

Instruction Manual
for
The Sting R1™, Sting R1 IP™ and Swift™

Release 3.0.14

Advanced Geosciences, Inc.

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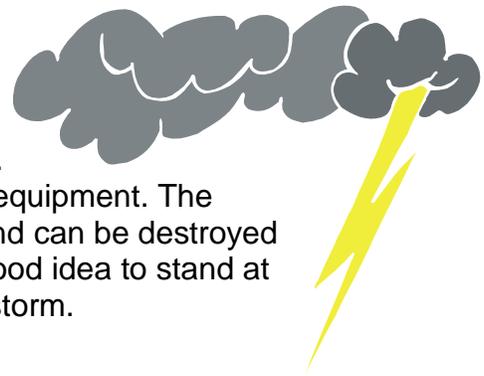
Safety first

Every AGI instrument is designed with safety in mind. However, even the best design must rely on the user to employ safety precautions when using the instrument. Therefore review the following safety precautions to avoid injury and prevent damage to the equipment. To avoid potential hazard, use this product only as specified.

Since the geophysical resistivity method implies that an electric current is transmitted into the ground, it is necessary to use electrically energized ground stakes. It is therefore absolutely necessary that the survey line with its ground stakes and connection be monitored for the duration of the survey so that people, children and animals do not touch the electrode stakes.

- Always inspect the Swift cables and connecting cables for insulation damage or exposed wiring. Damaged cables should be replaced.
- Use good rubber sole shoes (or rubber boots) and rubber gloves when setting out the cable.
- Never work alone.
- Use a safe practice when setting up the survey line. First pound all stakes into the ground. Then lay out the Swift cable. Make sure the electrode cable is not attached to the instrument when attaching the electrodes.
- The survey line should be sufficiently taped off with warning tapes.
- When setting up the instrument do not attach the survey cables (Swift cables) to the instrument until you are ready to start the survey.
- Before starting the instrument make sure that the survey line is clear and no one is touching the cable or an electrode stake.
- Use only the fuse type and rating specified for this product.
- Do not touch exposed connections and components when the system is energized.
- Do not operate with suspected failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.
- Do not operate in an explosive atmosphere.

- Do not operate during an approaching thunderstorm. Thunderstorms are dangerous both for you and the equipment. The instrumentation contains sensitive CMOS circuitry and can be destroyed by nearby lightning. For your own safety it is not a good idea to stand at the end of a long conductive cable during a thunderstorm.



1. Preface

1.1 Warranty

Each instrument manufactured by AGI is warranted to be free from defects in materials and workmanship. This warranty covers the servicing and adjusting of any defective parts (except for fuses, batteries and other consumables). The warranty is effective for 12 months after the date on which the instrument was shipped from the factory as set forth on the bill of lading, provided that the instrument is returned freight prepaid to AGI. If the fault has been caused by misuse or abnormal conditions, AGI will submit a cost proposal to the user prior to undertaking any repair work.

This warranty does not cover the costs of any steps that the purchaser takes or fails to take as the result of measurements made using our instrument or as the result of calculations carried out by the instrument or software.

If a fault occurs, contact AGI for instructions.

The 12 month warranty on all new AGI equipment and hardware is void if “third party” (i.e. non-AGI built) multielectrode cables or switching hardware are used with the system.

Using a 12 V automobile battery installed in a vehicle as an instrument power source will void the warranty. Using an automobile battery installed in a vehicle may damage the instrument beyond repair. Therefore when using a 12 V battery as external instrument power source, it has to be disconnected from the vehicle and placed on the ground on some insulating material like dry wood or plastic.

PRODUCT WARRANTY REGISTRATION CARD:

END USER'S NAME _____

COMPANY/ORGANIZATION _____

ADDRESS _____

CITY _____ STATE _____

COUNTRY _____

POSTAL CODE _____ PHONE _____

FAX _____ E-MAIL _____

NAME & SERIAL # OF INSTRUMENT _____

DATE OF PURCHASE _____

THIS WARRANTY REGISTRATION INFORMATION WILL HELP US TO KEEP OUR CUSTOMERS INFORMED OF UPDATES, CHANGES, AND NEW IMPLEMENTATIONS. PLEASE FAX THIS REGISTRATION CARD TO +1 512 258-9958 OR SEND IT VIA E-MAIL TO sales@agiusa.com.

KEEP A COPY OF THIS REGISTRATION FORM FOR YOUR RECORDS.
THANK YOU FOR PURCHASING PRODUCTS FROM ADVANCED GEOSCIENCES, INC. FOR FURTHER INFORMATION, CONTACT OUR LOCAL REPRESENTATIVE OR ADVANCED GEOSCIENCES, INC., 2121 Geoscience Dr., AUSTIN, TEXAS, 78726, U.S.A., PH # +1 512 335-3338,
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1.2 Register in the AGI Sting/Swift User Group

By registering in our web sites Sting/Swift User Group you will get the latest updates of our software free of charge, helpful hints regarding the use of the Sting and the Sting/Swift system, latest news regarding the system and ready made command files.

Any Sting or Sting/Swift owner is eligible for joining our Sting/Swift User Group. To sign up, log in to our web page at <http://www.agiusa.com> and click on User Group Registration in the yellow left side bar. Fill in the information and within short you will receive your registration password.

1.3 Unpacking the instrument

The following items should be enclosed in a standard Sting R1 shipment:

Item	Description	Code	Qty
1	The Sting instrument console, S/N is placed on the right side of the instrument enclosure	911000	1
2	Clip-on battery pack	911100	1
3	Battery charger for 110/220 V.	911503	1
4	Charger input cable	911501	1
5	Cable for communication Sting/PC	920009	1
6	The Administrator utility software on a CD	921002	1
7	Instruction manual	911001	1
8	Test resistor	920020	1
9	Allen wrench, 9/64"	920026	1
10	Set of two fuses, 2.0 Amp slow blow, 5x20 mm	F2A250V	2

The following items should be enclosed in a standard Sting R1 IP shipment:

Item	Description	Code	Qty
1	The Sting instrument console, S/N is placed on the right side of the instrument enclosure	911004	1
2	Clip-on battery pack	911100	1
3	Battery charger for 110/220 V.	911503	1
4	Charger input cable	911501	1
5	Cable for communication Sting/PC	920009	1
6	The Administrator utility software on a CD	921002	1
7	Instruction manual	911001	1
8	Test resistor	920020	1
9	Allen wrench, 9/64"	920026	1
10	Set of two fuses, 15 Amp, 125 V, 5x20 mm	F15A125V	2

An external power cable, ordered separately (order code 920018), is required to operate the Sting R1 IP in high power mode.

IMPORTANT: Make sure to set the battery charger current setting (110 or 220 V AC) for the appropriate voltage in your area immediately when unpacking the instrument.

If a Swift automatic multi-electrode system was included in the order the shipment may also contain the following items:

Item	Description	Code	Qty
11	Swift interface box	93100	1
12	Transmitter/receiver cable (ABMN cable)	938300	1
13	Sting/Swift communication cable with external power adapter	938200	1
15	The Administrator utility software on a CD	921002	1
16	Swift cable with a number of smart electrodes	depending on order	
17	Stainless steel electrode stakes	depending on order	
18	Non-polarisable electrodes (Sting R1 IP)	depending on order	
19	RES2DINV resistivity imaging inversion software for MS DOS type computer	depending on order	

1.4 About this manual

This manual covers the Sting R1, the Sting R1 IP resistivity meters and the Swift automatic multi-electrode system.

When the instructions are valid for both the Sting R1 and for the Sting R1 IP meters the instrument will simply be mentioned as “the Sting.” If the instruction is valid only for a specific instrument the full name will be spelled out.

This manual uses the following conventions:

Example	Description
M6	Go to menu 6, by pressing the number 6-key
M7/F1	Go to menu 7, by pressing the number 7-key and then press the F1 key

1.5 The different instruments covered by this manual

Sting R1 memory earth resistivity meter operates in manual mode or with the automatic Dual Mode (patent pending) Swift electrodes

Sting R1 IP is more powerful than the Sting R1 and also has induced polarization measurement (IP) capability. The current output is the same as for the Sting R1, but the higher power allows for more current to be sent out in the same geological environment.

Dual Mode Swift

The patent pending automatic electrode system used with the Sting R1 and the Sting R1 IP. The unique advantage with the Swift, Automatic Dual Mode electrode system is:

1. Dual Mode capability makes it possible to use non-polarisable electrodes for the potential measurement. Since this feature is patent pending, it is only available with AGI equipment.
2. All dual mode electrodes can have their addresses re-programmed without having to open them up. This is done with the Swift reprogramming kit (part #921000). This feature is important, for example, if one user wants to borrow a Swift cable set from another user. The electrodes can then be re-programmed so that the electrode addresses are in consecutive order. Another case is if an electrode needs to be replaced by a spare electrode. The spare electrode is then quickly re-programmed and placed in the faulty electrodes place.

1.6 Measurement strategy

The Sting instruments are DC resistivity instruments. The Sting R1 IP is also a time domain induced polarization (IP) instrument. The instruments automatically commutates the signal, but for the resistivity measurement it operates in the DC region of the signal.

The Sting R1 IP instrument has two modes of measurement, the resistivity (RES) mode and the resistivity/IP (RES/IP) mode.

Both the Sting R1 and the Sting R1 IP also have self potential (SP) measurement capability.

1.7 Resistivity mode

In the resistivity mode, for each measurement, the instrument injects a current, reverses polarity and injects the current and then reverse polarity back to original and injects the current again. The time for this cycle can be selected from four different settings: 1.2 sec, 3.6 sec, 7.2 sec or 14.4 sec. The default setting is 3.6 seconds.

Above method has been used in the Sting R1 instrument and has proved to be very effective for resistivity measurements. If only resistivity data is required, an advantage of this method is that it is faster than if the resistivity/IP option is selected.

1.8 Resistivity/IP mode

When measuring resistivity/IP the current injection pattern is different. The measurement cycle is: one period of current +ON, one period of current OFF during which IP is measured, one period of current -ON and finally one period of current OFF during which IP is measured again. For each time slot the last measurement is subtracted from the first and the average is presented as the result. The result for each time slot as well as the total is saved in the Sting data file.

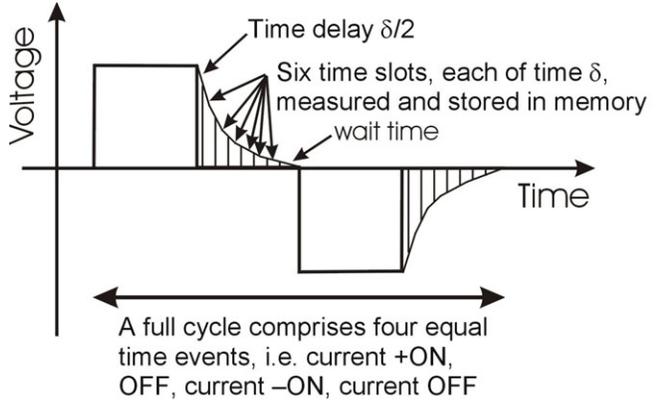


Figure 1 Resistivity/IP measurement sequence.

This method has become a standard for measuring time domain IP in the mineral industry. There are four user selectable time constants in the Sting: 1, 2, 4 and 8 seconds. The default setting is 2 seconds. The time constants and the different time events associated with each time constant is listed in the table below:

Time constant seconds	Total time cycle seconds	Time delay ($\delta/2$) mseconds	Time slot (δ) mseconds	Wait time mseconds
1	4	65	130	155
2	8	130	260	310
4	16	260	520	620
8	32	520	1040	1240

2. Quick start

Read this chapter to get started quickly if you are already somewhat familiar with earth resistivity meters and methods.

The Sting can be used in four basic modes:

1. By itself as a regular memory resistivity meter (see section 2.1 below) with four manually moved electrodes.
2. With the Swift automatic multi-electrode system for automatic recording (see section 2.2 **Automatic dipole-dipole mode**) of dipole-dipole data for resistivity (and IP by Sting R1 IP) imaging.
3. With the Swift automatic multi-electrode system programmed by the operator (see section 2.3 **User mode**) to perform any resistivity (and IP by Sting R1 IP) measurement automatically.
4. With the Swift automatic multi-electrode system controlled by a PC type computer (see section 2.4 **PC mode**) in the field.

2.1 Manual mode

Proceed as follows:

Connect four ground electrode stakes to the current (A and B) and potential (M and N) terminals on the instrument front panel.

With the battery pack attached, turn the instrument on by flipping the ON/OFF (I/O) switch to the ON (I) position.

Before you start measuring, you need to set a few parameters which will stay the same for the whole survey.

1. Press the number **1** key to get to menu 1. Press the **F1** key and select the array type (electrode configuration) you are going to use. Press "+" or "-" to select from the supported configurations. When the configuration of your choice is displayed on the screen, press the **MENU** key to get back to menu 1. The chosen configuration will now remain in effect until changed. Select any array except the USER MODE which is only used with the Swift automatic multi-electrode system. Press the **MENU** key to get back to menu 1.
2. Press the **F3** key and use the + or - key to select a suitable current setting. If the instrument can not send out the requested current because of local geological

conditions, it will automatically switch down to a lower current, which is possible to send out.

3. Go to menu 2 (M2) by pressing the number **2** key. Press **F1** and use the **+** or **-** key to select the number of cycles. Press **MEN** to get back to menu 2.
4. Press **F2** and use the **+** or **-** key to select a suitable threshold (2% is a recommended value for most surveys) for the error. If the standard deviation of the measurement falls below this value during the stacking, the measurement is automatically interrupted and the reading is stored in the internal memory. Press **MEN** to get back to menu 2.
5. Press **F3** followed by **F1** to select feet or meters for units.
6. Press **F2** to select 3.6 sec measurement time. Press **MEN** to get back to menu 2
7. Go to menu 3 by pressing the number **3** key. Press **F3/F1** followed by the **.** (dot) key to erase the memory from previously recorded data. Make sure that all important data in memory are downloaded to a computer prior to erasing the memory. Press **MEN** to get back to menu 3.
8. Press the number **4** key to get to menu 4 (M4) on the display. Press **F1** to set date and time.
9. Make sure the automatic measurement mode (only used with the Swift automatic electrode system) is turned off, by pressing the number **6** key to get to menu 6 and then pressing **F1**. Set the mode to **Off** by pressing the **+** key. Press the **MEN** key to get back to menu 6.

You are now ready to start measuring.

10. Go to menu 1 (M1) and press **F2** to enter electrode distances. When the distances are entered by pressing **F3**, the display is automatically changed back to menu 1. The instrument is now ready for measurement.
11. Press the **MEAS** key to start your measurement cycle. Measured data will automatically be stored in the memory and can later be downloaded to a computer using the "Stingdump" download module of the Administrator software (see section 6.1.9 below The Sting Measurement Download Module. If the displayed error σ is too large, you may want to repeat the measurement or you may want to increase the output current (Menu1 F3) and measure again.
12. After the first reading is taken, go to step 10 above to change the electrode distances and start a new measurement.

The measurement result is displayed on the LCD screen. The result screen differs somewhat for the different array types used (see below).

2.2 Automatic dipole-dipole mode

The Sting can be used with the Swift automatic dual mode electrodes to record resistivity data automatically. Three different modes exist:

- The built in dipole-dipole mode. This mode can always be used without any prior preparation (see section 2.2.2).
- The User Mode (see section 2.3). This mode allows the operator to program the Sting/Swift system to perform any type of resistivity survey or resistivity/IP survey (Sting R1 IP). This mode requires the operator to write a command file and download the command file to the Sting RAM memory. This is often performed in the office prior to the field survey. The appropriate command file is then selected on the Sting display in the field and the Sting will then use this command file to control the measurement procedure. Command files are created by using our CommandCreator software (see section 6.3), the 3D “Command create” module of the Administrator software (see section 6.1.7) or the “Crosshole command creator” module of the Administrator software (see section 6.1.6). Command files can also be created manually by using a regular text editor.
- The PC Mode (see section 2.4). This mode is similar to the User Mode, but in this case a PC is connected to the system at the Swift box. The command file is residing in the PC. Use the “Swift measure” module of the Administrator software (see section 6.1.5) to perform this type of survey. The advantage of this mode is the almost unlimited data storage since the measurement data is stored on the computer hard drive.

2.2.1 Check list for items used during Sting/Swift automatic measurements

Before going out in the field make sure to bring the following items:

Sting R1 or Sting R1 IP
Sting battery charger
Input cable for the charger
Swift box
ABMN Cable
Sting-to-Swift communication cable
Adapter cable for external battery
12V DC external battery
Charger for 12 V DC battery
Swift cables
Stakes
Extra rubber bands
Non-metallic tape measure (100 meter)
Sledge hammer
Download cable
Water container
Bucket

Salt
Re-programming kit

Optional items for checking the result in the field:

Lap-top computer
Printer (optional for printing result)
Res2Dinv hardware key (dongle)

2.2.2 Automatic mode for dipole-dipole resistivity imaging using the Swift Dual Mode electrode system

The automatic mode is used to automatically record a dipole-dipole array data set using the Swift automatic multi-electrode system.

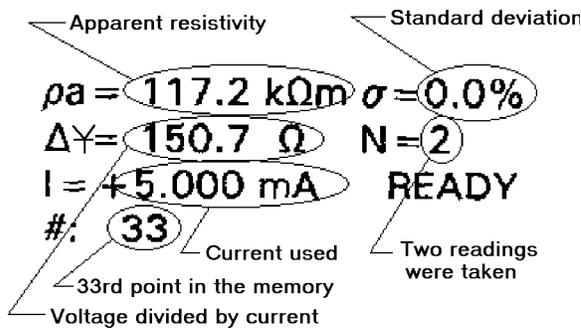


Figure 2 Result display for Schlumberger, Wenner, dipole-dipole, pole-dipole and azimuthal.

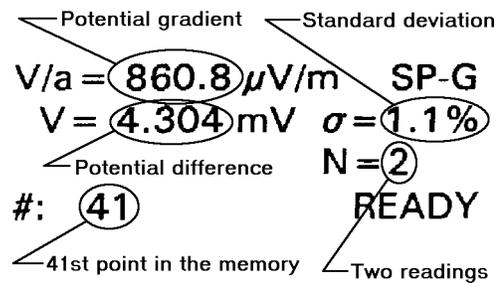


Figure 3 Result display for the SP-gradient array type.

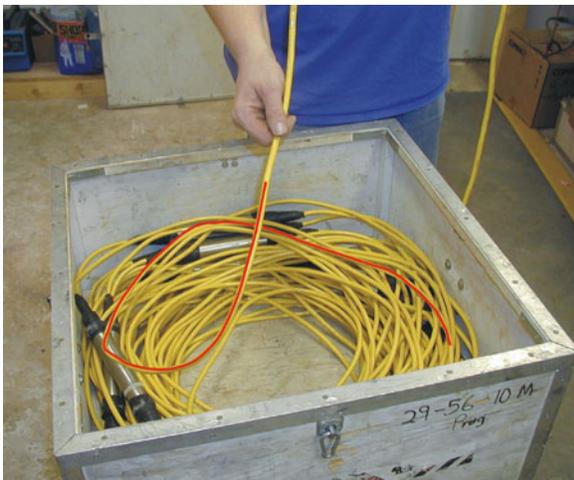


Figure 4 Incoming cable "over" the loop.

The Sting/Swift system is used to cost-effectively collect field data for resistivity imaging. Below follows a complete step by step guide on how to collect and present a dipole-dipole resistivity cross-section.

2.2.3 Treat the cables well and you will get good data

The Swift cables with the fixed cylindrical stainless steel switches are a sensitive part of the system. Therefore it is important to

handle them carefully. Here are some rules on how to handle the cable.

Under no circumstances drag the cable on the ground. Bring the cable box along the profile and lay out/take in the cable directly from/to the box.

- Do not force the cable when you put it back in its box. It is actually quite easy to put the cable in it's box once you know how. Lay the cable coils down either with the "incoming" cable end over the loop or under the loop as the cable wants to lay. By laying the cable nicely coiled in this way in it's box, it is easy to lay it out again without a tangled cable.



Figure 5 Incoming cable "under" the loop.

2.2.3.1 How to set up the system for a dipole-dipole field survey

The complete field system consists of:

1. The Sting instrument console
2. The Swift interface box **Note that the battery in the Swift interface box needs to be charged every day when in use, even if an external battery is used to power the Sting.**
3. Sting to Swift communication cable
4. Sting to Swift ABMN cable
5. Swift-cables with a number of addressable dual mode switches
6. Stainless steel electrode stakes

Make sure that all batteries are charged. Note that the Swift interface box needs to be charged daily when being used.

2.2.3.2 Field preparation

- Start by stretching a tape measure along the line.

- Place the stainless steel electrode stakes in the ground at predetermined spacing.
- Lay out the Swift cable. Drop one switch (smart electrode) at each stake. Note that the switches are numbered. The cables are marked with the switch numbers at each end of the cable. If several Swift cables are used, **it is important to lay out the cables in the correct order so that the switches are numbered in sequence** i.e. 1, 2, 3.....27, 28



Figure 6 Rubber band each switch to its electrode stake.

