

コメント [M1]:

Sting R1 Instruction Manual

Release 2.5.5

Advanced Geosciences, Inc.

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Sting R1 Instruction Manual Release 2.5.5
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1. はじめに

1.1 保証

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1.2 Stingの開梱

以下の項目が、標準のStingの出荷品として含まれています。

項目	品名	数量
1	Sting 本体, 製造番号は, 函体の右側に貼り付けてあります。	1
2	クリップ取り付け型バッテリーパック	1
3	バッテリー充電器, 110/220 V用	1
4	充電器入力ケーブル	1
5	通信ケーブル, Sting/PC用	1
6	STINGDMP, データ転送ソフトウェア 3.5"フロッピーディスクによる	1
7	操作マニュアル	1
8	試験用抵抗	1
9	六角レンチ, 9/64インチ	1
10	フェーズ (2本), 2.0 アンペア, 非即断, 5x20 mm	1

IMPORTANT: バッテリー充電器の入力電圧の設定は, 開梱後直ちに適切な電圧に(110 または 220 V AC)設定すること。

Swift 自動多電極システムが注文されている場合は, 以下のものがさらに含まれています。

項目	品名	数量
11	Swift インターフェースユニット	1
12	送信/受信ケーブル (ABMN ケーブル)	1
13	Sting/Swift 通信ケーブル	1
14	外部電源ケーブル	1
15	User Load ソフトウェアディスク	1
16	Sting/Swift Utility ディスク	1
17	Swift ケーブル, 多数の小電極スイッチ	1
18	ステンレス製電極棒	注文明細による
19	RES2DINV 比抵抗イメージングインバージョン ソフトウェア (MS DOS 型PC用)	注文明細による
20	現場運搬木箱	注文明細による

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1.3 このマニュアルについて

このマニュアルでは以下の熟語を用いています。

例

記述

M6
M7/F1

キー6を押して、メニュー6へ行く。
キー7を押して、メニュー7へ行き、さらに
F1キーを押す。

2. クイックスタート

すでに比抵抗電気探査装置とその手法について、いくらかの知識を持っている場合には、この章を読んでください。

Sting R1 は以下の4つの基本モードで使用できます。

1. 現場作業による通常の4電極の移動による、通常のメモリー型比抵抗電気探査装置 として (エラー! 参照元が見つかりません。 項のマニュアルモード参照)
2. Swift 自動多電極システムと併用したdipole-dipole 法比抵抗イメージングのデータ集録として(2.2 項の自動モード参照)
3. Swift自動多電極システムWith the Swift automatic multielectrode system programmed by the operator (see section 2.3 User mode) to perform any resistivity measurement automatically.
4. With the Swift automatic multielectrode system controlled by a PC type computer (see section 2.4 PC mode) in the field.

2.1 手動モード

以下の手順で使用できます:

Sting R1本体のフロントパネル上にある電流ターミナルA, B、電位ターミナルM, Nと4つの地上電極棒を接続します

バッテリーパックを取り付けてから、ON/OFF (I/O) スイッチをON (I) 側にして電源を入れます。

測定を始める前に、いくつかのパラメータ設定が必要です。

1. 1ボタンを押してメニュー1に進み、それからF1ボタンを押して探査に用いる電極配列のタイプを選択します。+ボタンや-ボタンを押すによってサポートされている電極配列のタイプがスクロールし表示されます。探査に用いるタイプになるまでスクロールしたら、MENボタンを押してメニュー1に戻ります。選択した配列タイプは変更をかけるまで有効です。ここでUSER MODEとはSwift自動多電極システムでしか使われませんので、選択しないでください。

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2. F3ボタンを押します。それから+ボタンや-ボタンを押して適切な電流設定を選択します。もしも地域的な地質条件によりSting R1本体から希望の電流を地中に送ることが出来なければ、さらに低い電流設定に自動的に切り替わります。
3. 2ボタンを押して、メニュー2に進みます。F1ボタンを押します。+ボタンや-ボタンを押してサイクル回数の設定を選択します。選択終了したらMENボタンを押してメニュー2に戻ります。
4. F2ボタンを押します。それから+ボタンや-ボタンを押してエラー率の適切なしきい値（たいていは2%）を選択します。スタッキング中にこの値を下回ると、測定は自動的に停止します。しかしそれまでの測定データは内部メモリーに保存されています。MENボタンを押してメニュー2へ戻ります。
5. F1ボタンに続きF3ボタンを押して長さの単位をfeetとmeterから選択します。
6. F2ボタンを押してmeasurement timeを3.6 secと選択します。それからMENボタンを押してメニュー2へ戻ります。
7. 3ボタンを押してメニュー3に進みます。F3ボタンに続きF1ボタンを押し、それから、（ドットボタン）を押して以前のメモリーデータを削除します。データ削除する前にメモリー内の重要なデータは全てコンピュータにダウンロードし保管しておいてください。MENボタンを押してメニュー3へ戻ります。
8. 4ボタンを押してメニュー4へ進みます。F1を押して日付・時間をセットしてください。
9. automatic measurement modeを必ずOFFにします。OFFにするには6キーを押してメニュー6へ進み、F1ボタンを押します。そこで+/-ボタンと使いOFFに切り替えます。それからMENボタンを押してメニュー6へ戻ります。

You are now ready to start measuring.

10. メニュー1へ進み、F2ボタンを押して電極間距離を入力します。F3ボタンを押して間隔を入力すると自動的にメニュー1画面へ戻ります。これによりSting R1本体の測定準備が完了します。
11. MEA (Measurement) ボタンを押して測定サイクルを開始します。測定されたデータは自動的にメモリー内に保存され、後でコンピュータへダウンロードできます。もしもerror σ is too largeと表示されたら、メニュー1からF3ボタンを押して出力電流の設定値を上げてから再度測定してください。
12. 最初の読み込みが行われたら、上記のステップ4へ戻り、電極間距離の設定を変更し、新しい測定を始めます。

測定結果はLCD画面上に表示されます。結果画面は使用した電極配列タイプにより異なります。下のfigure1,2をご覧ください。

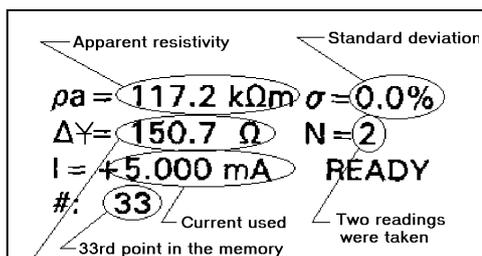


Figure 2 Result display for Schlumberger, Wenner, dipole, pole-dipole and azimuthal.

