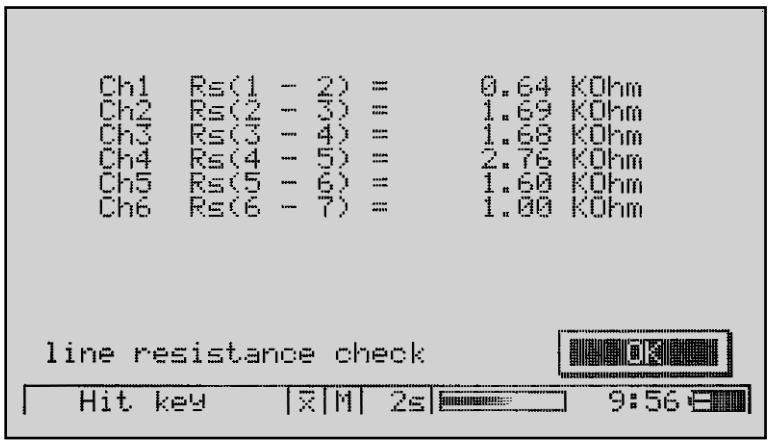


So, if you choose "**Yes**", the Rs check process will be run first before each set of measurements, displaying the resistance of the dipoles in the cable; then, between each set of measurements, the Rs check on the next measuring dipoles will be run and the resistance value of these dipoles will be stored

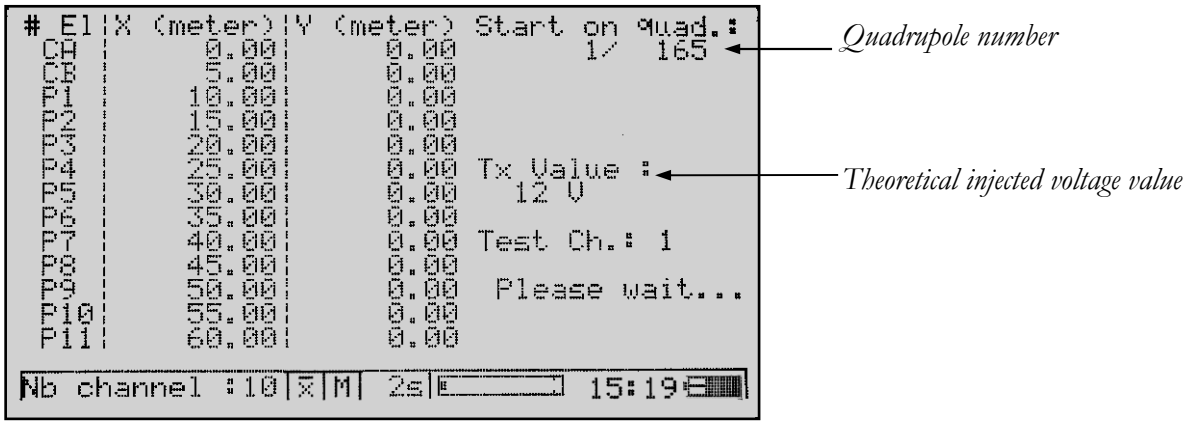
Note:
Keep in mind that this option is time consuming (acquisition time will be multiplied about by 2)

Be careful: During the measurement of the contact resistance, elevated currents and voltages are delivered by the unit. To avoid any risk of electrocution, do not touch the electrode during the RS-Check measurement. Shut down the Syscal before touching the electrode to improve the contact resistance.

If "**No**" has been selected, the Rs check process will be run but values won't be stored.



Then, if you selected previously "**Yes**", during a while, a screen with the "**Rs check**" message in the lower left part of the screen, will appear during a time required for the measurement.
Then, the next display will be:



Note:

On that screen, the **Tx value** displayed is a theoretical value which can be sometimes different from the actual value as a power or voltage limitation can occur, depending on the grounding resistance values and temperature conditions.

The measurements will be then displayed.
The previous screen will appear between each set of measurements.
Note that during the measurement, one has the opportunity to see various results and various type of screens (cf § II.3.6. for more information).

Notes:

• The estimated time left will be also displayed (in the upper right corner of the screen) after the first set of measurements and between each set of measurements.

• To stop a sequence, press the MENU button; if a sequence has not been stopped before the end, a message (**Sequence not ended…**) will be displayed in the master screen

Then, if a start on the same sequence is run, the following screen will be displayed:

Then, press "**Continue**" to continue the acquisition or press "**New**" to run a new acquisition.

II.3.4.3. High speed sequence

In that process, after having created a sequence (cf. II.3.4.), one has to specify that the acquisition has to be performed in **High speed sequence** mode.
Then select the "**Config|Mode**" menu; a screen indicating the current mode will appear; so if **High speed sequence** mode is selected, then press "**OK**".
If not, press "**Change**": the screen showing the available modes will appear; so, select the **High speed sequence** mode**.**

Procedure:

use the 2 and . keys to move up and down the cursor in the list and the ↵ key to select **High speed sequence**, then press the ↵ key

Important note:

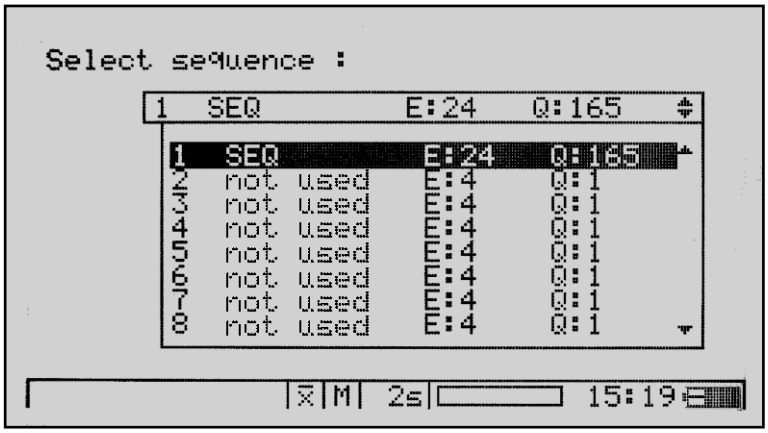
This mode uses by default the following parameters:

- Pulse duration: about 200 ms

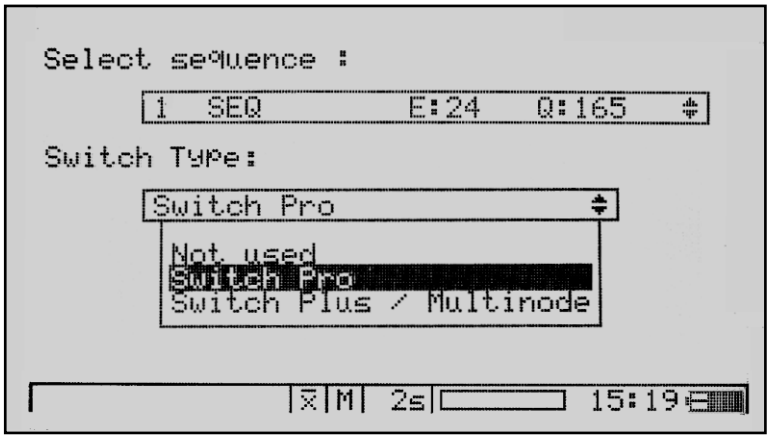
- Positive pulse followed by a negative pulse (In that mode, no IP measurements can be done).

Moreover, this mode requires to work with a constant value of injection. So, the sequence has to be created with a Vab requested value or this can be modified from the Tx parameters (cf. II.1.5.) before running the sequence.

After validation of the mode, the list of sequences present in the memory will so be displayed:



So choose from this list, by the 2 and . keys, the sequence you wish to run and validate by the ↵ key: the following screen appears:

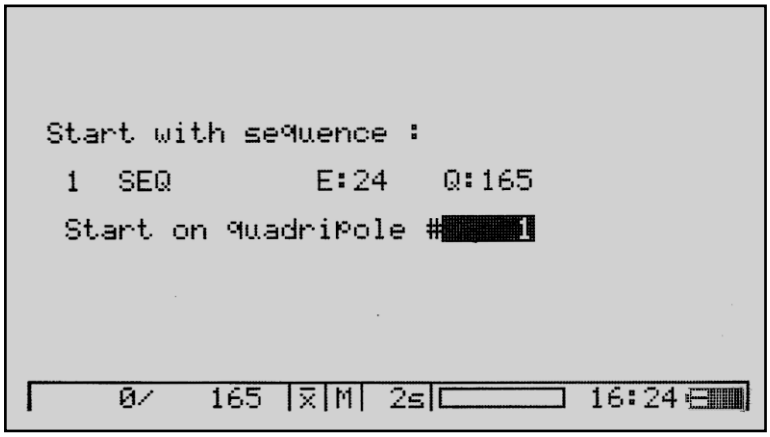


Then, specify the configuration of the system:

- **Not used** (no switching capability: 10 channels standard using): no meaning in that mode.
- **Switch Pro** (internal or external 10 channels switching capability)
- **Switch Plus / Multinode** (external 1 channel switching capability)

Then press the START key or select the "**Tools**|**Start**" menu.

The first screen will be relative to the filename, which you can change at this stage; then press the key: ↵ the following screen will appear:

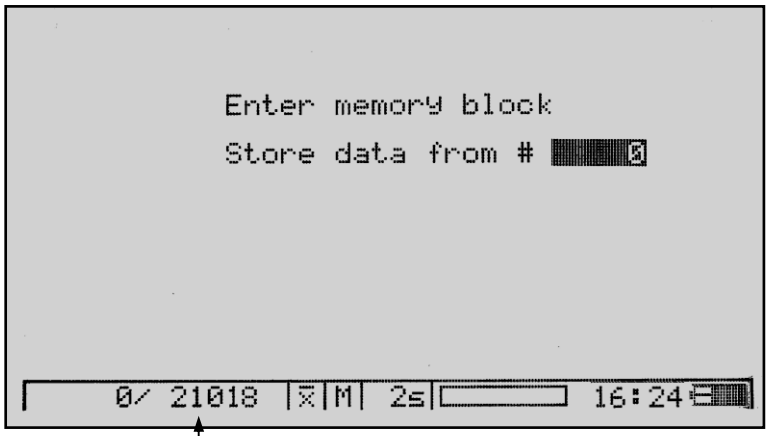


So, to start the measurement at the first quadrupole, then press the ↵ key (if you want to start the measurement from another quadrupole, enter its number and validate):

Note:

After validation, if the type of injection is not based on a constant Vab value ("**Vab requested**" mode), an error message will appear in a window. In that case, choose "**New**" from this window to reach directly the "**Tx Parameters**" screen to modify the type of voltage requested (cf. II.I.5.).

Before running the measurement, for the first acquisition, the program offers automatically to save the data from the first memory area ("0"):



Available range of the memory area

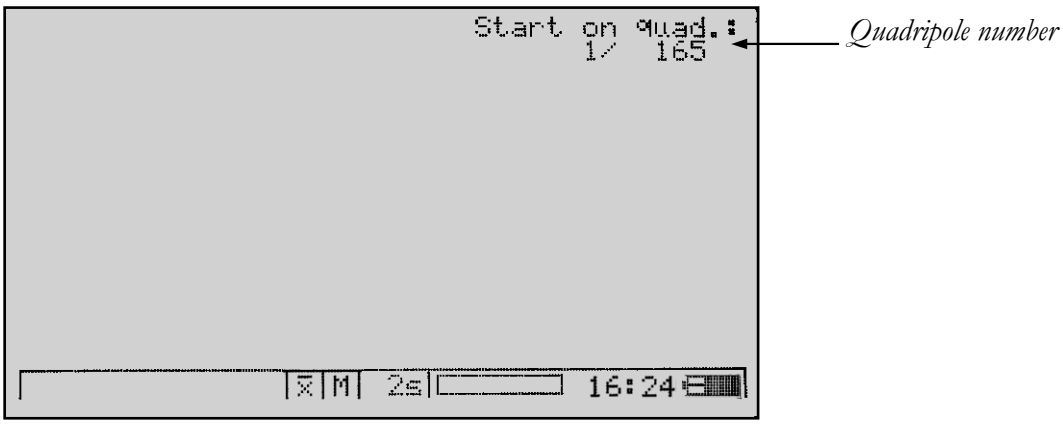
Note that if you want to store the data from a specific memory area, use the numeric keys.
Then, press the ↵ key to confirm.

Note:

If you want to store the data from a full memory area, the following warning message will be displayed:

So, press "**Yes**" to confirm, and "**Abort**" to skip this function without overwriting the data.
If you press "**No**", the program will check automatically the first free memory area and will offer to save the data from this one; then, press ↵ to validate.

Then, the following screen will appear directly (no Rs check is performed in that mode):



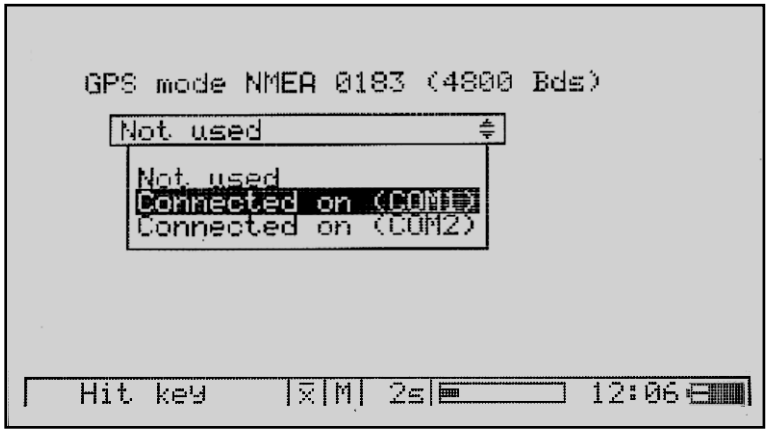
At the end of the sequence, the master screen will be displayed automatically.

II.3.4.4. Sp mode sequence

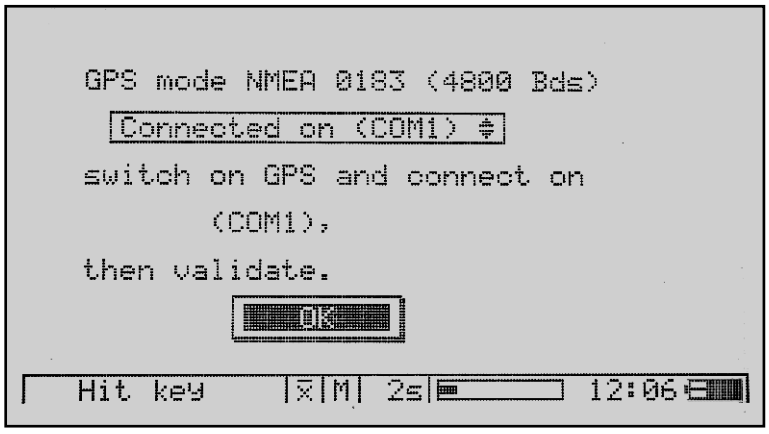
In that mode the measurement will be run without any injection process so as to be able to measure the Self potential parameter (please refer to Annex 12 for details).

II.3.5. Continuous survey

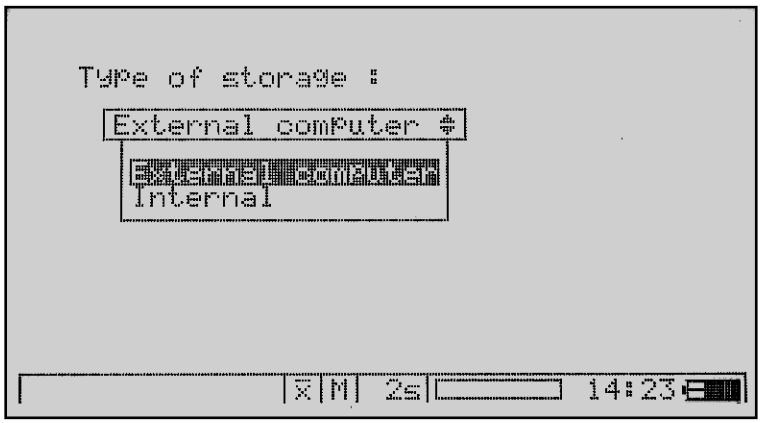
This type of acquisition can be reached from the "**Tools|Continuous survey**" menu.
This is a dynamic mode designed for marine acquisition.
In that mode, the SYSCAL Pro is in the **standard mode** configuration; it means than we can use simultaneously up to 10 reception channels (the marine cable being connected to the A-B-P1…P11 plugs of the unit by a specific connector); this corresponds to 10 levels of investigation.
In that mode, only resistivity measurements will be performed
After selection of that mode, one can specify if a GPS is connected to the unit:



Then, after validation, the following screen will appear:

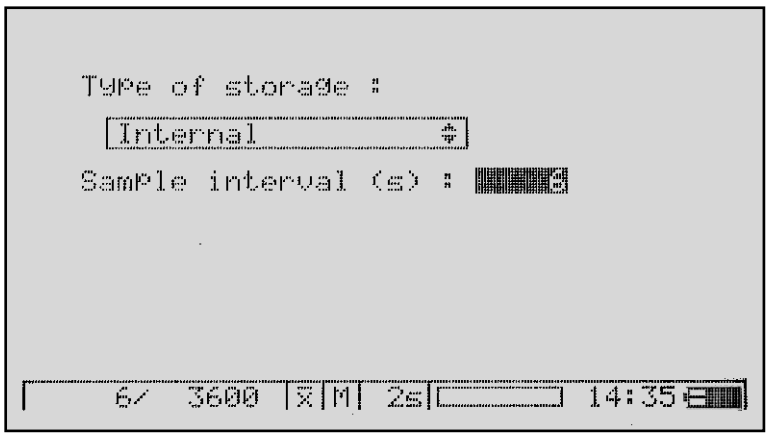


Then, press "**OK**": a waiting message ("**Remote control**") will appear then. If no GPS is used, the following screen will appear before the display of the waiting message:



• In case of "**External computer**" is selected, a waiting message ("**Remote control**") will appear; then, from a specific PC software, SYSMAR, one has to define the position of the electrodes, the pulse duration and the voltage value to inject; then the measurement can be run.