- Rubber band each switch to its electrode making sure that there is metallic connection between the switch and the electrode stake. Use double rubber bands on a windy day to ensure firm connection at all time.

2.2.3.3 Connecting the instrument

- Even though the Sting/Swift can be connected at either end of the cable lay-out, it is preferred to connect the Sting and Swift interface box in the middle of the Swift cable lay-out. By connecting in the middle of the cable lay-out, the effect of voltage drop in the cables is minimized.
- Connect the Swift cable middle end connectors to the Swift box where marked “Electrode Cable”.
- Connect the AB MN connector on the Swift

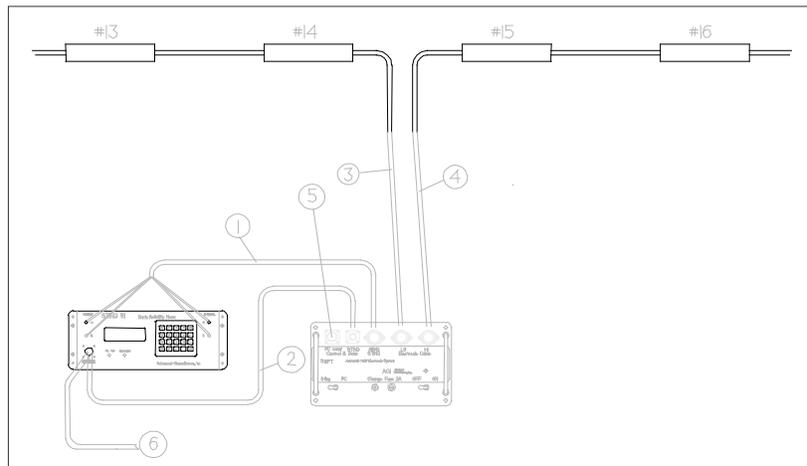


Figure 7 Sting/Swift connection: 1=ABMN cable, 2=Sting/Swift communication cable, 3=Swift cable with low numbers, 4=Swift cable with high numbers, 5=receptacle for PC connection, 6=connector for external 12 V DC battery.

box to the A, B, M and N terminals on the Sting.

- Connect the Sting/Swift communication cable between the RS232 connector on the Sting front panel and the Sting Control & Data connector on the Swift box.
- For automatic Swift surveys you must use a 12 V DC external battery connected to the piggy tail of the communication cable. Note that when using the Sting R1 IP the high power transmitter mode is only achieved if an external battery is used.
- The system is now laid out and ready for measurement after the Sting has been set up.
- Go to menu 3 and use **F3** then **F1** then . (dot) to erase the data memory. Make sure that any previously recorded important readings in the memory are downloaded to a computer prior to erasing the memory.
- Go to menu 6 and press **F3** to check that the switch addresses Start= and End= are entered and correspond to your switch addresses. Press the **MEN**-key.
- Go to menu 8 by pressing the 8-key. Press **F1** and enter the electrode spacing (enter by pressing F3) you are using. This will set the instrument for automatic recording of a complete dipole-dipole data set. **Note: It is important that you enter this value by pressing F3 every time you record a new profile, since this will re-set all the default values and start addresses correctly.**

The default settings are as follows:

M1/F1	Dipole-dipole measurement
M1/F3	Current = 200 mA The instrument will automatically switch down the current if it can not send out required current.
M2/F1	Max cycles = 2
M2/F2	Accuracy = 2 %
M2/F3/F2	Measurement time 3.6 seconds
M2/F3/F3	400 V
M5/F1	All functions are OFF
M5/F2	Log time = OFF
M6/F1	Auto
M6/F2	Linestart = 0
	Electrode separation = as selected previously (M8/F1)
	Max dipole = maximum dipole possible with used number of electrodes
	Nxt dipol = 1
	Max sep = 6
	Nxt sep n=1
	Direction = Forward
	Nxt B-loc= 0
M6/F3/F3	Max repeat = 1
M6/F3/F3/F1	Stop on error is OFF
M8/F3/F1	OFF

M8/F3/F2 Res

The instrument is now set to measure an automatic dipole-dipole profile. However, before starting the measurement, go to menu 7 by pressing the **7**-key and run the contact resistance test (M7/F1) prior to running the survey.

2.2.3.4 Contact resistance test

Test 1 (M7/F1). Use this test to measure the contact resistance along the profile. Since the electrode spacing is equidistant along the profile one can expect similar ground/contact resistance along the profile. If any of the electrodes should show a significantly larger value or if the test stops with an error code, go check that electrode to make sure that it makes good contact to the ground and that the switch makes proper contact with the electrode stake. If the contact resistance is high because of local soil conditions, it usually helps to pour some salt water on the ground where the electrode is planted. The goal is to get the contact resistance below 2 k Ω preferable below 1 k Ω .

The test may stop displaying the INOVL, TXOVL or HVOVL error message. INOVL stands for “input over-load” and TXOVL stands for “transmitter over-load”. Both these errors are likely to have the same cause. If the electrode stake is poorly planted in the ground or if there is dirt or corrosion where the electrode switch contacts the stake, the slightest vibration may stop the measurement displaying INOVL or TXOVL. The remedy is to plant that stake good in the ground and to make sure that the contact surfaces are clean. Note that very minute vibrations may cause the instrument to display the error code. It may very well seem that the electrodes are planted well in the ground even though they need improvement.

The HVOVL stands for “high voltage over-load” and is issued when current cannot be sent out. Typically this will happen if one of the electrode switches are not rubber banded to the stake and is just laying on the ground or if the ABMN cable has not been plugged in correctly.

If the test stopped at a certain electrode and after the problem has been solved, the test can be restarted from that point by pressing the **F1** key. Pressing **F2** will restart the test, starting after the problem electrode. From Sting firmware version 2.5.5 the result from the contact resistance test is stored in the internal data memory.

It is important to run this test (M7/F1) before you start the actual measurement. This way you can spot poorly connected/planted electrodes prior to starting. During the actual survey, the Sting/Swift will not stop for error codes (unless M6/F3/F3/F1 is set to OFF), instead it will simply skip those points. Therefore it is important to check all electrodes prior to start. By not stopping on an error, the survey goes much quicker and

the few points left out in most cases do not make too much difference to the final interpretation.

When the test is run, the actual measurement is started by pressing the **MEA**-key. The instrument will now run through a complete dipole-dipole survey. Data is automatically stored in the Sting memory and can later be downloaded to an MS DOS type computer using the “Sting measurement down load” module of the Administrator utility software. See section 6.1.9 for further information on downloading data to a computer.

The measurement is complete when the instrument stops at the last reading and displays “Ready.”

2.2.3.5 Data processing

In order to produce a resistivity image section, a few data processing steps need to be taken. First, the raw Sting data file (NAME.STG) is downloaded to a PC type computer using the “Sting measurement down load” module of the Administrator utility software (see section 6.1.9), delivered with your Sting instrument.

The next step is to extract and format the necessary data from the raw Sting data file (NAME.STG) to a file (NAME.DAT) readable by the inversion software RES2DINV.EXE. This is done by running the “Sting data conversion” module of the Administrator utility software. For information on how to run the conversion software see section 6.1.4.

The RES2DINV, purchased separately, inverts the measured apparent resistivity data into “true resistivity,” necessary for accurate depth determination and interpretation. If recorded, IP (induced polarization) data is also inverted. This software does also include terrain correction.

The result from the RES2DINV can be captured as an PCX-file and printed using, for example, Windows Paintbrush software or the resistivity data can be exported as an X,Y,Z-file (NAME.XYZ).

The XYZ file can be imported into a contouring software, for example, Surfer for Windows, for graphical presentation and print-out.

For more information on the RES2DINV software, read the RES2DINV software manual.

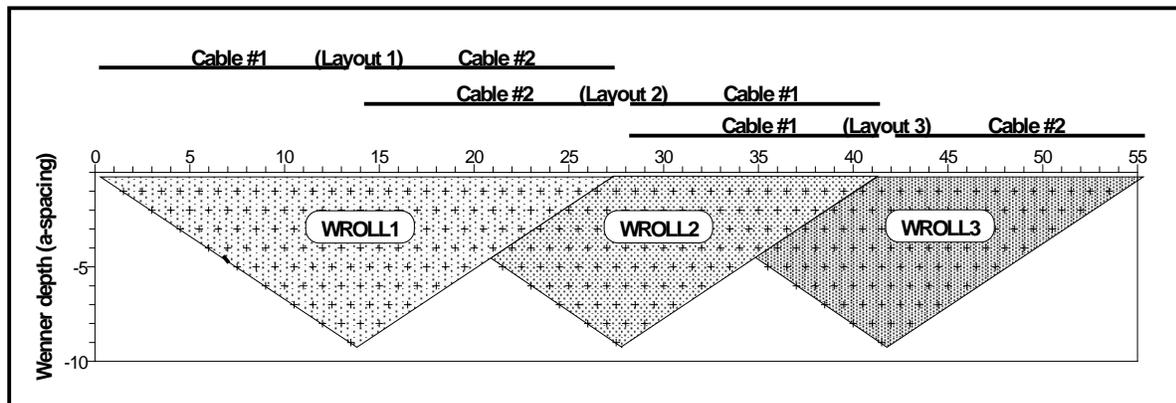


Figure 8 Data coverage using Wenner roll-along with 28 electrodes divided on two cables. Note that the overlapping readings are not measured as they are redundant.

2.3 User mode

User mode allows the operator to program any automatic array command file in a PC computer and download the command file to the Sting. The Sting/Swift can then be used to automatically record the data in the field without having to bring a fragile computer to the field. This feature makes the Sting/Swift extremely flexible.

Up to 16 command files, with a total of maximum 3000 measurements, can be stored in the Sting USER RAM memory.

- Make sure to have fully charged batteries for the Sting and the Swift interface box. **Note that the Swift interface box needs to be charged daily when in use.**

We recommend that you use an external 12 V DC battery (vehicle type) for the Sting, depending on how much data is collected during one day. The Swift system is delivered with a special adapter cable for this purpose. Just make sure that the battery is well insulated from the ground, preferably placed in a plastic box to make sure no creep current is leaking to the ground from the battery.

- When using the Sting R1 IP the high power transmitter mode is only achieved when an external battery is used.

2.3.1 Using the User Mode to record a Wenner roll-along file

To exemplify the use of the User Mode we will explain how to record a WENNER data set using the roll-along technique. The command files used in this example, WROLL1, WROLL2 and WROLL3, are found on the CD disk with the Administrator software delivered with your original Swift shipment. The enclosed command files are designed for electrode addresses 1-28 and for 3 meter electrode interval. The electrode interval

can easily be changed in a computer to any other electrode spacing using a regular text editor. We assume that the **User mode** command files have been downloaded, see section 6.1.8 “The UserLoad” module, to the Sting RAM memory using the UserLoad” module of the Administrator software also delivered with your original Swift shipment. We further assume that the field set-up consists of two Swift cables with addresses 1-14 (cable #1) and 15-28 (cable #2) totaling 28 smart electrodes.

When a profile is longer than the electrode lay-out, the profile can be measured using the two Swift cables in a leap-frogging fashion (see). This technique is known as the roll-along method and can be used to survey any length of profile.

At first the two swift cables are laid out with consecutive address numbering, that is cable #1 followed by cable #2 (addresses 1-28). Measurement is performed using the WROLL1 command file. After the first measurement is performed, cable # 1 is moved ahead of cable # 2 so that the address order now is 15-28, 1-14. Measurement is performed using the command file WROLL2. Cable #2 is now moved ahead of cable #1 so that addresses again are 1-28. The command file WROLL3 is now used to perform measurement. WROLL3 is similar to WROLL1 except it will omit taking double measurement in the area where two lay-outs over-lap. From this point on, command files WROLL2 and WROLL3 are used every other time.

To record a Wenner roll-along section in the field, proceed as follows:

Set out the field equipment as described in sections

1. Connect the Sting/Swift system as in.
2. Turn on the Sting and the Swift.
3. Set the PC/Sting switch on the Swift box in the Sting position.
4. Go to menu 3 and use **F3** then **F1** then . (dot) to erase the data memory. Make sure that any previously recorded important readings in the memory are downloaded to a computer prior to erasing the memory.
5. Go to menu 6 and press **F3** to check that the switch addresses Start= and End= are entered and correspond to your switch addresses.
6. Go to menu 8 by pressing the 8-key. Press **F2** and select the WROLL1 file using \pm to scroll among the files. Use F3 to enter your selection. This is assuming that the files WROLL1, WROLL2 and WROLL3 have been loaded using the UserLoad software. WRoll1 is a Wenner command file for 28 electrodes complete data set at 3 meter electrode spacing. WRoll2 is a Wenner command file for continued measurement when cable 1 (electrodes 1-14) has been moved forward, WRoll3 for measurement when cable 2 (electrodes 15-28) has been moved forward.
7. Enter the x and y position for the first electrode stake. When using the roll along technique make sure to enter correct coordinates for the first electrode, i.e. for

WRoll1 enter X=0, Y=0, for WRoll2 enter X=42 (14x3 meter), Y=0, WRoll3 enter X=84 (28x3 meter), Y=0 etc. (assuming 3 meter electrode spacing is being used).

8. This will automatically set the instrument default settings suitable for measurement in most cases (see page 24) .
9. Press MEA to start the actual measurement.

Do not forget to run the contact resistance test (M7/F1) before you start the actual measurement. This way you can spot poorly connected/planted electrodes prior to start.

The Sting does not stop for error codes (unless M6/F3/F3/F1 is set to OFF), it simply skips those points. Therefore it is important to check all electrodes prior to starting. By not stopping on an error, the survey goes much quicker and the few points left out in most cases do not make too much difference to the final interpretation.

After recording a complete profile, use the “Sting down load” module (see section 6.1.9) of the Administrator software to down load the data to a Windows type computer.

After downloading you have to create a new file, suitable for RES2DINV from the raw data file. For this purpose, use the “Sting data conversion” module of the Administrator software. For instructions on how to run this software go to section 6.1.4, in short it goes like this.

Make sure to first click on “All data sets into file” in order to get all your roll-along files formatted together. Then click on the button for “Output file type” for example 2D: Wenner also make sure that Output file format “2DINV and 3DINV” is checked. Then press “Load Sting file.” High-light all files in the “Data sets in file” window and then finally press “Save converted file.” The result is a file with the extension .DAT which you can run directly in the RES2DINV software.

If you have been recording IP data you need to click on the “IP Settings” button after you have pressed the “Load Sting file” button and high lighted the all files.

A window will open where you will be allowed to scroll through your data and specify how many of your 6 IP windows you would like to include in your DAT-file. When you are done click OK and then click “Save converted file.”

2.4 PC mode

The Sting/Swift system can be used connected to and controlled by a Windows type computer. The main advantage is that the data then is stored on the computer hard disk and virtually any amount of data can be stored. Below (section 2.4.1) is given an example on how to use the Sting/Swift with a computer.

2.4.1 Using the Sting/Swift together with a Windows type computer to perform a Wenner profiling

The Sting/Swift system can perform resistivity surveys using any array, controlled by an external MS DOS type computer. Information on how to write a command file controlling the measurement procedure is found in section 6.3. Below follows a complete step by step guide on how to collect and present Wenner profiling data.

2.4.1.1 Initial preparation

Make sure to have fully charged batteries for the computer, the Sting and the Swift interface box. **Note that the Swift interface box needs to be charged daily when in use.**

You may need to use an external 12 V DC battery (vehicle type) for the Sting, depending on how much data is collected during one day. The Swift system is delivered with a special adapter cable for this purpose. Just make sure that the battery is well insulated from the ground, preferably placed in a plastic box.

- When using the Sting R1 IP the high power transmitter mode is only achieved if an external battery is used.

Treat the cables well and you will get good data

The cables with the fixed cylindrical stainless steel smart electrodes are a sensitive part of the system. Therefore it is important to handle them carefully. Here are some rules on how to handle the cable.

- Under no circumstances drag the cable on the ground. Bring the cable box along the line and lay out/take in the cable directly from/to the box.
- Do not force the cable when you put it back in its box. Lay the Swift cable coils down either with the cable end over the loop or under the loop as the cable wants to lay.

How to set up the system for a Wenner profiling field survey

A complete field system consists of:

1. The Sting instrument console
2. The Swift interface box
3. Sting to Swift communication cable
4. Swift to Sting A, B, M, N cable
5. Swift to computer cable
6. A number of Swift-cables with addressable smart electrodes
7. Stainless steel electrode stakes

You will also need a Windows type computer with the Administrator software (see section 6.1) installed (The Administrator software is delivered on a CD with your Swift system).

2.4.1.2 Field preparation

Make the field preparation described in section 2.2.3.2 and connect the instrument as described in. Connect the computer to the Swift box using the download cable. Attach the cable to the RS232 port on the computer and the connector marked "PC COM." on the Swift box.

2.4.1.3 To set-up the Sting/Swift/computer for measurement

- Turn on the computer, the Sting and the Swift.
- Start the Administrator program and go to the "Swift measure" module (see section 6.1.5).
- Set the PC/Sting switch on the interface box in the PC-position.
- Go to menu 1 (M1) on the Sting. Use F1 to set the Sting in RESISTANCE mode. Use F3 to set the current, we recommend that you use 200 ma. The instrument will automatically switch down the current if it can not send out required current.
- Go to menu 2 (M2) and use F1 to set number of cycles. We recommend that you use 2 cycles. Use F2 to set accuracy, 2% is probably a good setting.
- Go to menu 5 by pressing the 5-key. Make sure that under Hardware settings Remote is ON and SAS300 mode is OFF. Log time interval should be OFF.
- Go to menu 6 by pressing the 6-key.
- Press F3 to check that the switch addresses Start=xx and End=yy are entered correctly (xx is lowest smart electrode address used and yy is highest smart electrode address used). REPEAT is a useful function which will automatically repeat the measurement if the Error is not within the limit specified on menu 2, F2. Repeat=1 will get the most readings within the limit without delaying the measurement too much. Press MEN to return to menu 6.
- Press F1 and use the + key to toggle the Swift mode to Ext-PC mode, press MEN to return to menu 6.
- Go to menu 8 (M8) and press F3, set F1 Separate MN: to OFF if the automatic electrodes are used in single mode operation (see page 53, single mode/dual mode) and to ON if the automatic electrodes are used in dual mode operation.
- Go to menu 8 (M8) and press F3. Set F2 to Res or Res/IP (resistivity survey or resistivity/IP combination survey)

The instrument is now set to automatically measure a profile. However, before starting the measurement go to menu 7, by pressing the 7-key and run the contact resistance test (M7/F1) prior to running the survey (see section 4.1.7.1) for more information on this test).

Before continuing remember to reset the Sting in the Swift Ext PC mode by going to menu 6, F1 (M6/F1/MEN) and reset the Sting/PC switch on the interface box to the PC position.

After the contact resistance test is run, it is time to start the survey.

On the computer click on the “Load command file” button and select the command file. Then click on the “Select result file” button and specify where the result shall be stored. Then click the “Start” button.

This will start the measurement sequence.

During measurement you will see the measurement progress on the Sting display as well as on the computer display.

The data will end up as an ASCII-file on the computer hard drive. Below follows an example of such a file:

```
Command file: WENNER10.CMD
Data file:    TEST.DAT
```

```
;Equipment= Advanced Geosciences, Inc STING R1 / SWIFT
;Start of Swift-PC measurement. Swift s/w version: 1.3
Mode,Date,Time,Resistance,Error,Current,A,Ax,Ay,B,Bx,By,M,Mx,My,N,Nx,Ny,Rapp
RESIST ,96-09-15,19:47:39, 1.9914e+01, 0, 5,1, 0, 0, 4, 30, 0, 2, 10, 0, 3, 20, 0, 1251.234
RESIST ,96-09-15,19:47:45, 1.9913e+01, 0, 5,2, 10, 0, 5, 40, 0, 3, 20, 0, 4, 30, 0, 1251.171
RESIST ,96-09-15,19:47:52, 1.9913e+01, 0, 5,3, 20, 0, 6, 50, 0, 4, 30, 0, 5, 40, 0, 1251.171
RESIST ,96-09-15,19:47:58, 1.9912e+01, 0, 5,4, 30, 0, 7, 60, 0, 5, 40, 0, 6, 50, 0, 1251.108
RESIST ,96-09-15,19:48:05, 1.9913e+01, 0, 5,5, 40, 0, 8, 70, 0, 6, 50, 0, 7, 60, 0, 1251.171
RESIST ,96-09-15,19:48:12, 1.9912e+01, 0, 5,6, 50, 0, 9, 80, 0, 7, 60, 0, 8, 70, 0, 1251.108
```

First line	name of command file used
Second line	name of file where data is stored
3 rd line	empty line
4-6 th line	general information about equipment/software used
From line 7	measured data
First field	indicates that this is a resistance measurement (could also be an SP measurement)
2 nd field	indicates the date of measurement
3 rd field	indicates time of measurement
4 th field	is the measurement V/I
5 th field	is the standard deviation in tenths of %
6 th field	is the current (I) used
7 th field	A-electrode address

8 th field	X-coordinate for the A-electrode
9 th field	Y-coordinate for the A-electrode
10 th field	B-electrode address
11 th field	X-coordinate for the B-electrode
12 th field	Y-coordinate for the B-electrode
13 th field	M-electrode address
14 th field	X-coordinate for the M-electrode
15 th field	Y-coordinate for the M-electrode
16 th field	N-electrode address
17 th field	X-coordinate for the N-electrode
18 th field	Y-coordinate for the N-electrode
19 th field	Apparent resistivity

Currently there is no support for computer controlled IP measurements.