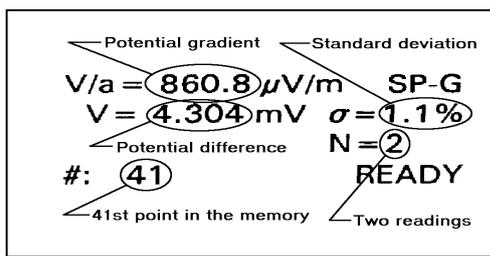


Figure 1 Result display for the SP-gradient array type

2.2 自動モードでSwift電極システムでdipole-dipole イメージング測定を行う

このモードはSwift自動多電極システムを用いて自動的にdipole-dipoleイメージングするために使われます。

Sting/Swiftシステムは効率的に現場データを収録します。以下の項では、dipole-dipoleによって断面図を得る方法を段階的に説明します。

2.2.1 ケーブルを正しく用いて、良いデータを得る

円柱状のステンレススチール製スイッチが取り付けられているSwiftケーブルは、このシステムにおいて特に壊れやすく敏感な部分ですので、慎重に取り扱ってください。ケーブルの扱い方のルールを下に示します。

- ケーブルは地面に引きずらず、ケーブル収納できるボックスから出し入れしてください。
- ボックスにケーブルを収納するときにケーブルを押し付けしないでください。ケーブルの両端をケーブルの上に乗せるように、ケーブル把を横たえてください。

2.2.2 dipole-dipole法による現場測定のためのシステムの設定

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 switches
6. Stainless steel electrode stakes

全てのバッテリーが充電されていることを確認してください。Swift interface boxは使用日ごとに充電してください。

2.2.2.1 現場での準備作業

- まず測線に巻尺を張ります。
- ステンレススチール製の電極棒を計画電極間隔ごとに地面に差し込みます。
- Swiftケーブルを展開します。ケーブルに取り付けられているスイッチを各電極棒付近に落としていきます。スイッチにはアドレスが割り当てられており、スイッチ付近にそのアドレス番号が印刷されています。Swiftケーブルを複数本用いる場合には、**特に正しい順番でレイアウトするように注意して下さい。** i.e. 1, 2, 3.....27, 28

- 電極棒にスイッチを当て、ゴムバンドで固定し、金属的な接触を保ちます。風の強い日にはゴムバンドを二つ重ねて使ってより確実に接触させてください。

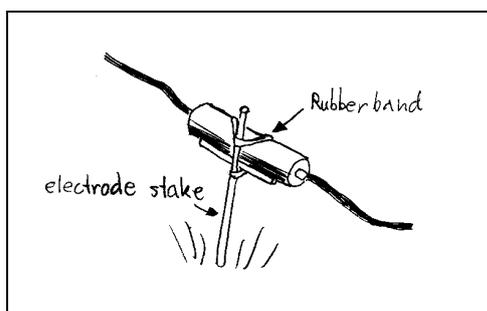


Figure 3 Rubber band each switch to its electrode stake

2.2.2.2 機器の接続法

- Sting console と Swift interface box はケーブルレイアウトの末端に配置することも可能です。しかしこれらをケーブルレイアウトの中心に配置すると、末端アドレスのスイッチでの電位減衰を最小限に抑えることが出来ます。そのため右図のように Sting console と Swift interface box をレイアウト中央部に配置することをお勧めします。
- Swiftケーブルの中央側のコネクタをSwift interface box上にある“Electrode Cable”コネクタに接続します。
- Swift box上のAB MNコネクタをSting上のA, B, M, Nターミナルに接続します。
- Sting本体フロントパネル上のRS232コネクタとSwift box上のSting Control & Dataコネクタを、Sting/Swift communication cableを使って接続します。
- Swiftシステムを使った自動探査には、12 V DC 外部バッテリーを使うことをお勧めします。
- これでシステムレイアウトは配置されました。下のSting R1本体の設定を行ってから、測定を始めてください。

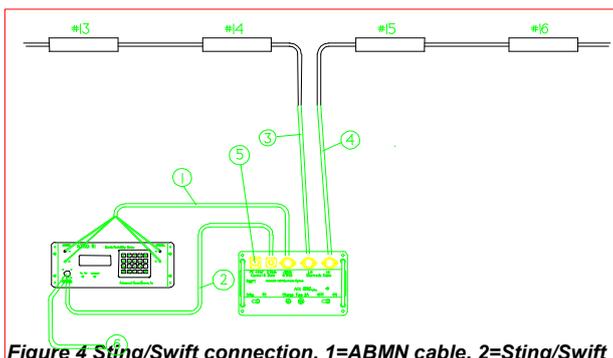


Figure 4 Sting/Swift connection. 1=ABMN cable, 2=Sting/Swift communication cable, 3=Swift cable with low numbers (1-14), 4=Swift cable with high numbers(15-28), 5=receptacle for PC connection, 6=optional connection to 12 V DC battery.

2.2.3 Sting/Swift の測定のためのセットアップ

- StingとSwiftの電源を入れます。
- Swift box上のPC/StingスイッチをSting側にします。
- メニュー3へ進み、以前の記録データを削除するためにF3ボタン、F1ボタン、. (ドット) ボタンを押します。データ削除の前に、以前に収録した重要なデータはコンピュータへダウンロードしてください。

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- メニュー6へ進み、F3ボタンを押してswitch addresses Start= と End= のところへ実際のアドレスを入力します。それからMENボタンを押します。
- メニュー8へ進み、F1ボタンを押してから実際の電極間隔 electrode spacing を入力してください。これによりシステムが自動的にdipole-dipoleデータを読み込めるようになります。

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.

以下に初期設定を示します：

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
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 = 3

この初期設定ではdipole-dipole自動測定を行えます。測定前には、7ボタンを押してメニュー7へ進みcontact resistance test (M7/F1)を行ってください。

2.2.4 Swift でのテスト

Test 1 (M7/F1). このテストでは、測線に沿って接地抵抗 contact resistance を計測します。電極間隔は常に一定ですので、同じような値が得られるはずですが、もしも極端に高い値を示したり、途中で何らかのエラーコードでテストストップしたら、その該当する電極へ行行って、地面との接触が適切であることを確認してください。高い接触抵抗値が地質的な要因によるものであれば、電極棒の差し込んである地面に塩水を注いでください。1 k Ω 以下を推奨しますが、最終的には2 k Ω 以下にしてください。

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特定の電極でテストストップしその問題が解決したら、F1ボタンを押すとその電極からテストを再スタートできます。Sting software version 2.5.5からは内部メモリーに接地抵抗テスト **contact resistance test** を保存できます。

実際の計測をスタートする前に**test (M7/F1)**を行うと、不十分な電極棒接地によるデータ不良を防ぐことができますので、必ず行って下さい。実際の探査中では**Sting**や**Swift**は (M6/F3/F3でOFF設定しなければ) エラーコードによる停止はせず、そのポイントをスキップします。そのため探査開始前でのチェックが重要となります。

探査実行しているとき、データは自動的に**Sting**内のメモリーに保存されています。そして探査後に**STINGDMP software**を使ってMS DOSタイプのコンピュータへダウンロードできます。コンピュータへのデータダウンロードについては**24**ページを参照してください。

Sting本体が停止したら探査終了で、“Ready.”と表示されます。

2.2.5 データ処理

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 STINGDMP.EXE software delivered with your Sting.