• In case of the internal memory of the unit is used, one has first to define the setup parameters from the options of the "**Config**" menu:
Note that from the "**Config|Tx parameters**" option (cf. II.1.5.), one has to specify a "Vab" requested value.
Then after selection of "**Internal**", the following window will be displayed:



Then, specify the interval between measurements, in second, in the range [6 – 3600]; in case of no GPS is connected, the minimum value of the sample interval is: 1 s

This value corresponds to the minimum step of measurement; then validate: one will have then to specify the first memory area from which the data will be stored; after validation, if the type of injection is not based on a constant Vab value (Vab requested), an error message will appear. In that case, apply the modification from the "**Config|Tx parameters**" menu and do anew the procedure.

Then, specify the first memory area to store data and then, the measurement will be run: no values will be displayed in that mode:
The acquisition will have to be stopped by the 

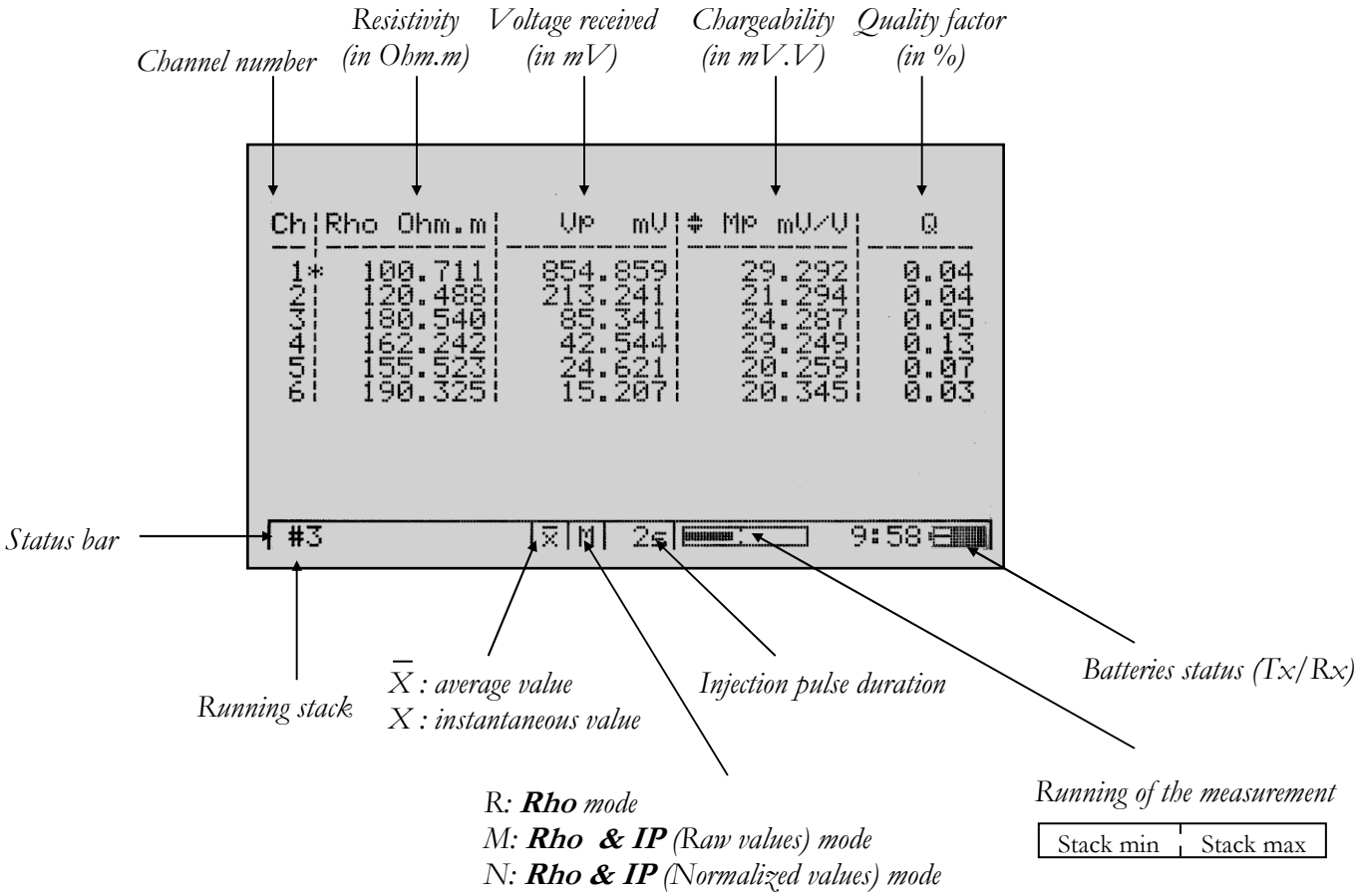
key.
In case of a GPS is connected, the minimum acquisition value is about 2 s; the measurements are stored automatically in the PC. The GPS data are also continuously recorded and stored for a precise location of the profile.
A GPS with a sounder can be also used for a continuous water depth recording.
Please refer to the on-line help file of SYSMAR software for more information.
Note:
In standard configuration:
- The cable (specific cable with a DB9 female output) has to be connected to the "Com 2" of the unit (serial link of the backside).
- The GPS has to be connected to the "Com 1" of the unit (serial link of the front panel) by the cable with a DB9 male output supplied; then a Rs232 cable, allowing to connect your own GPS to that DB9 male plug will have to be used.
If a GPS is used, you first have to set your GPS in NMEA mode (cf. Annex 10 for details).

II.3.6. Results during measurement

Whatever the operating mode (except for the **High speed sequence** mode), the screens showing the results will be the same:

The Result 1 key will show the results of the measurement, channel per channel whereas the Result 3 key will show the results of the measurement, for the whole channels.

• So, from the Result 3 key:



During the measurement, one can use the 2 and keys to change the displays:

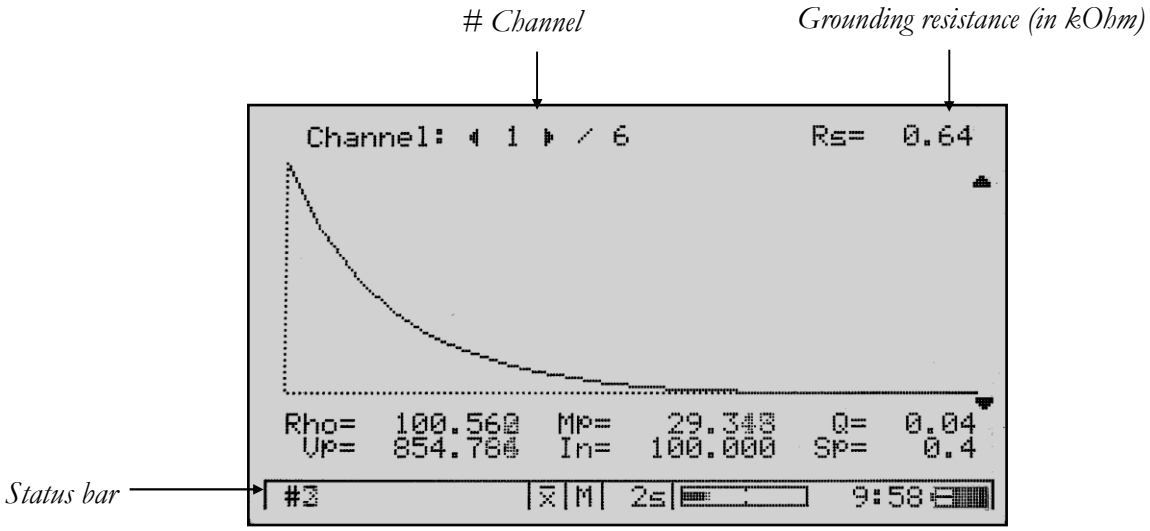
- Pressing the 2 key will allow to see the **current** value (in mA) instead of the chargeability (**Mp**) value.
- Pressing the 2 key one more time will allow to see the **Sp** value (Self potential in mV) instead of the **current** value.
- Pressing the 2 key one more time will allow to check if there are some **overload** in reception

The overload thresholds are the following ones:

$$V_{P1-P2} \leq 15V \qquad \text{and} \qquad \sum_{i=2}^{10} V_{Pi-Pi+1} \leq 15V$$

- And then, pressing the [2] key one more will allow to see the **decay curves** for the whole channels of measurement.
- Press the [2] one more time to come back to the first screen.

• And from the [Result 1] key:



During the measurement, one can use the [–] and [0] keys to see the results channel per channel.

At this stage, you can use also the [2] key to visualize the partial chargeability values of the current channel.

- Pressing the [2] key one more time will allow to visualize the spacing parameters
- Press the [2] key one more time to visualize the location of the profile (longitude and latitude position)
- Press the [2] key one more time to come back to the first screen.

Note:

The parameters displayed during the acquisition depend on the injection pulse duration selected. Indeed, if a low injection time has been selected (250 ms for example), only some of the parameters will be displayed.

II.4. AFTER ACQUISITION

II.4.1. Result

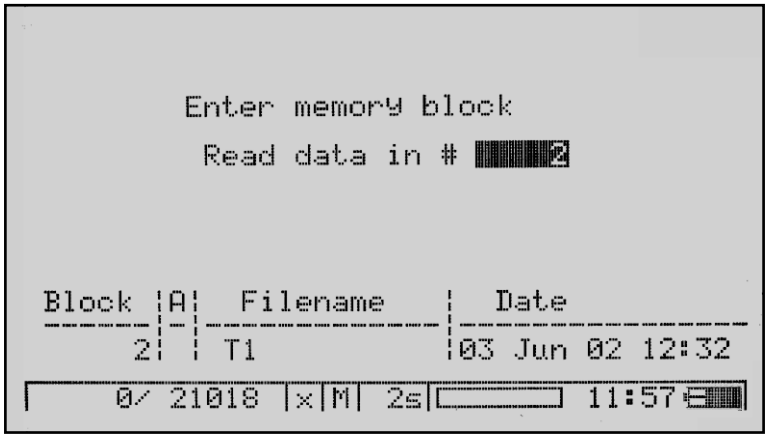
Once a measurement has been performed, the results can be visualized in the same way than during the measurement, by the Result 1 or by the Result 3 key.
The Result 1 key will show the results of the previous measurement, channel per channel.
This function can also be reached from the **"Tools | Result"** menu.
The Result 3 key will show the results of the previous measurement, for the whole channels.

The screens will be exactly the same that the ones shown during the measurement and you'll have the same functions offered (cf. II.3.6.).

Note:
This function is mainly useful for the Standard mode. Indeed, in the modes where a sequence of measurement has been run, we'll only have a view of the last measurement.

II.4.2. Memory

The memory size of the unit is more than 20 000 data points.
It's possible to read a data point previously stored into the memory of the unit.
Each data point is stored into a memory area.
To do that, select the **"Memory | Recall"** menu: the following screen will appear:



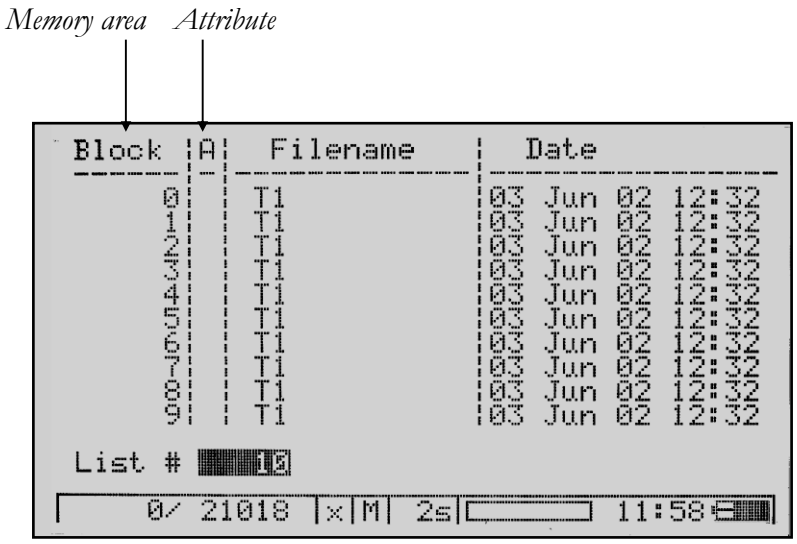
Then select the memory area you wish.

Procedure:

Use the numeric keys and validate by the  key

The screens will be exactly the same that the ones shown during the measurement and the same functions will be offered.

You can also visualize the whole data files stored in the memory by the "**Memory|Explore**" menu: the following screen will appear:



This option allows only to visualize the name of the data files with the storage date:

You can enter the memory area number you wish (**List #** area) in order to scroll up and down in the list.

The attribute (**A**) of the memory area can be the following one:

- " ": if a data is currently stored in that memory area
- "D": if the corresponding data has been deleted

Procedure:

Use the numeric keys and validate by the  key

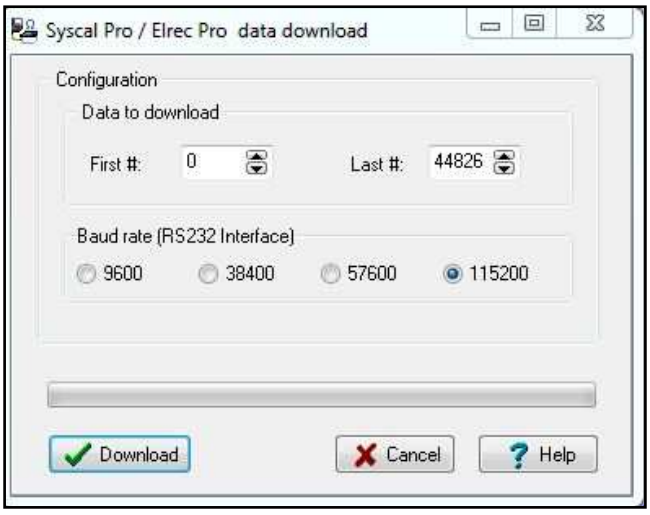
III. DATA MANAGEMENT

Once the measurement has been performed and the data stored in the internal memory of the unit, one can download the data to the PC, connected to the "**Com**" plug.
This has to be done by the PROSYS II software.
PROSYS II software is the data visualization, processing and export software for all the SYSCAL / ELREC type units of *IRIS Instruments*.
So, after having installed PROSYS II software in the PC (by the "IRIS Instruments" CD-ROM supplied with the unit), run the "ProsysII.exe" file from the installation directory.

Note:
PROSYS II software has an on-line help file, which will help you in the various tasks.

III.1. DATA DOWNLOAD

From PROSYS II software, select first the "**Communication|Communication port**" menu (USB (IRIS USB device required) or Serial link) then, the "**Communication|Data download|SYSCAL Pro/ELREC Pro**" menu; the following screen will appear:



So, you'll have the choice to select either the first and last data points to transfer ("**First #**" and "**Last #**") or to enter the name of a file to download the whole data stored with this file name ("**Specific filename**" area); note that you can enter a " *" to download the whole memory.

Note:
In regards to the PC capabilities, the baud rate (highest speed by-default) for download can be reduced.

