8. RESISTIVITY-PHASE INDUCED-POLARIZATION PROGRAM (RPIP)

8.1 INTRODUCTION

PROGRAM DESCRIPTION

The Resistivity-Phase Induced Polarization (RPIP) program is an enhanced frequency domain program using synchronous stacking, averaging, and Fourier integration to improve signal to noise ratio.

Refer to ***Section 6 – Receiver Setup*** for information concerning calibration, synchronization, generic screens and field parameters for all survey programs. Refer to the end of this section for suggestions for field measurement receiver connections.

FREQUENCY RANGE

The standard frequency ranges from 0.015625 Hz (0.016 Hz in the calibration tables) to 8192 Hz.

FILTER

The RPIP survey program has a digital telluric filter, also referred to as a Moving Average (MAV) filter, for rejection of low frequency tellurics. This filter is active for frequencies from 0.015625 to 1.0 Hz.

CALIBRATION CACHE

Calibration data for the RPIP Survey Program are stored in the Frequency Domain Calibration Cache.

***NOTE**: The CSAMT Survey Program also uses the Frequency Domain Calibration Cache. Overwriting calibration data in this cache causes CSAMT calibration data to be lost. However, the RPIP and CSAMT calibration data should be identical.*

PHASE

The RPIP survey program measures the absolute phase shift between the transmitted signal and the received signal.

For normal operations at low frequencies, the real-time phase shift should be in the range of $0 \geq \phi \geq -200$ milliradians. If the phase is closer to π radians (3142 mr) the receiver or transmitter leads are probably reversed. Remove the π radians of phase shift by either reversing the transmitter wires at the transmitter, or reversing the leads to the receiver channel in question. For multi-channel receivers, it is easiest to make the change at the transmitter, and then maintain the same polarity throughout the survey.

8.2 PROGRAM OPERATION

Field Survey programs operate using several parameter entry screens. Press CONTINUE Enter to move to the next screen or STOP AVG Escape to return to the previous screen.

For a complete description of each screen and generic fields refer to ***Section 5 – Accessing Programs***. Field parameters specific to this Survey Program are listed below.

SCREEN 1 - INITIAL PROGRAM SCREEN

Select or enter a parameter for each user programmable field. User programmable fields unique to RPIP are:

Survey Type

- **Non-reference RPIP**

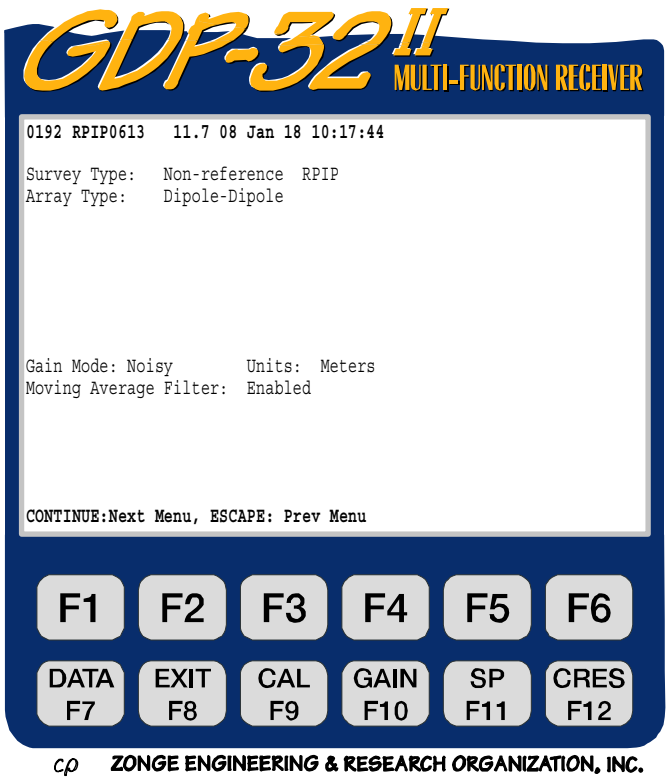
  (Default selection) This is the standard resistivity/phase IP program.

- **Continuous**

  This mode is an experimental program developed for continuous logging in downhole electrode and marine applications. Once started, measurements are repeated automatically at a user-specified time interval, until the STOP AVG Escape key is pressed.

- **Reference RPIP**

  Reference RPIP is a single-frequency, complex resistivity survey. It uses a selected channel to monitor the transmitter current, and then computes the system response (i.e. the deconvolved magnitude and the phase response) of the measured channels with respect to the reference channel array type.



Array Type

Select one of the seven array types using the SELECT UP Home and SELECT DN End keys:

- **Dipole-Dipole** **D-D**
- **Pole-Dipole** **P-D**
- **Schlumberger** **Sch**
- **Gradient** **Grd**
- **Pole-Pole** **P-P**
- **Downhole** **D-H**
- **Core Sample** **LAB**

If **Gradient** or **Schlumberger** arrays are chosen, then two additional lines, **Ax location** and **Bx location** appear in the menu. These are the transmitter current electrode locations.

If the **Downhole** array type is chosen, resistivities will not be calculated or displayed.