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 2D-CONV.EXE (DOS) or the SwiftCnv.exe (Windows) software. The 2D-CONV.EXE software is delivered with the RES2DINV software. Type 2D-CONV NAME and press **ENTER** to convert the data. For information on how to run the SwiftCnv software see section 6.5.

The RES2DINV, purchased separately, inverts the measured apparent resistivity data into “true resistivity,” necessary for accurate depth determination and interpretation. 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.

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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 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.

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 disk marked **Sting/Swift Utility** delivered with your original Swift shipment. The enclosed command files are designed for 3 meter electrode interval but 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 down loaded, see section **UserLoad** ソフトウェア page 54, to the Sting RAM memory using the **UserLoad** 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) totalling 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 Figure 5). This technique is known as the roll-along method and can be used to measure any length of profile.

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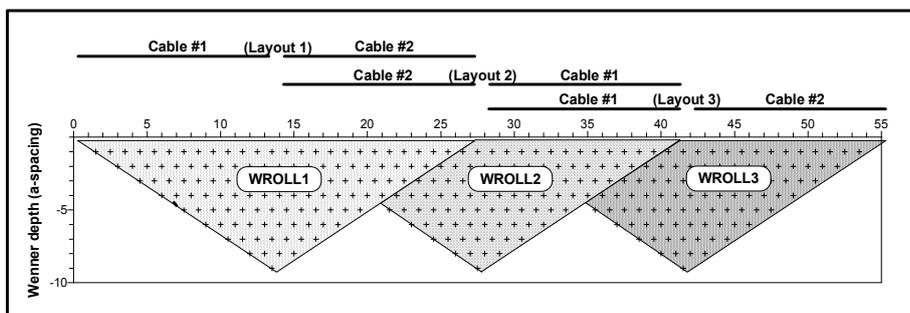


Figure 5 Data coverage using Wenner roll-along with 28 electrodes divided on two cables.
 Note that overlapping readings are not measured as they are redundant.

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:

1. Connect the Sting/Swift system as in Figure 4.
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 **F1** and enter the electrode spacing you are using. This will set the instrument default settings suitable for measurement in most cases.
7. Select USER MODE on Menu 1/F1.
8. Select the WROLL1 file on Menu 1/F2 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

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moved forward, WRoll3 for measurement when cable 2 (electrodes 15-28) has been moved forward.

9. 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).
10. Press Enter (F3) where it says Next=1 (this is starting from line 1 in the command file for the measurement, i.e. start from the beginning).
11. 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 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 section, use the StgdmPw.EXE to download 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 SwiftCnv.EXE Windows 3.xx software. You will find this software on the disk marked Sting/Swift Utility enclosed with the shipment. For instructions on how to run this software go to section **SwiftCnv ソフトウェア** on page 56, 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. Then press "Load Sting file." Finally press "Save converted file." The result is a file with the extension .DAT which you can run directly in the RES2DINV software.

2.4 PC mode

The Sting/Swift system can be used connected to and controlled by an MS DOS type computer. The main advantage is that the data then is stored on the computer harddisk 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 an MS DOS 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

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measurement procedure is found on page 56 section **The Swift software**. 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.

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 an MS DOS type computer with the Swift software installed (Swift software is delivered with your Swift system).

Create a directory named SWIFT in the computer. Copy the SWIFT.EXE and your Wenner command file to the SWIFT directory.

Field preparation

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Make the field preparation described in section エラー! 参照元が見つかりません。 on page エラー! ブックマークが定義されていません。 and connect the instrument as described in Figure 4 on page 15. Connect the computer using the down load cable. Attach the cable to the RS232 port on the computer and the connector marked "PC COM." on the Swift box.

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

- Turn on the computer, the Sting and the Swift.
- Go to the computer SWIFT directory.
- 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=3 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.

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 page 41 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. Being in the computer SWIFT directory, type:

SWIFT /C=FILENAME1 /D=FILENAME2 and press ENTER

This will start the measurement sequence. Use no extensions with the filenames. FILENAME1 should be the name of your Wenner command file, FILENAME2 the name of

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the file where you want your data to appear on the hard drive. The above start command means: start SWIFT using the FILENAME1.CMD file and store all data on the hard drive under FILENAME2.DAT.

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

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19th field

Apparent resistivity

2.5 PCへのデータ転送

There are two different programs for downloading data to a computer. The Stgdmw.exe is a Windows 3.xx program and the Stingdmp.exe is a DOS program.

2.5.1 Stgdmw.exe for Windowsを用いたデータ転送

Stingはバージョン2.5.5からバイナリーダウンロードモードによる高速データダウンロードを行うためのStgdmw.exeソフトウェアを使えるようになりました。またバージョン2.5.5以前のStgdmw.exeソフトウェアは、速度は遅いですがASCIIモードによる本体からのダウンロードができます。Stingソフトウェアのバージョンを確認するには、9キーを押しメニュー9へ進みます。

Stingフロントパネル上のコネクタとPCのシリアルポートとを、通信ケーブルを使って接続して下さい。それからStingに同封されたStgdmw.EXEソフトウェアを起動して下さい。さらに"File"と"Download Sting Data"をクリックして下さい。ファイル名とその新しいデータファイル用のディレクトリー名を入力します。Stingフロントパネルにおいて、メニュー3からF2キーを押して、データをPCへ転送、バイナリーデータ転送します。ASCIIオプション(F1)は主にDOS用のStingdmp.exeで使います。全データ組が転送されると、Sting上のスクリーンはメニュー3に戻ります。

2.5.2 Stingdmp.exe for DOSを用いたデータ転送

STINGDMP.EXE ダウンロードソフトウェアを使いデータをお手持ちのMS-DOSコンピュータへダウンロードしてください。STINGDMPソフトウェアはDOSで動作しますので、ご注意ください。下に手順を示します。

- Insert the STINGDMP.EXE disk in drive A: on your computer and copy the STINGDMP.EXE file to a suitable directory on your hard drive.
- Connect the Sting to the COM1 or COM2 communication port on your computer using the special Sting/PC communication cable delivered with your instrument.
- Turn the Sting on.
- Type STINGDMP only, or use any or all of the optional commands i.e.:
STINGDMP /f=filename /b=baudrate /p=com port number ? help
and then press ENTER.
(just STINGDMP gives default settings i.e. baudrate=4800 and com port=1)

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Use 2400 baud only with Sting software version 1.2.3 and earlier, see Software version page 29 for information on software version. "?" and "help" give information on how to run the STINGDMP software.