2.5 Downloading the data to a computer

Use the “Down load” module of the Administrator software (see section 6.1.9) to download data from the Sting memory to a Windows type computer.

2.5.1 Downloading

Connect the supplied communication cable between the Sting front panel connector and a serial port on your computer. Start the Administrator software, delivered with the Sting and select the “Sting down load” module. Click on the “Start Sting down load” button and select a file where to store the data. On the Sting press F2 on menu 3 to select “Send data” and then press F1 to start the data transmission. When the complete data set is transferred, the screen on the Sting is changed back to menu 3.

For file format, see section 4.2.2.

3. Your Sting R1, memory earth resistivity meter

The Sting R1 is a rugged, weatherproof instrument for earth resistivity field work. The Sting R1 IP model also has induced polarization capability built in. The instruments are powered by a clip-on battery pack secured to the bottom of the instrument enclosure. With the optional automatic multi-electrode system, the Swift, automatic measurement of any array type can be performed.

3.1 Getting to know the Sting

The Sting R1 is a memory earth resistivity instrument. The controls, the display and the connectors are all located on the front panel (for reference see figure 6).

1. I/O (ON/OFF)
2. Night light, used to illuminate the display during poor light conditions.
3. Keyboard with 20 tactile keys; numerical entry keys, menu key, function keys, measure key and contrast adjustment key.
4. The liquid crystal display (LCD) window with four text lines of 20 characters each.
5. Positive and negative current terminals (A and B). For use with banana connectors or stripped wire.
6. Positive and negative potential terminals (M and N). For use with banana connectors or stripped wire.
7. Connector used for data dump, external power and connection of the Swift automatic multi-electrode system.

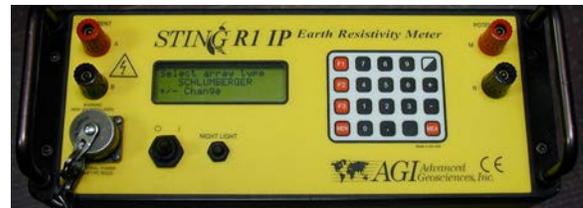


Figure 9 The instrument front panel.

The Sting is powered by a clip-on battery pack attached to the bottom of the instrument. The top face of the battery pack has the following items:

1. Four screw heads, one in each corner for guiding the battery to the correct position when fastened to the instrument.
2. Battery charger connector.
3. Battery pole terminal plates. The one closest to the charger connector is positive.

3.1.1 ON/OFF

When the battery pack is attached, turn the instrument on, by turning the I/O (On/Off) switch to the I (On) position. Text similar to this, will be displayed for a short moment in the display window, depending on how the instrument was set when it was previously turned off.

```
*** STING R1 ***  
SCHLUMBERGER 16.4h  
Checking battery  
Push MEN!
```

After a short moment the text will be replaced by a new message. At the top of screen, date and time is displayed. Schlumberger means that the instrument is set for a Schlumberger measurement with all settings as they were when the instrument was turned off. To the right of the array, the total time in hours, that the instrument has been on, is displayed. Battery status is displayed on the third line.

```
20000205 19:46:32  
SCHLUMBERGER 16.4h  
Battery= 12.57 V  
Push MEN!
```

The bottom line indicates that by pressing the MEN key you will get into the menu system.

The instrument can be turned off at any time and will keep its current settings until it is turned on the next time. Data in the memory will not be lost when the instrument is shut off or when removing the battery pack to be charged.

The instrument can be turned off at any time and will keep its current settings until it is turned on the next time. Data in the memory will not be lost when the instrument is shut off or when removing the battery pack to be charged.

Note that the instrument, in order to save battery, will automatically shut off if no keyboard action has been detected for 5 minutes. The automatic shut off function will cause no loss of data or instrument setting.

3.1.2 LCD contrast

The contrast of the LCD display can be adjusted by repeatedly pressing the contrast key, placed in the top right hand corner of the keyboard.

3.1.3 Charging the battery

To charge the battery, turn off the power and release the two battery fasteners, one on each side of the instrument enclosure. Lift off the instrument from the battery pack. Connect the charger output cable to the connector in top left corner of the battery pack (data in the memory is not lost when the battery pack is removed). Check to see that the

battery charger is set for the correct main voltage (110 V or 220 V). Connect the standard battery charger to the main outlet. A fully discharged battery is normally charged to full capacity within 1.5 hours.

The red light on the charger means that the battery charger is in the fast charge mode. When the red light goes off and the green light comes on, approximately 85% of the battery is charged. The battery charger is then in the float mode and can be left for a long time without risk for overcharging the battery.

To attach the battery pack to the instrument, place the instrument enclosure on top of the battery pack, ensuring that the guiding screw heads line the instrument up correctly. The battery pack should be oriented so that the charger connector is to the left when the Sting front panel text is readable to you.

3.1.4 Using external power

The Sting can be powered by an external battery connected to the front panel connector by using the optional "external power cable." When an external battery is connected, Sting will automatically use the power from the external battery. However, if external power is plugged in while the Sting is already on, the circuitry does not read the external source, but continues to draw from the internal battery, therefore always turn the Sting off when connecting to an external battery.

Note that when using the Sting R1 IP the high power transmitter mode is only achieved if an external battery is used.

The Sting battery pack should not be disconnected when an external battery is used, since the connector pins in the bottom of the Sting are then connected to the positive terminal of the external battery and therefore may cause erroneous readings.

Note that the external battery needs to be well insulated from the ground. It is not a good practice to use a vehicle battery still left in the vehicle.

No damage will happen to the Sting if wrong battery polarity is accidentally connected. However, the Sting will in such case draw power from the internal (clip-on) battery and not from the external battery.

3.1.5 Internal data memory

The instrument will automatically store measured data together with all relevant information in the internal memory. The memory capacity is 3000 data points. When the

memory is filled, the instrument will display a warning text and no more data can be stored. Measurements can however be continued, but will only be displayed on the screen without being stored.

Each data point is automatically assigned a consecutive number and can at any time be reviewed (see section 4.1.3.1) on screen.

All measured data, completed with at least one measurement cycle, will be stored in the internal memory. If, however, the measurement is interrupted by pressing "any key" before one measurement cycle is ready, that measurement will not be stored in the memory.

Data in the memory are not lost when the instrument is shut off or when the battery pack is removed for charging. To erase the data memory see section 4.1.3.3 .

3.1.6 Serial number

The instrument serial number is placed on a plate on the left hand side of the front panel. The serial number is also stored in the internal instrument memory and is displayed when the . (dot) key is held down when the instrument is turned on.

3.1.7 Software version

It is the policy of Advanced Geosciences, Inc. to continuously improve its instruments. The current instrument software version number is stored in the internal instrument memory and is displayed when the . (dot) key is held down when the instrument is turned on. For upgrading of your current software version, contact Advanced Geosciences, Inc. or your local distributor.

4. Menu system and operational settings

4.1 The menu system

Press the **MENU** key repeatedly and you will notice how the menu 1, menu 2, menu 3, menu 4, menu 1.....etc are cycled on the display. Go back to menu 1 by pressing **MENU**. Another way to get to the menu is to just press the number for that menu. Try going to menu 4 by pressing **4** and then back to menu 1 by pressing **1**. Menus 5, 6, 7, 8 and 9 are all reserved for settings which are not changed frequently. Try pressing **5** to get to menu 5. Try also pressing **6**, **7**, **8** and **9**.

4.1.1 Menu 1

To set survey mode (electrode configuration), electrode spacing etc. press **MENU** until you get menu 1 (M1) on the display.

```
M1: SURVEY DATA
F1 Array type
F2 Array dimensions
F3 Set max current
```

4.1.1.1 Electrode configuration

Press F1 on menu 1 to set the electrode array type. Plus and minus key on the keyboard will scroll you through the different measurement modes. The measurement modes which are currently being supported are: Schlumberger, Wenner, dipole-dipole, pole-dipole, pole-pole, azimuthal (Wenner), mise-a-la-masse, self potential (SP) gradient, SP absolute resistance and User mode measurements. When required measurement mode is displayed, press **MENU** to get back to menu 1.

4.1.1.2 Electrode distances

Press F2 on menu 1 to key in the electrode distances. Note that for each mode the old settings are given and can be overridden. Key in the new distance and press F3 to enter each distance. The instrument will automatically go back to menu 1, once all the appropriate distances have been entered. Press F1 (OLD) if you want to recall the previous distance once you have started entering the new distance. Use F2 (BSP) if you want to back-space and change a typo error when entering the distance. Make sure you have selected correct unit, meter or feet (see section 4.1.2.3), before entering electrode distances.

4.1.1.2.1 Enter Schlumberger electrode distances

Enter Schlumberger configuration on menu 1/F1. Press F2 on menu 1 to enter electrode distances. The previously used AB/2 distance (half the distance between the current electrodes) is now displayed. Type the new distance and enter by pressing F3. The previously used MN/2 distance (half the distance between the potential electrodes) will now be displayed. If you like to keep the old MN/2 value just press F3. If you like to enter a new MN/2 distance just type the new value and press enter. The new values will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.2 Enter Wenner electrode distances

Enter Wenner configuration on menu 1/F1. Press F2 on menu 1 to enter electrode spacing. The previously used Wenner distance a is now displayed. Type the new distance and enter by pressing F3. The new value will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.3 Enter dipole-dipole electrode distances

Enter the dipole-dipole configuration on menu 1/F1. Press F2 on menu 1 to enter electrode distances. The previously used dipole size a is now displayed. Most likely the same dipole size is kept, if so, press F3 to enter the old size. The distance between the two closest electrodes in the two dipoles is called na , n is therefore the number of dipoles which fits between the two dipoles. The old n -value is now displayed. Type the new n and enter by pressing F3. Note that n does not have to be an integer. At Apos= (A electrode position) enter the X-coordinate for the A-electrode followed by F3. The new values will be briefly displayed on the screen before the screen reverts to menu 1.

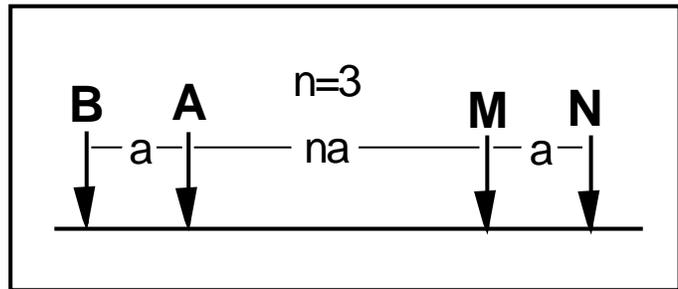


Figure 10 Dipole-dipole configuration

4.1.1.2.4 Enter pole-dipole electrode distances

Enter the pole-dipole configuration on menu 1/F1. Press F2 on menu 1 to enter electrode distances. The previously used dipole size a is now displayed. Most likely the same dipole

size is kept, if so, press F3 to enter the old size. The distance between the closest current electrode and the closest dipole electrode is called **na**, **n** is therefore the number of dipoles which fits between these two electrodes. The old **n**-value is now displayed. Type the new **n** and enter by pressing F3. Note that **n** does not have to be an integer. The distance **AB** between the two current electrodes is now displayed. Most likely this value is kept the same, if so press F3 to enter. The new values will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.5 Enter pole-pole electrode distances

Enter the pole-pole configuration on menu 1/F1. Press F2 on menu 1 to enter electrode distances. The electrodes are set up in the following order, **BAMN**. The previously used distance **a** (**AM**) is first displayed. Key in the new **a** value and enter by pressing F3. The old distance between the **A** and the **N** electrode is now automatically displayed. In most cases this value stays the same, if so press F3 to enter. If there is a new **AN**, type the new value and enter by pressing F3. The distance **AB** between the two current electrodes is now displayed. Most likely this value also stays the same. If so press F3 to enter. The new values will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.6 Enter azimuthal electrode distances

Enter azimuthal configuration on menu 1/F1. Press F2 on menu 1 to enter electrode spacing. The previously used azimuth (angle between the direction of the Wenner spread and north) is now displayed. Enter new azimuth or just press F3 enter to keep the old value. The previously used Wenner distance **a** is now displayed. Type the new distance and enter by pressing F3. The new value will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.7 Enter mise-a-la-masse electrode distances

Enter the mise-a-la-masse configuration on menu 1/F1. Press F2 on menu 1 to enter electrode coordinate. The previously used X-coordinate for the probing potential electrode is first displayed. Press F3 to enter if the X-coordinate stays the same. Type in the new X-coordinate followed by F3 if there is a new X-value. The previously used Y-coordinate for the probing potential electrode is now displayed. Press F3 to enter if the Y-coordinate stays the same. Type in the new Y-coordinate followed by F3 if there is a new Y-value. The new coordinates will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.8 Enter SP gradient electrode distances

Enter the SP gradient configuration on menu 1/F1. Press F2 on menu 1 to enter electrode spacing. The previously used spacing between the two probing electrodes is now displayed. Enter a new spacing and press F3 to change the spacing. The previously used X-coordinate for the measurement point is first displayed. Press F3 to enter if the X-coordinate stays the same. Type in the new X-coordinate followed by F3 if there is a new X-value. The previously used Y-coordinate for the measurement point is now displayed. Press F3 to enter if the Y-coordinate stays the same. Type in the new Y-coordinate followed by F3 if there is a new Y-value. The new coordinates will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.9 SP absolute electrode distances

The previously used X-coordinate for the probing SP-electrode is first displayed. Press F3 to enter if the X-coordinate stays the same. Type in the new X-coordinate followed by F3 if there is a new X-value. The previously used Y-coordinate for the probing SP-electrode is now displayed. Press F3 to enter if the Y-coordinate stays the same. Type in the new Y-coordinate followed by F3 if there is a new Y-value. The new coordinates will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.2.10 User mode

Select User mode on menu 1/F1. Note that User Mode will only be displayed if any command files are loaded to the Sting RAM memory. For information on how to load command files to the Sting see section 6.1.8.

Press **F2** on menu 1 and use the **+** or **-** key to scroll among the User Command Files available. Press **F3** to select a file. Key in the x-coordinate and the y-coordinate for the first electrode in the layout and press **F3** to enter. Press **F3** for enter when Next=1 is displayed if the automatic measurement shall start on command line number 1.

4.1.1.2.11 Resistance electrode distances

Press **F2** on menu 1 to enter the coordinates for the measurement station. The previously used X-coordinate for the measurement point is first displayed. Press F3 to enter if the X-coordinate stays the same. Type in the new X-coordinate followed by F3 if there is a new X-value. The previously used Y-coordinate for the measurement point is now displayed. Press F3 to enter if the Y-coordinate stays the same. Type in the new Y-coordinate

followed by F3 if there is a new Y-value. The new coordinates will be briefly displayed on the screen before the screen reverts to menu 1.

4.1.1.3 Output current

Press F3 on menu 1 to set the required current. Press "+" or "-" to cycle through the possible current settings (1, 2, 5, 10, 20, 50, 100, 200 and 500 mA). When required current is displayed, press **MENU** to return to menu 1. Note that if Sting can not send out the required current it will automatically reduce the current to a suitable level.

4.1.2 Menu 2

Press **MENU** or "2" to get to menu 2. The display will now look like this.

```
M2: INSTRUMENT SETUP
F1 Set max cycles
F2 Set accuracy
F3 General settings
```

4.1.2.1 Cycles

Press F1 on menu 2 to set the maximum number of cycles you want the instrument to repeat and average for each station. Use "+" and "-" to increase or decrease the number of cycles you want. Note that the instrument will interrupt the measurement cycles if the error σ is below the value specified on menu 2, F2. When required cycle number is displayed, press **MENU** to get back to menu 2. Maximum number of cycles possible is 300.

4.1.2.2 Accuracy

Press F2 on menu 2 to set the accuracy threshold or to turn this function off. Use the + and - key to set the threshold value. The threshold works so that the instrument will stop cycling and present the final result if the desired threshold setting is achieved during measurement before maximum number of cycles is reached. When required accuracy is displayed, press **MENU** to get back to menu 2.

4.1.2.3 Measuring units, cycle time and voltage mode

Press F3 on menu 2 to set measuring units (meter/ Ω m or feet/ Ω feet), measuring time for each cycle (1.2, 3.6, 7.2 or 14.4 seconds) or to toggle between low voltage mode (maximum 200 V) and high voltage mode (maximum 400 V). Press **MENU** to get back to menu 2.

4.1.3 Menu 3

Press **MENU** or "3" to get to menu 3. The display will now show:

```
M3: DATA EXCHANGE
F1  View data points
F2  Send data
F3  Erase memory
```

4.1.3.1 View data points

Press F1 on menu 3 to view data points in the instrument memory. The display will now show:

```
View readings
F1 View last
+/- x1 view step
F2/F3 x10 view step
```

Press F1 to display the last point in the memory on the screen. Press "+" or "-" to scroll through the different readings one step at a time. Press "F2" or "F3" to scroll up or down through the different readings ten steps at a time.

Any of the numerical keys 0-8 will act as quick keys and bring you to the corresponding hundreds. For example key #3 will bring up record #300 on the display. Press **MENU** to get back to menu 3.

4.1.3.2 Send data

Connect the supplied communication cable between the Sting front panel connector and a serial port on your computer. Start the "Down load" module of the Administrator software, delivered with the Sting. Click on the "Start Sting Down Load" button and enter a file name and directory for the new data file. On the Sting press F2 on menu 3 and then F1 to send data to the computer. When the complete data set is transferred, the screen on the Sting is changed back to menu 3. For further information on data downloading, see section 6.1.9.

4.1.3.3 Erase memory

Press F3 on menu 3 to get to the "ERASE MEMORY menu." The screen will look like this:

```
ERASE MEMORY
F1 Erase data memory
F2 Erase USER RAM
F3 Erase last point
```

Press F1 to erase the data memory, then press "." to confirm that the memory really shall be erased.

Press F2 followed by the "." (dot) key to erase the USER MODE command files in memory. Note that the command files can only be erased if the data memory has been erased. If the data memory is not empty when an attempt is made to erase the USER MODE command files (USER RAM) the following message is issued: "Error: data in RAM!"

Press F3 to erase the last point in the memory, then press "." to confirm that the last point really shall be deleted from the memory. Press MEN to return to menu 3.

4.1.4 Menu 4

Press **MENU** or "4" to get to menu 4. The display will now show:

```
M4: UTILITIES
F1 Set time/date
F2 Check battery
F3 USER prog admin
```

4.1.4.1 Set time/date

To set the internal time and date, press F1 on menu 4. F2 is used to change between time and date input mode.

Enter date as: YYMMDD

Enter time as: HHMMSS Use military time, i.e. 2PM is entered as 14 etc.

```
Now: 930714 11:51:35
New time =
F2 Time/date
F3: Enter
```

Press F3 to enter the new time or date.

4.1.4.2 Check battery

To check battery voltage press F2 when on the menu 4.

4.1.4.3 User program administration

Select F3 on menu 4 to load user programmed command files into the Sting RAM memory. Before any user programmed command files can be downloaded to the Sting RAM memory, the data memory has to be cleared (see section 4.1.3.3 to learn how to clear the data memory).

To upload a user programmed command file from a computer to the Sting see section 6.1.8.

4.1.5 Menu 5

Press "5" to get to menu 5. Press F1 for hardware settings or F2 for Log time interval.

```
M5: Special setup.  
F1 Hardware settings  
F2 Log time interval
```

4.1.5.1 Hardware settings

4.1.5.1.1 Remote measurement

Press F1 (M5/F1/F1) to toggle Remote measurement On and Off. Remote measurement is triggered by sending a 0-1-0 pulse (equal to -5V - +5V - -5V) to pin H of the RS232 connector on the Sting front panel. If pin F and H are interconnected in the cable (standard from early 1996) then a trig can be effected from the PC by sending a series of about 10 NUL characters (chr(0)) to Sting using the COM port at 1200 baud.

4.1.5.2 Log time interval

Press F2 on menu 5 to set time increment in seconds to start the Sting to take a reading. This function is used when the Sting is used to monitor a set of electrodes over a certain time period or when the Sting is used for a base station during SP (self potential) measurement. Measurement cycle starts at the given interval. Set 0 sec. followed by F3 (Enter) to turn this function off.

When the memory is full, the instrument will display the following message "Error: Memory full". The measurements continue, but new values are not stored in memory.