The **Core Sample** selection provides for input of cross-section area and length of core samples (in centimeters) to get correct resistivity values (in square centimeters). After continuing to the Data Acquisition Screen, press F5 to input the length, area and current monitoring shunt resistor values.

Ref Mode Shunt

When Reference Mode is selected, enter a value for the Reference Mode Shunt. The default value is 1.000Ω.

Gain Mode

Select one of the two gain modes using the SELECT UP Home and SELECT DN End keys:

- **Noisy**

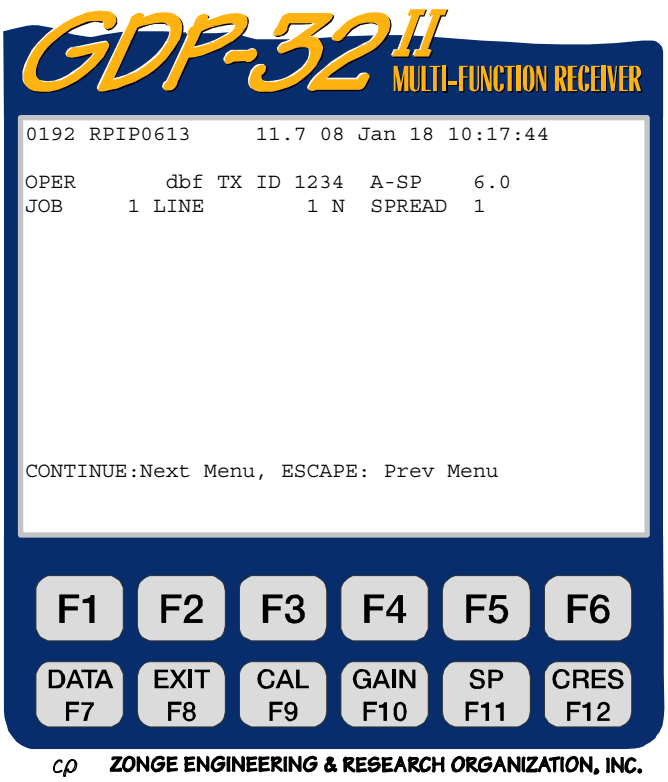
  (Default Selection) – Limits the gains to obtain a maximum of 1.0 Volts, leaving headroom for SP drift and random noise spikes.

- **Standard**

  Adjusts the gains for a maximum voltage of 2.25 Volts.

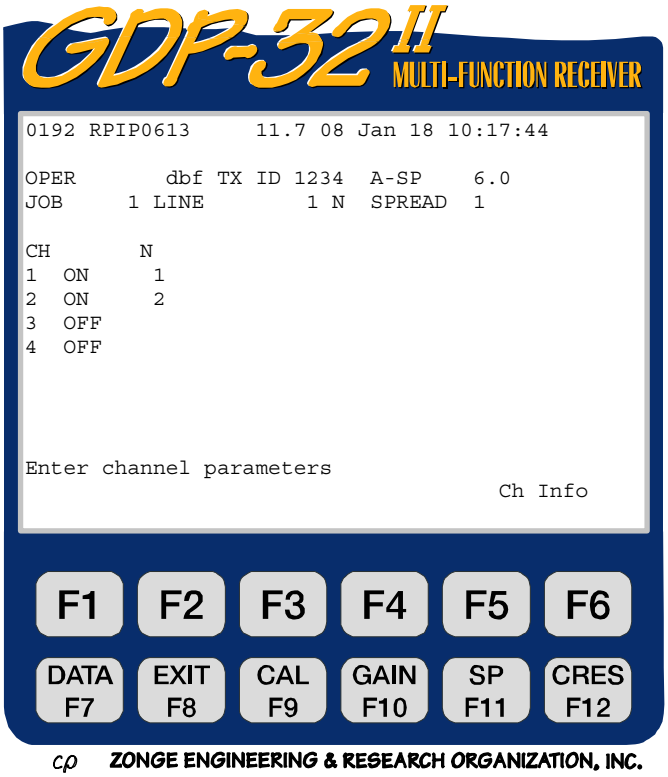
SCREEN 2 - OPERATOR INFORMATION SCREEN

Select a parameter or fill in the appropriate information for each of the user programmable fields as described in ***Section 5 – Accessing Programs***. If **GRADIENT** array is selected, the Y-coordinate of the transmitter dipole (Ay) will be displayed in place of the line designator.



SCREEN 3 - CHANNEL PARAMETERS SCREEN

Set the channels displayed to **ON**, **OFF** or **Ref** as needed. For more information refer to ***Section 5 – Accessing Programs***.