- Wait until the STINGDMP initial screen comes up with the message "Data will be stored in file: ?"
- Enter a filename for the file where you want to store your data. For example TEST. Note that the Sting will automatically add the extension STG to the name so that the full name will be TEST.STG
- Go to menu 3 on the Sting and press F2.
- You will now see data being transferred both on the Sting and the computer screen. When the transmission has stopped and the message "Data received and stored on disk. Press any key to exit." is displayed on the screen, press any key to exit the STINGDMP software.
- Your data are now stored under the filename you have chosen in your STINGDMP directory.

For file format, see section "Data file formats" on page 44.

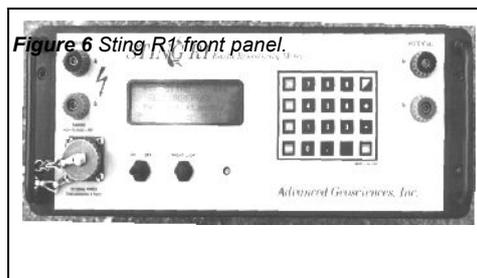
3. Your Sting R1, memory earth resistivity meter

The Sting R1 is a rugged, weatherproof instrument for earth resistivity field work. The instrument is 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.



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.

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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, type the total time in hours, that the instrument has been on, is displayed. Battery status is displayed on the third line. The bottom line indicates that the instrument is now ready either for a new measurement by pressing the "MEA" (measurement) key or for receiving a new setting after you have selected to press the MENU (menu) key.

```
*** STING R1 ***
SCHLUMBERGER
Checking battery
Push MEN or MEA!
```

```
931106 19:46:32
SCHLUMBERGER 136.7h
Battery= 12.57 V
Push MEN or MEA!
```

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 the battery pack is removed 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. No loss of data or instrument setting will be caused by the automatic shut off function.

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.

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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.

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 View data points on page 35) 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.

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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 on page 36.

3.1.6 Serial number

The instrument serial number is placed on a plate on the right 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 **MENU** 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**. By the way, 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.

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

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

modes. The measurement modes which are currently being supported (release 2.5.4) 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 page 35), before entering electrode distances.

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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.

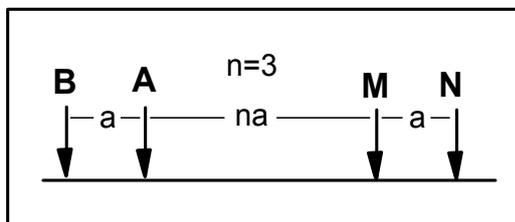


Figure 7 Dipole-dipole configuration

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.

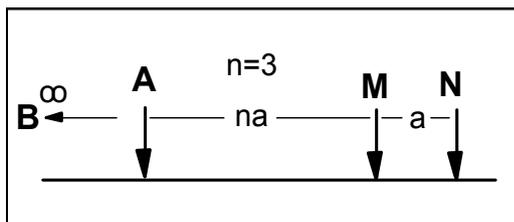


Figure 8 Pole-dipole configuration

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

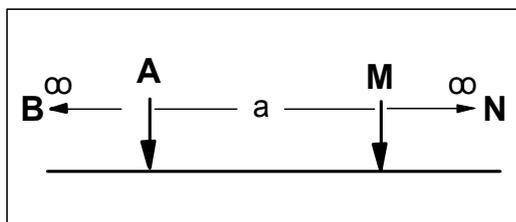


Figure 9 Pole-pole configuration

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

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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 4.1.4.3 on page 37.

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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 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.

4.1.2 Menu 2

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

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.

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

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

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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). Note that the instrument will always default back to low voltage mode (maximum 200 V) after being turned off. 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:

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.

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

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.

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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 StgdmpW.EXE Windows software, delivered with the Sting. Click "File" and "Download Sting Data". Enter a file name and directory for the new data file. On the Sting press F2 on menu 3 to send data to the computer and then F2 for binary data transfer. The ASCII option (F1) is used with the old Stingdmp.exe DOS program. 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 **PCへのデータ転送** on page 24.

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:

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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 page 36 to find out how to clear the data memory).

To download a user programmed command file from a computer to the Sting, proceed as follows.

1. Install the UserLoad software under Windows 95.
2. Connect the Sting to the computer using the Sting/PC communication cable.
3. Turn on the Sting.
4. Go to M6/F1 and make sure to set the Sting in Off mode, **not** the Auto or Ext-PC mode.
5. Go to menu 4 by pressing the **4** key and press **F3**.
6. Start the UserLoad program by double clicking the program icon.
7. Select the correct COM-part by clicking one of the COM-port buttons on the computer.
8. Click the "Select File" key on the computer.
9. Open the command file to be transferred.
10. Check in the lower left window that the coordinates for the electrodes seem to be correctly entered.
11. Click the "Transfer Program" key on the computer.
12. Press the F1 key on the Sting. You will now see command being transferred in the lower right window of the computer screen.
13. When the transfer is finished, press the **MEN** key on the Sting and click on the Quit key on the computer.

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4.1.5 Menu 5

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

4.1.5.1 Hardware settings

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

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.

4.1.5.1.2 Terrameter SAS 300 mode

Press F2 (M5/F1/F2) to set Terrameter SAS300 compatibility. This function is valuable if Sting is going to be used connected to a lap-top with software originally written for the Terrameter SAS300 resistivity meter. This function also makes it possible to run the Sting with the Multimac electrode system.

Note that when F2 is pressed to activate the SAS300 mode, the remote measurement (M5/F1/F1) is automatically turned **ON** to get full compatibility. The baud rate is also set to 300 (the SAS300 speed).

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 programmed to perform automatic dipole-dipole surveys. Any other array can be

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programmed by the user to be automatically measured using either the USER MODE function of the Sting (see section **User mode** on page 18 and section **User program administration** on page 37) or by being run by an MS DOS type computer connected to the Sting/Swift system.

