13. NATURAL SOURCE MAGNETOTELLURICS

13.1 INTRODUCTION

Natural source magnetotellurics (MT) or audio-frequency magnetotellurics (AMT) is a frequency domain EM program that uses naturally occurring random noise as the signal source. This data acquisition system uses cascade decimation and stacking and averaging of Fourier transformed cross and auto-power spectra of the 6th and 8th harmonics, to obtain amplitude and phase measurements of the electric and magnetic fields.

The frequency range of the MT/AMT program is from 0.0007 (6/8192) to 8192 Hz, and is divided into 4 groups as shown below, with the 6th and 8th harmonics displayed:

Low band (SR = 16 Hz)		High band (SR = 4096 Hz)		Very high band (SR = 32768 Hz)	
3. Hz	4. Hz	768	1024	6144	8192
1.5	2.	384	512	3072	4096
.750	1.	192	256	1536	2048
.375	.5	96	128	768	1024
.1875	.250	48	64	384	512
.09375	.125				
.046875	.0625	Medium band			
.023237	.03125	(SR = 256 Hz)			
.0117188	.015625	48	64		
.0058538	.0078125	24	32		
.0029297	.0039063	12	16		
.0014648	.0019531	6	8		
.0007324	.0009766	3	4		

Data for the low band are acquired on a continuous basis, with the filtering, decimation and Fourier transforms being done real-time. Data are acquired for the upper three bands in a "burst" mode with data processing being done between bursts.

Data are accepted or rejected according to coherency and outlier limit tests. The process is explained in more detail in the menu discussions, which follow.

Both electric field (Ex, Ey) measurements and magnetic field (Hx, Hy, Hz) measurements are utilized with this method. A calibrate buffer is provided for the magnetic antenna calibrates, and is labeled **`8) AMT Antenna Cal`** in the calibrate buffer area. The standard board calibrate buffer is labeled **`7) AMT Calibrate`**.

This manual is written in generic form for a 16-channel receiver. If your receiver has less than 16 channels, only information for the number of channels contained will be displayed.

Go to ***Section 6*** for information concerning calibration, synchronization and generic operation of all programs.

Go to the end of this ***AMT program manual*** for suggestions on connecting the receiver for field measurements.

13.2 FIXED FUNCTION KEYS

One of the differences between the GDP-32^{II} and its predecessor, the GDP-32, is the addition of six fixed function keys located below the six soft function keys (F1 through F6) at the bottom edge of the LCD.

These keys are activated with the same menus as before, and are denoted as follows, from left to right:

DATA F7

By pressing this key you enter the field data cache and can view data, escape back to other menus to initialize or view other data caches, or output data to a PC from the data caches. See ***Section 7*** for more details.

EXIT F8

Exit the data taking routine and return to the main menu for selection of other programs by pressing F2. When exiting the program at this point, the main menu will display **Back** above the F2 function key to enable the operator to return to the **AMT** program, if desired.

CAL F9

Press this key to enter the calibrate and system checking program. See ***GDP Section 6.1, Calibration*** for more details.

GAIN F10

Press this key to enter the automatic or manual gain setting and SP buckout menu.

Note: *The MT/AMT program is the only one that automatically enables the front-end gain stage (**G0**). For the best results with natural source MT/AMT, always permit the receiver to use **G0**.*

SP F11

Pressing this key will automatically buck out any self potential (SP) or amplifier offset, for any channel that is turned on.