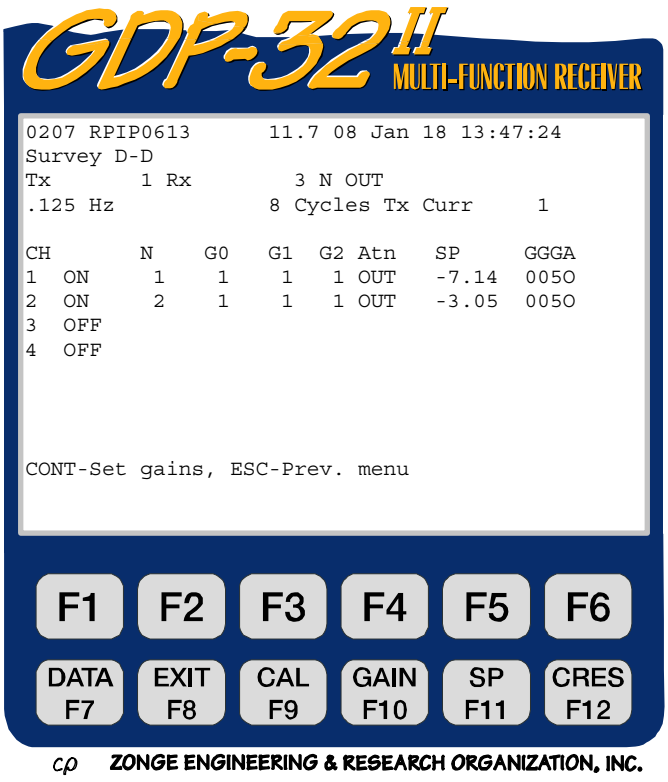
SCREEN 4 – DATA ACQUISITION SCREEN

Primary survey settings are displayed after the initial parameters and channels have been set.

Initiate the following routines from this screen:

- Calibration or System Check — CAL F9
- Gain Setting and Stack Count — GAIN F10
- Bucking out Self-Potential — SP F11
- Measuring Contact Resistance — CRES F12
- Reviewing Data — DATA F7

Refer to ***Section 5 – Accessing Programs*** for more information on Survey Program Screen. Refer to ***Section 6 – Receiver Setup*** for information on setting up the GDP-32^{II} receiver prior to gathering data.



8.3 DATA COLLECTION

Begin collecting data after setting up the receiver for an RPIP field survey. For complete information on receiver setup see Section 6. To begin, press 

from the Data Acquisition Screen.

DATA COLLECTION EXAMPLE

The following example displays the screens and results of an RPIP Dipole - Dipole Field Survey. For this example the field parameters are set as follows:

Initial Program Screen

```
Survey type              Non-Reference RPIP
Array type               Dipole - Dipole
Gain Mode                Noisy (default)
Units                    Meters (default)
Moving Average filter    Enabled (default)
```

Operator Information Screen

```
OPER          SMITH
TX ID         1234
A-SP          6.0
JOB           94001
LINE          1 N (default)
SPREAD        1 (default)
```

Channel Parameters Screen

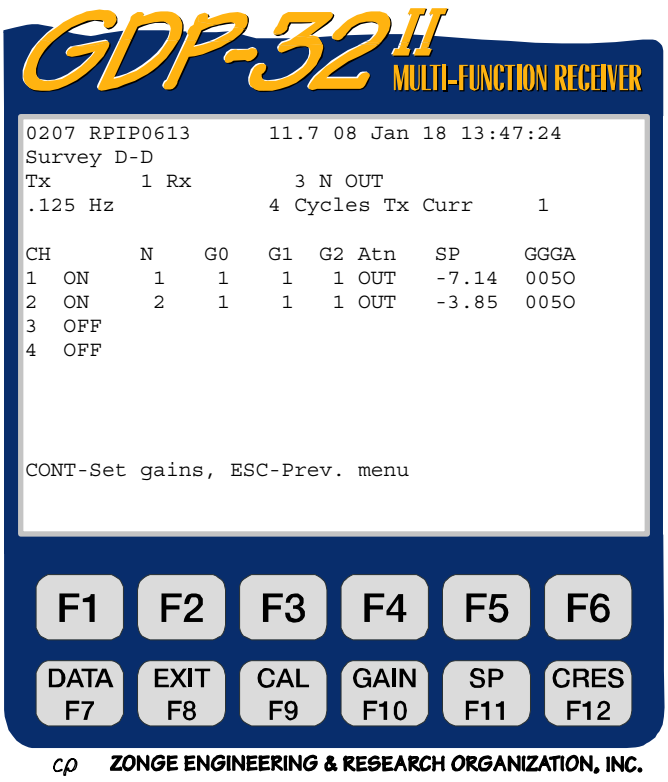
```
CH          N
1    ON     1
2    ON     2
3    OFF
4    OFF
```

Data Acquisition Screen

```
Frequency     0.125 Hz
Cycles        4
TX Curr       1 (default)
```

The Data Acquisition Screen below is displayed when:

- Channels 1 and 2 are turned ON.
- The battery voltage has been measured and the A/D converter automatically calibrated before each measurement cycle.
- Gains are set automatically (default).



Screen Explanation

G0,G1,G2 - Gain stages 0, 1 and 2. Stages 0 and 1 set to unity, stage 2 set for 32.