The advantage of the User Mode function is that a PC is not necessary 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 are 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.

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
F3Swift 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

First make sure that the Sting is set for a dipole-dipole survey at menu 1, F1 and for Auto at menu 6, F1. Then press F2 on menu 6 to set up the dipole-dipole array parameters. Electrode placements are according to the following convention: B - A - - - -M - N. Note that a default setting reasonably good for most situations can be set by just entering the electrode spacing at menu 8, F1. The following default values are set when the electrode spacing is entered at menu 8/F1..

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.

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- 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.

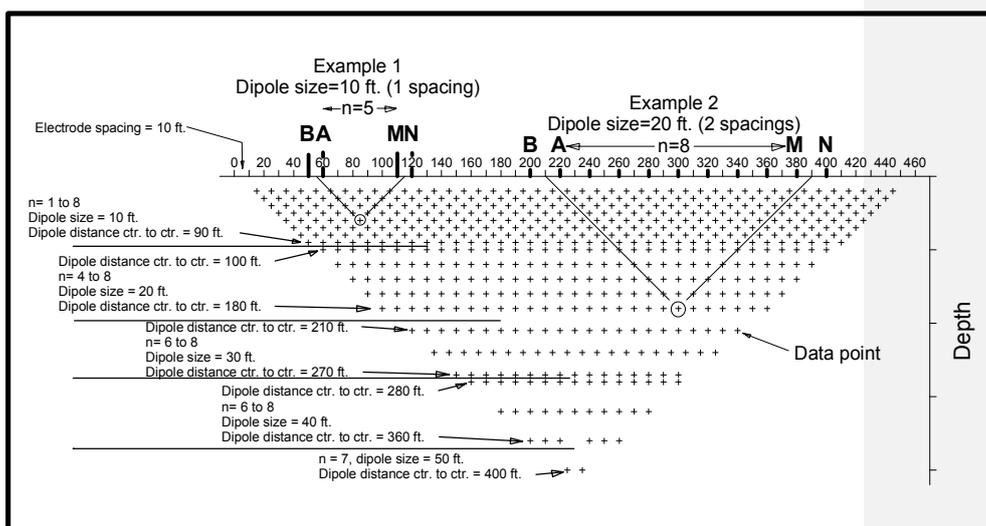


Figure 10 Data configuration for a complete dipole-dipole data set automatically recorded using 47 smart electrodes. Note that the measurement process occurs from left to right, layer by layer from the top; not from top at an angle towards the bottom as is the case in most manual arrays.

- 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.

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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 **Difficulty to send out required current** on page 63.

If the test stops with an error code at a certain electrode, push the stake deeper into the ground, add water to the soil and make sure that the smart electrode makes proper contact to the stake. The test can be restarted from that point by pressing the **F1** key (restart including the faulty smart electrode, i.e. re-test the smart electrode). Pressing **F2** will restart the test, starting after the problem electrode (excluding the faulty smart electrode).

From Sting software version 2.5.5 the result of the contact resistance test, as a 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 interpretation.

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 designed to be performed indoors on a test bench. 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. Connect the Sting and the Swift box as described in Figure 4 on page 15.

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.

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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 is designed to be performed indoors on a test bench. 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. Connect the Sting and the Swift box as described in Figure 4 on page 15.

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.

4.1.8.1 Set Swift default

Use this option to quickly set the Sting/Swift system for a standard dipole-dipole survey. When pressing F1 the text Elect sep= X.XXX m will appear. Enter the electrode spacing to be used

```
M8: SWIFT
F1 Set Swift default
```

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and press F3. All parameters for a standard dipole-dipole survey with the selected electrode spacing are now set in the Sting. If any special setting is desired, go to menu 6, F2 (see page 39).

This function is quite handy to use to set up the Sting for any kind of measurement; manual measurement (M6/F1=Off), external PC mode (M6/F1=Ext-PC) or USER MODE (M6/F1=Auto). Just remember to set M6/F1 to the correct setting **after** using M8/F1. Also be sure to select the correct array at M1/F1 and select correct array dimensions M1/F2.

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 **PCへのデータ転送** on page 7.

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
```

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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

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

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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

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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 trigger 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): $V=3.652\text{E-}2$ <CRLF> (36.52 mV)
Resistance (all resistance methods): $R=3.652\text{E-}3$ <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.

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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
```

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```
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 multi-electrode accessory for the Sting

5.1 The Swift components

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	Sting/Swift Utility disk (3.5" disk) comprising: StngdmpW.exe, Swift.exe, UserLoad.exe, Surfconv.exe, Swiftcnv.exe, 2d-conv.exe, Remote.exe and miscellaneous example command files	1
6	At least one Swift cable with a number of switches (electrode take-outs)	

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.

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, 2.0 Amp 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.

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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 HIGH	Connect male Swift cable connector to this connector. Connect female Swift cable connector to this connector.

For further information on how to connect the Sting/Swift system, see Figure 4 on page 15.

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 a few hours. 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 **Using external power** on page 28.

5.1.3 The Swift cable with electrodes

The Swift cable is an electrode cable with cylindrical stainless steel electrodes/switches mounted at fixed places on the cable. There are two types of Swift cables, cables with the electrode switches permanently mounted on the cable and cables with quick-couplings for the switches. The quick-couplings make it possible to replace a damaged electrode switch or cable section in the field.

The individual switch cylinders are addressable by the Sting. The address (1-254) of each electrode/switch is either marked on the cable beside the cylinder (permanently mounted switches) or marked with an engraved number in the middle of the stainless steel cylinder (cables with quick-couplings). Each cable has a male connector in the low address end of the cable and a female 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.

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

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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. Output from the relay box is connected to the numbered banana connectors.

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 **User mode** on page 18) or with an external PC controlling the measurement as described in the section **The Swift software** on page 56.

6. 関連ソフトウェア

6.1 STINGDMP ソフトウェア

Stingdmp ソフトウェアには二つのタイプ、一つはDOS (Stingdmp.exe) でもう一つはWindows (Stgdmw.exe)があります。Windows バージョンを用いるときには、Sting 本体は2.5.5 かそれ以上のタイプで、Stingの (M3/F2/F2)でバイナリーの転送を選んで、高速のデータ転送を行うことができます。データ転送は、これによりバイナリーモードで転送時間を短くし、非常に大きなデータセットでも数分で完了します。転送されたデータは最終結果として、表示・読み取りに便利なASCII ファイルとなります。バイナリーモードで実行される唯一の実際のデータ転送です。Sting本体のバージョンを見るには、小数点キー「.」を押したままで、Stingのパワースイッチをオンにします。

6.1.1 Stingdmp for DOS

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. Use the download software STINGDMP.EXE. Start the download software by typing STINGDMP and press **ENTER**. Enter a filename where the downloaded data will be stored, and then press **F2** on menu 3 on the Sting. Then select ASCII by pressing **F1** on the Sting. Data in the Sting memory are now being transferred to the computer. The down loaded file is a raw data ASCII file which will be used for further data processing.