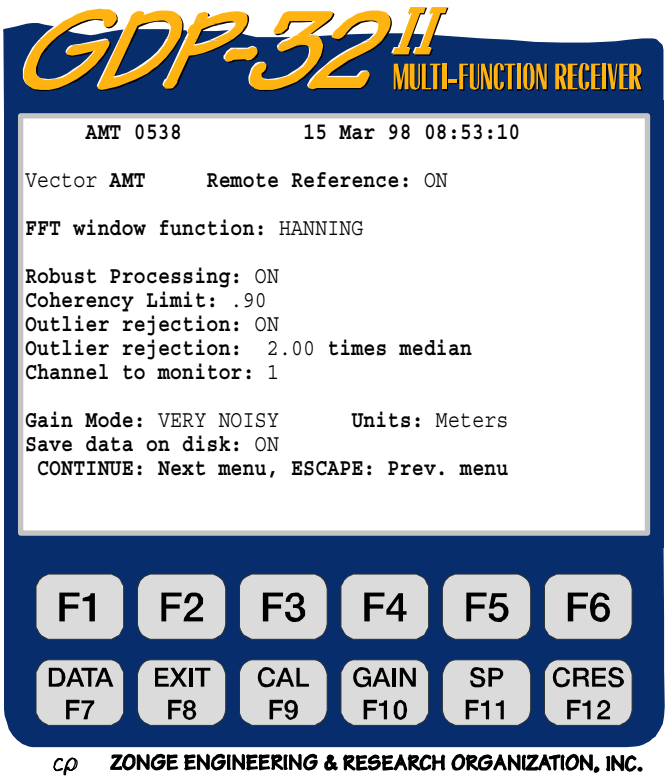
CRES F12

Press this key to measure the contact resistance or coil output resistance. See ***GDP Section 6.3, Measuring Contact Resistance*** for more details.

13.3 MT/AMT PROGRAM OPERATION

MENU 1:

In all of the following menu descriptions, the bold fields in the boxes are the parameters that can be changed by the operator.



<— Robust processing menu for Scalar and Vector only

The DATA F7 key is active.

AMT 0538. Program name and version.

15 Mar 98. Date.

08:53:10. Time.

Robust Processing for scalar and vector data acquisition only.

Vector. There are two choices at this time:

Vector **VEC** (Scalar is a subset of vector)

Tensor **TEN**

The **Vector** AMT configuration is the default option, and is similar to vector CSAMT. The scalar option (multiple E-fields and one H-field) can be used also in this mode, to run EMAP style MT.

Remote Reference: ON. This switch enables or disables the remote reference option.

FFT window function: HANNING. Two window functions are provided in this version: **HANNING** and **RECTANGULAR** (or **BOX CAR**). The **HANNING** window is the

default and should be used for normal operation. The **RECTANGULAR** window can be used when detecting synchronous signals (same frequency as the GDP time base).

Robust Processing: Turns on and off the robust processing mode with the following parameters. This menu is displayed only for the vector mode of operation.

Note: Robust processing is turned off in the GDP-32^{II} at this time, while software modifications are being made.

Coherency Limit: .90. This is the coherency coefficient limit that can be manually set from .00 to .99. This parameter is used in the real-time data acquisition mode to improve the data quality. Default is 0.9. It is suggested that you do not lower the limit past 0.5 for normal data acquisition.

Coherency for the E_xH_y component is defined as:

$$\frac{|E_xH_y^*|^2}{H_yH_y^* \cdot E_xE_x^*}$$

where $E_xE_x^*$, $H_yH_y^*$, and $E_xH_y^*$ are average auto-powers and cross-powers. The same formula is used for the E_yH_x components.

Outlier Rejection: ON. Turns on/off the outlier rejection option.

Outlier rejection: 2 times median. Specifies the rejection limits for the outlier rejection option.

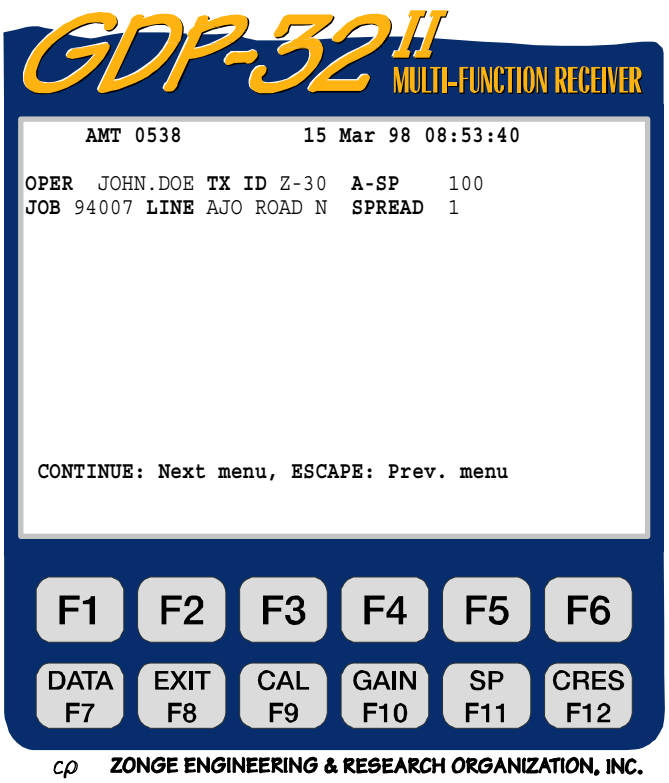
Channel to monitor: 1. Specify the E-field channel to monitor for coherency acceptance. This is valid only for Scalar data acquisition.