Then, click on the "**Download**" button: the following screen will appear:

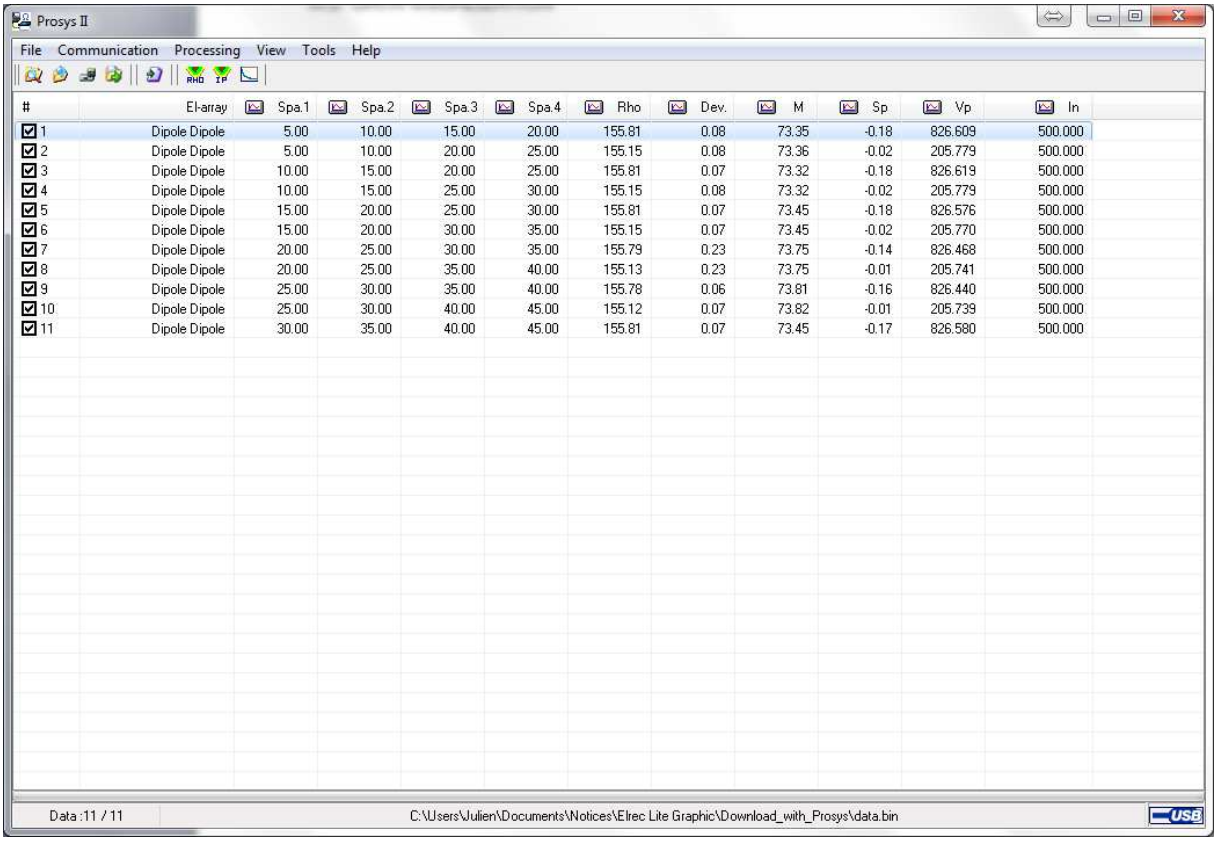
Then, press the  key (or select the "**Memory|Data download**" menu) from the SYSCAL Pro.
Then, click on "Ok" on the computer and the data transfer will begin; a bar graph showing the transfer progress will appear in the PROSYS II window.

After data transfer, PROSYS II offers to save the data with a filename; the extension of the file is "bin".

Note that data can be also downloaded to the IRIS SD reader: in that case, select the "**Memory|SD card download**" menu.
For more information, please refer to the Annex 11.

III.2. DATA VISUALIZATION

Once a data file has been transferred, one can visualize it thanks to the "**File|Open**" menu. Then select the ".bin" file you wish to open; the following screen will appear:



#	El-array	Spa.1	Spa.2	Spa.3	Spa.4	Rho	Dev.	M	Sp	Vp	In
1	Dipole Dipole	5.00	10.00	15.00	20.00	155.81	0.08	73.35	-0.18	826.609	500.000
2	Dipole Dipole	5.00	10.00	20.00	25.00	155.15	0.08	73.36	-0.02	205.779	500.000
3	Dipole Dipole	10.00	15.00	20.00	25.00	155.81	0.07	73.32	-0.18	826.619	500.000
4	Dipole Dipole	10.00	15.00	25.00	30.00	155.15	0.08	73.32	-0.02	205.779	500.000
5	Dipole Dipole	15.00	20.00	25.00	30.00	155.81	0.07	73.45	-0.18	826.576	500.000
6	Dipole Dipole	15.00	20.00	30.00	35.00	155.15	0.07	73.45	-0.02	205.770	500.000
7	Dipole Dipole	20.00	25.00	30.00	35.00	155.79	0.23	73.75	-0.14	826.468	500.000
8	Dipole Dipole	20.00	25.00	35.00	40.00	155.13	0.23	73.75	-0.01	205.741	500.000
9	Dipole Dipole	25.00	30.00	35.00	40.00	155.78	0.06	73.81	-0.16	826.440	500.000
10	Dipole Dipole	25.00	30.00	40.00	45.00	155.12	0.07	73.82	-0.01	205.739	500.000
11	Dipole Dipole	30.00	35.00	40.00	45.00	155.81	0.07	73.45	-0.17	826.580	500.000

Then, from the master menu, you'll be able to visualize graphically the results, process (filtering - topography insertion…) the data and create some export files for the commonly used interpretation software.

For more information, please refer to the on-line help file of PROSYS II software.

Note:

Another possibility to manage the data is to use the FIELDVIEW software

This software allows to plot the apparent resistivity pseudo-section in real time and to save automatically the associated "bin" file in the PC. (Note that the data will be also stored in the Syscal Pro memory)

For more information, please refer to the on-line help file of FIELDVIEW software.

IV. OTHER FUNCTIONS

IV.1. FROM CONFIG MENU

IV.1.1. Load default

The **Load default** option allows to load the default set-up parameters.

IV.1.2. Skip electrode menu

The "skip electrode" option allows the user to measure on a limited part of the cable and to skip up to five punctual electrodes in the measurement sequence.
The first and last electrodes used on the cable can be defined through the **"First used"** and the **"Last used"** electrode parameters.
Then, specific electrodes located in the range [First used Last used] can be skipped. Enter the electrode number in front of **"Skip electrode:".** Up to five electrodes can be skipped.

IV.2. FROM TOOLS MENU

IV.2.1. Rs Check

Dangerous voltages and currents are transmitted by the Syscal Pro through the cables and electrodes. During the entire duration of a RS Check or of the measurement, the operator must always have full control of the entire electrode cable layout, so that people and animals do not get close to the electrodes and electrode take-outs connected to the measurement cables!

The **Rs Check** option allows to run a grounding resistance measurement for the dipoles.
The screen is the same that the first one appearing after having pressed the START key:
In that process, the consecutive dipoles are tested and the resistance value is displayed in kOhm.

Notes:

• In **High speed sequence** mode, this option is particularly useful as no Rs check process is performed before running the measurement

• In **Manual sequence** - **Automatic sequence** - **High speed sequence** and **Sp sequence** modes, the Rs check process can be stopped by the 

button.

IV.2.2. Remote

This option allows to use the system in the following ways:

• Connect a modem to the "**Com 1**" of the unit to be able, remotely, to upload a sequence from the ELECTRE Pro software and download the data from the PROSYS II software.

For more information, please refer to the on-line help file of ELECTRE Pro and PROSYS II software.

• Or, connect a PC directly to the unit ("**Com 1**") to drive it from a specific PC software (*COMSYS Pro* software)

IV.2.3. GPS Connection

This function allows to validate the use of a GPS plugged into one of the communication port of the unit ("Com 1" – "Com 2" (Extension Link) or "GPS PPS External Command" (option)).

Note:

For units with internal GPS an additional switch is present below the micro USB socket:

To validate the GPS operating:

- Set the Switch to "Internal GPS" position
- Select by the the "**Tools|GPS Connection**": **GPS PPS On**

In that case the sequence upload and the data download can be only done by the micro USB socket (SD card can not be used in that case) – the front panel "Com1" is indeed inactive so the "Remote" and "Continuous survey" modes can not be used.

When the switch is set in "Wiconnect" position:

- The internal GPS is un-validated
- In that case the sequence upload and the data download can be done by the front panel "Com1" or the micro USB socket – A GPS can be plugged into the "Com1" port
- The "Remote" and "Continuous survey" modes can be used
- The SD card can be used

IV.2.4. Start w/o synchr.

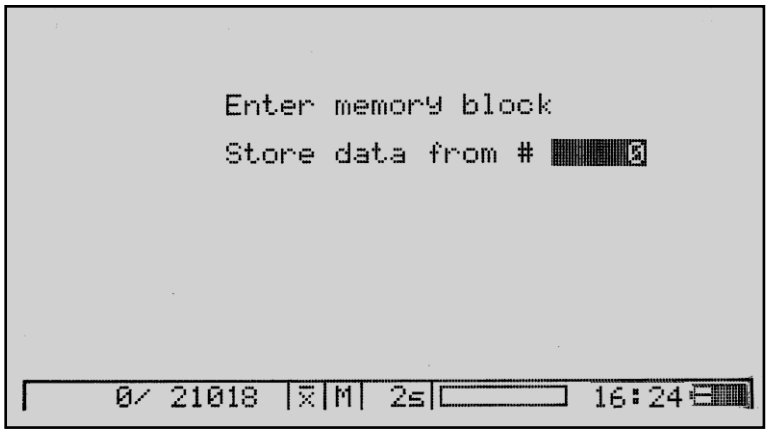
This function (option) allows to run the data acquisition when the unit is used as a receiver ("Rx-Only" mode) without waiting for a synchronization with the transmission signal. This can be interesting in case of the Syscal Pro cannot synchronize with the transmitter signal due to low or noisy reception.
In that case, the measurement will be run with only 1 reception channel with a max. input voltage of 5V.

IV.2.5. Full Wave record

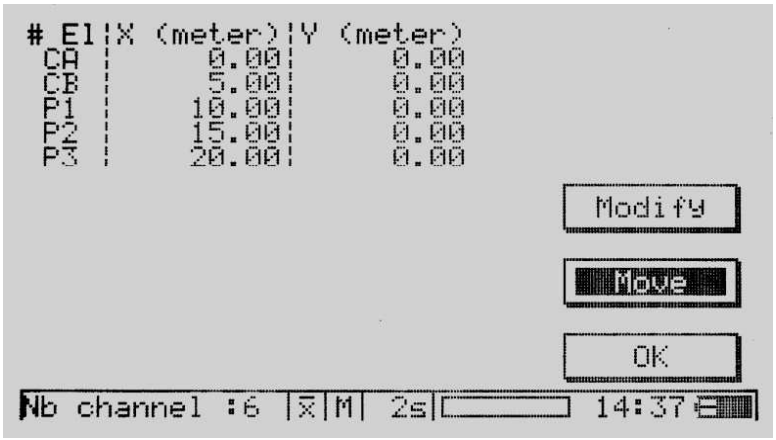
This function (option) stores the whole samples (with a sampling rate of 10 ms) allowing thus to do a post processing by the FULLWAVEVIEWER software.
It can be interesting to use a GPS PPS (Pulse per Second) in that mode so as to make easier this post-processing, in particular for a "RX only" use in combination with a IP transmitter (such as VIP or TIPIX).

The recording in Full Wave mode can be done in "Standard" or in a "Sequence" mode (the sequence can be run in "Tx-Rx" or "Rx-only" configuration).

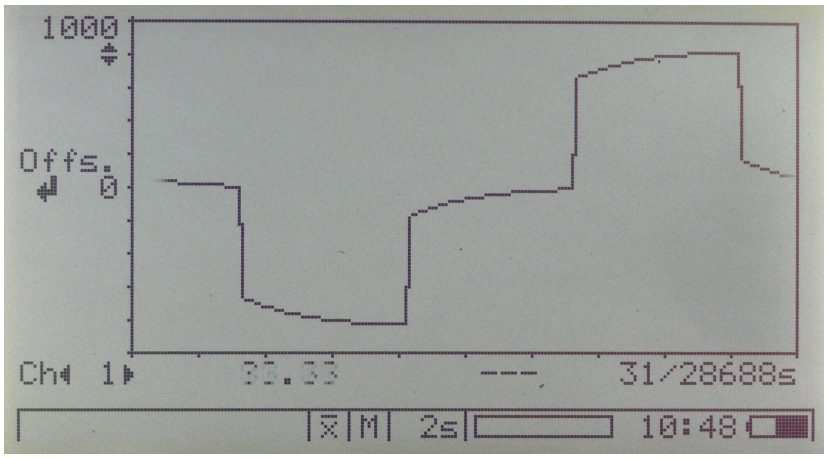
Before the measurement, the program offers automatically to save the data in the first memory area ("0"):



Then, one will have to enter the number of channels.
In case of measurement in "Sequence mode", one will have to define the first quadrupole on which the sequence will start (by default, the measurements start on the first quadrupole).
The unit will then display the max. recording time possible ("**Record. Time max**", in seconds). One will have to enter the measurement duration ("**Min duration per acq**", in seconds). Once these parameters are entered, press 
In "**Sequence**" and "**Rx only**" mode, one will have also to indicate the injection current ("**Tx current In**", in mA) and the maximal input voltage ("**Max input voltage**", 5 V or 15 V).
In "**Standard**" and "**Rx only**" mode the only parameter to give is the number of channels. One will have to modify manually afterward the electrode positions.



The unit will display Vp voltage measured on the first channel. In sequence mode, the measurement will be displayed quadrupoles after quadrupoles, always displaying the first channel. To visualize the previous and following channels, press 0 and _



In "**Standard**" and "**Rx only**" mode, the measurement will be stopped manually by pressing STOP ← Bs

The total amount of measurements that can be stored in the memory depends on the number of channel used. The total memory can be divided in a fixed number of pages (here 44826 but older units may contain 22413). Each page measure 528 bytes and contains both a header and data. The maximal number of data in a page depends on the number of channels:

Channel(s)	Maximal page numbers	Data point per page	Maximal measurement time (seconds)	Maximal measurement time (hours)
1	44826	64	28688	8.0
2	44826	42	18826	5.2
3	44826	32	14344	4.0
4	44826	25	11206	3.1
5	44826	21	9413	2.6
6	44826	18	8068	2.2
7	44826	16	7172	2.0
8	44826	14	6275	1.7
9	44826	12	5379	1.5
10	44826	11	4930	1.4

For the data download, one will have to select "**Data + FullWave**" from the "**Memory|Data download**" menu – and the transfer will have to be done by the FULLWAVEVIEWER software, instead of PROSYS II software.

Please refer to the on-line help file of the FULLWAVEVIEWER software for more information.

IV.3. FROM MEMORY MENU

IV.3.1. Store

After a measurement, one has the choice to store the data directly or not.
If you choose not to store to data (to check them beforewards for example), you'll have in a second time the opportunity to store them thanks to the "**Memory|Store**" menu.

IV.3.2. Store index

This option allows to select a memory area from which the next measurements will be stored.
This option is useful if you programmed a wake up of the unit (thanks to the "**Alarm**" options of the "**System**" menu (cf. IV.5.5.).

IV.3.3. Delete data

This option allows to delete some data from the internal memory; one has just to specify the block to erase (first and last data point to erase); a message will ask you to confirm the delete.

IV.3.4. Undelete data

This option allows to undelete 1 datum point that have been previously deleted. So, this means that if some data have been deleted, you'll have the opportunity to retrieve these data. To do that, you'll have to enter the area number of the data point; a message will indicate if the undelete process was successful or not.

Note:
This can be done only if you didn't write into this memory location in the meantime.

IV.4. FROM SEQUENCE MENU

IV.4.1. Upload (from Pc or SD card)

The "**Upload|From PC**" menu allows to load a sequence from ELECTRE Pro software.
The "**Upload|From SD card**" menu allows to load a sequence from the SD reader, developed by *IRIS Instruments* (option)
A waiting message will appear on the screen; then, upload the sequence from the software.
By ELECTRE Pro software, you can create any type of sequence (directly created by the software, or via Excel).
- Optimized sequences for multi-channel reception
- 2D - 3D or borehole sequences.

For more information, please refer to the on-line help file of ELECTRE Pro software.

IV.4.2. Modify Config

This option allows to modify some parameters of a sequence:
So, first select in the list the sequence you wish to modify and then, you'll have access to the following parameters:
- Tx parameters (cf. II.1.5)
- Electrode array (cf. II.1.6)

IV.4.3. Delete

This option allows to delete one ("**One**" button) or the whole sequences ("**All**" button) stored in the SYSCAL Pro memory.
If you choose "**One**", you'll have then to select from the list the sequence you wish to erase.
If you choose "**All**", a message will ask you to confirm the delete.
Press "**Abort**" to skip this function and reach the master menu

IV.4.4. Undelete

This option allows to undelete a sequence previously deleted. So, this means that if some sequences have been deleted, you'll have the opportunity to retrieve these sequences. To do that, you'll have to enter the # of the deleted sequence; a message will indicate if the undelete process was successful or not.

Note:
This can be done only if you didn't create any sequence in the meantime.

IV.5. FROM SYSTEM MENU

IV.5.1. Clock

This option allows to program the internal clock of the unit; the date/time are stored into the memory.

IV.5.2. Check Switch

In that option, one has the possibility to test 1 specific electrode or several electrodes.

- **Check 1 electrode**:
In that option, one has just to specify the electrode to be switched and create a short circuit between this electrode and the P2 plug of the front panel: a resistance measurement (in kOhm) will be performed; this test allows to check the open line condition on a specific electrode.
This test requires to plug manually the concerned electrode to the P2 plug of the front panel. A high measured resistance means that the electrical circuit is not closed (open loop).