6.1.2 Stgdmw for Windows

転送ケーブルをStingのフロントパネルとPCのシリアルポートコネクタとの間で接続します。Stingの電源をオンにします。Windows 3.xx あるいは Windows 95 の場合には、Stgdmw.exe プログラムを選びます。“File” から “Download Sting Data”をクリックします。ダウンロードされたデータを保存すべきファイル名を入力しますStingでmenu 3 のF2を押して、さらにASCII にするべく、Stingがバージョン2.5.5以下である場合はF1を押し、バージョン2.5.5以上である場合はF2を押します。Stingのメモリーにあるデータは、これでPCへ転送されます。転送されたデータはASCIIファイルそのまま、次のデータ処理に用いられます。

6.2 2D-CONV ソフトウェア

このソフトウェアは、RES2DINVソフトウェアで読み取り可能なファイルを、元のStingのDipole-Dipoleデータファイルから作成するために用いられます。

2D-CONVのファイル名 (ファイル名は元のStingデータファイルで拡張子がないものである) をタイプし、さらにENTERを押す。作成されたデータファイルは、元のStingデータフ

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ファイルと同じ名前であるが、拡張子として.DATが付いています。FILENAME.DAT ファイルはRES2DINV ソフトウェアでそのまま直接読み込むことができます。2D-CONV ソフトウェアはDOS プログラムです。

6.3 UserLoad ソフトウェア

The UserLoad ソフトウェアはPCで作成されたコマンドファイルをStingのRAMメモリーに転送するためのものです。コマンドファイルは、これで現場にて容易に起動され、現場でコンピュータを用いる必要なく比抵抗の自動計測を実施することができます。UserLoad ソフトウェアはWindows 3.xx用です。

コマンドファイルはASCIIで書かれており、通常のテキストエディターで簡単に作ることができます。コマンドファイルは .CMD の拡張子を持っています。(6.3.1のUser Mode のCMD タイプのコマンドファイルの項を参照)

UserLoad ソフトウェアをインストールするには、UserLoad ソフトウェアを、それとともに入っている.ini ファイルと共に、何らかのディレクトリーにコピーします。

Sting のRAM メモリーにユーザーファイルを書き込むには、以下の手順で行います。

1. 機器と共に供給されたデータ転送ケーブルでStingとPC間を接続します。
2. プログラムのアイコン上をダブルクリックして、プログラムを起動します。
3. Stingの電源をオンにしてmenu 3に入ります。データのメモリーをF3/F1/. (ドット)と押して消去します。消去する前に全ての貴重なデータが保存されていることを確認しておきます。
4. メモリー内の古いコマンドファイルを保存しておく必要がなければ、RAMメモリーを消去します。もしコマンドファイルメモリーに保持されていなければならないのであれば、この手順を省きます。このRAMメモリーは最大16までのコマンドファイルを保持することができ、さらに総計3,000のデータ点数を保持することができます。
5. M6/F1 に入りStingがOffのモードであることを、つまりAutoやExt-PCのモードでないことを確認します。
6. menu 4 に入りF3を押します。
7. PC側の適切なCOMポートを選びます。
8. "Select File" ボタンをクリックして、適切なコマンドファイルを開きます。
9. ウィンドウの左下に使用している電極の相対的な位置が表示されています。"Transfer Program" ボタンをクリックします。

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10. StingでF1を押します。 ウィンドウの右下にコマンド列が転送されているのを見ることが出来るでしょう。元のASCIIコマンドファイルとは異なるように見えることに留意してください。
11. 転送が完了したら、Exitボタンをクリックして、さらにStingの**MEN** キーを押してください。
12. これで転送されたコマンドファイルは、**menu 1** からF1 を押せば選択できるようになります。+ キーを用いて**USER MODE** を選び、さらに**MEN**キーを押します。
13. **menu 1** のF2 に入り、+ キーを用いて正しいコマンドファイルをスクロールします。
14. F3 を押して選択します。Enter X- 座標とY-座標を入力し、展開の最初の電極の位置座標を決め、F3を押してNext=1 を入力し最初のコマンド行からスタートします。

UserLoad ソフトウェアは、メニューバーの”Special”のオプションで、3Dのpole-pole コマンドファイルを作成する時にも用いることができます。

6.3.1 User Mode の.CMD タイプのコマンドファイル

PCがSting とSwift を制御する場合には、Swift.exe プログラムで用いられている.CMD タイプのコマンドファイル (6.6 の項Swift ソフトウェア参照)は変更することができ、User Mode のダウンロード可能なファイルとして用いることができるようになります。

コマンドファイルは、ヘッダーコマンド下でUserLoadソフトウェアと共に用いられるべく、ProgID とUnit情報とを持つ必要があります。以下にUserLoadソフトウェアと共に用いられるべく変更された.CMDファイルの例を示します。

```
;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
```

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1A, 2M, 3N, 4B, R
2A, 3M, 4N, 5B, R
;End

プログラムのIDは最大7文字までで、かつMS DOSのファイル名のみが許容されています。

6.4 CommandCreator ソフトウェア

CommandCreator はWindows 3.xx プログラムで、Stingのためにコマンドファイルを自動的に作成することができます。CommandCreator はまたPCの画面上で測定順番を視覚的に表示し、意図したとおりに動作していることを確認することもできます。

CommandCreator はまた、ロールアロングファイルを素早く作るのにも、電極一つが無い場合にも、あるいは特別な他の用途にも用いることができます。

6.5 SwiftCnv ソフトウェア

Swiftcnv.exe ソフトウェアは、Sting/SwiftによるUSER MODE での測定値を、RES2DINV ソフトウェアで読み取ることができるようなファイルを作成するためのものです。SwiftCnv ソフトウェアはWindows 3.xxで動作します。

Swiftcnv ソフトウェアのインストールは、プログラムファイルを何らかのディレクトリにコピーのみです。このプログラムは以下の手順で使用します。

1. Swiftcnv をプログラムアイコンをダブルクリックで起動します。
2. コンピューター側で、出力ファイルフォーマットを例えばRES2DINV, RES3DINV, Surfer for Windows あるいはResix Plusなどから選択します。
3. 適切な出力ファイルを選びます。つまりWenner, Schlumberger など...
4. 所望の特別な選択をする。例えば: 全てのデータセットを一つのファイルにする、負の値を削除し、かつあるいはおおよび大きな誤差のデータを削除する、(誤差は%の1/10つまり10%のときは100とする)。
5. "Load Sting File" のボタンをクリックし、適切なUSER MODE Sting ファイルを開く。
6. "Save Converted File" のボタンをクリックすると、先に選んだソフトウェアによって読み取り可能なファイルがこれで保存できるようになります。

6.6 The Swift software

The Swift software is a DOS program used to run an automatic resistivity survey in the field with a MS DOS type computer connected to the Sting/Swift system. The SWIFT.EXE (v 1.5.2) is a DOS software delivered on a 3.5" disk with the Swift system.