4.1.6 Menu 6

Press "6" to get to menu 6, the "Swift settings" menu. Swift is an automatic multi-electrode system, which can perform automatic measurements with up to 254 electrodes. The Sting is pre-programmed to perform automatic dipole-dipole surveys. Any other array can be programmed by the user to be automatically measured using either the USER MODE function of the Sting (see section 2.3 **User mode** and section 4.1.4.3 **User program administration**) or running a Windows type computer connected to the Sting/Swift system (see section 6.1.5).

The advantage of the User Mode function is that a PC is not necessarily in the field. All data are stored in the Sting internal data memory. The advantage of the computer

controlled function is that data storage is virtually unlimited since data in this mode is stored on the computer internal hard drive.

The User Mode command files or the computer command files are easily programmed by the operator to control the complete measurement sequence for any array (see sections 6.3, 6.1.7 and 6.1.6)

4.1.6.1 Swift mode

Press F1 to set the Swift mode. Use the + key to toggle between Off, Auto and Ext-PC. Press **MEN** to return to menu 6. Note that this function may appear “stuck” on Auto if USER MODE is active on menu 1/F1.

```
M6: SWIFT settings
F1 Swift mode
F2 Setup array
F3 Swift hardware
```

- The Swift Off mode is used when measurements are performed in manual mode with regular cables and the Swift system is not used.
- The Swift Auto mode is used when automatic dipole-dipole surveys are to be performed using the Swift system or when the USER MODE is in effect (user programmed command files are used to make automatic measurements).
- The Ext-PC mode is used when an external PC is connected to the Swift box and the computer is used to run operator programmed measurement sequences.

4.1.6.2 Setup a Swift dipole-dipole array

Go to menu 8 and press F1 for Dipole-dipole survey. Enter the appropriate electrode distance. This will set up the instrument default settings for an automatic dipole-dipole measurement. Electrode placements are according to the following convention: B - A - - - - -M - N. Note that the default setting are reasonably good for most situations. The following default values are set when the electrode spacing is entered at menu 8/F1 (see figure 13).

Linestart	Give the X-coordinate for the first (lowest number) electrode in the lay-out. This is the location of the B-electrode at the very first measurement. Default value is 0.000. Use the F3 key to enter your selection.
Elect sep	Distance between electrodes. Enter your electrode spacing and press F3.
Max dipol	The smallest value a dipole can have is the electrode separation. In order to "see deeper," the dipole size can be increased to 2, 3 or more electrode spacings. Default value is 1.

- Nxt dipol The dipole size used when starting the measurement, usually 1 (default value).
- Max sep n This is the required maximum distance between the A and M electrodes, which will be used. This value, expressed in number of dipoles, is selected depending on required depth penetration, general noise level at the site, electrical resistivity ground conditions etc. Default value is n=6.
- Next sep n Sting first measures along the profile with n=1 then n=2 then n=3 etc.until n=Max sep n. By using Next n the user can start at any n. Default value is n=1.
- Direction The dipole-dipole survey can be performed in two directions, forward and reverse. Forward is measured from lower electrode addresses towards higher, reverse is measured from higher addresses towards lower addresses. Change direction with the plus and minus key. Default direction is forward.

Forward	B	A	M	N															
Reverse	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	N	M	A	B
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	

- Nxt B-loc Next B-location. This value is used if one wishes to continue an interrupted measurement sequence from a special B location. When starting a survey, First loc and Nxt B-loc shall always be the same. Default value is 0.000.

Note that it is not recommended to change the default values as unexpected result easily will occur

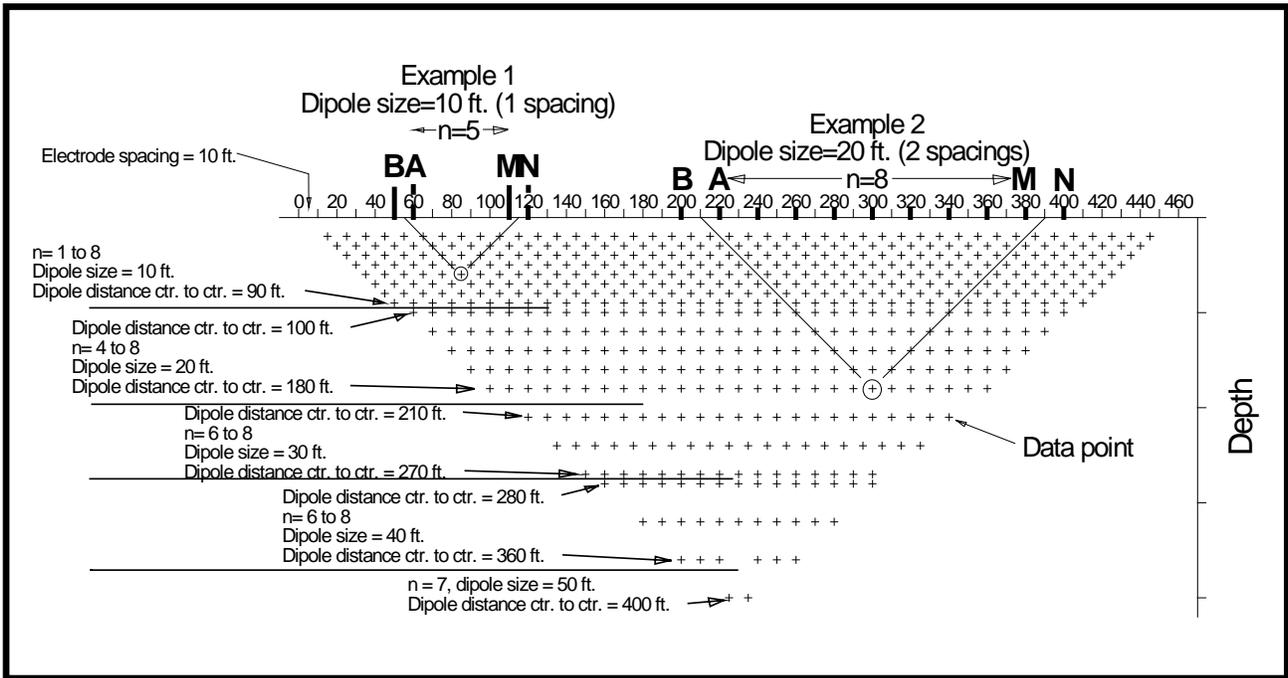


Figure 11 Data configuration for a complete dipole-dipole data set automatically recorded using 47 smart electrodes. Note that the measurement process occurs form left to right, layer by layer form the top; not from top at an angle towards the bottom as is the case in most manual arrays.

4.1.6.3 Swift hardware

Press F3 on menu 6 to enter the first (F1) and last (F2) electrode addresses on the Swift cable used. Sting will remember these addresses even after power is off or battery pack is removed. Therefore, when the same Swift cable is used with the Sting, it is only necessary to enter these addresses once.

Press F3 on menu 6 and then ± to set Max repeat. This function has been shown to be valuable for filtering out sporadic noise "spikes." This is how the function works. If the standard deviation is larger than the selected accuracy (M2/F2) after all cycles have been performed, then the repeat function will reject this value and try again. Sting will attempt to collect a value with standard deviation within a selected range for as many times as selected by the repeat function.

If a measurement with a standard deviation lower or equal to the specified value has not been achieved by the last repeat, the last measurement will be stored in the memory.

During automatic measurement, error codes may be issued by the instrument. By pressing the F1 key the “Stop on error “ function can be turned ON or OFF. If the “Stop on error” is turned ON the instrument will stop the automatic measurement and wait for the operator to start the survey again by pressing the **MEA** key.

4.1.7 Menu 7

Press "7" to get to menu 7, the "Swift tests" menu. Perform the contact resistance test (F1) prior to running an automatic Swift survey. Tests F2 and F3 are for testing the Swift cable. The Sting can be in any Swift mode, Off, Auto or Ext-PC mode (menu 6/F1) when running any of the Swift tests.

```
M7: SWIFT tests
F1 Contact resist.
F2 Cable resist.
F3 Switch relays
```

4.1.7.1 Contact resistance test

This test measures the contact and ground resistance along the complete Swift cable layout. When the test is started, the instrument will send out a current between the first two electrodes and at the same time measure the voltage. Therefore, a value comprising of the contact resistance between the first stake and the ground, the resistance in the ground and the contact resistance between the ground and the second stake will be measured. The value is displayed on the instrument display, then the test will continue between electrodes 2 and 3 and so on. If the electrode spacing is equidistant along the profile, one can expect similar ground/contact resistance along the profile.

Use this test to measure the contact resistance along the profile. If any of the electrodes should show a significantly larger value, check that electrode to make sure it makes good contact to the ground and that the switch makes proper contact with the electrode stake. If the contact resistance is high because of local soil conditions, it usually helps to push the stake deeper into the ground and/or to pour some salt water on the ground where the electrode is planted, see section 7.6.3 Difficulty to send out required current on page 85.

The test may stop displaying the INOVL, TXOVL or HVOVL error message. INOVL stands for “input over-load” and TXOVL stands for “transmitter over-load”. Both these errors are likely to have the same cause. If the electrode stake is poorly planted in the ground or if there is dirt or corrosion where the electrode switch contacts the stake, the slightest

vibration may stop the measurement displaying INOVL or TXOVL. The remedy is to plant that stake good in the ground and to make sure that the contact surfaces are clean. Note that very minute vibrations may cause the instrument to display the error code. It may very well seem that the electrodes are planted well in the ground even though they need improvement.

The HVOVL stands for “high voltage over-load” and is issued when current cannot be sent out. Typically this will happen if one of the electrode switches are not rubber banded to the stake and is just laying on the ground or if the ABMN cable has not been plugged in correctly.

If the test stopped at a certain electrode and after the problem has been solved, the test can be restarted from that point by pressing the **F1** key. Pressing **F2** will restart the test, starting after the problem electrode.

From Sting software version 2.5.5 the result of the contact resistance test, as a data quality control, is stored in the internal data memory.

It is important to run this test (M7/F1) before starting the actual measurement. This way poorly connected/planted electrodes can be spotted prior to start. During the actual survey, the Sting/Swift will not stop for error codes (unless M6/F3/F3 is set to OFF), instead it will simply skip those points. Therefore it is important to check all electrodes prior to starting. By not stopping on an error, the survey goes much quicker and the few points left out in most cases do not make too much difference to the final result.

4.1.7.2 Swift cable resistance

This test is performed to check that a voltage difference signal between two different smart electrodes can be measured by the Sting. A current is sent through a 1 Ω resistor in the Swift box. At the same time, the resulting voltage over the resistor is measured by four leads in the Swift cable utilising two smart electrodes.

Note that this test is to be performed indoors on a test bench, do not perform this test when the cables are set up in the field since the test will then be totally misleading. Before testing the Swift cable, place it on a dry non-conductive surface in a way so that the smart electrodes do not touch each other. Before testing the Swift cable, connect the Sting and the Swift box as described in section 2.2.3.3.

Go to menu 7 and press **F2** then **F1** to start the test. The instrument will cycle through all the smart electrodes displaying the resistance value in Ω in the lower right hand corner of the Sting display. The test is finished when the instrument stops testing and displays “Done.” Press the **MEN** key to return to menu 7.

In case the test stops displaying the word ERROR, the smart electrode needs to be repaired or replaced. Note down the address for the erroneous smart electrode, displayed on the Sting display. Contact your authorized AGI distributor or AGI directly for further information.

The test can be continued after stopping with the ERROR message by pressing **F1** (restart including the faulty smart electrode, i.e re-test the smart electrode) or **F2** restart at the following smart electrode (excluding the faulty smart electrode).

4.1.7.3 Swift switch relays

This test is performed to check that the Swift cable is continuous and that the relays in the smart electrodes are working properly. A test current is sent through each lead in the Swift cable to make sure that there is continuity, proper functioning of the relays, no leakage between leads and to test the relays for “sticking.”

Note that this test can be performed when the instrument and cables are set up in the field.

Connect the Sting and the Swift box as described in section 2.2.3.3. This test can be performed indoors on a test bench or set up in the field.

Go to menu 7 and press F3 then F1 to start the test. The instrument will cycle through all the smart electrodes testing continuity and relays. The test is finished when the instrument stops testing and displays “Done.” Press the **MEN** key to return to menu 7.

In case the test stops displaying the word ERROR, the smart electrode needs to be repaired or replaced. Note down the address for the erroneous smart electrode, displayed on the Sting display. Contact your authorized AGI distributor or AGI directly for further information.

The test can be continued after stopping with the ERROR message by pressing **F1** (restart including the faulty smart electrode, i.e re-test the smart electrode) or **F2** restart at the following smart electrode (excluding the faulty smart electrode).

4.1.8 Menu 8

Press "8" to get to menu 8, the "Swift" menu.

Note that when using F1 Dipole-dipole or F2 Usermode, the instrument default settings will automatically be set. **Therefore if some setting needs to be changed, it is important to change it every time after M8/F1 or M8/F2 has been used.**

```
M8: SWIFT
F1 Dipole-Dipole
F2 Usermode Default
F3 Set Measure Mode
```

The default values are as follows:

M1/F3 = 200 mAmp
M2/F1= 2 cycles
M2/F2= 2%
M2/F3/F1= meter
M2/F3/F2= 3.6 seconds
M2/F3/F3= 400 Volt
M5/F1= Remote MEA = OFF, SAS300 mode = OFF
M5/F2= OFF
M6/F1= Auto
M6/F2= For default values see section 4.1.6.2.
M6/F3/F3/ Stop on error = OFF, Max repeat = 1
M8/F3/F1 Separate MN: OFF
M8/F3/F2 Mode: Res

4.1.8.1 Built in automatic dipole-dipole survey

Use this option to quickly set the Sting/Swift system for the built in standard dipole-dipole survey or a user programmed command file. When pressing F1 the text Elect sep= X.XXX m will appear. Enter the electrode spacing to be used and press F3. All parameters for a standard dipole-dipole survey with the selected electrode spacing are now set in the Sting.

4.1.8.2 Run a survey with a user programmed command file

When pressing F2 on menu 8, the text Current = name of command file (if any) will appear. Use the + or – key to scroll through the available command files. When the appropriate command file appear, press F3 to enter this choice. Now the text Xloc= x.xxx m will appear. Enter, by pressing F3, the x-coordinate for the first electrode stake in your electrode array. In most cases this value is 0.000 when a new line is started. Now the text

Yloc= x.xxx m will appear. Enter, by pressing F3, the y-coordinate for the first electrode stake.

4.1.8.3 Set measure mode

When pressing F3 on menu 8, two new options for measurement mode appear.

4.1.8.3.1 Separate potential electrode measurement

When pressing the F1 key, the dual mode electrodes can be set to measure the potential separately through the small take-out on the dual mode electrode (dual mode operation, set Separate MN: ON) or to measure potential through the large take-out (same as the current take out) on the dual mode electrode (single mode operation, set Separate MN: OFF).

Separate potential measurement may be used if non-polarisable electrodes (porous pots) has been specified for an IP survey. In such case the non-polarisable electrodes can be placed at a small distance and offset to the electrodes stakes connected to the small take-out of the dual mode electrode.



Figure 12 Electrode in dual mode configuration.

4.1.8.3.2 Measurement mode

By pressing the F2 key, you can select resistivity or resistivity/IP mode.

4.2 Data formats

Recorded data can be downloaded to an MS-DOS PC compatible type computer via the supplied communication cable. For instructions on how to download data to a computer see section 6.1.9.

```
Measure Mode Select
F1 Separate MN:OFF
F2 Mode: RES
```

4.2.1 Digital communication parameters

The Sting uses the following fixed communication parameters:

Baud rate: 4800
 Data bits: 8
 Parity: None
 Stop bits: 1

4.2.2 Data file formats

The downloaded file is a comma delimited ASCII file. The first row contains information about the instrument used. The second row informs of which software version is installed in the instrument, the survey period of the data in the file and how many records the file contains. The third row informs whether the unit used was meter or feet at the time of downloading. The following rows contain one data point each and the last row contains the word END to indicate that the complete data file has been transmitted. Below is an example of a short downloaded Sting file:

```
Advanced Geosciences, Inc. STING R1 Resistivity meter. S/N: S57053141
Software version: 2.5.4 betaC Survey period: 960919-960919 Records: 11
meter
 1,RESIST ,96-09-19,11:49:14, 1.9917e+01, 0, 5, 1.0000e+01, 2.0000e+01
 2,SCHLUMB,96-09-19,11:49:33, 1.9915e+01, 0, 5, 2.3452e+04, 3.0000e-01, 1.5000e+01
 3,WENNER ,96-09-19,11:50:01, 1.9915e+01, 0, 5, 6.2566e+02, 5.0000e+00
 4,DIP-DIP,96-09-19,11:50:38, 1.9914e+01, 0, 5, 1.8769e+04, 5.0000e+00, 1.5000e+01,
1.2500e+01
 5,POL-DIP,96-09-19,11:51:29, 1.9913e+01, 0, 5, 3.0155e+03, 2.0000e+00, 6.0000e+00,
1.0000e+02
 6,POL-POL,96-09-19,11:52:06, 1.9913e+01, 0, 5, 2.0932e+03, 2.1500e+02, 1.5000e+01,
2.0000e+02
 7,AZIMUTH,96-09-19,11:52:29, 1.9912e+01, 0, 5, 1.2511e+03, 1.0000e+01, 1.5000e+01
 8,MISE ,96-09-19,11:52:44, 1.9911e+01, 0, 5, 1.0000e+01, 2.0000e+01
 9,SP-GRAD,96-09-19,11:53:52, 9.5521e-06, 0, 4.7761e-06, 2.0000e+00, 1.0000e+01, 2.0000e+01
10,SP-ABS ,96-09-19,11:54:06, 1.1409e-05, 0, 1.0000e+01, 2.0000e+01
 1,USER ,96-09-19,11:54:57, 1.9910e+01, 0, 5, 1.2510e+02, Crosst1, 1.1000e+01,
0.0000e+00, 1.4000e+01, 0.0000e+00, 1.2000e+01, 0.0000e+00, 1.3000e+01, 0.0000e+00
END
```

The first data field of each data point is a consecutive data record number. Note that when using USER MODE this number refers to the command file line number. That way a record in USER MODE can be connected to its command in the command file.

The second data field tells what type of measurement the particular line of data refers to. The formats of the individual measurements are described below.

In order to avoid unnecessary number of zeros in the result, the values of the data fields are given in scientific notation. To read these values, simply move the decimal point to the

right if the suffix is positive and to the left if the suffix is negative. For example: the value 2.5889e+02 is read 258.89 and the value 7.7424e-03 is read 0.0077424.

4.2.2.1 Resistance data format

The following data format is used for data collected in the resistance mode:

Record number, RESIST, date, time, V/I, error in tenths of percent, output current in mA, x-coordinate for the measurement point, y-coordinate for the measurement point.

Note that this format is also used for the contact resistance test. In this case the two last fields refer to the address of the first and second electrode used for the test and not the x- and y-coordinate.

4.2.2.2 Schlumberger configuration data format

The following data format is used for data collected in the Schlumberger mode:

Record number, SCHLUMBERGER, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , MN/2 distance, AB/2 distance

4.2.2.3 Wenner configuration data format

The following data format is used for data collected in the Wenner mode:

Record number, WENNER, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , Wenner distance a

4.2.2.4 Dipole-dipole configuration data format

The following data format is used for data collected in the dipole-dipole mode:

Record number, DIP-DIP, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , dipole size a, distance between dipoles na, X-coordinate for the midpoint between the two dipoles

4.2.2.5 Pole-dipole configuration data format

The following data format is used for data collected in the pole-dipole mode:

Record number, POLE -DIP, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , dipole size a, distance na from pole to dipoles, distance between current electrodes

4.2.2.6 Pole-pole configuration data format

The following data format is used for data collected in the pole-pole mode:

Record number, POL -POL, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , distance between A and N, distance between A and M, distance between current electrodes (AB)

4.2.2.7 Azimuthal configuration data format

The following data format is used for data collected in the azimuthal mode:

Record number, AZIMUTH, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , Wenner distance a, angle

4.2.2.8 Mise-a-la-masse configuration data format

The following data format is used for data collected in the mise-a-la-masse mode:

Record number, MISE, date, time, V/I, error in tenths of percent, output current in mA, X-coordinate for the measurement electrode, Y-coordinate for the measurement electrode

4.2.2.9 Gradient self potential data format

The following data format is used for data collected in the gradient SP mode:

Record number, SP-GRAD, date, time, V, error in tenths of percent, SP gradient, MN distance, X-coordinate for the measurement point, Y-coordinate for the measurement point

4.2.2.10 Absolute self potential data format

The following data format is used for data collected in the absolute SP mode:

Record number, SP-ABS, date, time, V, error in tenths of percent, X-coordinate for the measurement point, Y-coordinate for the measurement point

4.2.2.11 User mode data format

The following data format is used for data collected in the User mode:

Command line number, USER, date, time, V/I, error in tenths of percent, output current in mA, apparent resistivity in Ωm or Ωft , command file identifier, X-coordinate for the A-electrode, Y-coordinate for the A-electrode, X-coordinate for the B-electrode, Y-coordinate for the B-electrode, X-coordinate for the M-electrode, Y-coordinate for the M-electrode, X-coordinate for the N-electrode, Y-coordinate for the N-electrode. Note in the illustration

above that the USER record wraps on two lines in the manual due to its length. It is actually one single line in the output data from Sting.