- **Check all electrodes**:
In that option, one has to specify the electrodes to be tested: specify the first and the last electrode number: in that case, all the dipoles combinations will be tested; a resistance measurement (in kOhm) for each dipole will be performed; this test allows to check the short circuit condition in a cable. This test is equivalent to the RS Check procedure (IV.2.1)

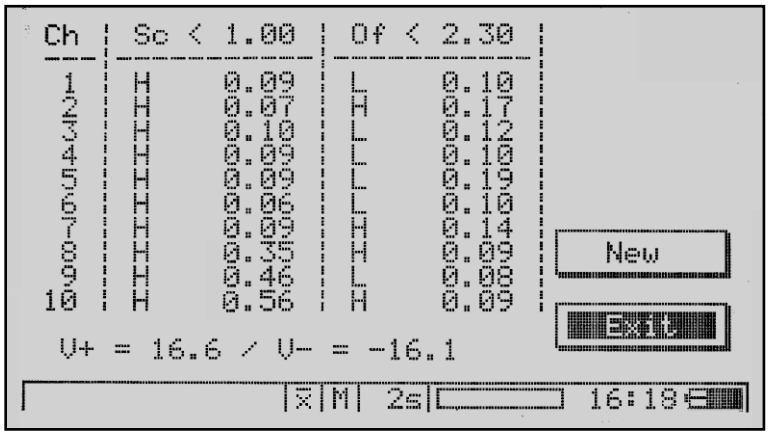
IV.5.3. Calibration

This option allows to run the calibration of the whole channels.

This has to be done after firmware upgrade and also if you have a doubt about the received voltage levels.

This operation has to be performed without connected dipoles.

After having chosen this option, the following screen will appear:



The result of the latest calibration is so displayed; to perform a new one, press "**New**" button.

The results have to be the following ones:

Sc < 1.00 and **Of < 2.30** for the whole channels.

Press the "**Exit**" button to skip this option.

IV.5.4. Restore all data

This function allows to cancel the deleting of some points that have been previously erased. So, this means that those points can be retrieved after deleting.

Note:

However, note that this can be only done if you didn't write into the memory in the meantime.

IV.5.5. Format

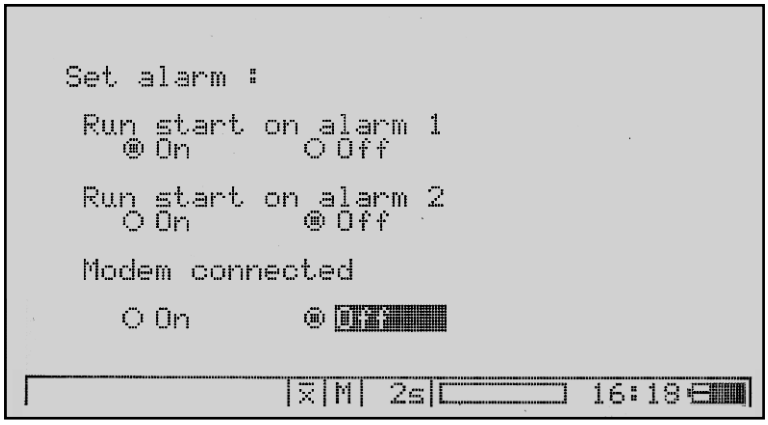
This option will re-initialize the unit; so, all the data and sequences will be lost if you perform this operation; a message will ask you to confirm the format.

IV.5.6. Alarm

This option has to be used to program a wake up of the unit.

This allows to specify the time (hour/minutes) of the wakeup (2 wake up can be programmed in the unit (**"Set Alarm 1" - "Set Alarm 2" options**).

After that, the **" Start Alarm"** option has to be used: the following screen will appear:



Then, make you selection by the arrow keys and validate by the  key.

If the device is shutdown while configured in Alarm mode, it will restart in Alarm mode after being switched on. It is therefore able to inject at any time. Thus, the operator must always have full control of the entire electrode cable layout, so that people and animals do not get close to the electrodes and electrode take-outs connected to the measurement cables during the Alarm mode.

V. FIRMWARE UPGRADE

The SYSCAL Pro unit is programmed in flash ROM.
To upgrade it, a "NEC RENESAS " programmer can be delivered.
This programmer has to be used to upgrade the firmware of the reception (Rx) and the transmitter (Tx) boards.
A specific PC software has to be installed to perform this process.

Note:
Before performing the upgrade, transfer the whole measurements to a PC.
Indeed, depending of the upgrade version, the memory will be totally erased.

So, after having installed the software in the computer run the executable file from the installation directory.
For more information, please refer to the help file of the "RENESAS" software.

After firmware upgrading, we advise to run a calibration of the system (by the "**System|Calibration**" menu (cf. IV.5.3.).

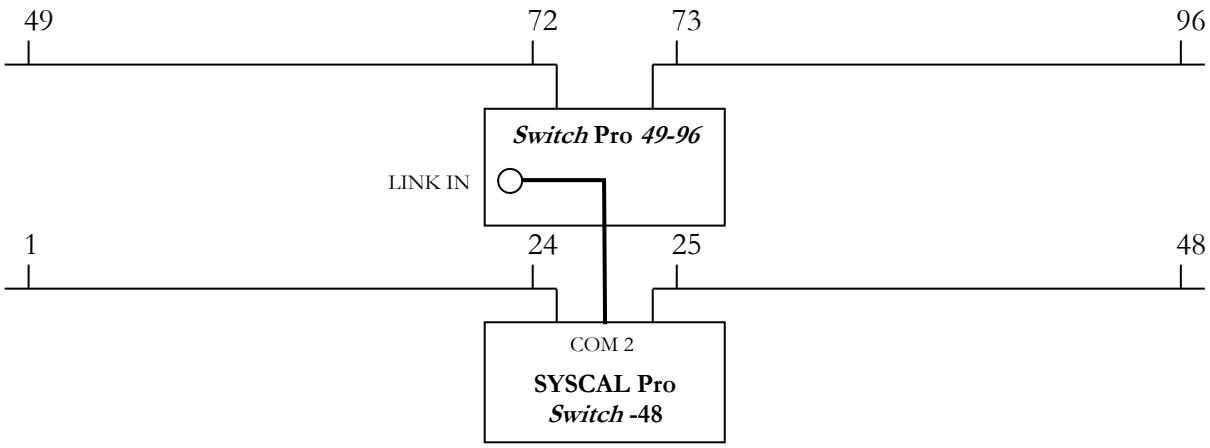
ANNEX 1: EXTERNAL SWITCH PRO BOX

To perform 3D acquisition keeping the capability to use 10 reception channels in switching mode, an external switching box, called *Switch* Pro has been developed.

This external box can be connected to the SYSCAL Pro unit (Standard or *Switch* version), by a specific cable connected between the "**Extension link**" plug of the SYSCAL Pro and the "**Link in**" plug of the *Switch* Pro).

This switching box exists in different versions from 24 to 192 electrodes; to extend the number of electrodes several boxes can be connected by specific cables connected between the "**Link out**" plug of the previous *Switch* Pro box to the "**Link in**" plug of the next *Switch* Pro box.

The following scheme shows the in-the-field configuration of the electrodes of a SYSCAL Pro *Switch*-48 unit with a *Switch*-48 Pro box:



On the *Switch* Pro box, a display with two keys ("**MENU**" - "**CHANGE**") allows to choose the numbering of the electrodes to make it compatible with your SYSCAL Pro unit.

The "**MENU**" key allows to reach the "increment node function": then by the "**CHANGE**" button, choose the numbering. Press the "**MENU**" key to reach the "decrement node function".

Then, press anew the "**MENU**" key to see the type of *Switch* box (Pro in standard); you can change it by a *Switch Plus* box (1 channel switching) to be compatible with a SYSCAL *Switch* unit.

Note:

The *Switch* Pro box has an internal rechargeable 12V – 7 Ah battery. As for the Syscal Pro, a valve for an automatic pressure regulation is present on the right side of the casing.

An external 12V standard car battery can be connected to the front panel ("+" and "-" plugs (Input 12 V). If the battery level becomes insufficient (lower than 10 V), a "**Low Batt**" message will appear on the screen and a "**Switch Error**" message will appear on the SYSCAL Pro.

ANNEX 2: GEOMETRICAL PARAMETERS AND RESISTIVITY

The methods for measuring the subsurface resistivity by DC current injection are all based on the same principle:

- a current is sent in the ground through two electrodes (A, B - electrodes connected to the transmitter).
- the current creates an equipotential distribution making it possible to measure a potential difference between two other electrodes, which are potential ones (some arrays allowing to drive simultaneously up to ten potential dipoles (P1, P2…P10, P11).
- an apparent resistivity is then defined by: **Ro = K.V/I** where K (geometric factor) only depends on the geometric array of the electrodes in the field and is expressed by:

For the dipole i: $\mathbf{K_i = 2\pi / |1/APi - 1/APi+1 - 1/BPi + 1/BPi+1|}$

The various configurations only differ by the position of the electrodes with K assuming a more specific expression.

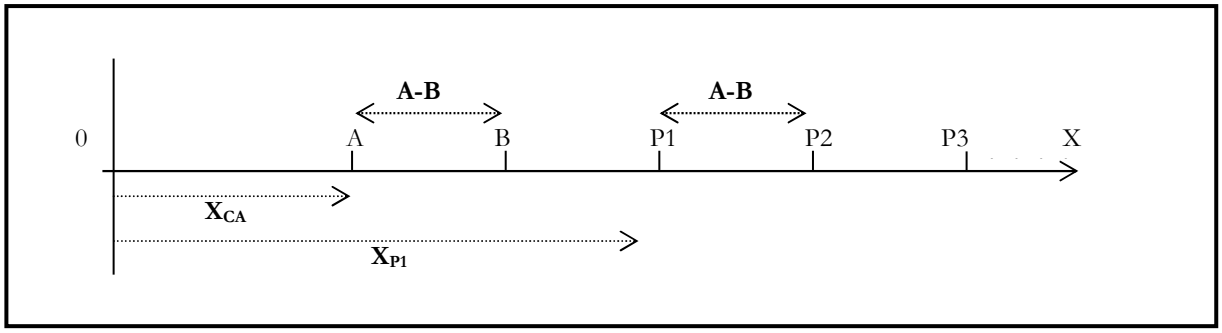
In regards to the chosen electrode array (Array 5 key), one will have several specific parameters to enter:

Electrode array	Geometrical parameters to specify				Max. number of dipoles
Dipole-Dipole	X_{CA}	A-B	X_{P1}		10
Pole-Dipole	X_{CA}	X_{P1}	P1-P2		10
Pole-Pole	X_{CA}	X_{P1}			1
Wenner	Mid	AB/3			1
Schlum	Mid	AB/2	MN/2		1
Grad. rctgl	X_{CA}	A-B	X_{P1}	P1-P2	10
Mixed/Poly-Dip	X_{CA}	A-B	X_{P1}	P1-P2	10
Poly-Pole	X_{CA}	X_{P1}	P1-P2		10

Remark:

In the following pictures, the X axis is defined as the AB axis, the Y axis is directly perpendicular to AB and the origin 0 is taken as any arbitrary point.

• **Dipole-Dipole**



- $\mathbf{X_{CA}}$: abscissa of the first current electrode

- $\mathbf{X_{P1}}$: abscissa of the nearest potential electrode from the AB dipole

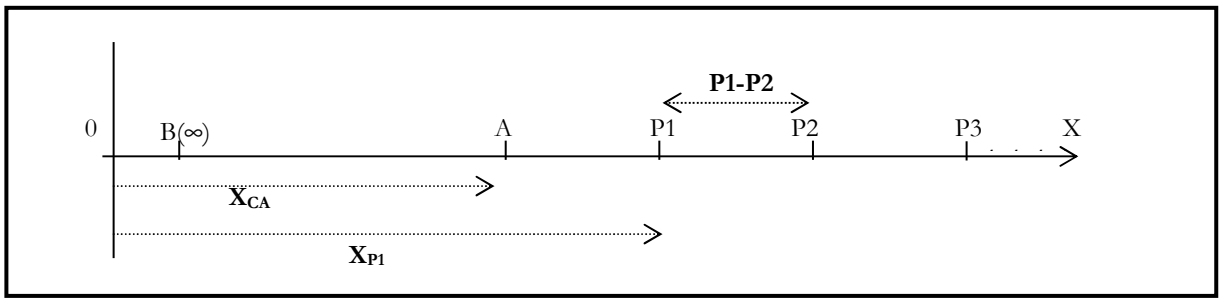
- A-B: length of dipoles (current and potential):

|AB| = |P1 P2| = … = |P10 P11|

By setting n_iD as the distance between the midpoints of the dipoles AB and PiPi+1, we have:

$K_i = \pi\, n_iD\, (n_i^2 - 1)$

• **Pole-Dipole**



The current electrode B has to be placed sufficiently far from the other electrodes to be able to ignore 1/BPi (generally 5 times the maximum distance between A and P)

- $\mathbf{X_{CA}}$: abscissa of the first current electrode

- $\mathbf{X_{P1}}$: abscissa of the nearest potential electrode from the AB dipole

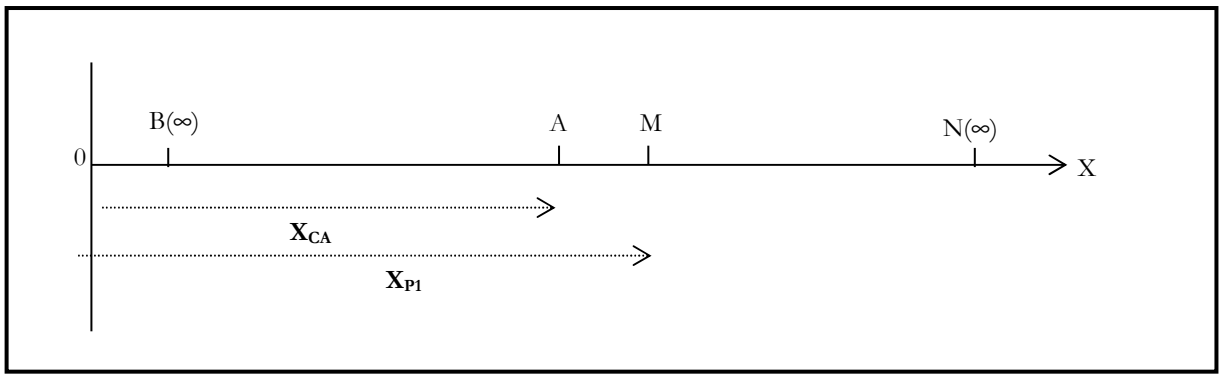
- P1-P2: length of the potential dipoles:

|P1 P2| = … = |P10 P11|

$K_i = 2\pi / (1/APi - 1/APi+1)$

• **Pole-Pole**

In this array, the electrodes B and N have to be set sufficiently far from the A and M to be able to ignore 1/BM, 1/BN and 1/AN (about 10 times the maximum distance between A and M)

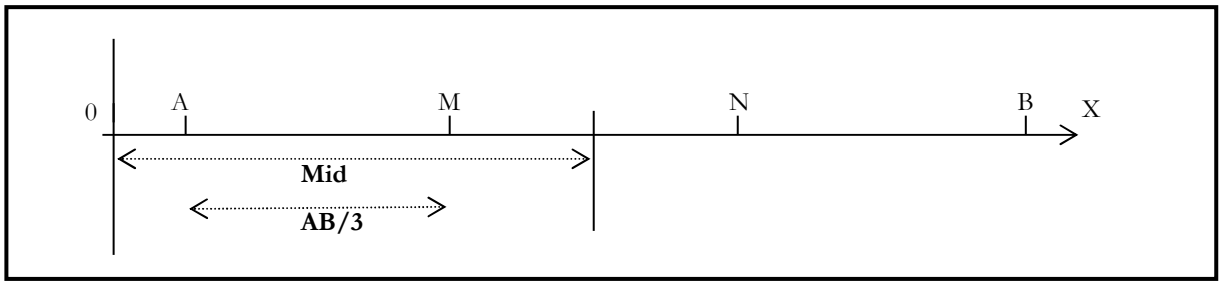


- X_{CA}: abscissa of the current electrode

- X_{P1}: abscissa of the potential electrode

K = 2π / (1/AM)

• **Wenner**

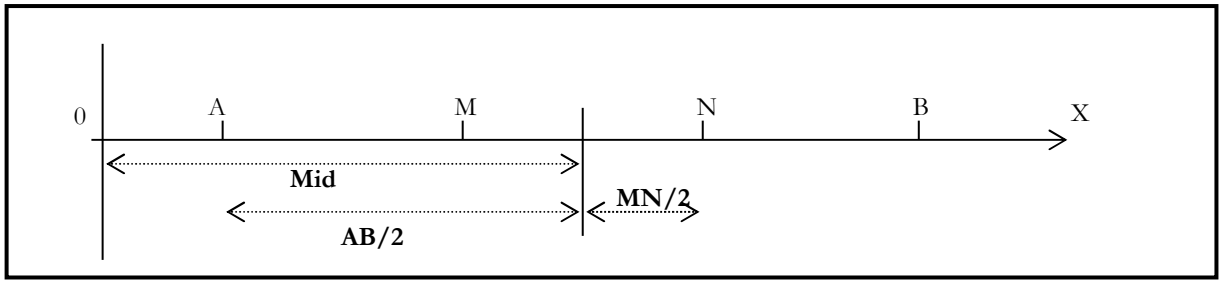


- **Mid**: abscissa of the centre of MN

- **AB/3**: a third of the distance between the current electrodes

So K remains constant all along the profile axis.