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The software runs an operator programmed ASCII command file created in a regular text editor. The command file must always have .CMD for extension.

To start the program type SWIFT /c=XXXX /d=xxx

where XXXX is the command file name and xxx is the result data file.

The syntax is: SWIFT /c=<commandfile> /d=<datafile> [/h[elp]][?]

Enter filename without the extension.
Valid file names are 8 characters or less.
The command file must be of the type .CMD.
The data file will be of the type .DAT.
The default name for both files is SWIFT.

The command file consists of a number of lines containing program comments, header information, geometry information and commands.

Program comment lines always start with a semicolon. Comment lines are not used during the actual program execution but are there for information only.

Header information follows the **:Header** command. Header information is not used by the program but is strictly copied to the result data file for documentation purpose.

Geometry information follows the **:Geometry** command. The geometry information is used by the program to calculate the apparent resistivity.

The command section, following the **:Command** command, consists of comma separated electrode addresses and electrode functions. Example 5A means that electrode 5 will be an A-electrode during next measurement. The letter R terminates each command line and executes a measurement according to the information on the line. The system is completely universal, so that any connection is allowed. The Sting/Swift can also measure SP automatically. For SP measurements set the Sting in SP mode (M1/F1) before switching to External PC mode (M6/F1).

Below is an example of a command file:

```
;Measurement command file for the SWIFT multi electrode system      Semicolon indicates program comment
;WENNER layout used with 7-electrode demo cable

;Header information, no action taken on these lines
:header      Here starts the header information
Project= Swift demo      These lines are just copied to the data result file
Client= Advanced Geosciences, Inc      "
```

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```
ClientAddress=Austin, Tx      “
Azimuth=0                    “
Location=India                “
ArrayType=WENNER              “

;Now follows the section on electrode geometries
;Geometry                    Here starts the geometry information
;format: <switch address>, X, Y
;Test cable 5 m electrode spacing
1,0,0
2,5,0
3,10,0
4,15,0
5,20,0
6,25,0
7,30,0

;And now follows the command section
;Commands                    Here starts the command file
; Separation a= 10
1A,3M,5N,7B,R

; Separation a= 5
1A,2M,3N,4B,R
2A,3M,4N,5B,R
3A,4M,5N,6B,R
4A,5M,6N,7B,R

;That's it!
```

The data ends up on the computer harddrive under the specified data file name.

Example of data result file:

```
Command file: DEMOWEN.CMD      Command file used was DEMOWEN.CMD
Data file:   GSI.DAT          Result data file is GSI.DAT

;Project Swift demo          Header information copied from the command file
;Client Advanced Geosciences Inc “
;ClientAddress Austin Tx “
;Azimuth 0 “
;Location India “
;ArrayType WENNER “