4.3 Remote control

In some applications it is necessary to remotely control the Sting. There are three different ways the Sting can be remotely controlled.

4.3.1 Remote, menu 5/F1/F1

Sting will be triggered by a trig-pulse, data will end up in the internal Sting memory without being sent out. Remote measurement is triggered by sending a 0-1-0 pulse (equal to -5V - +5V -5V) to pin H of the RS232 connector on the Sting front panel.

4.3.2 SAS 300 mode, menu 5/F1/F2

Remote measurement is triggered by sending a 0-1-0 pulse (equal to -5V - +5V -5V) to pin H of the RS232 connector on the Sting front panel. Measured data; one start bit, seven data bits and two stop bits are sent out on pin A at 300 baud.

The format is:

Voltage (SP-ABS and SP-GRAD): V=3.652E-2 <CRLF> (36.52 mV)
Resistance (all resistance methods): R=3.652E-3 <CRLF> (3.652 mV)

When several cycles (M2/F1) are automatically measured, the data is transmitted after the last measurement is performed. Data is simultaneously stored in the Sting internal memory.

4.3.3 Swift PC, menu 6/F1

The Swift PC setting (M6/F1=Ext-PC) can be used for remote triggering by a PC even if the Swift system is not being used. The advantage is that the data is transmitted at 1200 baud and full data information is given including full resolution, time and standard deviation. No data is stored in the Sting memory, therefore measurements can continue without being interrupted by a full memory.

Measurement is possible using the SP-ABS and RESIST array (M1/F1).

If the Array type is set to SP-GRAD, the measurement is automatically reset to SP-ABS. All resistivity arrays are automatically reset to RESIST.

The output format is as follows:

```
Method, date, time, , voltage, standard deviation in 1/10th %
SP-ABS ,94-07-28,22:34:41,-1.8946e-05, 17
```

```
Method, date, time, V/I, standard deviation in 1/10th %, current I (mA)
RESIST ,94-07-28,22:35:16, 2.0029e+01, 0, 5
```

Below follows a Quick Basic program example for triggering the Sting from a PC type computer. The trig is effected by sending 10 NUL characters in a packet to Sting.

NOTE:

This is possible only if pins F and H are connected together in the RS232 connector on the Sting panel (the cables delivered with Sting from spring 1996 have this connection).

```
CLS
PRINT "    Advanced Geosciences, Inc"
PRINT
PRINT "Sting remote control example program."
PRINT
PRINT "Press M to start a measurement, Q to quit."

OPEN "COM1:1200,N,8,1,BIN" FOR RANDOM AS 1

DO
  DO
    k$ = UCASE$(INKEY$)
    LOOP WHILE k$ <> "M" AND k$ <> "Q"

    IF k$ = "M" THEN
      PRINT #1, STRING$(10, 0); 'Trig Sting measurement

      LOCATE 10, 1
      PRINT "Waiting for Sting ....."

      LINE INPUT #1, result$ 'Read result from Sting
      WHILE ASC(result$) < 32: result$ = MID$(result$, 2): WEND
      LOCATE 10, 1
      PRINT SPACE$(70)
      LOCATE 10, 1
```

```
        PRINT result$           'Print result on screen
    END IF
LOOP WHILE k$ <> "Q"
CLOSE 1
END
```

5. Swift, the automatic dual mode multi-electrode system for the Sting

5.1 The Swift components

The Swift Dual Mode smart electrode system is designed for efficient acquisition of large amounts of resistivity data when performing resistivity imaging surveys. A complete system consists of: one interface box and up to 254 electrode switches (smart electrodes) placed on electrode stakes and connected by a multi-lead cable to the central interface unit. The switches are capable of connecting any combination of the Sting terminals (A, B, M, N) to each electrode.

The Swift system is controlled directly by the Sting R1 or Sting R1 IP memory resistivity meter. The Sting can automatically run a complete dipole-dipole survey or any operator programmed array (i.e. Schlumberger, Wenner, pole-pole, pole-dipole, square array etc.). Since the Sting can be programmed to perform any electrode array measurement, there is no need to bring a computer to the field. However, optionally a computer can be connected to the Sting/Swift system.

Measurement procedure is simple. First set out a number of electrodes at even intervals and connect the Sting/Swift system, erase the memory, enter the electrode interval into the memory, run a contact resistance test and then press the MEA-key to start automatic measurement.

The following items should be enclosed in a standard Swift shipment:

Item	Description	Qty
1	The Swift interface box	1
2	Swift/Sting communication cable with take out for external power	1
3	External power adapter cable	1
4	Swift/Sting ABMN cable	1
5	The Administrator software	1
6	The CommandCreator software	1
7	At least one Swift cable with a number of switches (electrode take-outs)	1

5.1.1 The Swift interface box

The Swift interface box handles the communication between the Sting/PC and the logical circuit boards in the electrode switches.



Figure 13 The Swift interface box.

5.1.1.1 Controls and connectors

ON/OFF	Turns the interface box on and off.
Indicator light	The indicator light, located above the ON/OFF switch, will only be lit when the ON/OFF switch is in the ON-position and the interface box is connected to the Sting. If a PC is used (mode switch in PC position), the light will only come on when the computer is connected and turned on.
Fuse holder	Located on the front panel. To open, use a flat screwdriver and turn 1/8 counterclockwise. Use a 5x20 mm type, 2.5 Amp slow blow fuse for replacement.
Charge	Use the Sting battery charger to charge the interface box internal battery. Note that the Swift internal battery is used even if the Sting is powered by an external battery. The Swift battery therefore always needs to be kept charged.
Sting/PC	Set this switch in Sting mode position when only the Sting is used with the Swift system. Set the switch in the PC mode position when an external MS DOS type PC is used and connected to the Sting/Swift.
PC COM.	Used when a PC is used to control the Sting/Swift measurements. Use the Sting standard dump cable (delivered with your Sting) to connect the Swift PC COM. to the RS232 connector on a PC.
STING Ctrl & data ABMN	Use the special cable to connect the Swift STING CONTROL & DATA connector to the RS232 connector on the Sting front panel Use the special cable to connect the Swift to the A, B, M and N terminals on the Sting front panel to the connector marked AB MN on the Swift interface.
LOW	Connect male Swift cable connector to this connector.
HIGH	Connect female Swift cable connector to this connector.

For further information on how to connect the Sting/Swift system, see section 2.2.3.3.

5.1.2 The Sting/Swift communication/external power cable

When using the Sting/Swift system intensively, the standard clip-on battery may be drained in less than an hour. Use the adapter for the Swift/Sting communication cable to connect the system to an external 12 V automobile battery. The red Mueller clip connects to the positive pole and the black Mueller clip to the negative pole of the battery. For further information on how to use an external battery, see section 3.1.4.

5.1.3 The Swift cable with electrodes

The Swift cable is an electrode cable with two cylindrical stainless steel take-outs mounted at even intervals along the cable.

The individual switch cylinders are addressable by the Sting. The address (1-254) of each electrode/switch is marked on the cable beside the cylinder. Each cable has a female connector in the low address end of the cable and a male connector at the high address end of the cable. It is possible to connect cables with up to a maximum of 254 electrode/switches to one system.



Figure 14 The dual mode electrode switch.

The surface of the cylinders acts as the electrode. In order to ensure good ground coupling, the cylinders are fastened to stainless steel ground stakes using a rubber band.



Figure 15 Electrode used in dual mode configuration.

When the electrodes are used in dual mode they allow an automatic measurement to be performed, using stainless steel stakes when the electrode is a current electrode and automatically switching to the non-polarisable



Figure 16 Electrode used in single mode configuration.

electrodes, placed near the stainless steel stake, for the potential measurement. When high resolution IP data is required this is the preferred method to perform an automatic IP survey. However, if the highest resolution

IP data is not required the electrodes can be used in single mode so that both current and potential are measured through the stainless steel stake.

5.2 The Swift relay box accessory

In certain applications, as in model measurement experiments, fixed buried electrode time monitoring, slim borehole measurements etc., it is useful to have the electrode switching device near the instrument and have single lead cables going to each of the individual electrodes. In such applications it is convenient to use the Swift relay box.

The Swift relay box makes it possible to program monitoring or measurement of any array with up to 28 electrodes (optionally up to 254 electrodes), using an MS DOS type computer to control the system. The Swift relay box is connected to the Swift interface box at the "HIGH electrode cable," using the special connection cable. The relay box can be ordered with either banana jacks or male NK-27 connectors for output.

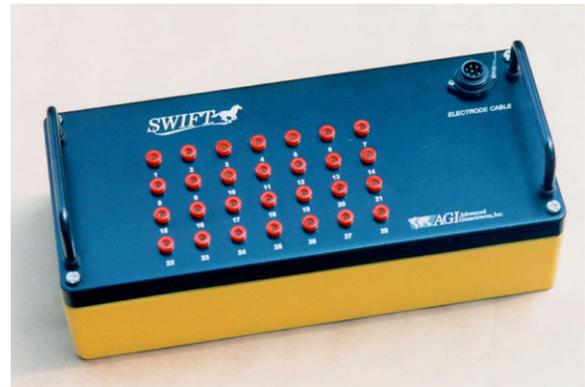


Figure 17 The Swift relay box.

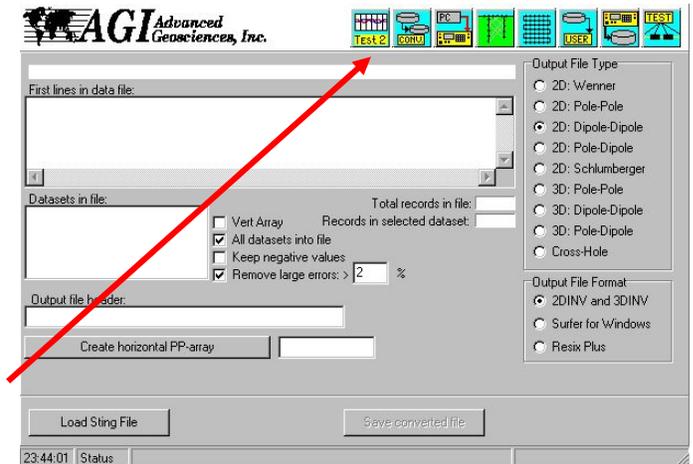
A complete system consists of the Sting, the Swift interface box and the Swift relay box connected to electrodes.

Measurement and programming are done either in the USER MODE (see section 2.3 **User mode** on page 27) or with an external PC controlling the measurement as described in section 2.4.

6. Miscellaneous software

6.1 The AGI Administrator Program Group

The AGI Administrator is a group of utility software for the Sting/Swift resistivity imaging system. Several of the old utility programs, such as UserLoad, Swiftcnv and StgdmpW have been upgraded and incorporated into the new program group. Several new utility functions, such as cable tester, cross bore hole command creator and programmable switch addresser has been added.



Pressing one of the buttons in the top right corner does selection of program function to use.

6.1.1 Initial Software Setup

The Administrator uses special access to the PC hardware in order to perform the Swift cable address programming function. Because this access is handled differently in Win95/98 and WinNT4 there are separate files needed for these cases. Therefore the Administrator must be installed on the PC using the setup program supplied. The setup program will check the operating system version and install the proper files for you.

Windows NT notice:

To install Administrator on a Win NT computer you must be logged on to an account with administrative privileges because of the way NT handles the hardware through so called kernel mode drivers.

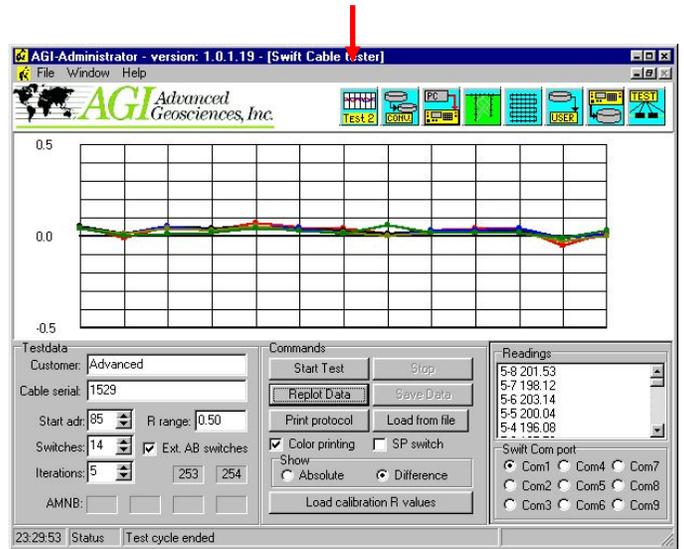
6.1.2 Setup process

Just start the setup program and it will walk you through the process. Answer the questions as they appear (there will not be many questions asked). One question that will appear is the directory into which you will install the software. Use the default directory or select another at your discretion.

The Admin icon will be placed on your start menu ready to use.

6.1.3 The Swift Cable Tester Software

The Swift Cable Tester software is used to test the integrity of the Swift cables. To use the software, a test kit (AGI part number 933910) is required. The kit comprises a test jig and the software module with the values of 13 carefully measured resistors. The jig comprises a set of 14 clamps connected to each other. Between each clamp is a built in resistor connected. The Swift cable to be tested is placed on a dry non-conductive surface and the test-clamps are attached to each electrode switch.



During the test, a simulated Wenner measurement is performed along the cable, in order to measure the resistance of the calibrated resistors, and graphically presented on the computer screen.

The Sting/Swift system is set up in the usual way and the computer to be used during the test is attached between the Ext PC port on the Swift box and the computer serial port, using the regular dump cable.

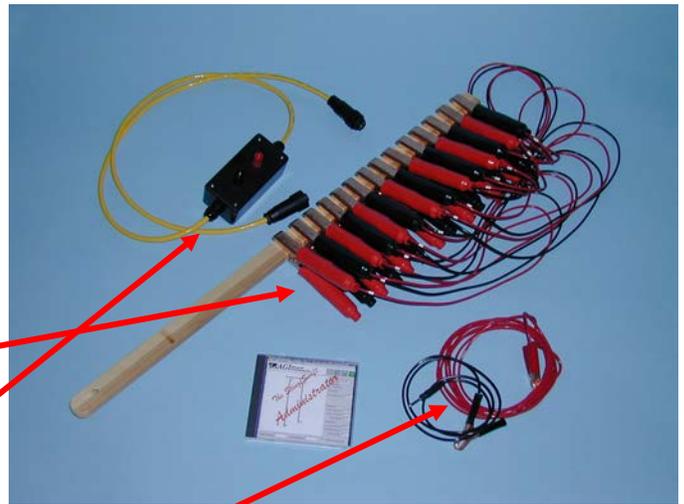


Figure 18 Cable test kit, part number 933910

The test clamps are placed over each switch in number sequence, so that the test clamp number 1 is placed on the lowest number switch on the cable to be tested and test clamp number 14 over the highest number switch to be tested.

The external switch box is connected to one end of the cable to be tested. The other end of the external switch box is connected to the Swift interface box.

The red jumper cable is connected to the red banana connector on the external switch box and the other end is connected to the lower address number end of the cable to be

tested. The black jumper cable is connected correspondingly to the high address number end of the cable to be tested.

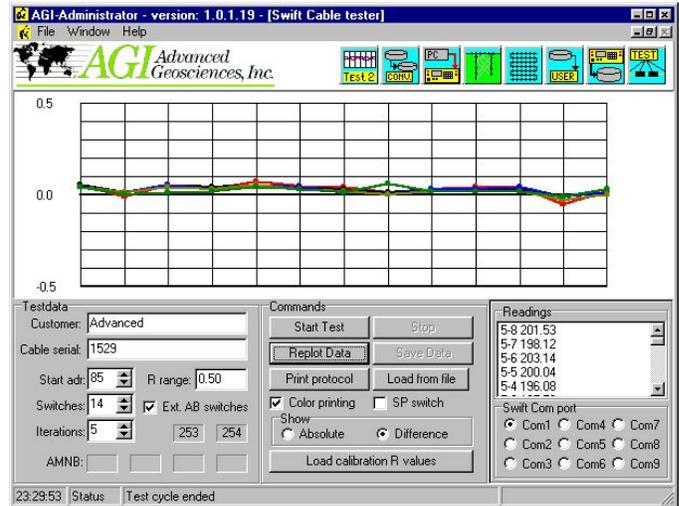
The Sting/PC switch on the Swift interface box is set to PC.

Turn on the Sting and the Swift interface box.

The Sting is set up in the following way:

- Current 5 mA (Menu 1/F3)
- Cycles 1 (Menu 2/F1)
- Time 1.2 seconds (Menu 2/F3/F2)
- External PC mode (Menu 6/F1)

The first time the program is used you will have to load the calibrated resistor values into the program. This data will then reside in the program memory and it is not necessary to load them again. To load the resistor values click on the “Load calibration R values” button. Specify the NominalR.dat file delivered on your Administrator CD.



Before starting the test, on the computer, enter the following information:

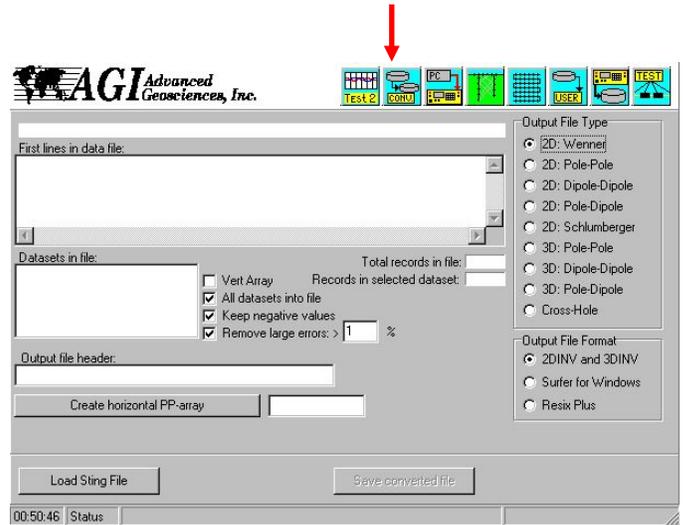
- Customer (or user)
- Cable serial number
- Start address – enter the lowest address number of the cable to be tested. If for example a cable section with addresses 15-28 is to be tested, enter 15
- Switches – enter the number of switches on the cable to be tested, typically 14
- Iterations – enter the number of times the cable shall be tested. We recommend 5 times in order to see the spread of the measurements.
- Set Show to Difference to display difference between measured and calibrated resistance values (set Absolute to display measured values)
- Set R Range to 0.5 when using recommended Difference display.
- Click on Start Test to start the test.

The plotted curve should show a horizontal curve close to zero when plotted in the Difference mode (i.e. measured value minus calibrated value). The curve will typically be within $\pm 0.3 \Omega$ of the zero line.

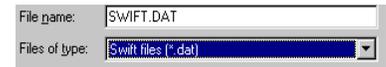
6.1.4 The Sting Data Conversion software

The Sting Data Conversion software is used to convert the raw Sting data for use in the Res2Dinv, the Res3Dinv, the Surfer for Windows and the Resix Plus software.

- Select Output File Type
- Select Output File Format
- Select All Datasets Into Files in case all data is going to be processed as one data set, as for example when performing a roll-along survey
- Make sure that the “Keep Negative Values” box is un-checked
- Check the Remove Large Errors box and specify at what error data shall be omitted
- Select data file to convert by clicking the Load Sting File button
- Click on the Save Converted file button to specify where to save the converted data file
- The data set is now converted to selected format

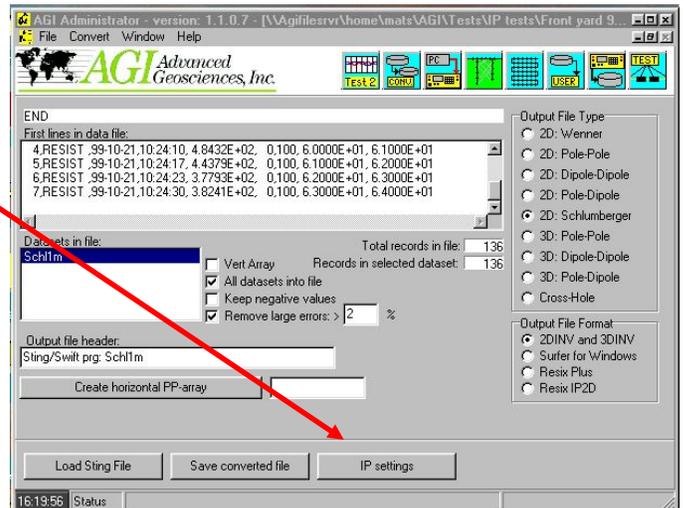


Note that data collected using a computer connected to the Sting/Swift and the old Swift.exe DOS program can be converted if *.dat is selected in the box “Files of type” when selecting the data file to convert. For data collection with a lap-top it is however recommended to use the “Swift measure” module of the Administrator instead of the old DOS Swift.exe program.