• **Schlumberger**



The electrodes keep constant relative positions.

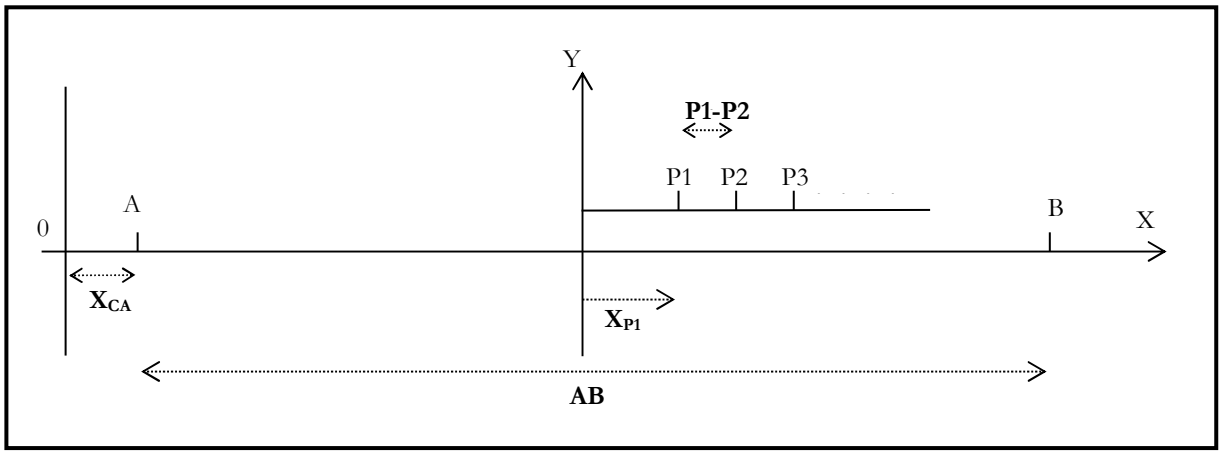
- **Mid**: abscissa of the centre of MN
- **AB/2**: half-distance between the current electrodes.
- **MN/2**: half-distance between the potential electrodes.

K is a constant of the profile:

If AB/2 = a and MN/2 = b

$K = \pi (a^2 - b^2) / 2b$ (if AB/2 > MN/2).

• **Grad. rctgl (Gradient rectangle)**



In this array, the AB electrodes are fixed and the Pi electrodes are moved parallel to AB inside a zone located in the central part of AB. This array serves to observe variations in resistivity on a surface for a relatively high investigation depth without the need to move the current electrodes.

- $\mathbf{X_{CA}}$: abscissa of the first current electrode
- $\mathbf{X_{P1}}$: abscissa of the first potential electrode
- **A-B**: length of the current dipole
- **P1-P2**: length of the potential dipoles

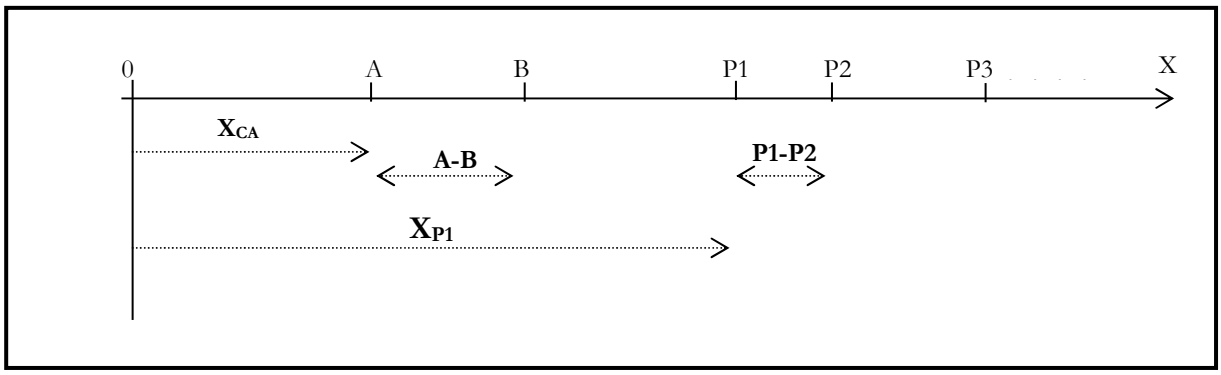
|P1 P2| = … = |P10 P11|

Note:

In that configuration, the Y coordinate of the reception electrodes (Pi) can be introduced directly from the SYSCAL Pro.

• **Mixed/Poly-Dip**

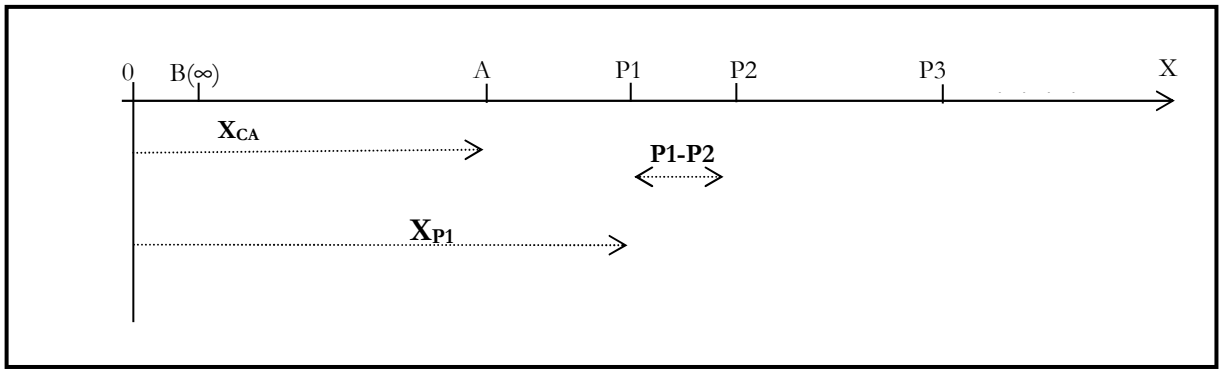
This array is similar to the Dipole-Dipole one with potential dipoles lengths that can be user specified.



- X_{CA}: abscissa of the first current electrode
- X_{P1}: abscissa of the nearest potential electrode from the AB dipole
- **A-B**: length of the current dipole
- **P1-P2**: length of the potential dipoles

Note:
And, in a second step, you can modify the position of each potential electrode, selecting the "**Move**" button after having introduced these spacing parameters.

• **Poly-Pole**



This array is similar to the Pole-Dipole one with potential dipoles lengths that can be user specified.
The current electrode B has to be placed sufficiently far to be able to ignore 1/BPi

- **X_{CA}**: abscissa of the current electrode
- **X_{P1}**: abscissa of the nearest potential electrode from the AB dipole
- **P1-P2**: length of the potential dipoles

Note:

And, in a second time, you can modify the position of each potential electrode, selecting the "**Move**" button after having introduced these spacing parameters.

$K_i = 2\pi / (1/APi - 1/APi+1)$

ANNEX 3: IP PARAMETERS AND CHARGEABILITY

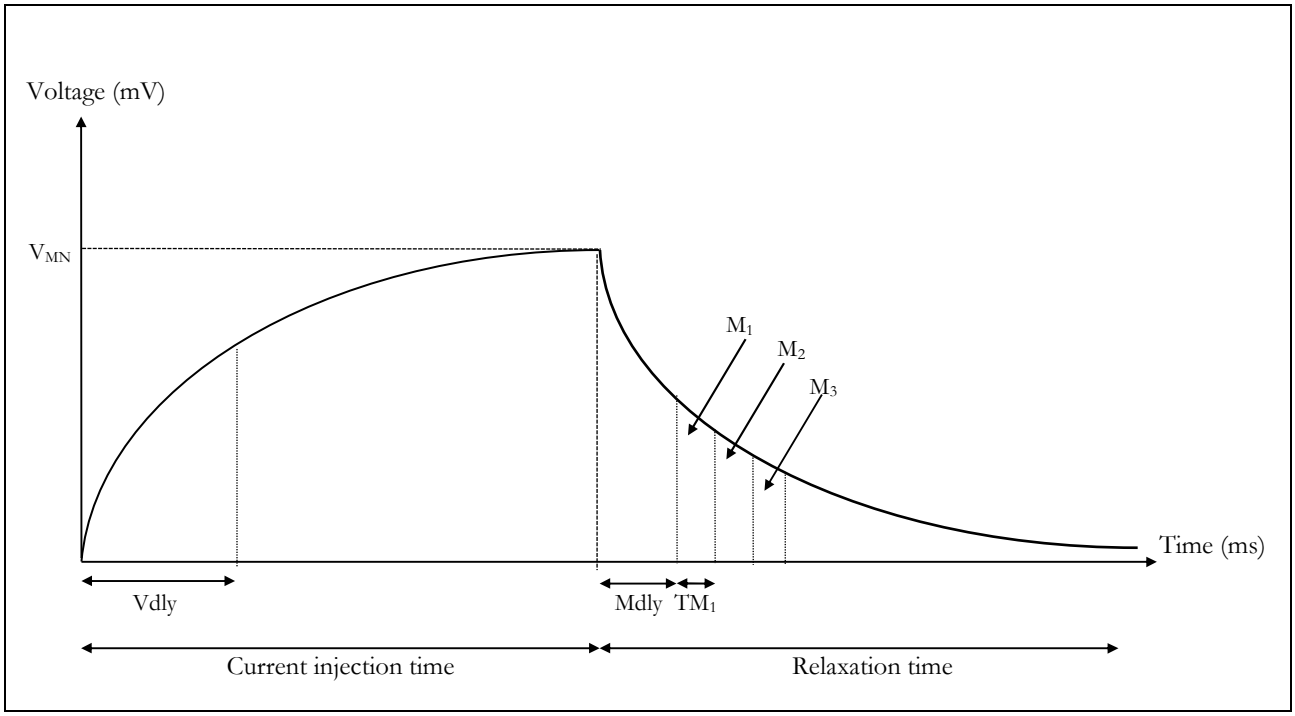
The partial chargeability measurements (M_i) and the average global one deduced (M_g) give some information regarding the ability of the soil to charge itself due to a current flow.
The partial chargeability of the window "i" is measured thanks to the following formula:

$$M_i = \frac{1}{V_{MN} \cdot TM_i} \int_{TMi} Vdt$$

And the global chargeability is computed thanks to the following formula:

$$M_g = \frac{\sum_{i=1}^{n} (M_i \cdot TM_i)}{\sum_{i=1}^{n} TM_i}$$ (n: number of IP windows)

The discharge phenomena observed during the relaxation time can be described according to the following curve:



With the SYSCAL Pro, up to 20 IP windows can be used to define the decay curve.

The number of IP windows available for the measurement depends on the type of IP mode and on the current injection time:

⇒ **Current injection times** available (cf. II.1.5): 500 ms - 1 s - 2 s - 4 s - 8 s

⇒ Types of **IP mode** available (cf. II.1.5): Arithmetic – Semi logarithmic – Logarithmic Cole-Cole - Programmable

For a given current injection time and IP mode, the program will choose automatically the IP parameters (Mdly, Vdly, TM_i) that will be used for the measurement.

Note:

The programmable mode is a mode where 20 fully programmable windows are available. The operator has to select the delay time (Mdly) with a minimum of 20 ms and the width of each partial window (TM_i) with a minimum of 10 ms. Vdly is automatically determined by the injection time chosen.

In the following tables, the preset TM_i values are given for each IP mode (1 means TM_1 ...):

- **Time = 500 ms**

Mode	Vdly	Mdly	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arith.	280	60	40	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semi	280	40	40	80	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Log.	280	160	80	180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cole	280	160	80	180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

- **Time = 1000 ms**

Mode	Vdly	Mdly	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arith.	580	120	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Semi	580	40	20	20	20	20	20	20	20	20	40	40	40	40	40	40	80	80	80	80	80	80
Log.	580	160	120	220	420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cole	580	20	10	20	20	20	20	20	30	30	30	40	40	40	50	50	50	60	60	70	80	90

- **Time = 2000 ms**

Mode	Vdly	Mdly	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arith.	1260	240	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Semi	1260	40	40	40	40	40	40	40	80	80	80	80	80	80	80	160	160	160	160	160	160	160
Log.	1260	160	120	220	420	820	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cole	1260	20	20	30	30	30	40	40	50	60	70	80	90	100	110	120	130	140	150	160	180	200

• **Time = 4000 ms**

Mode	Vdly	Mdly	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arith.	2620	480	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160
Semi	2620	160	80	80	80	80	80	80	80	80	160	160	160	160	160	160	320	320	320	320	320	320
Log.	2620	160	120	220	420	820	1620	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cole	2620	20	40	50	60	70	80	90	100	110	120	140	160	180	200	220	250	280	320	380	450	530

• **Time = 8000 ms**

Mode	Vdly	Mdly	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Arith.	5340	960	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320	320
Semi	5340	320	160	160	160	160	160	160	160	160	320	320	320	320	320	320	640	640	640	640	640	640
Log.	5340	160	120	220	420	820	1620	3220	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cole	5340	20	40	60	80	100	120	150	180	220	250	280	320	360	400	450	500	580	700	850	1010	1180

About the **IP values type**, note that the changing "raw (R) ⇔ normalised (N)" can be realised after the acquisition.

The normalization allows to homogenize the data that have been obtained with various injection and integration times. This is made with respect to a standard decay curve, which is the one obtained with the following parameters:

Mode: *Logarithmic*

Injection time: *2000 ms*

Vdly: *1260 ms*

Mdly: *160 ms*

TM_1: *120 ms*

TM_2: *220 ms*

TM_3: *420 ms*

TM_4: *820 ms*

The coefficients to multiply, allowing to go from a type to the other one, are indicated in the following tables:

500 ms								
Arithmetic			**Semi logarithmic**			**Logarithmic**		
	R → N	N → R		R → N	N → R		R → N	N → R
M_g	0.72	1.39	M_g	0.94	1.06	M_g	1.32	0.76
M_1	0.60	1.67	M_1	0.55	1.81	M_1	1.06	0.94
M_2	0.75	1.33	M_2	0.82	1.22	M_2	1.47	0.68
M_3	0.88	1.13	M_3	1.25	0.80			

1000 - 2000 - 4000 - 8000 ms					
Arithmetic			**Semi logarithmic**		
	R → N	N → R		R → N	N → R
M_g	1.08	0.93	M_g	0.96	1.04
M_1	0.56	1.79	M_1	0.38	2.63
M_2	0.64	1.56	M_2	0.42	2.38
M_3	0.72	1.39	M_3	0.46	2.17
M_4	0.78	1.28	M_4	0.51	1.96
M_5	0.85	1.18	M_5	0.55	1.82
M_6	0.91	1.10	M_6	0.59	1.69
M_7	0.97	1.03	M_7	0.62	1.61
M_8	1.03	0.97	M_8	0.66	1.51
M_9	1.10	0.90	M_9	0.72	1.39
M_{10}	1.16	0.86	M_{10}	0.80	1.25
M_{11}	1.23	0.81	M_{11}	0.86	1.16
M_{12}	1.29	0.77	M_{12}	0.93	1.07
M_{13}	1.35	0.74	M_{13}	0.99	1.01
M_{14}	1.41	0.71	M_{14}	1.05	0.95
M_{15}	1.47	0.68	M_{15}	1.14	0.88
M_{16}	1.54	0.65	M_{16}	1.26	0.79
M_{17}	1.60	0.62	M_{17}	1.39	0.72
M_{18}	1.66	0.60	M_{18}	1.52	0.66
M_{19}	1.72	0.58	M_{19}	1.65	0.61
M_{20}	1.78	0.56	M_{20}	1.78	0.56

Logarithmic								
	1000 ms		**2000 ms**		**4000 ms**		**8000 ms**	
	R → N	N → R	R → N	N → R	R → N	N → R	R → N	N → R
M_g	1.16	0.86	1.00	1.00	0.90	1.11	0.79	1.27
M_1	0.72	1.39	0.51	1.95	0.39	2.56	0.29	3.45
M_2	1.02	0.98	0.67	1.50	0.47	2.13	0.35	2.86
M_3	1.53	0.65	0.95	1.05	0.62	1.61	0.43	2.33
M_4			1.43	0.70	0.87	1.15	0.56	1.79
M_5					1.37	0.73	0.79	1.27
M_6							1.28	0.78

ANNEX 4: OUTPUT CURRENT AND VOLTAGE SPECIFICATIONS

The following diagram shows the output current curve (in A), versus the grounding resistance (in Ohm).

One can note the limit of the output characteristics of the unit, in terms of current (2.5 A) - power (250 W) and voltage (1000V for Syscal Pro Standard or 800 V for Syscal Pro Switch), in regards to the resistance value.