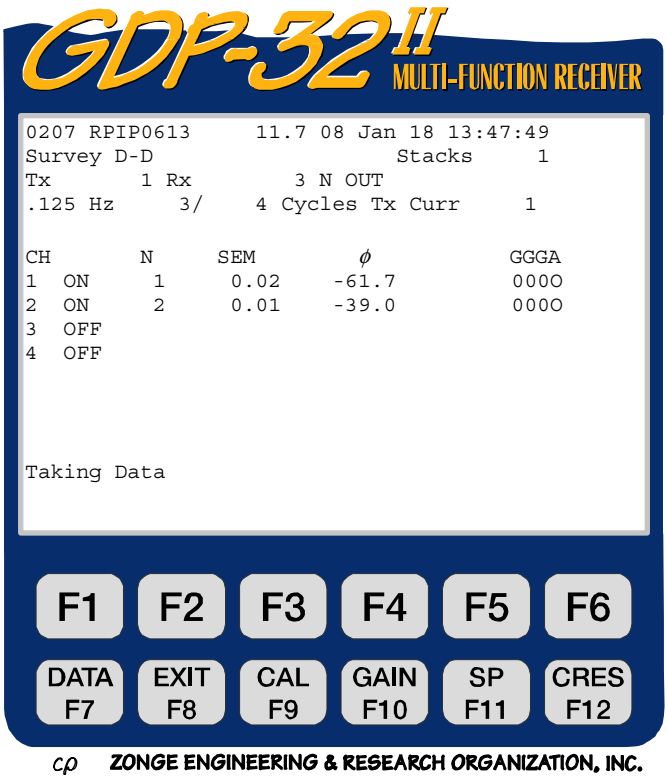
Atn - Set to **OUT** (bypassed)

SP - The SP buckout values are 3.24 mv for Channel 1 and -4.09 mv for Channel 2.

GGG - Gain settings for stages 0, 1 and 2 (in powers of 2). For this example, gain stages 0 and 1 = $2^0 = 1$ and gain stage 2 = $2^5 = 32$.

The program first sets up the Gains, bucks out the SP and then begins gathering data. Since we are operating in the default or "Noisy" gain mode, all of the necessary gain is put into G2 first. For more information on setting gains see ***Section 6.5***.

Upon pressing CONTINUE Enter, the program acquires four cycles of data for all enabled channels (unless the STOP AVG Escape key is pressed before completion) and the results will look similar to the following for the real-time displays (while data are being acquired).

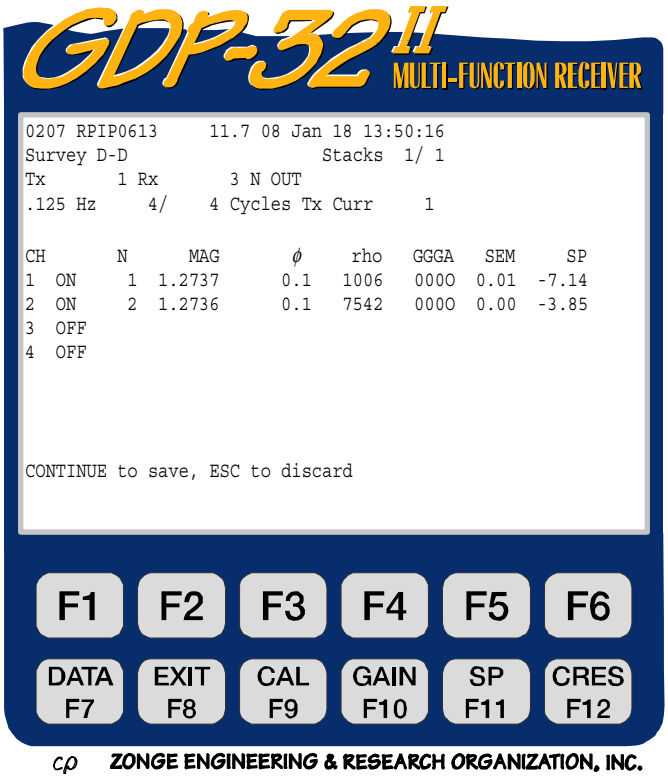


Screen Explanation

SEM - Standard Error of the Mean, (in milliradians), calculated after each cycle.

ϕ - Average Phase in milliradians.

After the selected number of cycles have been acquired (or STOP AVG / Escape is pressed), the final display appears:



Screen Explanation

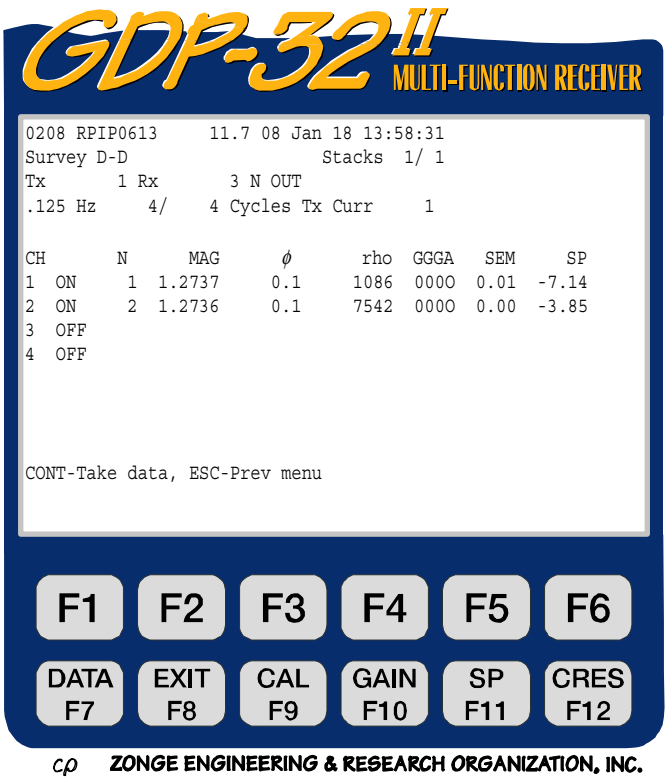
MAG - Magnitude of the received signal in volts, with magnitude calibration (located in the Frequency Domain cache) applied. The scaling factor "m" after the number means "millivolts".