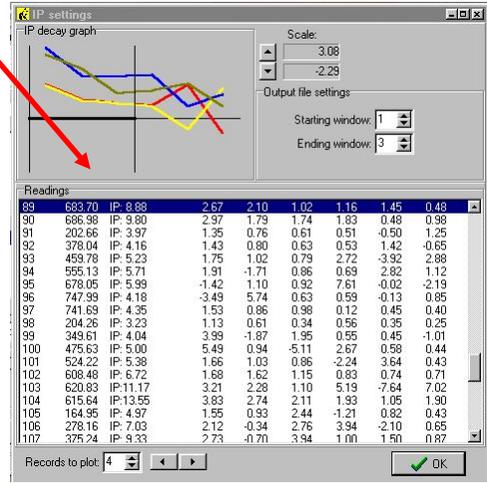
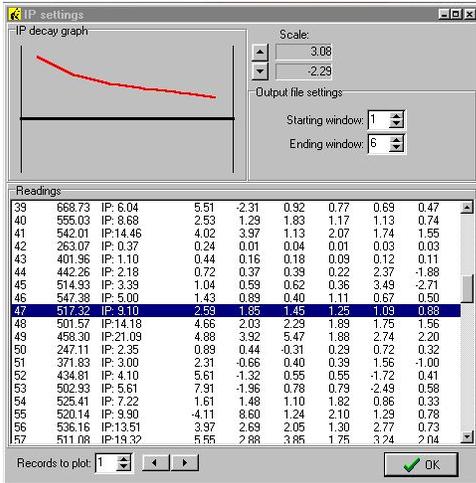


6.1.4.1 Converting data containing resistivity and IP data

If your data contains IP data a new button will lit up when loading the data into the software. To select the IP time windows to include in the inversion click on this button.



A new window will open where the IP data can be graphically inspected. A single IP curve can be displayed or multiple curves. The windows with data to invert is chosen after scrolling through the data and selecting the windows which displays the least amount of noise (jagged curve contour).

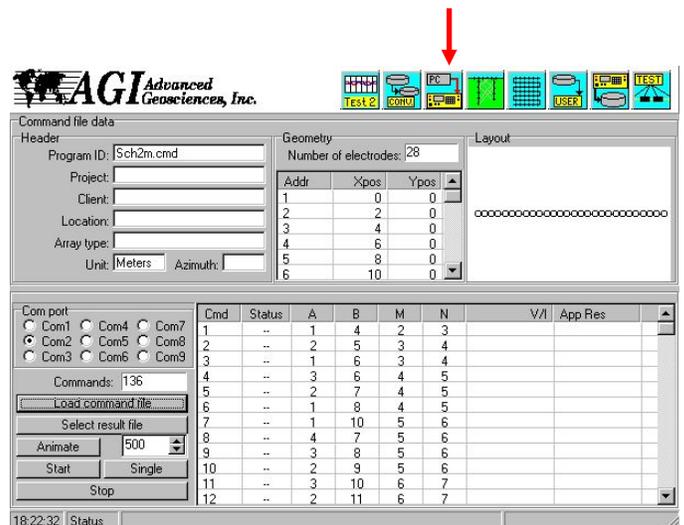


After your selection is made, click on OK and then click on the Save Converted File button to specify where to save the converted data file. The data set is now converted to selected format.

6.1.5 The Swift Measure Module

By using the Swift measure module it is possible to run a survey from a computer using a Swift command file. The main disadvantage of running a survey using a computer is the non-field worthiness of most computers. However, there are a few advantages of running a survey controlled by a computer:

- The data points are stored on the computer hard drive and there is therefore virtually unlimited storage capacity for the data
- It is possible to monitor the survey in more detail on the computer screen as the measurement progress.



- It is possible to run an automatic SP survey (this is not possible in any other mode/configuration)

To run a survey proceed as follows:

- Connect the Sting and the Swift as usual and then use the serial dump cable to connect the PC Com. connector on the Swift interface box to the serial port of a computer
- Set the Sting/PC switch on the Swift box in the PC position
- Set the Sting in RESISTANCE mode or SP-ABS mode depending on what type of measurement shall be performed (menu 1/F1)
- Set the Sting in the Ext. PC mode (menu 6/F1)
- In the Admin Swift Measure Module select Load Command File
- In the Admin Swift Measure Module Select Result File
- Click on Start to Start the measurement
- Click on Stop to stop the measurement or wait until the complete command file has been run

In SP survey mode the Swift software only uses the SP-ABS mode, therefore the Sting will be automatically reset to SP-ABS if it is set to SP-GRAD when performing Swift SP surveys.

The Single function is used to take one reading only.

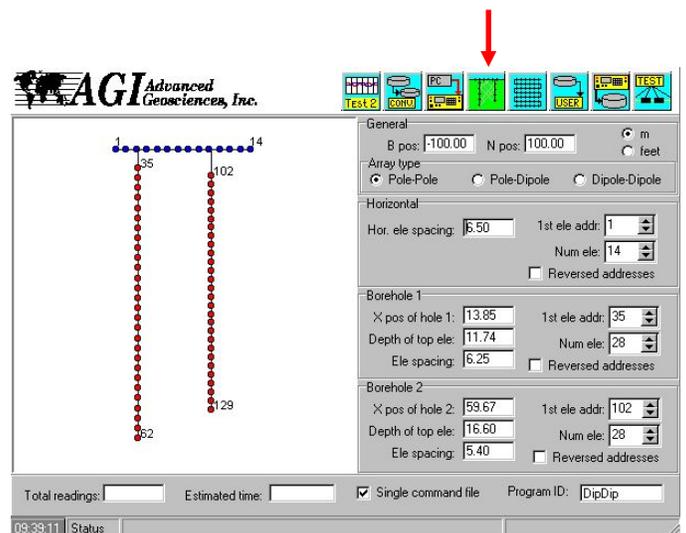
The Animate function is used to test a command file in the office.

6.1.6 The Create Cross-hole Command File Module

The Create Cross-hole Command File Module is used to create command files for use when measurements are performed between bore holes and bore holes to surface.

The AGI bore hole cables are to be used in open water filled holes. The holes can not be cased by PVC or steel casing, only slotted PVC can be used.

In holes which does not hold water it is



suggested to grout PVC casing with stainless steel ring electrodes in place. In this case the Swift Relay Switching Box has to be used.

The Create Cross-hole Command File Module is used to create the command file which is then loaded into the Sting RAM memory using the Userload Module. The actual survey is then performed with the Sting in User Mode (menu1/F1).

To create a cross-hole command file proceed as follows:

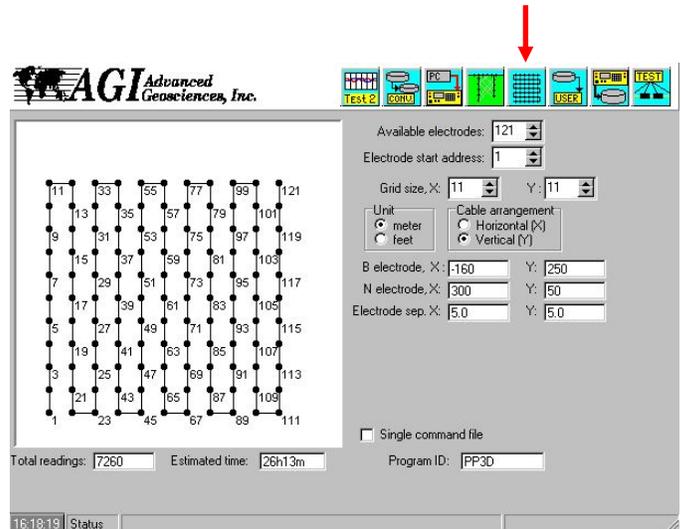
- Under Array Type select the type of array to be used
- If pole-pole array, specify the X-coordinate for the B and N electrode. Origo is placed on the surface at the first (leftmost) surface electrode. For pole-dipole it is only necessary to specify the X-coordinate for the B-electrode. It is not necessary to specify B or N coordinates if the dipole-dipole method is to be used
- In the Horizontal Box specify electrode spacing and addresses for the surface cable. Note that one electrode shall be placed on the surface at each of the bore holes. Two electrodes will as default be placed to the left of bore hole 1. Check the Reverse Addresses box in case the surface electrodes are laid out in the opposite direction
- in the boxes for Bore hole 1 and Bore hole 2 enter X-position of the hole, depth of top electrode, electrode spacing, first electrode address and number of electrodes. You can also check the box for Reversed addresses in case your cable has the low address number at the bottom of the hole.
- Along the bottom of the window Total number of readings and estimated time for the survey is given
- It is important to enter the Program ID, since this is the name of the command file you will see on the Sting display when selecting the command file to use. Note that this name can have maximum 7 characters and does not have to correspond to the file name
- There is also a box for Single Command File. The Sting can store a maximum of 3,000 readings in it's memory. By not checking this box the command file will be divided into blocks of maximum 3000 readings each. This way a very large survey can be performed by first loading the command file no. 1 into the Sting RAM memory using the Userload module, then run this survey, download the recorded data to a computer using the Sting Download module, then load command file no. 2 into the RAM and continue recording the bore hole data and so on
- If the survey is run using the Swift Measure module and a computer to control the survey, there is virtually unlimited storage space on the computer hard drive and there is therefore no need to divide large command files into blocks of maximum 3,000 data points. In such case make sure to check the Single Command Files box
- To save the command file click on Commands and then click on Save Command Files

6.1.7 The Create 3D Command File Module

This module is used to create a pole-pole 3D command file.

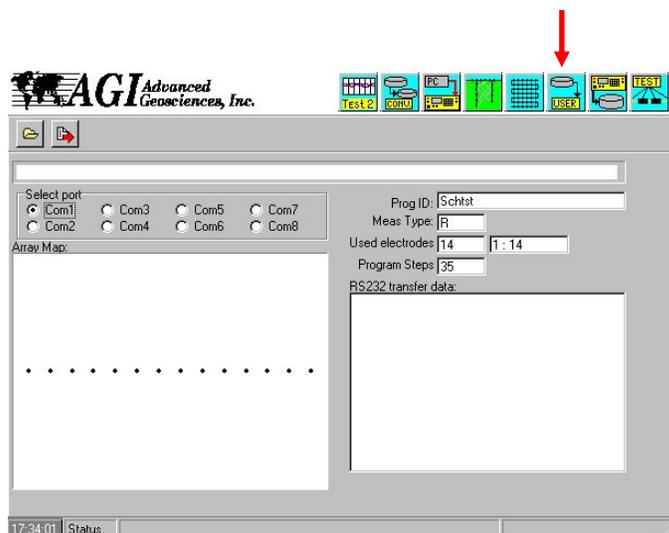
To create a cross-hole command file proceed as follows:

- In the box Available Electrodes, specify number of electrodes to be used
- In the Electrode Start Address box enter start address for the lowest number of the electrode addresses to be used
- In the Grid Size X box enter the number of electrode columns to be used
- In the Grid Size Y box enter the number of electrode rows to be used
- Specify if the Swift cable shall be put out in a horizontal pattern or a vertical pattern by checking the appropriate box
- Enter the X- and Y coordinate for the B and N electrodes
- Enter the separation between the electrodes in X and Y direction
- Along the bottom of the window Total number of readings and estimated time for the survey is given
- It is important to enter the Program ID, since this is the name of the command file you will see on the Sting display when selecting the command file to use. Note that this name can have maximum 7 characters and does not have to correspond to the file name
- There is also a box for Single Command File. The Sting can store a maximum of 3,000 readings in it's memory. By not checking this box the command file will be divided into blocks of maximum 3000 readings each. This way a very large survey can be performed by first loading the command file no. 1 into the Sting RAM memory using the Userload module, then run this survey, download the recorded data to a computer using the Sting Download module, then load command file no. 2 into the RAM and continue recording the 3D data and so on
- If the survey is run using the Swift Measure module and a computer to control the survey, there is virtually unlimited storage space on the computer hard drive and there is therefore no need to divide large command files into blocks of maximum 3,000 data points. In such case make sure to check the Single Command Files box
- To save the command file click on Commands and then click on Save Command Files



6.1.8 The Userload Module

The Userload module is used to load command files into the Sting RAM memory. By using command files the user can, home in the office, program any type of survey to be performed automatically in the field. The command file is then loaded into the Sting RAM memory using the Userload module and can then be recalled and used to perform the automatic survey in the field, without the use of a fragile computer in the field. To load a command file into the Sting RAM memory proceed as follows:



- Connect the Sting to the computer by using the data download cable supplied with the instrument
- Start the Userload module
- Turn the Sting on and go to menu 3. Erase the **data** memory by pressing F3/F1/. (dot). Make sure any valuables data is saved before being deleted.
- Erase the RAM memory if you do not want to keep the old command files in memory. If the command files shall still be kept in memory skip this step. The RAM memory can hold up to 16 command files with a total of 3,000 data points
- Go to M6/F1 and make sure to set the Sting in Off mode, **not the Auto or Ext-PC mode**
- Go to menu 4 and press F3
- On the computer select the appropriate Com port
- Click on the “Open Command File” button to open the appropriate command file
- The relative position of the used electrodes is now displayed in the lower left window. Click on the “Transfer To Sting” button
- On the Sting press F1. You will now see commands being transferred in the lower right window. Note that the commands look different than the original ASCII command file
- When the transfer is done, click on the Exit button and press the **MEN** key on the Sting

The transferred command file can now be selected by going to menu 1 and pressing F1. Use the + key to select USER MODE and press **MEN**. Go to menu 1 F2 and use the + key to scroll to the correct command file. Press F3 to enter the selection. Enter X- and Y-coordinates for the first electrode in the layout and enter Next=1 by pressing **F3** to start at the first command line.

6.1.9 The Sting Measurement Download Module

The Sting Measurement Download module is used to download raw Sting data to a computer for further processing. To download data proceed as follows:

- Connect the download cable to the Sting front panel connector and to the serial port connector on your PC type computer.
- Turn the Sting on.
- Start the Sting Measurement Download module
- On the computer select the appropriate Com port
- Click on the Start Sting Download button and enter a filename where the downloaded data shall be stored
- On the Sting press **F2** on menu 3 select **F1** for ASCII if you have a Sting with software version lower than 2.5.5. Press **F2** for binary if you have software version 2.5.5 or higher. Note that the transferred data in both cases are going to be ASCII data. The binary option only refers to the way the data is being transferred.
- Data in the Sting memory are now being transferred to the computer. The downloaded file is a raw data ASCII file which will be used for further data processing.

There are four check-boxes for special output.

The 4 Digit Year box should be checked if Y2K compliance is required.

When the box “Keep USER prog” is checked, the command file which has been used when recording the data will also be downloaded from the Sting and saved as a file on the computer hard drive. This option is useful when the original command file has been lost and there is a need to edit the command file.

The check box for “Add Sting settings” should be checked in case there is some problem with the survey and you want to e-mail (support@agiusa.com) the data file to AGI for analysis. When this box is checked some instrument settings which are of interest for our analysis is added at the end of each record. The settings added are: GR = Gain range for the receiver, HV = High voltage output for the current transmitter, MT= Measurement time and CYK= Cycles of measurement.

6.1.10 Switch and Cable Test Center Module

To use this software module, a test kit AGI part number 921001) is required.

6.1.10.1 Initial Hardware Setup

1. Connect the smart electrode programmer to the connector on the swift interface box labeled “AB MN Sting”.
2. Connect the parallel port connector of programming apparatus to the parallel port on the computer.
3. Connect the Swift cable to the connector on the swift box labeled “Electrode Cable”.
4. Connect the Swift interface serial cable (dump cable) from the Swift box connector labeled “PC COM” to the serial port on the computer.
5. Attach the Metal Tube Clamp of programming apparatus to the Electrode to be programmed.
6. Set the PC/Sting switch on the Swift interface box to the PC position.
7. Switch on the power to the Swift interface box.

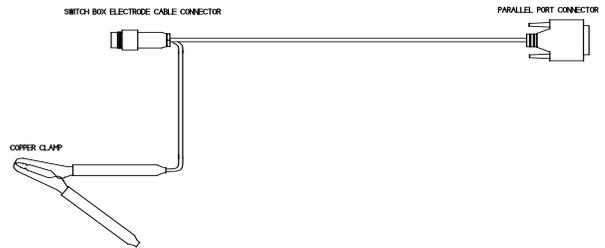
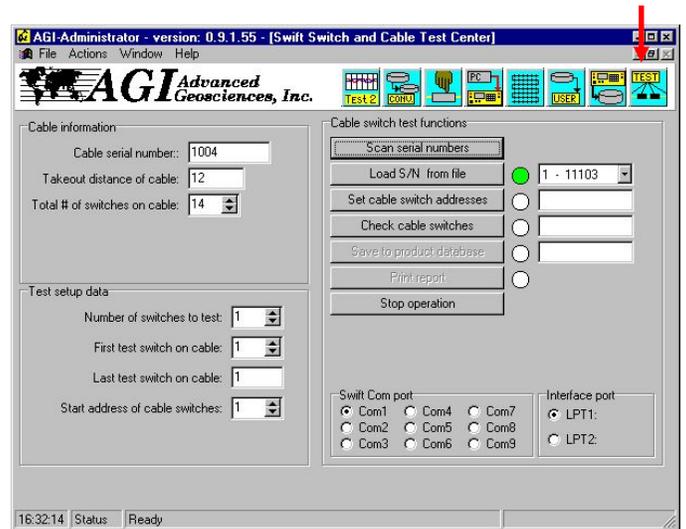


Figure 19 The Swift address programming harness.

6.1.10.2 AGI-Administrator Software Instructions

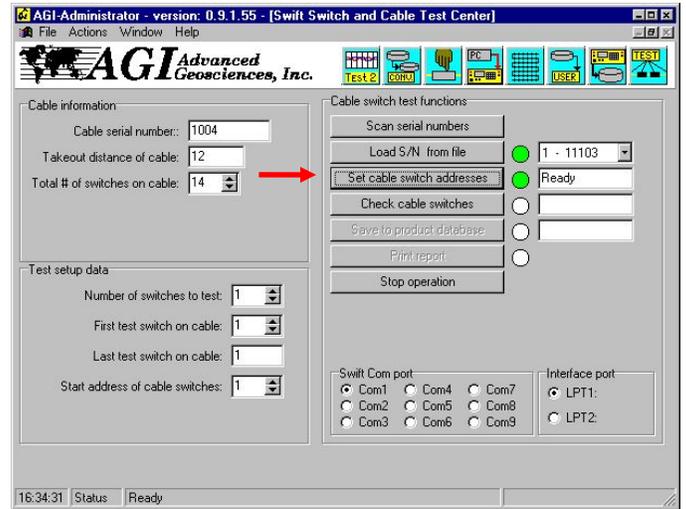
1. Click on the “Test” button.
2. Set the correct COM port setting by clicking on the correct button in the “Swift Comport” area
3. In the Test Setup Data area set the number of switches to 1 by setting one in the “Number of Switches to Test” box.
4. Set “First Test Switch on Cable” box to 1
5. Set “Last Test Switch on Cable” box to 1
6. In the “Start Address of Cable Switches” box enter the new address of the electrode to be programmed. For example, if the



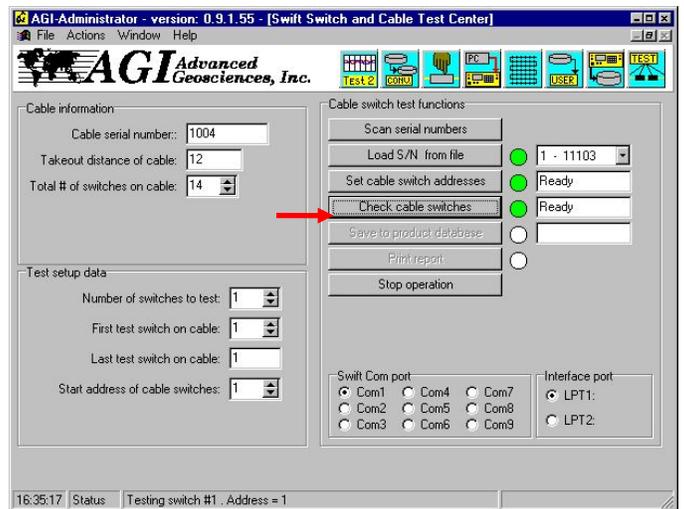
electrode is to become electrode 59 in the cable, set this box to 59.

- under the “Cable switch test functions” area click on the “Scan Serial Numbers” Button. To assure this operation is working correctly the electrodes should now begin to make a faint clicking sound. The circle next to the button will indicate the status of the operation. If the circle is yellow, the action is currently in operation. Once the operation has finished the, circle should become green and the serial number of the electrode should appear in the box. If the circle turns red then the process failed and then the user should double check the hardware setup and the settings in the Test Setup Data area.

- Next click on the “Set Cable Switch Addresses” button. The software will now program the address entered in the “Start Address of Cable Switches” box into the electrode. As before if the circle is green the operation passed, but if the circle is red the operation failed



- Finally click on the “Check Cable Switches” button. This operation will now test functionality of the electrode to assure that the address has been programmed and that it is operating correctly. If the circle is green then the complete process of programming the address is complete, if the circle is red a failure has occurred.