Gain Mode. The default mode is "Very Noisy", which limits the gains to obtain a maximum voltage of 0.5 Volts, leaving adequate headroom for SP drift and random noise spikes. The other option is "Noisy", which adjusts the gains for a maximum voltage of 1.0 Volts. See Section 6. Noisy gain mode should be used under normal circumstances to provide sufficient margin for telluric drift.

Units. The operator can select meters or feet. The default is meters.

Save data on disk: ON. This indicates that the operator wants to save the raw time-series data on disk for further processing. This data will be stored to disk prior to internal GDP processing.

MENU 2:



The DATA F7 key is active.

OPER. User defined identification. Alphanumerics permitted.

TX ID. User defined identification. Alphanumerics permitted.

A-SP. E-field dipole size in meters (a-spacing). E-field dipoles can be of different sizes - see Menu 3 below.

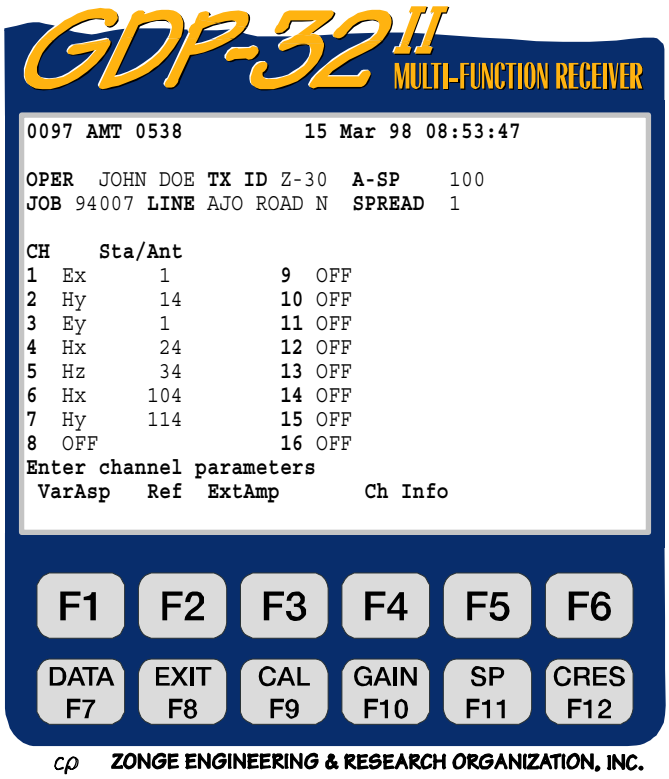
JOB. User defined identification. Alphanumerics permitted.

LINE. Two fields available: **xxxxxxxx** defines the line number and **N, E, S, W, NE, SE, SW, NW** designators are available by using the SELECT UP Home and SELECT DN End keys. Alphanumerics are permitted for the line number field.

SPREAD. User defined identification, a subdivision of the **LINE** designator above. Alphanumerics permitted.

MENU 3:

The following example is for a single station tensor setup with remote reference.



The DATA F7 function key is active.

CH. Any channel designator other than **OFF** will turn the channel **ON**.

Ex, Ey - Electric field designators

Hx, Hy, Hz - Magnetic field designators

Sta/Ant. Dual usage field:

1) E-field designator: Identifies the station number for multiple E-field measurements.
2) H-field designator: Identifies the magnetic field antenna used for that channel. The number in this field must have an exact matching number in the antenna calibrate cache.

Sta/Ant

NNNC **NNN** is the antenna designator or serial number.
C is the antenna type or filter designator.