;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, Pa
RESIST ,95-11-16,07:36:02, 4.5720e-02, 0, 5, 1, 0, 0, 7, 30, 0, 3, 10, 0, 5, 20, 0, 2.872672
RESIST ,95-11-16,07:36:09, 4.9754e-02, 0, 5, 1, 0, 0, 4, 15, 0, 2, 5, 0, 3, 10, 0, 1.563068
RESIST ,95-11-16,07:36:17, 3.0256e-02, 0, 5, 2, 5, 0, 5, 20, 0, 3, 10, 0, 4, 15, 0, 9505202
RESIST ,95-11-16,07:36:24, 5.2444e-02, 0, 5, 3, 10, 0, 6, 25, 0, 4, 15, 0, 5, 20, 0, 1.647577
RESIST ,95-11-16,07:36:31, 3.6980e-02, 0, 5, 4, 15, 0, 7, 30, 0, 5, 20, 0, 6, 25, 0, 1.161761
```

6.7 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.

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6.8 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. Import the XYZ file produced by RES2DINV into the Surfer software. For further information, see the Surfer for Windows instruction manual.

6.9 The SURFCONV software

In case a resistivity inversion software is not available, the Surfer for Windows can be used to produce a "pseudo cross-section." The SURFCONV software, delivered on your original STINGDMP disk or Utility disk in case you received a Sting/Swift system, is used to prepare the dipole-dipole field data (extension .STG) for use with the Surfer for Windows software.

To run SURFCONV type: SURFCONV FILENAME (no extension).

The resulting two files, extension .DAT and .BLN are used to plot the pseudo cross-section using the "Surfer for Windows" software.

The FILENAME.DAT contains three data fields, the X, the Y and the Z coordinates. X is the coordinate for the dipole/dipole array midpoint along the profile, Y (the depth) is calculated as the negative half distance between the dipole midpoints $((n+1) \times \text{dipole size}/2)$ and Z is the apparent resistivity.

7. Field procedure

7.1 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, the instrument is recommended to be powered by an external 12 V DC deep cycle type battery.

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.

7.1.1 Swift control box battery

The internal rechargeable battery in the Swift control box is not equipped with an automatic shut-off on low voltage as is the case with Sting. Therefore it is important to make sure that this battery is regularly charged when the Swift box is being used. When the 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 7 volts. To avoid any problem, the Swift battery should be recharged every night when in use.

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7.2 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 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.

7.3 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.

7.3.1 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 salt 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.

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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 Electrodes

For regular resistivity work, use our stainless steel electrodes. For self potential surveys (SP) use our non-polarisable electrodes.

7.4.1 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.

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!

7.4.2 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 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.

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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.

7.5 Common problems

7.5.1 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. 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.

7.5.2 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.

7.5.3 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 1/2-1 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

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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.

7.6 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 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 inhomogeneities 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 Figure 11). 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.

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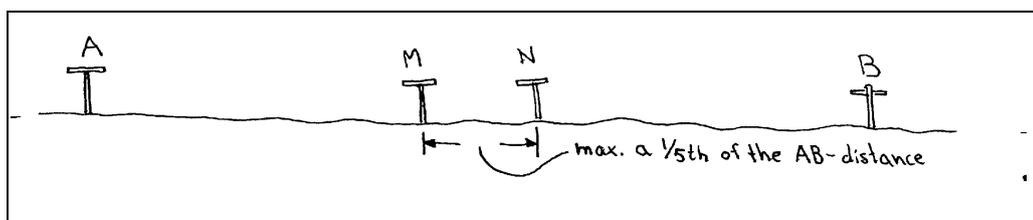


Figure 11 The MN distance is kept small, less than a 1/5th of the AB distance.

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 Figure 12), 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.



Try to separate the potential and current cables as much as possible to prevent error caused by "crosstalk" between the cables (see Figure 13).

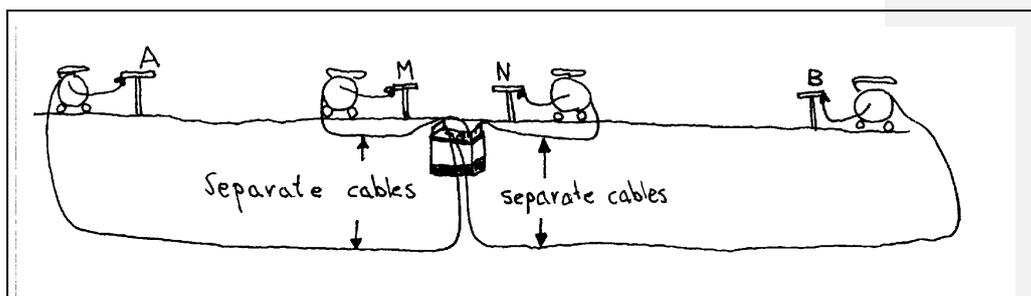


Figure 13 Make sure to separate the cables in order to avoid crosstalk between cables.

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 Figure 14).

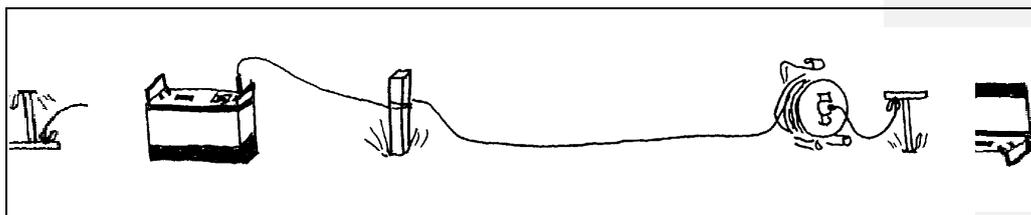


Figure 14 Tie off cables to some fixed object to prevent cables from accidentally being pulled out of the instrument when the electrodes are moved.

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):

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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.

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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 sounding 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 (orebody, underground pipe line, pollution plume etc.) which you want to map the extent of. The other current electrode (B) 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.

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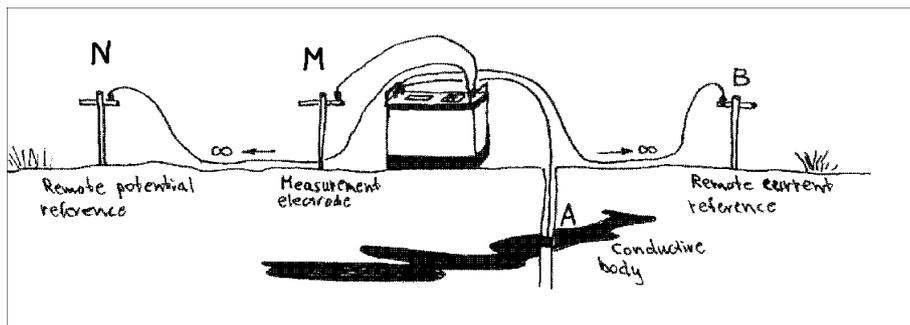


Figure 15 Sting used for mise-a-la-masse measurement. Note that N and B are reference electrodes placed at "infinity".

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."

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8.4.1 Equipment

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

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.

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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.

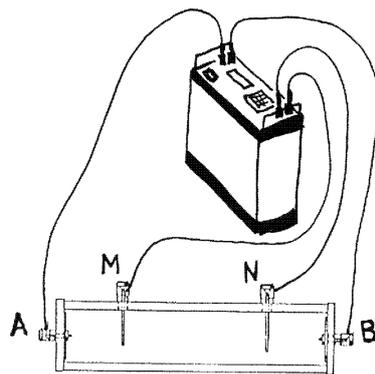


Figure 16 Sting with the soil box accessory for laboratory measurement of soil samples.

The saturated measurement will provide a "worst-case" resistivity and can be usefully compared with "as-received" resistivity measurements. 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 Figure 16.
- 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.

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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 use 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 35, 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 35, 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)	0.000002

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:

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

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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 to the current terminals and the potential terminals respectively. 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 $\pm 1\%$. Contact your Sting distributor or Advanced Geosciences, Inc. in case the value deviates more than 1% from the test resistor value.

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 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. The fuse holder is located on the left side of the top circuit board. Use a 5x20 mm type, 2.0 Amp slow blow 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.

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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 **STINGDMP** ソフトウェア on page 53 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 Replacing the Swift switch circuit board

If a Swift electrode switch circuit board needs to be replaced, proceed as follows. Make sure to perform the work at a static-free workstation.

- Unscrew the 6 phillips screws holding the electrode cylinder.
- Carefully and with a twisting motion (not to damage the o-ring seals inside) slide the steel cylinder off to one side revealing the inside of the electrode switch.
- Desolder the wires going to solder towers marked A, B, M, N, CTR1 and CTR0. Make sure to note which wire attaches to respective solder tower.
- Unscrew the four phillips screws holding the circuit board to the end plugs.

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- Remove the circuit board, making sure not to lose the springs or contact pins located in one of the end plugs.
- Reverse procedure to install the new circuit board.
- Before closing the electrode switch, use a small flat screw driver to set the correct electrode address using the two HEX switches on the circuit board. Facing the two switches, the left switch indicates values from 1-16 and the right switch indicates base of 16. For example the address #43 is set in the following way. The right switch is set to 2, equalling $2 \times 16 = 32$ and the left switch is set to B equalling 11. Now the electrode address is set to $32 + 11 = 43$.

10.6 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 77 for information on how to act.

Error: data in RAM! See page 36 for further information.

Error: Memory full See page 38 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.

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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 ($\Delta V/I$) and apparent resistivity (Ωm or Ωft). 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

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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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