6.2 User Mode command file of type.CMD

Command files, of the **.CMD** type used with the Swift.exe program when a PC type computer controls the Sting/Swift system can be modified so that they can be used as **User Mode** downloadable files.

The command files need to have the **ProgID** and the **Unit** information under the **:header** command in order to be used with the **UserLoad** software. Below is an example of a modified **.CMD** file for use with the **UserLoad** software.

```
;960711 ML

:header
progID= Test
unit= meter
type= resist

:geometry
1,0,10
2,0,11
3,0,12
4,0,13
5,0,14
6,0,15
7,0,16
8,0,17

:commands
1A,2M,3N,4B,R
2A,3M,4N,5B,R
3A,4M,5N,6B,R
4A,5M,6N,7B,R
5A,6M,7N,8B,R
1A,2M,3N,4B,R
2A,3M,4N,5B,R
3A,4M,5N,6B,R
4A,5M,6N,7B,R
5A,6M,7N,8B,R
1A,2M,3N,4B,R
2A,3M,4N,5B,R
;End
```

Note that the program ID can only have a maximum of 7 characters and only characters allowed in MS DOS file names are allowed to be used in the program ID.

6.3 The CommandCreator software

The CommandCreator is a Windows 3.xx program for automatically designing command files for the Sting. The CommandCreator will also display the measurement sequence graphically on the computer screen to make sure that the command file performs as intended.

The CommandCreator is also used to quickly create roll-along files, command files where one electrode is missing and other command files for special applications. For further information see the CommandCreator instruction manual.

6.4 The RES2DINV software

The RES2DINV, the automatic inversion software, is purchased separately. For instructions on how to run the RES2DINV software, please read the software manual.

6.5 The Surfer for Windows software

For presentation of the resistivity data, calculated by the RES2DINV software, use a contouring software like, for example, the "Surfer for Windows" software (part number 920064). Import the XYZ file produced by RES2DINV into the Surfer software. For further information, see the Surfer for Windows instruction manual.

6.6 The Slicer/dicer software

For presentation of the resistivity data, calculated by the RES3DINV software, use a contouring software like, for example, the "Slicer/dicer" software (part number 920078). Import the XYZ file produced by RES3DINV into the Slicer/Dicer software. For further information, see the Slicer/Dicer instruction manual.

7. Field procedure

7.1 Weather conditions

7.1.1 Rain

The instrument and the smart electrodes are weather proof, meaning that they can be out in the rain. However they can not be submerged into water. Further, any moisture on the front panel of the instrument or in the connectors increase the chance of electrical leakage between the current and potential lines resulting in degrading data quality. Water in the connectors will cause electrolysis and may cause severe corrosion of the contact pins and contact receptacles. Therefore make sure to keep the instrument and connectors clean and dry at all times. Use dust caps on connectors which are not in use.

Heavy rain will affect your survey negatively. After a rain storm, surface water will percolate down into the ground. When water moves through soil, streaming potentials are created and these will be recorded by the instrument resulting in a “noisy” image of characteristic look. Therefore try to wait for a day after a heavy rain storm.

7.1.2 Cold weather

The instrument will work well below 0°C. However around 0°C the LCD screen becomes “sticky” and changes of display happens slower and slower the colder it is. Around -10°C the LCD will stop working. Therefore if you are planning to work in colder weather you will need to somehow keep the Sting warm. The smart electrodes work well down to at least -20°C.

Snow and ice is highly resistive but does not affect the measurement in any other way. Actually the resistivity method works well for mapping permafrost.

7.1.3 Hot weather

When temperatures approaches +40 °C the insulation performance of some plastic material starts to break down and may cause electrical leakage problems between the current and potential lines. It is therefore important to make sure to keep the instrument as cool as possible. By keeping the instrument in shade from direct sun light the internal temperature of the instrument is lowered 10° – 15° °C.

7.1.4 Blazing sun

The LCD may darken when heated up by the sun. Should that happen it can easily be compensated by repeatedly pressing the LCD contrast key in the top right corner of the key board until the display is clear.

As described above, it is a good practice to shade the instrument during sunny days, booth to eliminate overheating problems and darkening LCD display.

7.1.5 Thunderstorms

Thunderstorms are dangerous both for you and the equipment. The instrumentation contains sensitive CMOS circuitry and can be destroyed by nearby lightning. For you it is not a good idea to stand at the end of a long conductive cable during a thunderstorm.

Thunderstorms typically move very quickly and it takes some time to pick up the equipment, therefore it is time to interrupt the survey and pick up the equipment when you first hear the thunder in the distance.

7.1.6 Night time

Do not leave cables out over night. Many animals, like deer, rabbits, mouse etc. are moving around during the night time and their way of testing if something is edible is to chew on it. Therefore it is important to keep animals off the survey line during the day and bring the equipment in during the night.



Typical deer chew

7.2 Battery economy

The Sting is powered by a rechargeable battery which should last well over a normal working day using manual measurements. For extensive work or during automatic measurements with the Sting/Swift system, powering the instrument by an external 12 V DC deep cycle type battery is recommended.

For external battery, try to find the “deep cycle” type of battery. It is the type of battery fishermen use for their electric trawling motors. These batteries are designed to be charged and discharged repeatedly, without being damaged. A regular automobile battery will also work, but will lose its capacity quicker when being discharged many times.

When using an external vehicle type battery, power consumption is really not a problem since such a battery will last for continuous measurements all day. When using the rechargeable Sting clip-on battery, however, it is a good practice to save power by not using unnecessary amounts of current. Here are some tips on how to conserve on your battery.

1. Turn off the Sting when waiting, for example when electrodes are moved or other matter needs to be taken care of. The Sting keeps its current settings in the memory and will instantly be back on, the same as it was when you turned it off. Data in the memory will not be lost.
2. Use the night light only when necessary.
3. Do not use excessive current when measuring. This is maybe the hardest to learn, but will come with experience. Use less current when the electrodes are close together, maybe 5 or 10 mA, and gradually more as the electrodes are separated during the sounding. A good way of estimating current setting is to watch the error reading. If the error σ starts to increase as you move your electrodes out you might want to increase the current setting.
4. Set the accuracy "threshold" to a reasonable required limit so that the instrument will stop cycling when the limit is achieved or alternatively limit the number of required maximum cycles.

7.2.1 Swift interface box battery

There is an internal rechargeable battery in the Swift interface box. It is important to make sure that this battery is regularly charged when the Swift box is being used. **Note that the Swift box is not charged by the external battery used with the Sting.**

When the Swift box battery is drained the measurements will be unreliable because the smart switches are not activated properly. The Swift box contains a battery regulator that keeps this from happening until the battery voltage drops below about 10 volts. To avoid any problem, the Swift battery should be recharged every night when in use.

7.3 Manual cables

The most common field problem relates to problem with the cables. Therefore it is a good practice to treat the cables carefully. Below



Figure 20 Short cable set, current 2x150 m, potential 2x50m.

follow some hints on how to avoid "cable problems."

1. In order to avoid "crosstalk" between the cables, try to run the current cables and the potential cables at a distance from each other where possible.
2. Do not un-reel and reel in cable by pulling the cable. Instead "walk" the cable in and out.
3. Inspect the cable frequently to detect any cut in the insulation. Remove worn sections of the cable.
4. Use plastic reels in order to avoid "creep currents" to the ground. Do not use metal reels.
5. Of the cable problems, the most common has to do with the banana connectors. The best way is to use banana connectors which are soldered on the cables and carry a set of spare banana connectors of the "screw on type" in case one of the soldered connectors comes off in the field. Note that in case you do not have a spare banana connector, the wire can be stripped and attached to the current or potential terminals of the Sting.



Figure 21 *Medium cable set, current 2x400 m, potential 2x135*



Figure 22 *Long cable set, current 2x750 m, potential 2x250 m.*

7.4 Swift cables

The Swift cables with the fixed cylindrical stainless steel switches are a sensitive part of the Sting/Swift system. Therefore it is important to handle them carefully. Here are some rules on how to handle the cable.

- Under no circumstances drag the cable on the ground. Bring the cable box along the profile and lay out/take in the cable directly from/to the box.
- Do not force the cable when you put it back in its box. Lay the cable coils down either with the cable end over the loop or under the loop as the cable wants to lay.

7.4.1 Helpful hints

For a successful Sting/Swift survey follow these helpful hints.

1. Knock the electrode stakes into the ground so that the crossbar is about 5 cm (2") above ground.
2. Water the stakes with some saltwater, about ½ liter for each stake. Make sure not to pour water on the smart electrodes.
3. Make sure that the smart electrode makes metallic contact to the stake, i.e. there is no grass or rubber band between the smart electrode and the stake.
4. On a windy day, double up on the rubber bands so that the smart electrodes are held firmly to the stake.
5. Do not let the yellow Swift cable hang on branches so that the wind movement is transferred to the smart electrodes. The slightest movement may cause noisy data.
6. Make sure that the stakes are free from dirt, corrosion or rubber residues where it makes contact to the smart electrode. The contact surface can be easily cleaned using a wire brush.
7. Be careful with the Swift cable, **never drag the cable**, always “walk” the cable in and out of the box.

7.4.2 Picking up the Swift electrode cable and stakes

When picking up the Swift electrode cable and the electrode stakes after the survey is performed it is easier to pick up the stakes before picking up the Swift cable. The



Figure 23 It is not easy to find the stakes once the cable is gone (left picture). Instead follow the cable and pick up the stakes before picking up the cable (right picture).

reason is that it is easy to follow the yellow Swift cable, but very hard to locate the stakes once the cable is gone.

7.5 Electrodes

For regular resistivity work, use our stainless steel electrode stakes. For self potential surveys (SP) or highest quality IP surveys use our non-polarisable electrodes.

7.5.1 Stainless steel electrodes

For regular resistivity work stainless steel electrodes are sufficient. Connect the cables to the electrodes with a solid copper Muller-clip soldered to the cable. When the electrode distance is short at shallow surveys, remember not to push the electrodes too deep into the ground. In these cases, do not put electrodes deeper into the ground than about 5% of the distance between the electrodes.

Dual mode smart electrodes on Swift cables are simply “rubber banded” to the electrode stake. In these cases you must make sure that there is a good contact between the smart electrode and the stake. No dry grass etc between the stake and smart electrode please!



Figure 24 Stainless steel stake, 457 mm x 9.5 mm

7.5.2 Non-polarisable electrodes

Non-polarisable electrodes are used in self-potential (SP) surveys. The non-polarisable electrodes are shipped dry. To prepare for use, just unscrew the end with the porous tip, and fill with distilled water to 1 cm (1/2") below the threads. Replace the tip and shake the electrode to dissolve the copper sulfate crystals.

Note that there shall always be some undissolved copper sulfate crystals in the



Figure 25 Non-polarisable electrodes.

electrode, i.e. the copper sulfate solution shall be saturated.

For operation, connect the top copper terminal of the electrode to the potential cables (M and N). Remove the vinyl protective cap from the ceramic porous tip. Place ceramic tip in contact with the moist soil and take your reading.

Always replace the vinyl cover on the electrode after each usage to prevent moisture loss in the ceramic plug.

If the solution level is getting low, remove the porous tip end of the electrode and fill with distilled water. Replace the end piece, making sure both ends are on firmly to affect proper sealing. Shake electrode to obtain proper solution saturation.

7.6 Common problems

7.6.1 Negative readings

Sometimes negative readings appear on the screen both for $\Delta V/I$ and ρ_a . This is most commonly caused by cables being connected the wrong way (reversed A and B or M and N). Therefore check that your cables are connected correctly.

If the standard deviation σ is high and you measure negative readings at the same time, it may be because the measured signal is too small compared to the background noise. In this case try to increase the current output (Menu 1, selection F3) in order to get a stronger signal to measure.

If nothing else helps try an electrode array with stronger signal. Signal strength for different arrays increase in the following order: dipole-dipole, Schlumberger, Wenner, with Wenner having the strongest signal strength. Note that lateral resolution is in reversed order so that you may want to use dipole-dipole if possible.

7.6.2 High standard deviation

Normally standard deviation (σ) values less than 2% are acceptable for most applications. If larger standard deviation values are presented on the screen during measurement, the signal to noise ratio can be improved by increasing the current output (menu 1, selection F3). When performing Schlumberger sounding, a large σ value may indicate that the MN electrodes need to be moved out in order to create a better signal to noise ratio.

7.6.3 Difficulty to send out required current

The Sting will automatically switch the current down to the next lower setting when the ground conditions are such that the required current can not be sent out. If the ground resistance is very high the Sting may not be able to send out a current at all. In such case the Sting will issue the HVOVL message and stop. In most cases, this is caused by very high contact resistance between the **current** (A and B) electrodes and the ground. By pouring about ½-1 liter salt water on the ground where the stainless steel stake is planted the resistance between the stake and the ground can be bridged. In many cases this simple action can reduce the contact resistance from several thousand ohm to only a few hundred ohms. If the Swift system is used be careful not to pour salt water on the Swift cable with smart electrodes.

Note that high contact resistance does not only occur in dry ground but sometimes also in wet soil. Clean water, like rain water has very high resistance and if there are low concentrations of minerals in the soil the contact resistance can be very high even in conditions of wet soil. A little bit of salt solution around the stake will help also in these cases.

7.7 Helpful hints for a successful Sting/Swift survey

- In order to create a large contact surface to the ground, knock the electrode stakes into the ground so that the crossbar is about 5 cm (2") above ground.
- Water the stakes with some saltwater, about ½ liter (½ quart) for each stake. Make sure not to pour salt water on the smart electrodes.
- Make sure that the smart electrode makes metallic contact to the stake, i.e. there is no grass or rubber band between the smart electrode and the stake.
- On a windy day, double up on the rubber bands so that the smart electrodes are held firmly to the stake.
- Do not let the yellow Swift cable hang on branches so that wind movement is transferred to the smart electrodes. The slightest movement may cause noisy data.
- Make sure that the stakes are free from dirt, corrosion or rubber residues where it makes contact to the smart electrode. Especially when using salt water, electrolysis has a tendency to corrode the electrode stakes resulting in poor contact. The contact surface can easily be cleaned using a wire brush or steel wool.
- After hours in the sun, the rubber bands may leave a rubber residue on the switches (steel cylinders) resulting in poor connection. Use steel wool to polish off any rubber residue on the switches.
- Make sure to charge the internal battery in the Swift interface box every night.
- Be careful with the Swift cable, **never drag the cable**, always “walk” the cable in and out of the box.

8. Resistivity methods

8.1 Vertical electrical sounding

Vertical electrical sounding, sometimes called electrical drilling, is a method where the earth resistivity meter is used to measure thickness of horizontal layers and their associated electrical resistivity. The electrical resistivity can in many cases be used to classify different horizontal layers in geological terms such as clay, sand and gravel, bedrock, etc.

Vertical electrical soundings can be performed either with regular manual cables or automatically using the Sting/Swift system. Below is a description on how to perform sounding using regular manual cables.

The method utilizes four electrodes placed in the ground on one line symmetrically around a mid-point, the measurement point. A current I , is sent out through the outer electrodes and the potential difference ΔV between the inner electrodes is measured simultaneously. The measurement and the distances between the electrodes are used to calculate the apparent resistivity. The electrodes are moved out around the midpoint and a new measurement is taken. For each new measurement a new apparent resistivity is calculated. Since the current tends to penetrate the ground deeper when the current electrodes are further apart, changes in apparent resistivity reflect changes in resistivity/geology at different depths. The method assumes that the ground consists of geological layers which are homogeneous and horizontal.

The vertical electrical sounding is normally performed with the Schlumberger or the Wenner electrode configuration. We strongly recommend the Schlumberger electrode configuration because of two reasons:

- When using the Schlumberger method, most of the time, you only have to move the

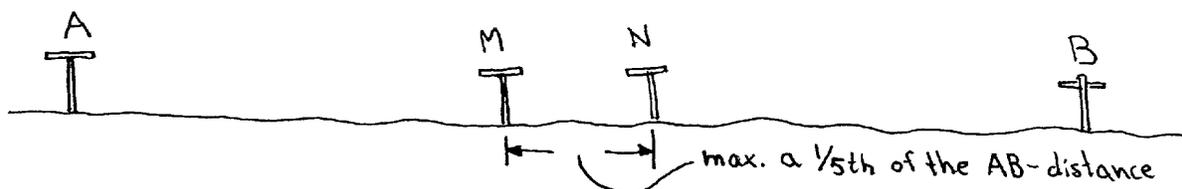


Figure 26 The MN distance is kept small, less than a 1/5th of the AB distance.

outer current electrodes for each measurement, thereby saving time.

- Since the inner potential electrodes stay in the same place, your data will be less affected by local in-homogeneities and therefore tends to be less "noisy."

When performing Schlumberger sounding, one uses two inner potential electrodes (M and N) placed close together and two current electrodes (A and B) at a distance. Never let the MN distance become larger than 1/5th of the AB distance (see). The electrodes are connected to the instrument with a set of cables on four plastic cable reels. Four jumper cables with banana plugs in one end and Mueller clips in the other are used to connect the cable reel to the electrode.

For best performance in the field, the cables are to be used in the following way. Always have the cable reels close to the electrodes (see)that way it is easy to un-reel cable when the electrodes have to be moved. Use the jumper cables to connect the electrodes to the reel. The A and B electrodes should be connected to the A and B current terminals on the Sting, while the M and N electrodes are connected to the M and N potential terminals.



Figure 27 Place the cable reel close to the electrode, not the instrument. Use a jumper cable to connect the reel to the electrode.



Figure 28 Tie off cables to some fixed object to prevent cables from accidentally being pulled out of the instrument when the electrodes are moved.

Try to separate the potential and current cables as much as possible to prevent error caused by "cross-talk" between the cables (see).

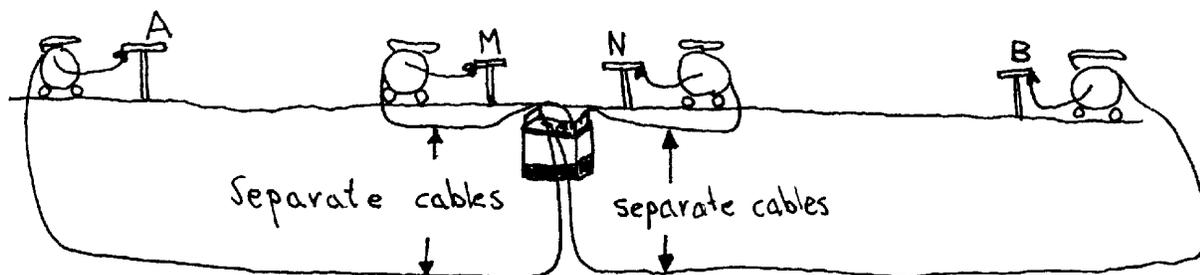


Figure 29 Make sure to separate the cables in order to avoid cross-talk between cables.

Also, it is a good practice to "tie off" the cables to some fixed object, for example a wooden (non-conductive) stake, close to the instrument, to prevent the cables from accidentally being pulled out of the instrument when the electrodes are moved (see).

The instrument sends out a pre-selected current through electrode A and B. At the same time the potential (voltage) is measured between electrode M and N.

The Sting can send out a current in the range 1-500 mA. Try a low current setting, like 5 mA when the current electrodes are close together. If the error displayed on the screen is high (maybe more than 1%), increase the current one step and try again.

WARNING Make sure no one is touching the electrodes when you are measuring. Specially with the high voltage mode engaged, the voltage can reach 400 V!

Take readings so that the data will be evenly spread over a double logarithmic diagram. Below is one set of AB/2 distances for 7 readings per logarithmic decade.

Seven readings per decade (meters):

0.5 0.7 1.0 1.4 1.9 2.7 3.7 5.0 7.0 10 14 19 27 37 50 70 and so on.

Of course you can make up your own set of distances if you want denser readings.

Never let the MN distance become more than a fifth of the AB distance. If you start with an AB/2 distance of 0.5 meter, then the MN/2 distance should not be larger than 0.1 (less than a fifth of the AB/2 distance). After taking a reading you move your A and B electrodes to the next station (0.7 meter) and take a new reading while keeping the M and N electrodes at 0.1 meters.

Keep taking readings as described above. Eventually you must move your MN electrodes since the potential created over the M and N electrodes by the current through A and B is too small to be detected by the Sting. This typically occurs when V/I is somewhere below 10 mohms.

A good way to determine when you have to move the M and N electrodes is to closely monitor the error for each measurement. Increase the current when the error increases. At a certain point the noise can no longer be reduced by increasing the current. Instead the potential electrodes have to be moved. Then move the M and N electrodes out to approximately 1/5th of the A and B distance and take your next reading. Keep moving the A and B electrodes and take new readings until you have to move the M and N electrodes the next time.

In order to ensure data quality, it is a good practice to always plot your data in the field on a double logarithmic diagram. Use enclosed field diagram (Appendix 1) to plot the data. This diagram has vertical lines for each $AB/2$ distance, 7/decade, to ensure fast and convenient plotting in the field.