ϕ - Phase in milliradians, with phase calibration (located in the Frequency Domain Calibration Cache) removed.

ρ - Apparent resistivity in ohm-meters.

NOTE: **PREV** *and* **NEXT** *(above* F1 *and* F2 *keys) are displayed only when more than eight channels are installed in the receiver.*

Upon pressing CONTINUE Enter to save the data (or STOP AVG Escape to discard the data), the screen appears as follows. The only difference in screens is the change in last block number (0095) and the bottom command line.



VIEWING DATA

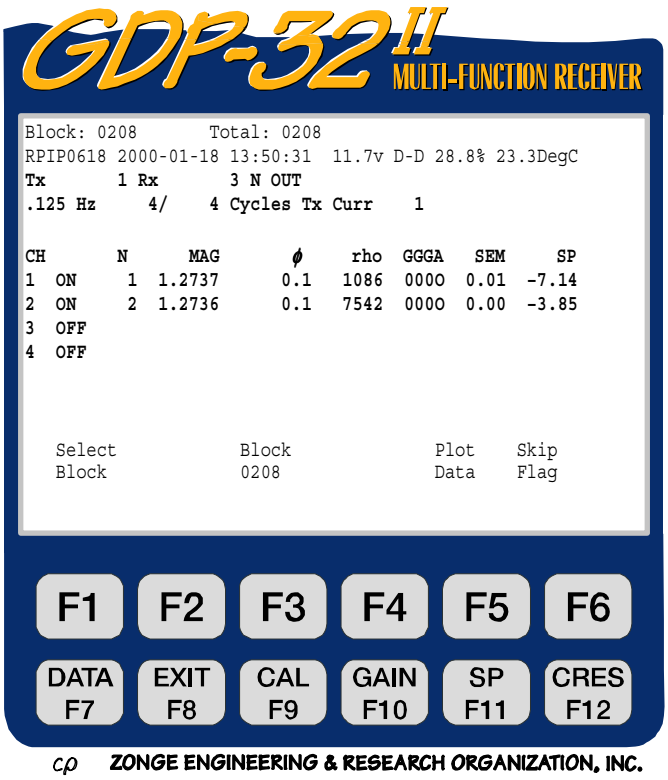
Press DATA F7 to display the last stack. The data display is in the following format:

The SEM, SP and contact resistance values have been saved, but are off the screen to the right.

To view these numbers press → several times.

To move back to the left, press ←.

NOTE: The "O" for Attenuator **OUT** *is included with the powers of 2 gain settings above (e.g.* **005O***).*



Data Acquisition Options

Plot Data - Press F5 to access the plot routines. Only complex plane plots are enabled for this version of RPIP.

Skip Flag - Pressing F6 places an '**x**' between the version number and the date in the header for the block being viewed. This flag is recognized by the plot routines and the flagged data is skipped when averaging multiple blocks for plotting. Pressing F6 again removes the '**x**'.

SAMPLE DATA BLOCKS

Data are exported to a computer in the following format:

These data were acquired using an RC network and a constant current laboratory transmitter.

Program Data Header

```
0003
TDIP0528  94-03-15   14:44:02  12.6v  D-D
OPER     1  TX ID     1 A-SP   100.0
JOB  91001  LINE         1 N   SPREAD   1

1 DiffAmp   Notch+60,3-50,3  S/N  185 Passed 1.00192
2 DiffAmp   Notch+60,3-50,3  S/N  177 Passed 0.99835
3 DiffAmp   Notch+60,3-50,3  S/N   61 Passed 0.99921
4 DiffAmp   Notch+60,3-50,3  S/N   57 Passed 1.00329
5 DiffAmp   Notch+60,3-50,3  S/N   60 Passed 0.99876
6 DiffAmp   Notch+60,3-50,3  S/N   66 Passed 0.99586
```