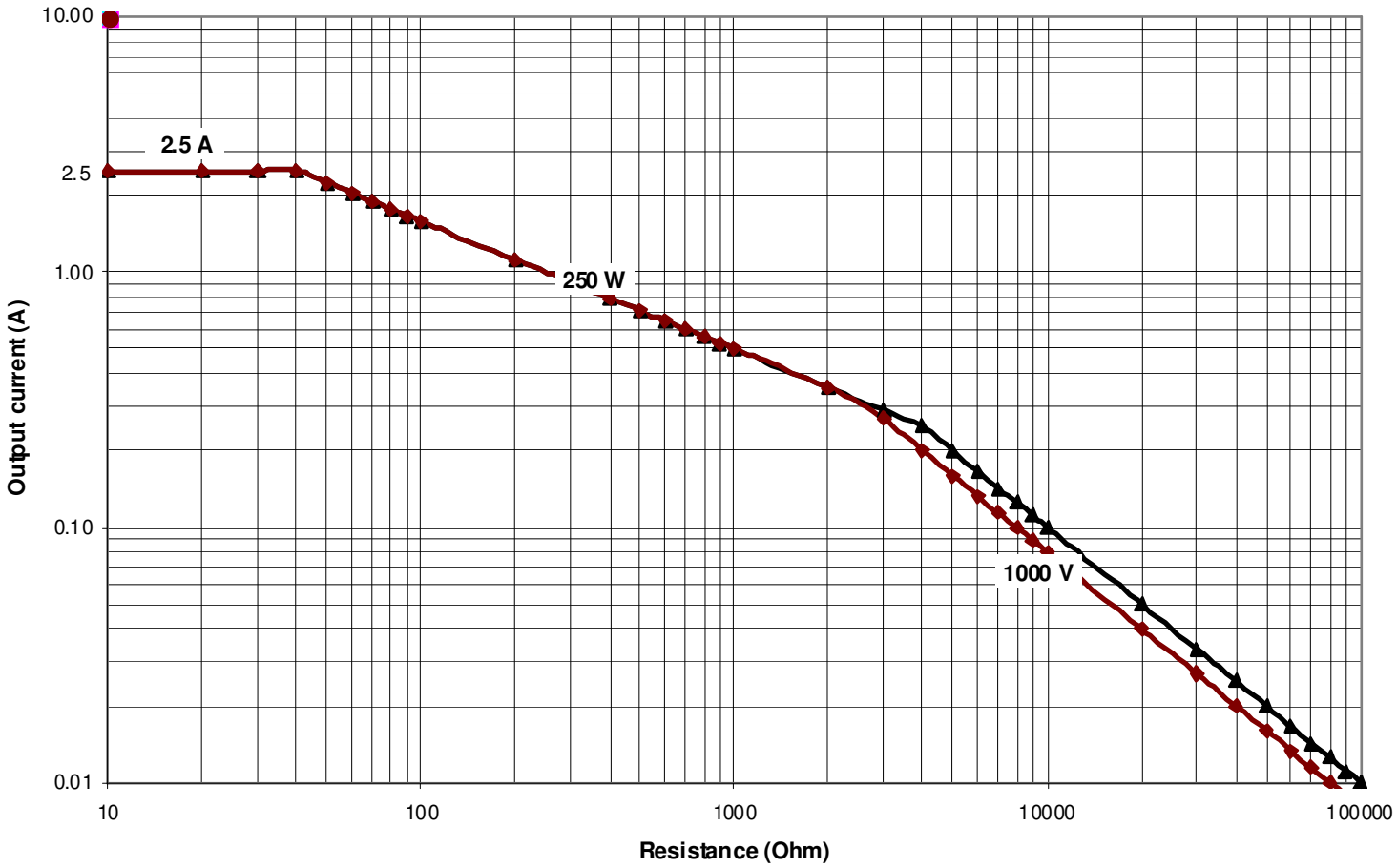
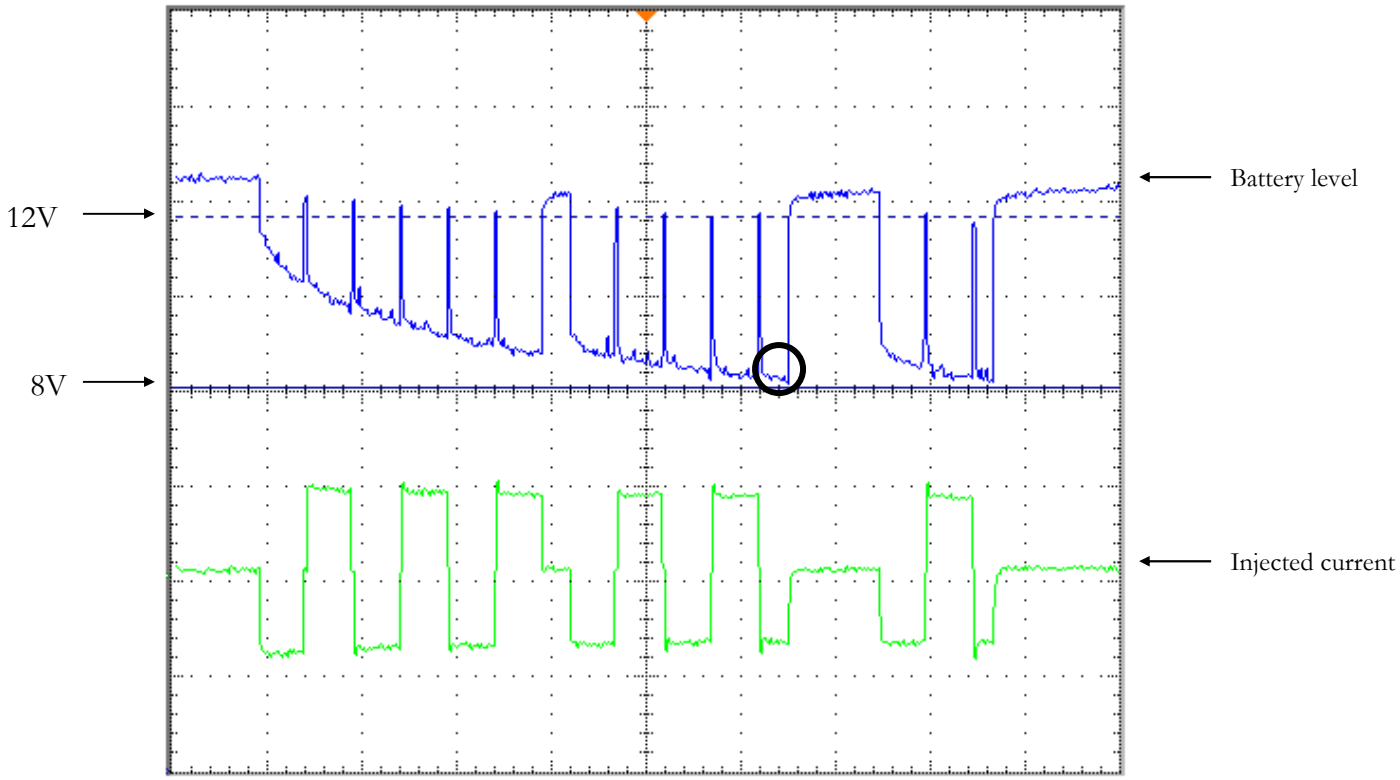


Figure 1: Output current and voltage specifications for the Syscal Pro standard (black curve) and for the Syscal Pro Switch (red curve).

ANNEX 5: BEHAVIOUR OF A BATTERY WITH TIME

The following diagram shows the behaviour of a battery becoming weak with time.



One can note that, before injection, the voltage value is about 13 V.

Then, one can point out that this level decreases regularly with the number of injection realized.

The peaks going up means that just after the injection, the voltage battery increases quickly due to an instantaneous recharge phenomenon.

When the battery becomes low (9 V), a warning message will appear; you can continue the acquisition, but note that if the battery level drops to 8 V (black circle in the diagram), the unit won't inject any current; however, during this time, as the battery has not been used, the recharge allows to inject the next stack, and so on…

Of course, if the battery is not recharged, after a while no more injection will be done.

By default, whatever the mode used (excepted for the **High speed** mode) and whatever the number of stacks selected, the unit will inject by default three pulses:

- If the battery level becomes too low during the three first pulses, the current value will be erroneous ("9999.00 mA")

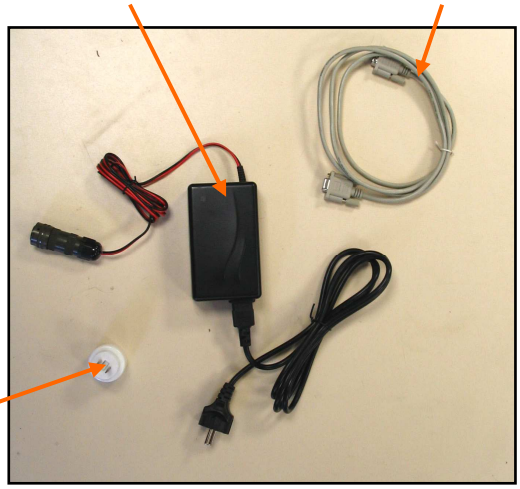
- If that situation appears after the three first pulses, the injected current and reception voltage values stored will be erroneous but the ratio, so the resistivity, will be correct as the computation of the resistivity will be done with the current and voltage values obtained when the transmitter injected properly.

Note that in **High speed** mode or in **Continuous survey** mode, as the classical three first pulses are not generated, the current value will be "9999.00 mA" if the situation appears during the first pulse (positive pulse).
If the situation appears during the second pulse (negative pulse), the current value will be:
I = (I (first pulse) + 9999.00) / 2

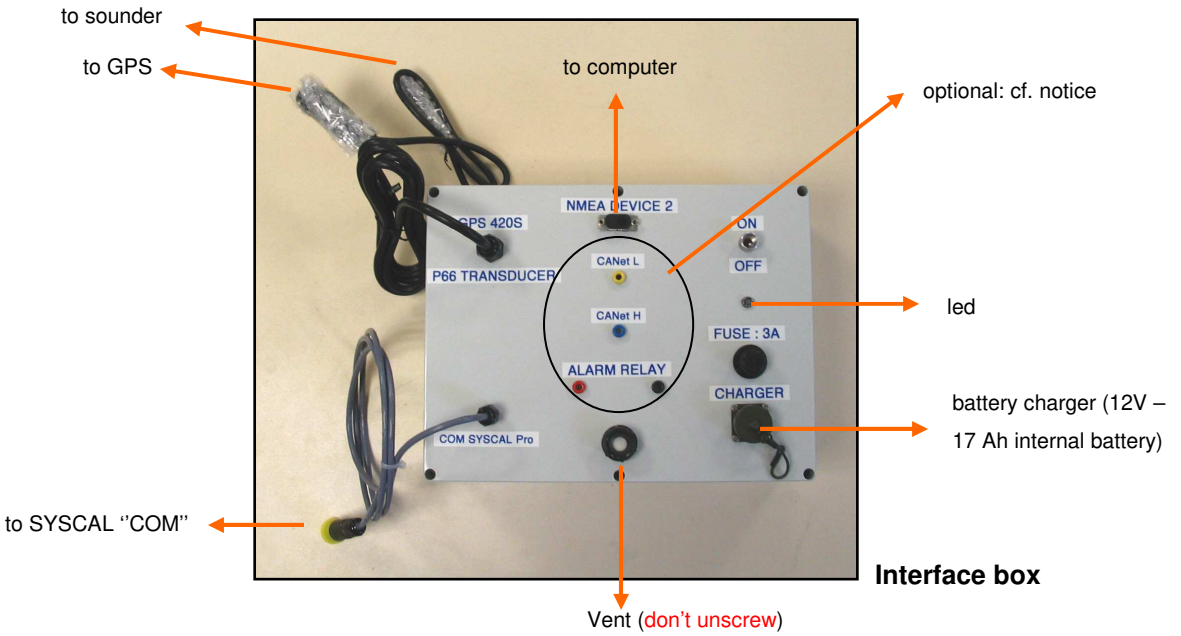
Conclusion:
One has to keep in mind that even if a battery has a good voltage value before injection, one has to be sure of the level during current transmission. So, one can advise to check this value regularly during injection, with a voltmeter.

ANNEX 6: SYSMAR OPTION (for the GARMIN GPS 420) – ITEMS REQUIRED

SYSCAL Pro rear side



Accessories



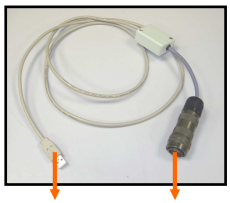
Interface box

DB9 female plug – "COM2" plug

to Pc serial port (*Sysmar* Software)

to SYSCAL "Extension link" (COM2)

USB plug – "COM2" plug



to Pc USB port (*Sysmar* Software)

to SYSCAL "Extension link" (COM2)

Remark:

The LED is:

- green above 11.3 V
- green / red winkling from 9.8 to 11.3 V
- red below 9.7 V (recharge the internal battery)

ANNEX 7: INITIALIZATION TROUBLE

If, after a switch on of the unit, the introduction of the serial number is requested, it means that the unit has been re-initialized.

Then, enter the serial number written on the sticker of the unit, and after validation, the following message will appear:

"Format… Please confirm. **Yes** or **No**"

Then, in that case press "No" (if not the data stored will be automatically deleted).

If the trouble stays on, a way back of the unit to IRIS Instruments premises will have to be done

ANNEX 8: WIRING DIAGRAM OF SWITCH CABLES

CABLE MAINTENANCE RECOMMENDATIONS

COLLECTING CABLES

For collecting the multi-core cables, specially when the surface of the ground presents irregularities, it is recommended **not to pull the cable on its entire length**, but to walk a few meters, roll some additional cable that has been recovered, then pick up the reel, move again, and repeat the operation step by step until the end of the cable: in such a way, obstacles such as roots or stones will not apply any mechanical stress on the connector located at the free end of the cable.

In rough topography areas, it is also possible **to collect the cable around ones's neck and shoulder**, walking step by step along the cable . This way of doing avoids to damage the cable by friction against the ground, and maintains the connectors in the best possible mechanical condition.

SPECIAL CARE FOR MULTI-CORE CABLES

On the one hand, the SYSCAL Switch resistivity equipment can drive currents up to **2.5A, 800V**, depending on models.

On the other hand, the signal measured can be as low as **a few mV.**

The plugs must then be **extremely clean and dry** to avoid any short circuit or resistant contact or current leakage, which would lead to irreversible damages.

This is the reason why **a special care** has to be taken when using the multi-core cables. In particular, plugs should never be left in the open, or uncovered state. See the recommendations on the back of this sheet.

Note: *in the seismic methods, the multi-core cables are used only to measure signals; they do not transmit any energy, which makes their use less sensitive than the multi-core cables for resistivity methods.*

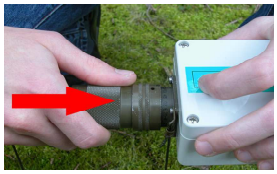
CABLE CONNECTION (up to 800V voltage)

ANY MOISTURE and/or ANY DUST → **DANGER OF SHORT CIRCUIT & PLUG DESTRUCTION**

RULE # 1:

PLUGS & CAPS MUST BE SCREWED UNTIL A **"CLIC" SOUND** IS PRODUCED

1 PUSH STRAIGHT



2 TURN FIRMLY

RULE # 2:

A PLUG MUST **ALWAYS** BE CONNECTED TO ANOTHER PLUG OR COVERED WITH ITS CAP

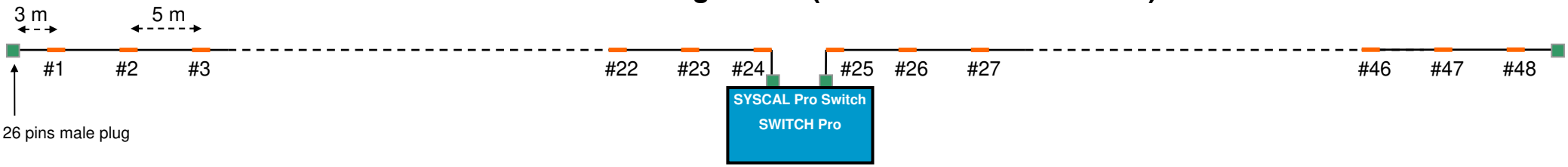
RULE # 3:

PLUGS & CAPS MUST BE CLEANED FROM TIME TO TIME WITH HUMIDITY REMOVER

PRESS 5 sec. WITH A HUMIDITY REMOVER CAN (WD40, HOLTS, ...) TO DRY CONTACTS

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM UNIT
48 ELECTRODES – 5 METERS SPACING BETWEEN TAKEOUT

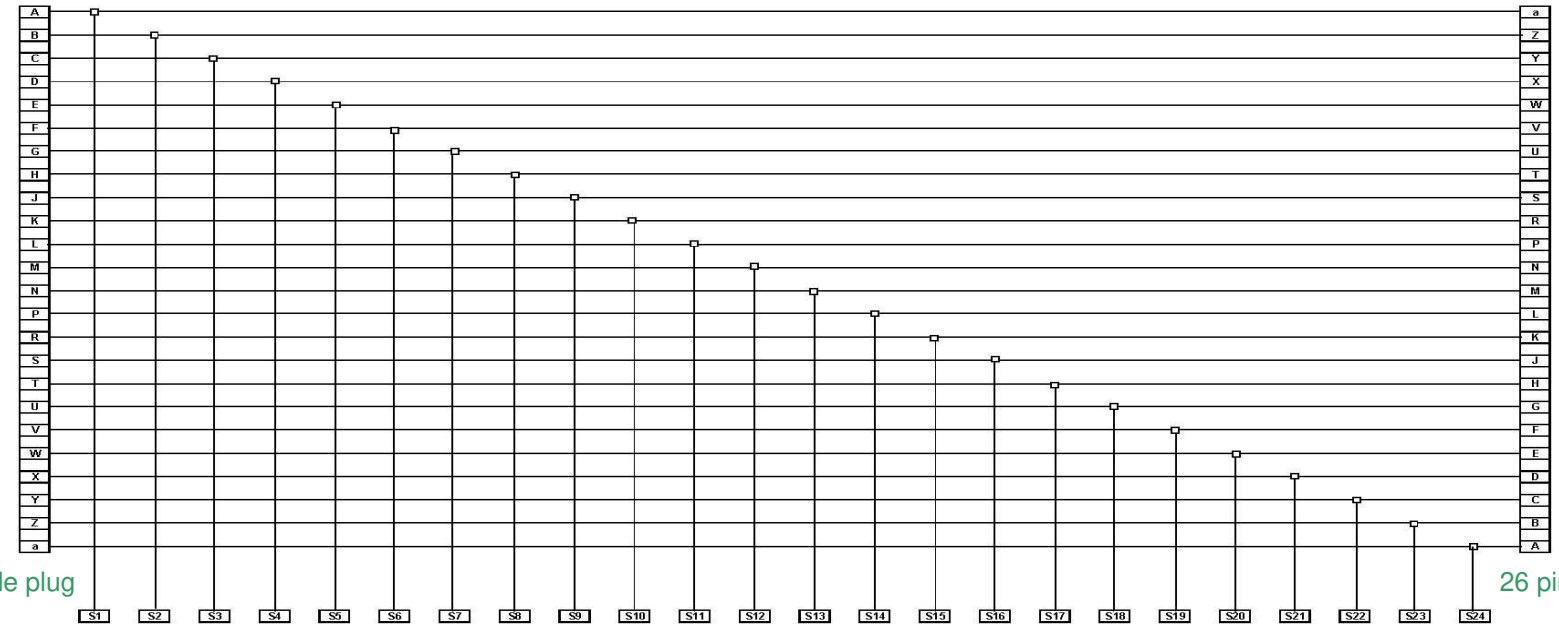
In the field configuration (2 cables with 24 takeout)



Wiring diagram of a switch cable (24 electrodes)

26 pins male plug ref.:
851 06A 16 26 P PG 50
Cap ref.:
BF N PT 16

26 pins female socket ref.:
851 02 E 16 - 26 S 50
Cap ref.:
BECN 16

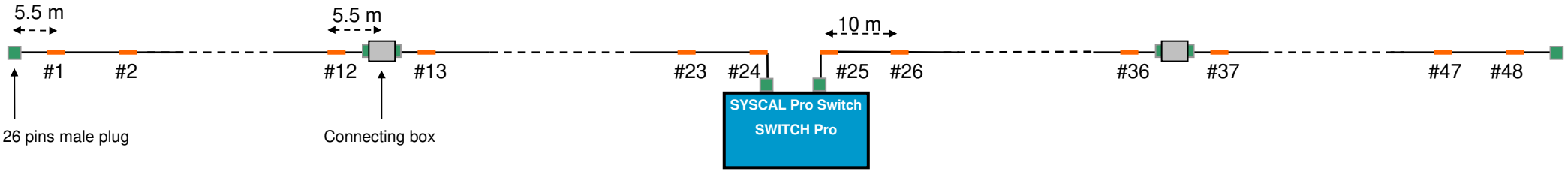


26 pins male plug

26 pins male plug

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM UNIT
48 ELECTRODES – 10 METERS SPACING BETWEEN TAKEOUT

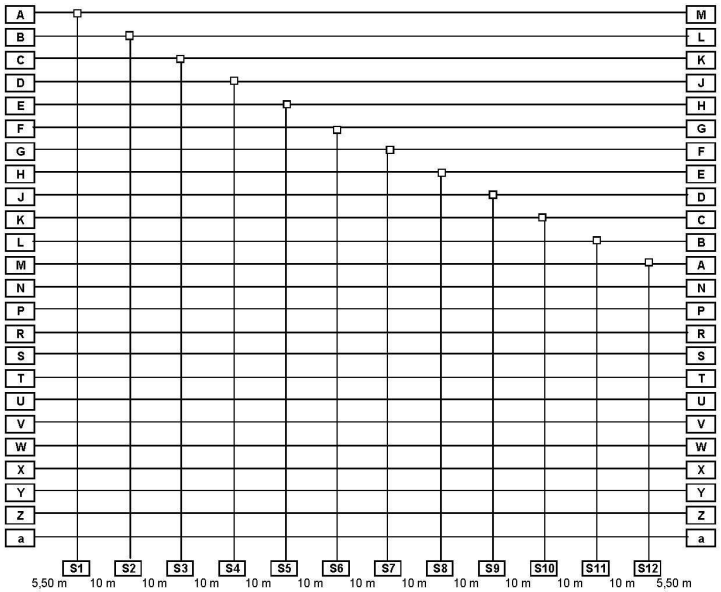
In the field configuration (4 cables with 12 takeout – 2 connecting boxes)



Wiring diagram of a switch cable (12 electrodes)

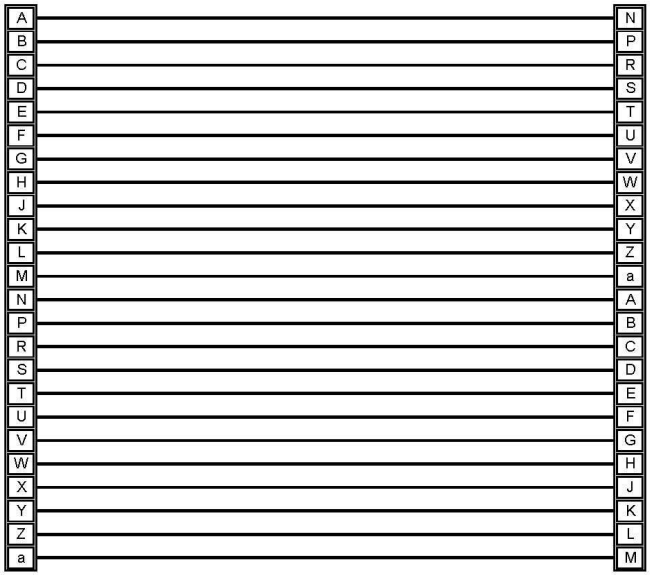
26 pins male plug ref.:
851 06A 16 26 P PG 50
Cap ref.:
BF N PT 16

26 pins female socket ref.:
851 02 E 16 - 26 S 50
Cap ref.:
BECN 16



26 pins male plug 26 pins male plug

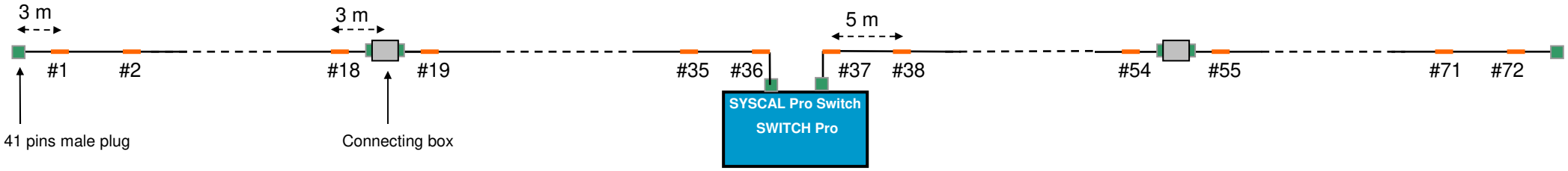
Wiring diagram of a connecting box



26 pins female socket 26 pins female socket

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM
72 ELECTRODES – 5 METERS SPACING BETWEEN TAKEOUT

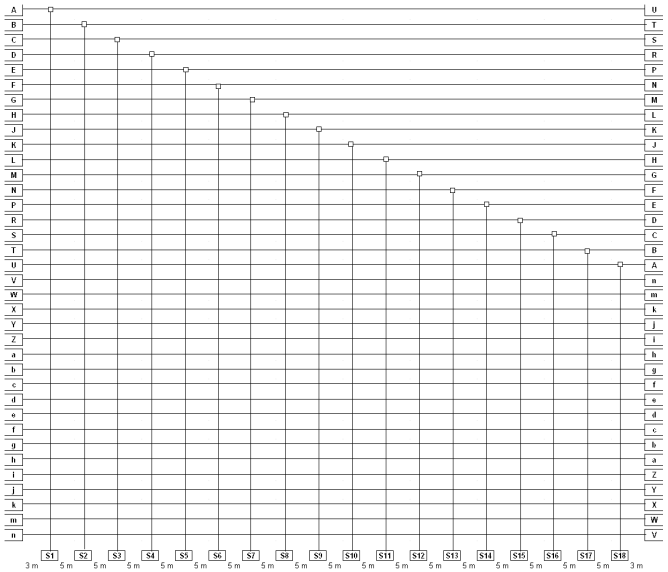
In the field configuration (4 cables with 18 takeout – 2 connecting boxes)



Wiring diagram of a switch cable (18 electrodes)

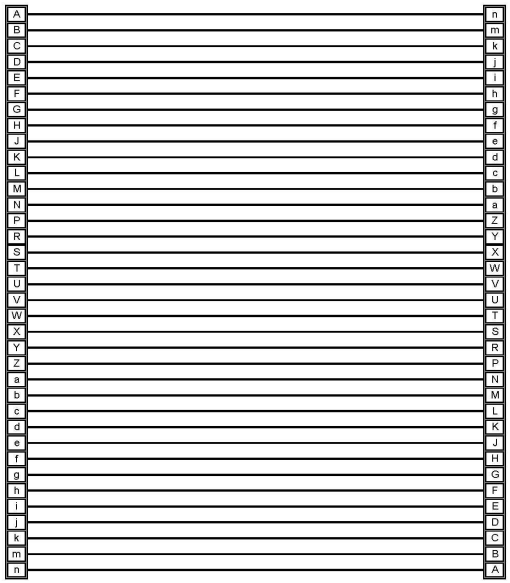
41 pins male plug ref.:
851 06A 20 41 P PG 50
Cap ref.:
BF N PT 20

41 pins female socket ref.:
851 02 E 20 - 41 S 50
Cap ref.:
BECN 20



41 pins male plug — 41 pins male plug

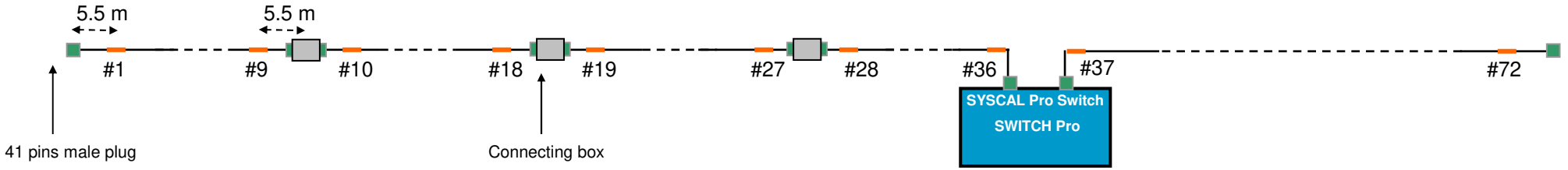
Wiring diagram of a connecting box



41 pins female socket — 41 pins female socket

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM
72 ELECTRODES – 10 METERS SPACING BETWEEN TAKEOUT

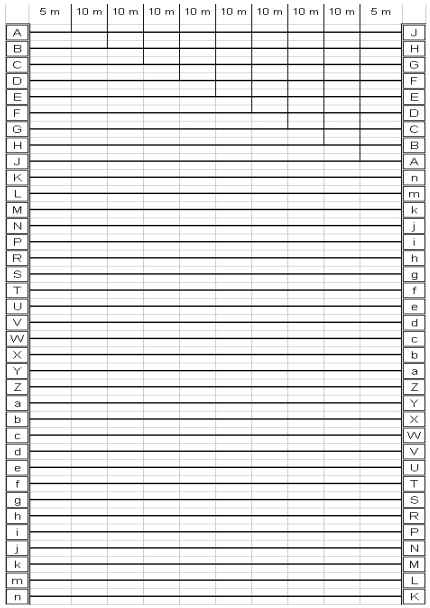
In the field configuration (8 cables with 9 takeout – 6 connecting boxes)



Wiring diagram of a switch cable (9 electrodes)

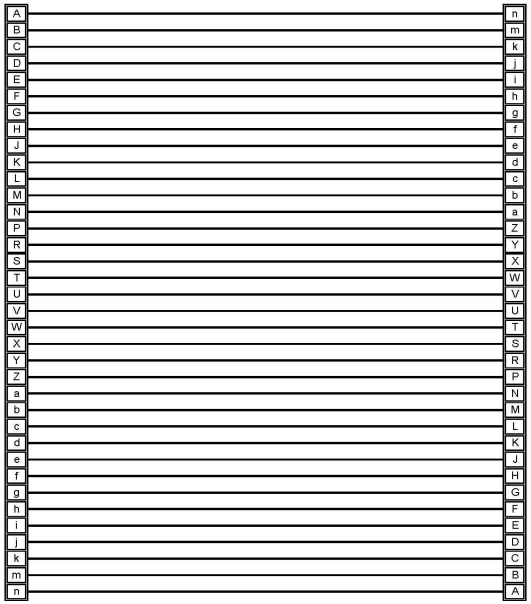
41 pins male plug ref.:
851 06A 20 41 P PG 50
Cap ref.:
BF N PT 20

41 pins female socket ref.:
851 02 E 20 - 41 S 50
Cap ref.:
BECN 20



41 pins male plug 41 pins male plug

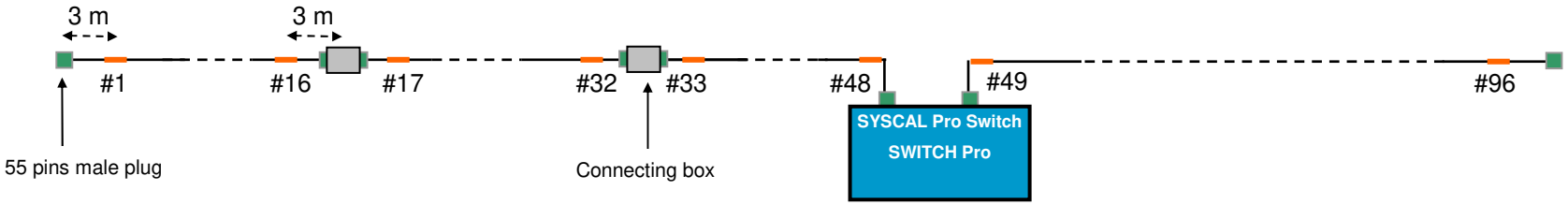
Wiring diagram of a connecting box



41 pins female socket 41 pins female socket

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM UNIT
96 ELECTRODES – 5 METERS SPACING BETWEEN TAKEOUT

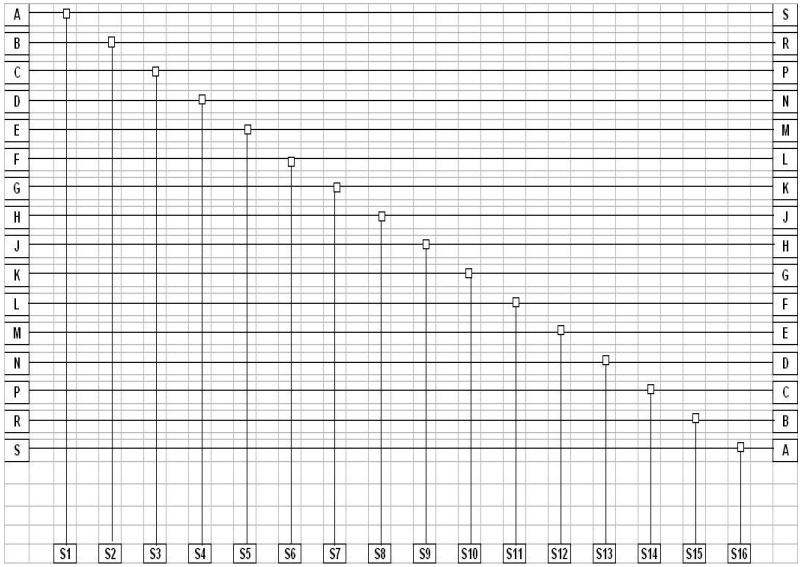
In the field configuration (6 cables with 16 takeout – 4 connecting boxes)



Wiring diagram of a switch cable (16 electrodes)

55 pins male plug ref.:
851 06A 22 55 P PG 50
Cap ref.:
BF N PT 22

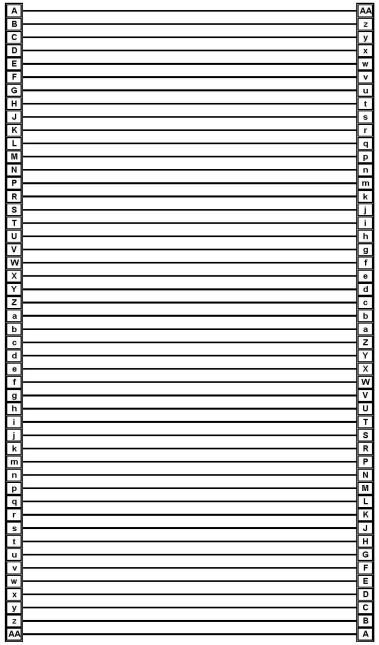
55 pins female socket ref.:
851 02 E 22 - 55 S 50
Cap ref.:
BECN 22