Using the Sting, it is easy to plot apparent resistivity versus $AB/2$. Just read apparent resistivity from the instrument display and plot against the $AB/2$ distance. Each curve section (i.e. for same M and N distance) should ideally describe a smooth curve. The different sections are typically offset somewhat from each other. It is important to plot the data as you are measuring since you can then directly detect any mistakes and correct them by repeating the reading immediately while on location.

How far out shall I go with my A and B electrodes? A good rule of thumb, which is valid in many cases, is to go out at least so far that the distance between the A and the B electrode is five times the depth you want to reach. This is not always true but is at least a good guideline to follow.

For your convenience we have enclosed an empty sheet of the double logarithmic paper. Please feel free to photo copy and use as you wish.

8.2 Profiling

Profiling, sometimes referred to as "trenching," is used to map horizontal changes in resistivity. A fixed electrode array is moved as an entity forward along a line and a reading is taken at each position. The array can be oriented parallel or perpendicular to the survey line, most commonly the electrode array is parallel to the survey line.

Profiling can be performed either with regular manual cables or automatically using the Sting/Swift system. Below is a description on how to perform profiling using regular manual cables.

The most suitable electrode array for profiling is the Wenner array. When using the Wenner array the last electrode is normally moved up front at the selected a-spacing in the direction of advance along the survey line.

When using the Wenner array the a-spacing (spacing between the electrodes) is considered the depth of investigation. The a-spacing is chosen so that it will cover the depth of interest. Sometimes it is of interest to survey the same line with several different a-spacings in order to see features at varying depths. It is recommended to carry out a few vertical electrical soundings over the target structure in order to determine the depth of interest.

The measurement point is defined as the midpoint of the array and is plotted as apparent resistivity along profiles or presented as apparent resistivity plotted and contoured in the form of a map. Relatively lower apparent resistivity values are indication of more conductive material, for example electrolyte-contaminated pollution plumes, salt water intrusions or material with more clay content.

8.3 The mise-a-la-masse method

Mise-a-la-masse measurements, sometimes referred to as the "charged-body potential method", are performed with the Sting R1 in the MISE-A-LA-MASSE mode (Menu 1, F1 Array type, MISE A LA MASSE).

The general procedure for a mise-a-la-masse survey is as follows. One current electrode (A) is placed in contact with the conductive body (ore body, underground pipe line, pollution plume etc.) which you want to map the extent of. The other current electrode (B)

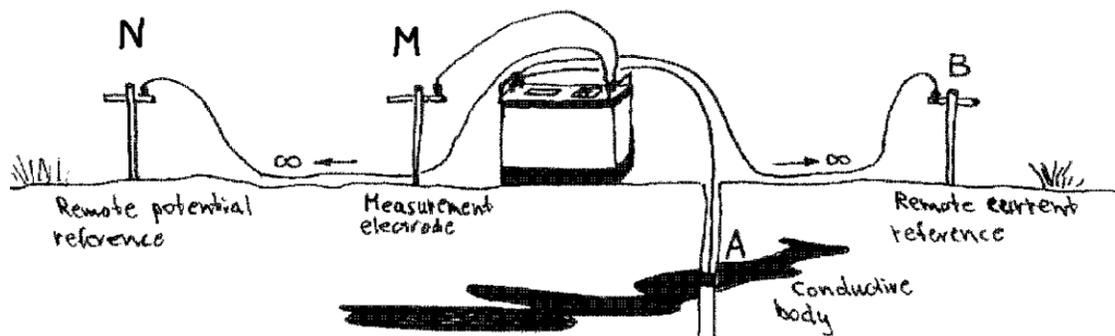


Figure 30 Sting used for mise-a-la-masse measurement. Note that N and B are reference electrodes placed at "infinity".

is placed at a large distance. The voltage distribution is measured around the conductive body using one reference potential electrode (N) at large distance (diametrically placed in relation to the current reference electrode), and one electrode (M) which is moved between stations to be surveyed. Go to M1/F2 and enter the X- and Y-coordinates of the probing electrode M before each measurement.

Using the Sting in the mise-a-la-masse mode, you will get the measurement value displayed in milli-ohms, ohms or kilo-ohms for each station measured. When drawing your potential distribution map, you simply plot the values and consider a fictitious transmitted current of 1 Amp. The measured resistivity value then equals the corresponding potentials in milli-volt, volts or kilo-volts per ampere.

If the electrical noise in the area is high, increase the current and thus improve the signal/noise ratio.

Use stainless steel electrodes both as current and as potential electrodes for mise-a-la-masse measurements.

8.4 Laboratory measurement of soil samples

The resistivity of any material is defined as the resistance in ohms (Ω) between opposite faces of a unit cube of that material. If R is the resistance of a block of conductive material having length (L), in a cross-sectional area (A), then the resistivity (ρ) is expressed by the formula:

$$\rho = \frac{R \times A}{L}$$

Resistivity, being a fundamental property of material, is independent of the volume. Resistance, however, depends upon the shape and the size of the specimen.

The soil resistivity test box is designed so that the readings are taken directly in Ωcm . Therefore the values are not to be multiplied by any "box constant."

8.4.1 Equipment

The equipment required for the measurement of the resistivity of soil samples in the laboratory are:



Figure 31 Test box for soil samples.

1. the Sting R1, earth resistivity meter
2. a soil resistivity test box
3. a straight edge
4. four insulated test leads
5. water (tap and distilled)

8.4.2 Sample preparation

Soil samples should be representative of the area of interest. Where the stratum of interest contains a variety of soil types, it is recommended to sample each type separately. It will also be necessary to prepare a mixed sample. The sample should be reasonably large and thoroughly mixed so that it will be representative.

The resistivity of soils is to a large degree also a function of moisture content. Therefore it is important to protect the samples from drying during storage/transportation by wrapping them in plastic sheet or putting them in plastic bags. Measurement should be taken as soon as possible after sampling and as soon as possible after removing them from their container/wrapping.

Unscrew and remove temporarily the two potential terminals (brass pins) to facilitate filling the soil box. The soil should be well compacted in layers, with air spaces eliminated as much as possible. Fill the box and level off the top with a straightedge. Replace the two potential brass pins.

The measured resistivity is depending on the degree of compaction, moisture content, constituent solubility and temperature. The effect of variation in compaction and moisture content can be reduced by fully saturating the sample before placing it in the box. When possible use ground water from the sample excavation for saturation. Otherwise use distilled water. If the soil resistivity is expected to be below 10,000 Ωcm , local tap water can be used without introducing serious error. Some soils absorb moisture slowly and contain constituents that dissolve slowly, and the resistivity may not stabilize for as much as 24 hours after saturation.

The saturated measurement will provide a "worst-case" resistivity and can be usefully compared with "as-received" resistivity measurements.

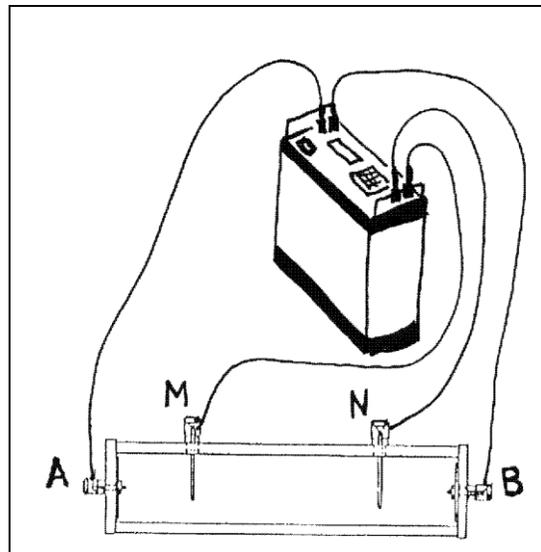


Figure 32 Sting connection to the soil box.

Surplus water should not be poured off as this will remove soluble constituents.

8.4.3 Measurement procedure

- Connect the Sting to the terminals of the soil box, see
- Go to menu 1 and set the array type (F1) for RESISTANCE.
- Go to menu 6/F1 and set the Swift option to Off.
- Go to menu 1 and set the current (F3) to a low setting, for example 1 or 2 mA. Press **MENU** to get back to menu 1.
- Press the measurement key (MEA) and note the result on the display. Note that the read-out is given directly in Ωcm (even though the display will not show cm). Also carefully note the unit prefix, for example k Ω for 1000 Ωcm (kilo Ωcm).

8.4.4 Cleaning

The soil box should be thoroughly cleaned between measurements in order to avoid contamination by previous sample. It is easy to disassemble the box and clean, first with tap water then rinse with distilled water.

8.4.5 Temperature correction

The resistivity of soils is a function of temperature. In order to obtain results which best agree with field conditions, the sample should be at the same temperature as would be experienced at the test site.

Correction to 15.5°C (60°F) is recommended if the sample temperature exceeds 21°C (70°F).

$$R_{15.5} = R_T \left(\frac{24.5 + T}{40} \right)$$

where T = soil temperature, °C

R_T = resistivity at T °C

8.5 Soil resistivity measurements for corrosion control

Soil resistivity measurements are performed to be used in the control of corrosion of buried metal structures. Normally the measurements are carried out using the Wenner electrode configuration with a number of specified Wenner-spacings. The Wenner spacing used is in most cases fairly short, most commonly not more than 5 meters (15 feet). For spacing of 1 - 5 meter (3 - 15 feet) use at least 20 mA or more in order to get noise free data.

The resulting resistivity measurement represents a weighted average resistivity of a hemisphere of soil of a radius equal to the electrode spacing (Wenner spacing).

The result is reported as Ωcm . If the Sting has been set for meters (Ωm) in the field, see page 42, then just multiply the apparent resistivity with 100 to get the value in Ωcm .

In the United States, soil tests are standardized to be measured with Wenner-spacing in feet and the result reported in Ωcm . This is easiest achieved by setting the Sting in feet-mode, see page 42, when collecting the field data. Then change the Sting to meter-mode before viewing or dumping the data to a computer. In meter-mode all apparent resistivities are automatically recalculated to Ωm , therefore this value only has to be multiplied by 100 to give Ωcm .

9. Resistivity\Apparent resistivity

In homogeneous ground the apparent resistivity is the true ground resistivity (the table below shows some typical resistivity values for naturally occurring materials).

Typical Ranges of Resistivity for Some Terrestrial Geological Materials	
Rock/material type	Resistivity Range (Ωm)
Igneous	100 - 1000000
Limestone	100 - 10000
Sandstone	100 - 1000
Sand and gravel	600 - 10000
Alluvium and sand	10 - 800
Clays	10 - 100
Soil	1 - 10
Fresh water	3 - 100
Sea water	0.2 - 1
Copper (native)	0.0000002

In inhomogeneous ground the apparent resistivity represents a weighted average of all formations through which the current passes.

The following formulas have been used in the Sting when calculating the apparent resistivity.

Schlumberger configuration:

$$\rho_a = \pi n(n+1)a \frac{\Delta V}{I}$$

Wenner configuration:

$$\rho_a = 2\pi a \frac{\Delta V}{I}$$

Dipole-dipole:

$$\rho_a = \pi n(n+1)(n+2)a \frac{\Delta V}{I}$$

Pole-dipole:

$$\rho_a = 2\pi n(n+1)a \frac{\Delta V}{I}$$

Azimuthal configuration:

$$\rho_a = 2\pi a \frac{\Delta V}{I}$$

Mise-a-la-masse:

$$\frac{\Delta V}{I}$$

SP, gradient:

$$\frac{\Delta V}{a}$$

SP, absolute:

$$\Delta V$$

Resistance configuration:

$$\rho = \frac{\Delta V}{I}$$

10. Maintenance

10.1 Instrument test

A test resistor is supplied with the instrument. Use the test resistor to check proper functioning and calibration of the Sting.

Connect the test resistor leads, one side to the current terminals and the other side to the potential terminals. With the Swift mode off (menu 6 F1=Off), set the instrument in RESISTANCE mode (menu 1, F1, RESISTANCE). Use a current setting of 2 mA (menu 1, F3, 2 mA). Press the MEA key to take a reading. At room temperature (72°F), the measured reading should correspond to the test resistor value +/- 1%.

Contact your Sting distributor or Advanced Geosciences, Inc. in case the value deviates more than 1% from the test resistor value.



Figure 33 Test resistor.

10.2 Fuse

The fuse holder is located inside the instrument enclosure. To replace the fuse, proceed as follows. Use a 9/64" Allen wrench to remove the four hex screws located under the handles on the instrument front panel. Carefully slide the circuit board assembly out of the instrument enclosure by holding the instrument enclosure firmly and pulling the handles on the front panel. The fuse holder is located on the left side of the top circuit board. For the Sting R1 use a 5x20 mm type, 2.0 Amp slow blow fuse and for the Sting R1 IP use a 5x20 mm type, 15 Amp fuse for replacement.

10.3 Clip-on battery pack

The Sting clip-on battery pack is a 12 V, 5 amp/hour NiCd battery. The battery pack is designed to be recharged many times. With age however, the capacity of the battery will go down and at a certain time the capacity will be too low to be practical to use in field work. The battery pack can then be sent to your distributor for reconditioning or you can order and install the battery cells yourself. Please contact your local distributor for further details.

In order not to damage the battery pack, both the Sting and the Swift box has a shut-off circuit so that the batteries can not be discharged below 9 Volts. However if the instrument has been sitting on the shelf without charge for a long time it may have discharged completely.

If a battery pack shows less than 9 Volt it may have been permanently damaged. You may be able to recover the battery by performing the following steps.

Place the battery pack on a power supply. The power supply should be able to provide 24 volts, but the current should be limited to a maximum of 450 mA. The 450 mA charge should be applied for 24 hours. This high voltage, low rate charge may recover any low voltage cells in the pack.

After charging, let the battery rest for 1 to 2 hours and read the open circuit voltage. (OCV). If the OCV is below 12.5 volts the pack is not good and should be recycled. If the OCV is above 12.5 volts, let the battery rest for about 24 hours. If the OCV is still above 12.5 volts, the battery still has some life.

While voltage is good, runtime (5 Ah capacity) may not be fully recovered. Put the battery in your Sting to test it for runtime to see if the capacity has been recovered. If the battery passes the voltage and runtime tests, it has been recovered.

10.4 Memory back-up battery

The memory of the Sting is being backed-up by a lithium battery cell when the instrument is shut off or when the main clip-on battery pack is removed for charging. When the instrument displays "Warning! Back-up battery low, save RAM data to PC!" on power up, the lithium battery needs to be replaced within a reasonably short time. To replace the lithium battery, proceed as follows:

- Save all your important data in the Sting memory by downloading the data to a computer (see section 6.1.9 for instructions on how to download data).
- Remove the main clip-on battery from the instrument.
- Use a 9/64" allen wrench to remove the four hexscrews located under the handles on the instrument front panel. Carefully slide the circuit board assembly out of the instrument enclosure by holding the instrument enclosure firmly and pulling the handles on the front panel.
- Disconnect the front panel/circuit board assembly from the instrument enclosure by disconnecting the power cable which goes to the bottom of the instrument enclosure.

- Facing the instrument front panel, the lithium battery holder is located on the left side of the bottom circuit board.
- Carefully slide the old battery out of its holder. Using a tweezers may assist in the removal of the old battery.
- Slide a new 3 V CR2032 lithium battery cell, with the positive side up, into the holder.
- Connect the battery power cable and assemble the instrument.
- Go to menu 3 and erase the memory (M3/F1/.) This will reset the memory and make it ready to accept new data.
- Go through all menus and check the settings on each. You will have to enter new values where the old ones have been lost. Many values have been reset to instrument defaults which may not be what you had used previously.

10.5 Swift cable

Small cuts and holes in the yellow polyurethane jacket of the Swift cable can be repaired by using a soldering iron set for not more than 200°C to melt together the insulation. Use extreme caution not to melt the insulation of the inner leads.

11. Error codes and messages

- HVOVL** Issued when the Sting can not find any usable current setting. Usually caused by a discontinuity in the AB circuit. Check for disconnected cables or try to decrease current electrode contact resistance by wetting the soil around the electrode with water.
- TXOVL** Issued when there is a problem with the transmission of the current after the measurement cycle has started. Could be caused by poor electrode contact to ground (varying resistance) or loose connections somewhere in the AB circuit. When using the Swift, the measurement is automatically restarted if Repeat (M6/F3) is not set to Off. If this error persists during the last Repeat, then the Swift measurement is continued and this measurement station is skipped.
- INOVL** Issued when the input amplifier has been overloaded during measurement cycle 2 or higher. If the input amplifier is overloaded during the first cycle the measurement cycle is restarted with a lower gain without error message. When using the Swift, the measurement is automatically restarted if Repeat (M6/F3) is not set to Off. If this error persists during the last Repeat, then the Swift measurement is continued and this measurement station is skipped.
- BATT** When in automatic Swift mode the instrument system acquires data at a high rate and therefore also consumes power at a higher rate. Therefore in order to monitor the battery voltage, the Sting will check battery voltage, displaying "BATT", every 10 readings. If the voltage is below 10.8 V, a warning is issued for 3 seconds before the next reading is performed. If the voltage is below 10.0 V, a warning is issued and the measurement is interrupted. At this point replace with a fully charged battery and press **MEA** to continue.

Warning! Back-up battery low, save RAM data to PC! See page 98 for information on how to act.

Error: data in RAM! See page 43 for further information.

Error: Memory full See page 45 for further information.

Calibration Error!! when turning the instrument on. The instrument needs to be calibrated. Contact your nearest AGI distributor or Advanced Geosciences, Inc.

Repeated beeping, blank screen Battery too low, charge the battery.

12. Technical specification

Measurement modes	Apparent resistivity, resistance, voltage, battery voltage
Measurement ranges	400 kohms to 0.1 milliohm (resistance) 0-500 V full scale autoranging (voltage)
Measuring resolution	max 30 nV, depends on voltage level
Screen resolution	4 digits in engineering notation.
Output current	1-2-5-10-20-50-100-200-500 mA,
Output voltage	The user can switch between high and low voltage limit for the transmitter (800 Vp-p or 320 Vp-p voltage limit). Actual electrode voltage depends on transmitted current and ground resistivity. Instrument always starts up in low voltage setting.
Input gain ranging	Automatic, always uses full dynamic range of receiver.
Input impedance	>20 Mohms
Input voltage	Max 500 V
SP compensation	Automatic cancellation of SP voltages during resistivity measurement. Constant and linearly varying SP cancels completely.
Measure cycles	Running average of measurement displayed after each cycle. Automatic cycle stops when reading errors fall below user set limit or user set max cycles are done.
Cycle time	Basic measure time is 1.2, 3.6, 7.2 or 14.4 s as selected by user via keyboard. Autoranging and commutation adds about 1.4 s.
Signal processing	Continuous averaging after each complete cycle. Noise errors calculated and displayed as percentage of reading. Reading displayed as resistance (\square V/I) and apparent resistivity (\square m or \square t). Resistivity is calculated using user entered electrode distances.
Noise suppression	better than 100 dB at f>20 Hz better than 120 dB at power line frequencies (16 2/3, 20, 50 & 60 Hz)
Total accuracy	Better than 1% of reading in most cases (lab measurements). Field measurement accuracy depends on ground noise and resistivity. Instrument will calculate and display running estimate of measuring accuracy.
System calibration	Calibration is done digitally by the microprocessor based on correction values stored in memory. The correction values are found in final production testing and are also established during later periodical recommended yearly checks at authorized service centers.
Data storage	Full resolution reading average and error are stored along with user entered coordinates and time of day for each measurement. Storage is automatic.
Memory capacity	Over 3000 measuring points can be stored in the internal memory.
Data transmission	RS-232C channel available to dump data from instrument to PC computer on user command. PC program supplied with instrument.
Communication setting	4800 baud, 8 data bits, no parity, 1 stop bit
User controls	20 key tactile, weather proof keyboard with numeric entry keys and function keys. ON/OFF switch. MEASURE button integrated within main keyboard. LCD contrast adjustment. LCD night light switch (push to light)
Display	Alphanumeric LCD display (4 lines x 20 characters). Used for display of results and menus. Night light by LED backlight panel available on switch operation.
Connectors	4 banana plug pole screws for current and potential electrodes. 10-pole KPT connector for external power, charge, RS-232 and synch connections.
KPT connector signals	A Transmit RS-232 data B Battery (-) C Battery (+) D - E +5V supply out for external units F Receive RS-232 data G Signal ground H Synchronization input and remote start J - K Synchronization output
Power supply	12 V, 5 Ah NiCd rechargeable snap-on battery. External power connector on front panel, the instrument automatically selects external battery if present.
Operating time	Depends on conditions. At 20 mA output current and 10 k Ω electrode resistance more than 2000 cycles are available from a fully charged battery pack.
Battery charger	Dual stage charger with switchable input (115/230 V AC @ 50/60 cycles).
Instrument dimensions	Width 112 mm (4.4"), length 293 mm (11.54") and height 308 mm (12.11").
Instrument weight	6.6 kg (14.5 lb) including snap-on battery pack.

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