Dipole-Dipole array used

Card status: Passed or Failed QC test

Gain factors for each card

Analog card information

modification level indicator

Main Data Block

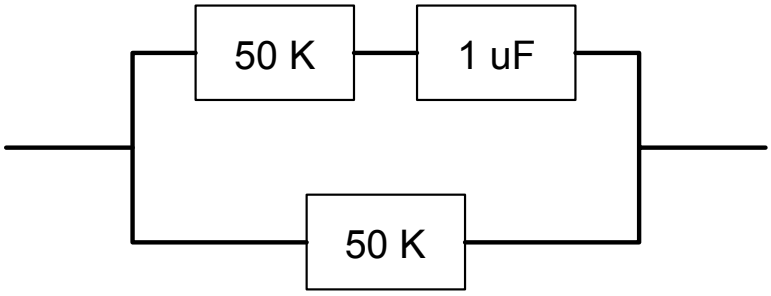
```
0004
TDIP0528  94-03-15  14:55:48  12.6v  D-D
Tx          1 Rx          3 N  OUT
.125 Hz       4 Cyc  Tx Curr   1.00
1  ON      1  211.60m      2.6   398.9   030O    .47   2.96   1.23K
2  ON      2  212.13m      2.6   1.599K  030O    .47   0.12   690.1
3  ON      3  212.16m      2.6   3.999K  030O    .47  -0.56   1.02K
4  ON      4  211.96m      2.6   7.991K  030O    .46  -1.78   2.27K
5  ON      5  211.76m      2.6   13.97K  030O    .48  -3.56   1.17K
6  ON      6  212.09m      2.6   22.39K  030O    .47  -5.92   1.63K
```

SEM's in mr

SP in mv

Contact Resistance in ohms

The RC network is as follows:



Block 0008 is the ***Program Data Header***. A new Program Data Header is written to the data cache whenever the operator returns to the Operation Information Screen.

Block 0009 is the ***Data Block*** and is written to the data cache when CONTINUE Enter is pressed at the end of each data acquisition cycle.

8.4 FIELD CONFIGURATIONS

Be very careful when running a multiple channel receiver to avoid common mode problems. Common mode effects are caused by lack of a reference voltage or level (floating ground), or a reference level that exceeds common mode limits of the input amplifiers.

The maximum permissible common mode level for the standard configuration of the GDP-32^{II} is ±10 volts. With isolation amplifiers, this level can extend to several thousand volts, but the tradeoff is higher noise and lower overall frequency response.

The best configuration that we have found is to install a standard copper/copper-sulfate ***Reference Electrode*** (or equivalent) connected to both analog ground (**COM** on the analog side-panel) and the case ground (**CASE GND** on the side panel). Place the electrode next to the receiver and at least two meters from the nearest receiving electrode. This also provides maximum protection from static discharge and nearby lightning strikes.

Additional protection in lightning-prone areas can be gained by using a galvanized iron plate (or equivalent) as a reference electrode. This plate should be buried close to the receiver in a hole that has been well watered and the soil mixed to make good mud contact with the plate. Typical size for the plate would be 30 cm by 30 cm.

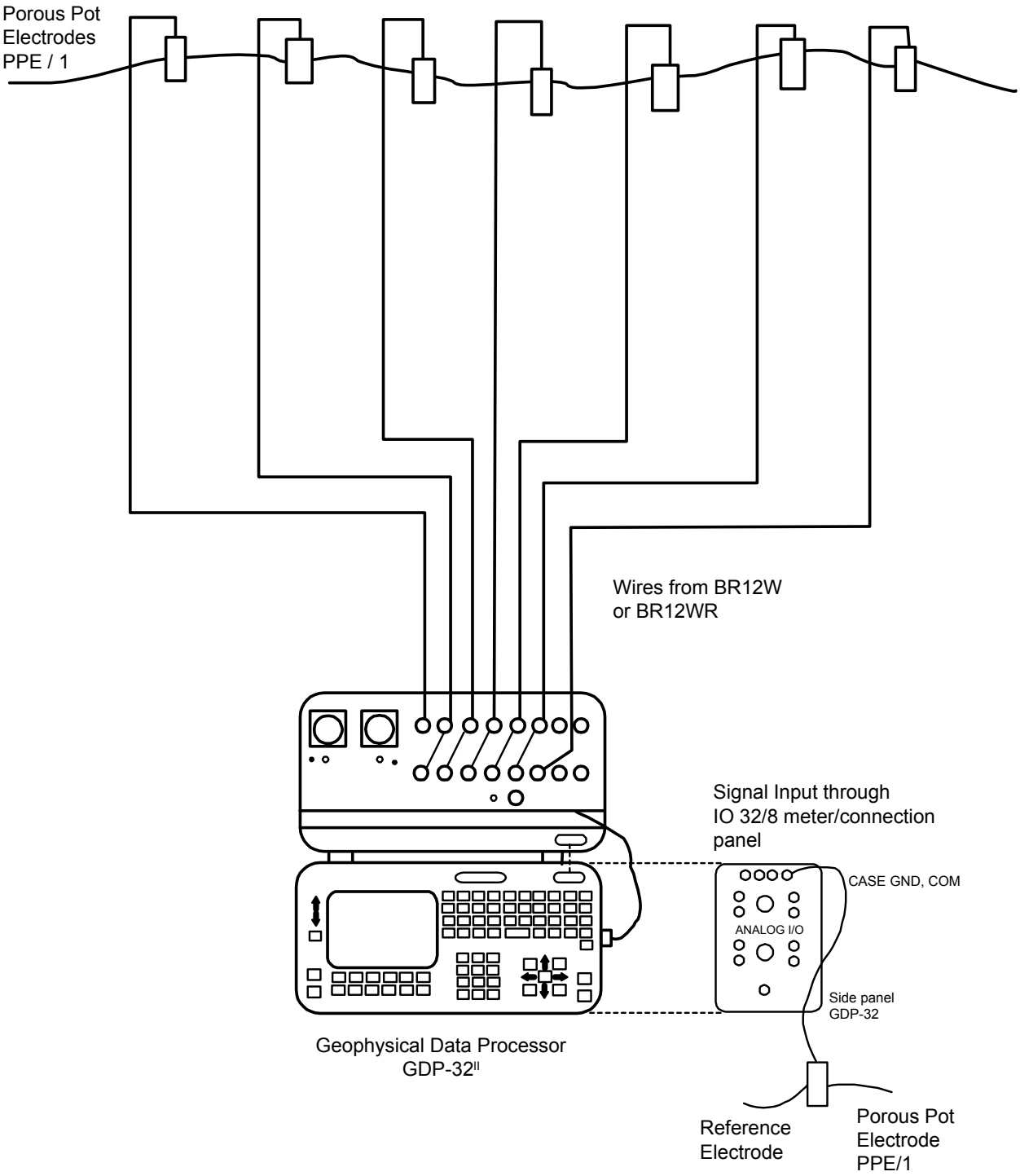
The following figures provide examples of receiver connections using the Reference Electrode or ***Reference Pot*** connected to both analog ground (**COM**) and case ground (**CASE GND**).