55 pins male plug

55 pins male plug

Wiring diagram of a connecting box

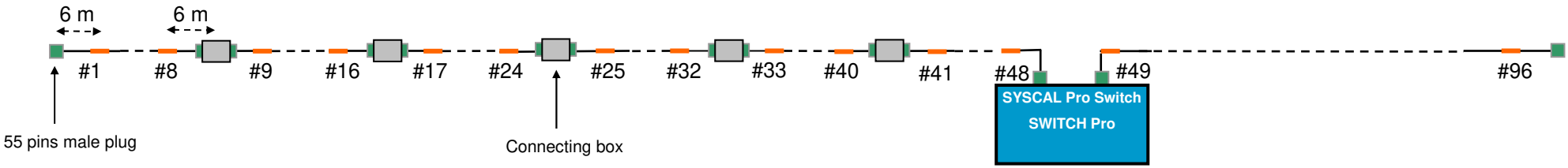


55 pins female socket

55 pins female socket

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM UNIT
96 ELECTRODES – 10 METERS SPACING BETWEEN TAKEOUT

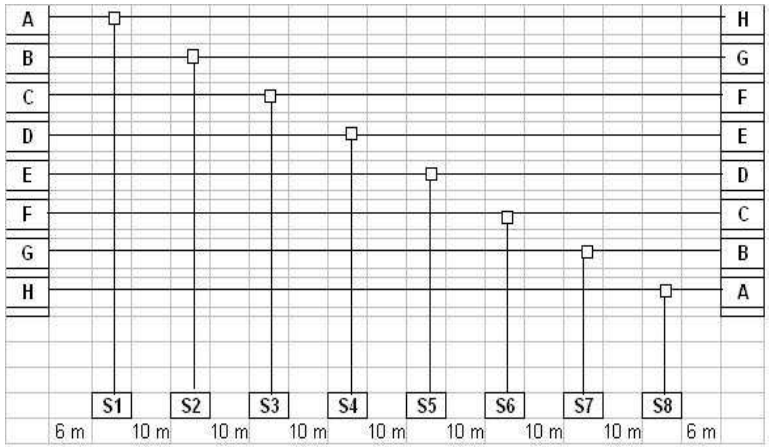
In the field configuration (12 cables with 8 takeout – 10 connecting boxes)



Wiring diagram of a switch cable (8 electrodes)

55 pins male plug ref.:
851 06A 22 55 P PG 50
Cap ref.:
BF N PT 22

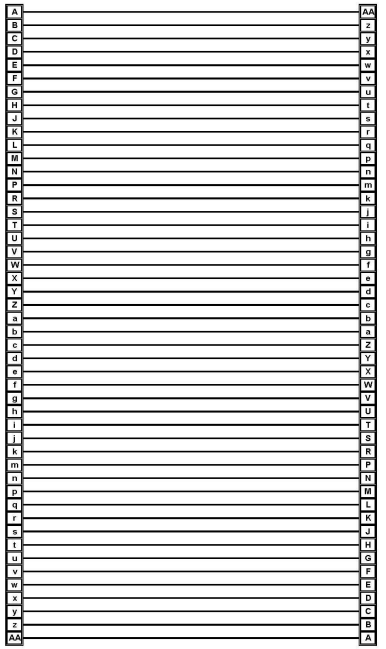
55 pins female socket ref.:
851 02 E 22 - 55 S 50
Cap ref.:
BECN 22



55 pins male plug

55 pins male plug

Wiring diagram of a connecting box

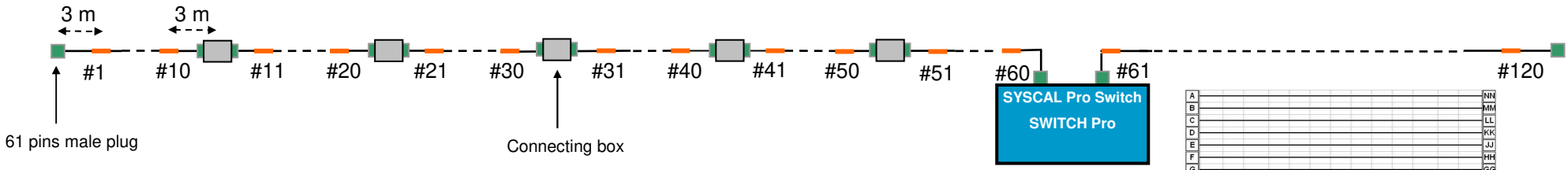


55 pins female socket

55 pins female socket

SWITCH CABLE OF A MULTI-ELECTRODE SYSTEM UNIT
120 ELECTRODES – 5 METERS SPACING BETWEEN TAKEOUT

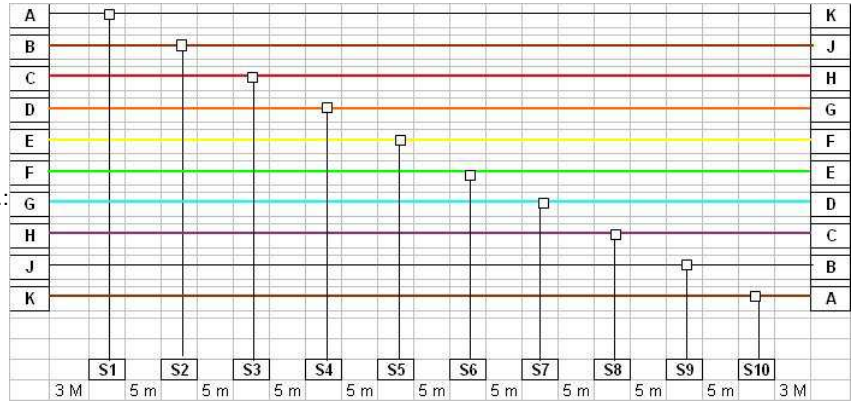
In the field configuration (12 cables with 10 takeout – 10 connecting boxes)



Wiring diagram of a switch cable (10 electrodes)

61 pins male plug ref.:
851 06 E 24 61 P 50
Cap ref.:
BF N PT 24

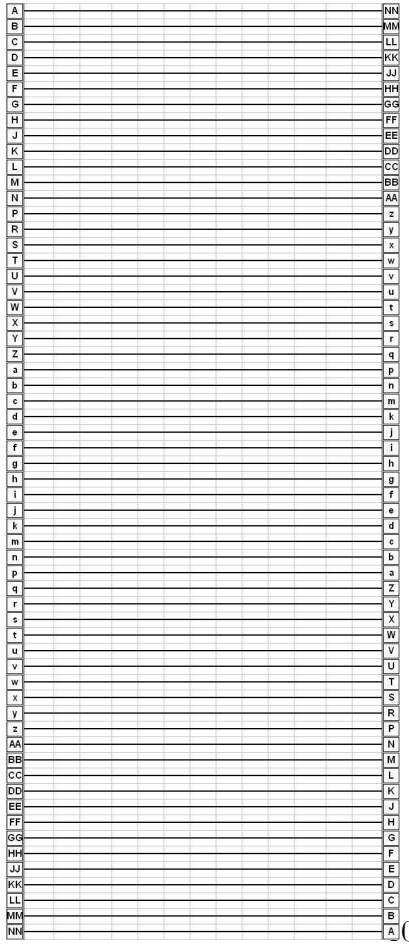
61 pins female socket ref.:
851 02E 24 61 S 50
Cap ref.:
BECN 24



61 pins male plug

61 pins male plug

Wiring diagram of a connecting box



61 pins female socket

61 pins female socket

ANNEX 9: GPS DATA FORMAT - NMEA 0183

NMEA is a standard protocol, used by GPS receivers to transmit data.
NMEA output is RS-232 compatible (4800 bps - 8 data bits - no parity and one stop bit).
NMEA 0183 sentences are all ASCII; each sentence begins with a dollar sign ($)
and ends with a carriage return linefeed (<CR><LF>) and data is comma delimited (all commas must be included as they act as markers).
Following the $ is the address field aaccc. aa is the device id. GP is used to identify GPS data. Transmission of the device ID is usually optional. ccc is the sentence formatter, otherwise known as the sentence name

Sentence GPGGA: Global Positioning System Fix Data

$GPGGA,hhmmss.ss,llll.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh

1 = UTC of Position
2 = Latitude
3 = N or S
4 = Longitude
5 = E or W
6 = GPS quality indicator (0=invalid; 1=GPS fix; 2=Diff. GPS fix)
7 = Number of satellites in use [not those in view]
8 = Horizontal dilution of position
9 = Antenna altitude above/below mean sea level (geoid)
10 = Meters (Antenna height unit)
11 = Geoidal separation (Diff. between WGS-84 earth ellipsoid and mean sea level. - = geoid is below WGS-84 ellipsoid)
12 = Meters (Units of geoidal separation)
13 = Age in seconds since last update from diff. reference station
14 = Diff. reference station ID#
15 = Checksum

Sentence DBT : Depth below transducer

$SDDBT,x.x,f,x.x,M,x.x,F*hh

1 = Depth, feet

2 = f = feet

3 = Depth, meters

4 = M = meters

5 = Depth, Fathoms

6 = F = Fathoms

7 = Checksum

ANNEX 10: SD CARD Reader

A SD CARD reader developed by IRIS can be connected to the serial port ("com1") of the Syscal Pro so as to load sequences and download data without using the computer in the field.
The reader is supplied with 2 R6 cells.

When connected to the PC, by the USB port, the IRIS SD CARD reader is recognized as an external device – so, files can be copied easily in the explorer window.

Here is the meaning of the led colours of the SD reader:

Status	Meaning
Steady Green (>3s)	Ready: waiting for transfer
Steady Red (>3s)	Error (SD Card missing or full, low battery, communication error)
Orange	Initializing SD card before transfer
Red/Green Flashing	Initializing SD card, browsing card, getting free space (if the card has just been formatted, it can take tens of second
Fast Green Flashing	Transferring data
Fast Red Flashing	Writing data on SD Card
Slow Green Flashing	Transfer terminated, user can disconnect the SD reader

For the Syscal pro, the IRIS SD card reader is able to read the following extension files:

. **pro**: data downloaded from a Syscal Pro
. **sqz** : sequence created by Electre Pro
. **sds** : sequence created by Electre Pro and converted to the "sds" format

20 characters is the maximum number for the file names in the SD reader.

Note:
If the SD card contains "sds" and "sqz" files, they will be both displayed – but, as soon as one "sds" file has been transferred, the "sqz" files won't appear anymore (because, with time, the "sds" format is the one that will become the standard format for the Syscal Units) - (it contains all the information of the sequence whereas the "sqz" contains a part of the information).

Remarks about the version numbers:
Electre Pro software (from V.1.6) can generate sequences with the "sds" format
Prosys II software (from V. 2.29) can read the dataset extension ("pro").
Syscal Pro (from V. 4.3.0 for the Rx) can upload sequences from the IRIS SD reader or can download data files to the IRIS SD reader.

ANNEX 11: SP SEQUENCE MODE

The **"Sp Sequence"** mode of the Syscal Pro unit (reached by the **"Config|Mode"** menu) allows to do measurements of the Self Potential parameter (also known as Spontaneous Polarization), in Multi-electrode mode.

This requires the use of a sequence, previously created in the PC and uploaded into the unit.

The creation of the sequence can be done by Excel for example, and has to be opened in Electre Pro so as to be uploaded into the unit.

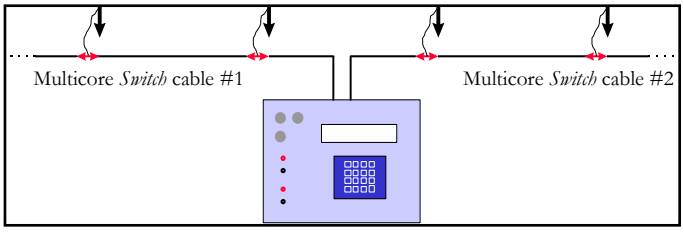
For Sp measurements, there's no injection process as these are the natural potentials that are measured by the unit (Vp) – so the measurement is done only between two electrodes for this passive method.
To avoid "noise" coming from the polarization of the electrodes, some non-polarizing electrodes (made of Cu/CuSo4 for example) are commonly used for this type of measurement.

Non polarizing electrode

For this type of acquisition, two measuring ways are classically used: the Fixed-Base configuration and the Potential Gradient array:

Example with a Syscal Pro Switch-48 unit with 5m spacing:

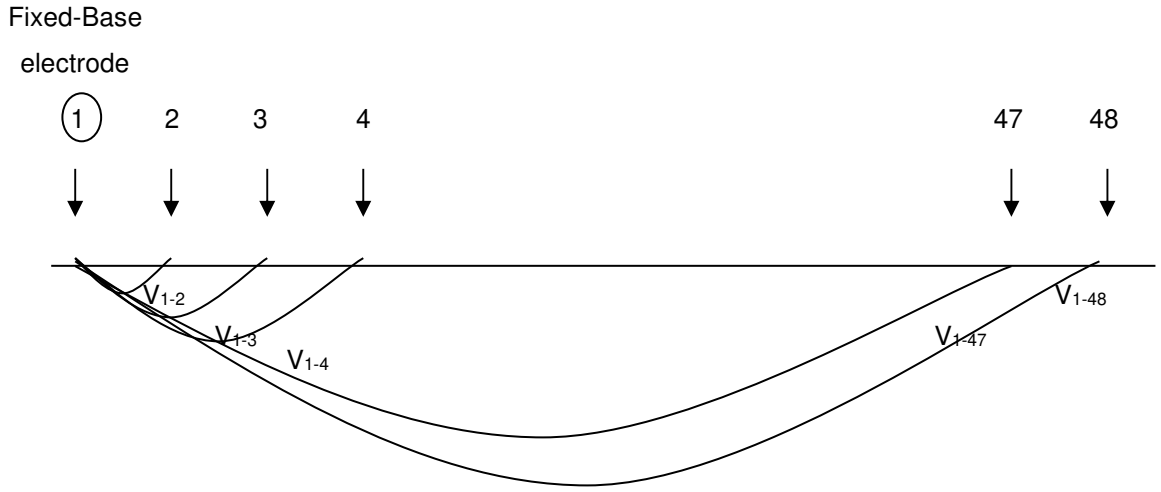
Connect the Multi-core cables as for a classical multi-electrode measurement.



Fixed-Base configuration:

For that array, an electrode is kept fixed all along the acquisition and a mobile electrode is shifted regularly along the profile.

Thanks to the multi-electrode mode of the Syscal Pro Switch unit, this can so be automated very easily as the electrodes of the system, automatically switched by the unit, can serve as the mobile electrode along the profile – so one electrode will stay always the same for the measurement (the Fixed-Base electrode (#1 in that example) and the other one will change every time (#2 to #48).



For such configuration, here is the structure of the sequence:

```
# X  Y Z
1 0  0 0
2 5  0 0
3 10 0 0
…
48 235 0 0
```

Definition of the abscissa of the electrodes along the profile

```
# A B M N
1 0 0 1 2
2 0 0 1 3
3 0 0 1 4
…
47 0 0 1 48
```

Definition of the measuring dipoles

Note that in the sequence, the A and B electrodes are not used, so their number is "0".

Potential Gradient configuration:

For that array, the reception dipole is moved all along profile.
Thanks to the multi-electrode mode of the Syscal Pro Switch unit, this can so be automated very easily as the electrodes of the system, automatically switched by the unit, can serve as the mobile dipole along the profile.

For such configuration, here is the structure of the sequence:

```
# X Y Z
1 0  0 0
2 5  0 0
3 10 0 0
…
48 235 0 0
```

Definition of the abscissa of the electrodes along the profile

```
# A B M N
1 0 0 1 2
2 0 0 2 3
3 0 0 3 4
…
47 0 0 47 48
```

Definition of the measuring dipoles

Note that in the sequence, the A and B electrodes are not used, so their number is "0".

Sum-up of the Procedure:

In the PC:

- Create the sequence respecting the format, by Excel for example.
- Save the sequence with a "txt" extension
- Open Electre Pro software and import the sequence by the "**File|Open**" menu and select the "txt" type (no needs to specify the "Syscal parameters" from the "Configuration" tab, as the parameters are automatically fixed in that mode)
- Connect the USB cable and select the "**USB**" communication port (after installation of the USB driver)
- Select the "**File|Upload**" menu

In the Syscal:

- Select the "**Sequence|Upload from PC**" menu.
- Then, from the "**Config|Mode**" menu, select the "**Sp mode Sequence**" and validate and then you will reach the list of sequences stored into the unit: select the Sp sequence you wish and validate: then, select the Switch type "Internal / Switch Pro".
- At last, run the measurement by the "Start" key and follow the procedure as usual.

After acquisition, download the data into the PC by PROSYS II software and the self-potential values will appear in the Vp column (mV).