To obtain the best noise rejection, Zonge Engineering recommends connecting the analog ground (**COM**) to the case ground (**CASE GND**) on the Analog I/O side panel.

NOTE: The standard configuration of the GDP-32^{II} receiver has a captive jumper between **COM** *and* **CASE GND**.

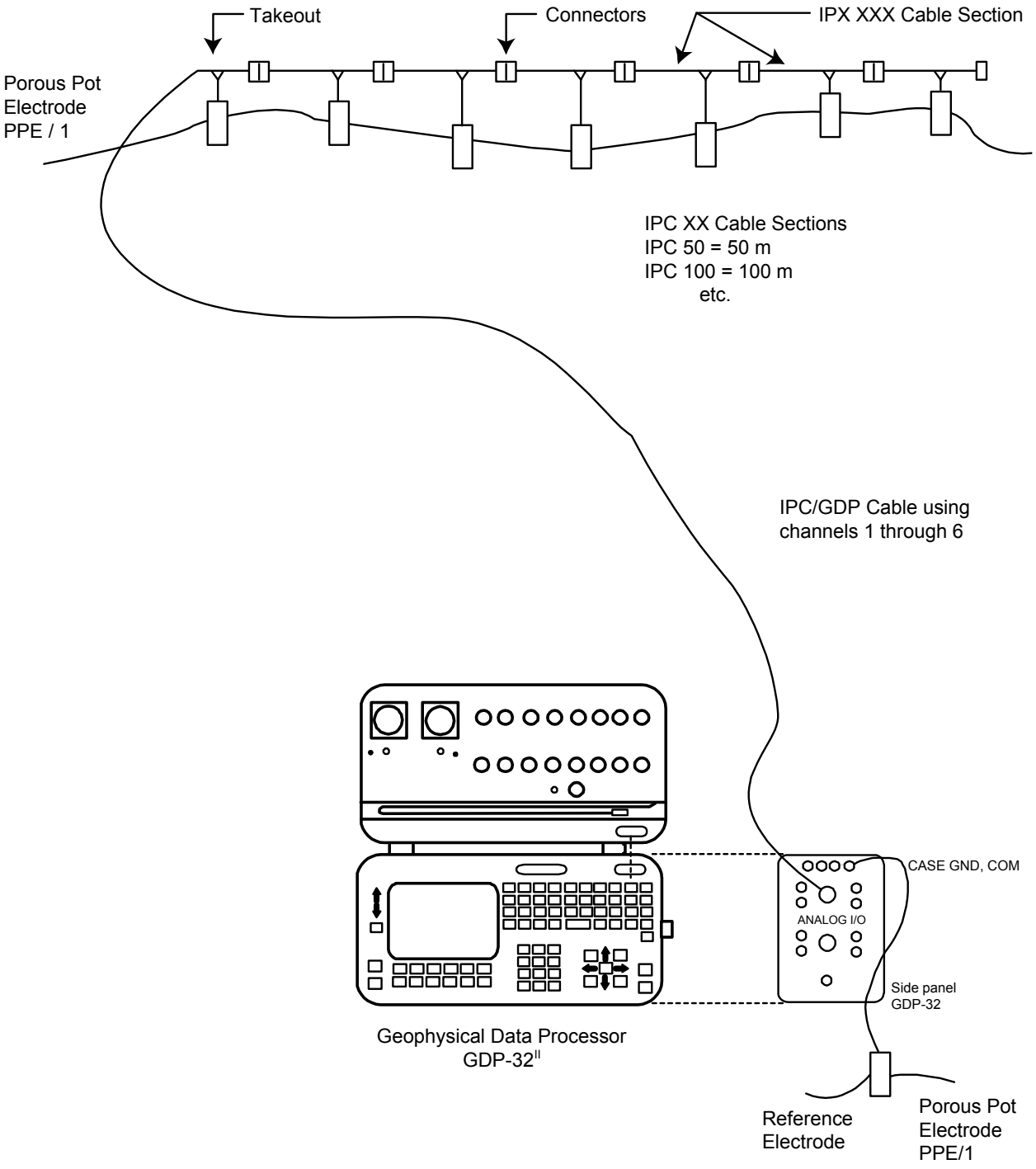
RECEIVER SETUP

Receiver Setup for Resistivity, Time Domain IP, Resistivity / Phase IP, and Non-Reference Complex Resistivity



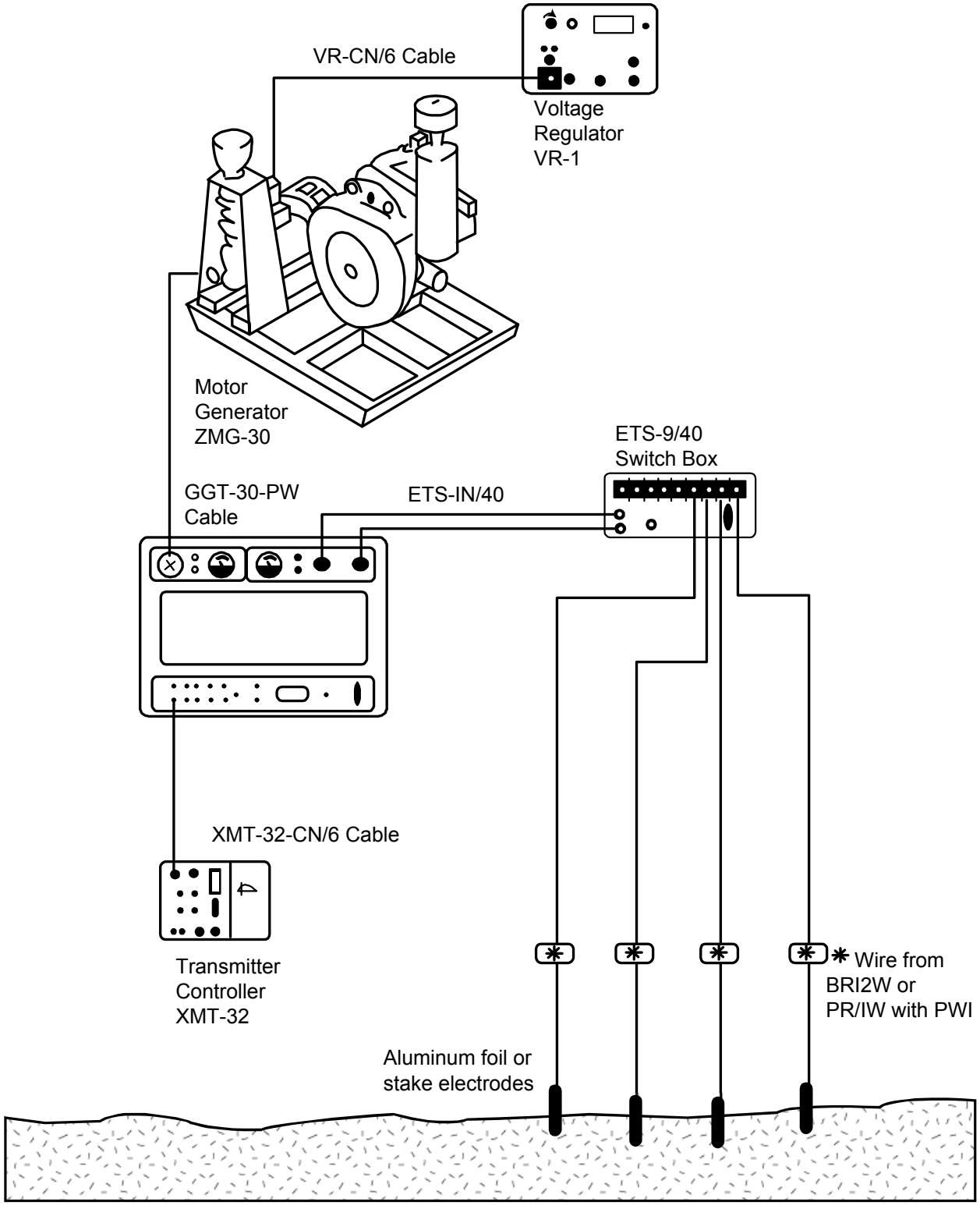
RECEIVER SETUP USING THE ROLL-ALONG CABLE

Receiver Setup for Resistivity, Time Domain IP, Resistivity / Phase IP, and Non-Reference Complex Resistivity Using the Roll-Along Cable



TRANSMITTER SETUP

Tx Setup for Time Domain IP, Resistivity/Phase, and non-Reference CR



FULL REFERENCE CALIBRATION

CRIP Full Reference Calibration Wiring Diagram