104 Designates an MT antenna, serial number 10.

50 Designates an ANT/1 antenna (0), serial number 5.

189 Single channel TEM/3 (9), serial number 18.

366 MT/AMT antenna, serial number 36.

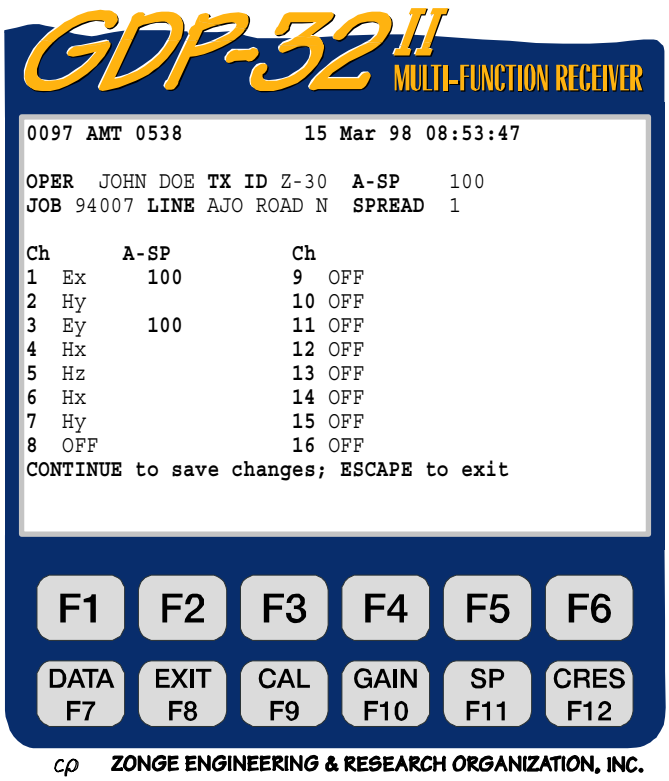
Notice that the H-field antenna designator is offset by one space to the right when compared to the E-field designators. This has been done to easily differentiate between the two types of numbers. The STA field is used with the E-field designators to indicate the station number for multiple E-field measurements. See **Menu 4** and the section on **RESTRICTIONS** for more information.

At this point, pressing the soft function keys in **Menu 3** will result in the following:

VarAsp. Pressing F1 will put the operator in the variable A-spacing input routine as shown below:

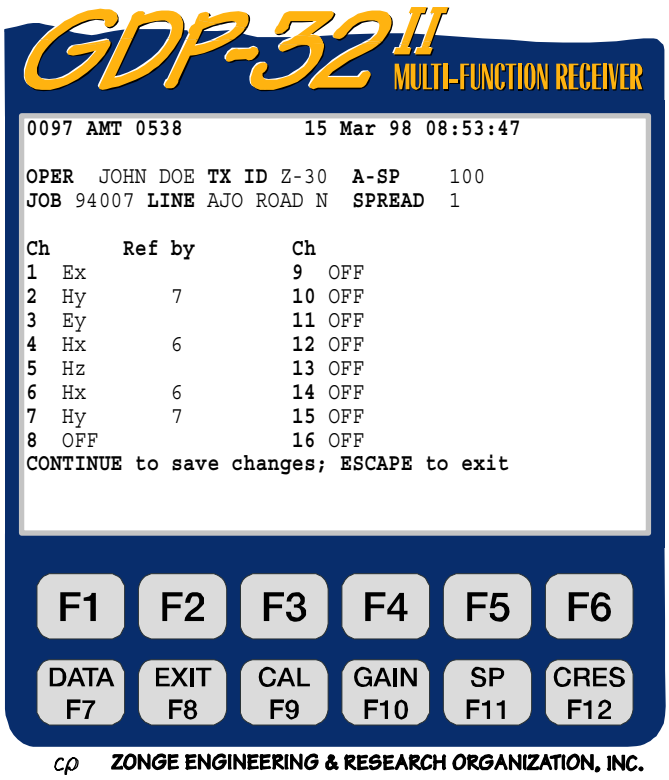
MENU 3A

Ref. Pressing F2 will permit the operator to choose reference stations for remote reference vector or tensor MT measurements. In the diagram below, Channel 6 Hx is chosen as the remote reference for Channel 4 (Ey,Hx) and Channel 7 Hy is chosen for Channel 2 (Ex,Hy) as seen below:



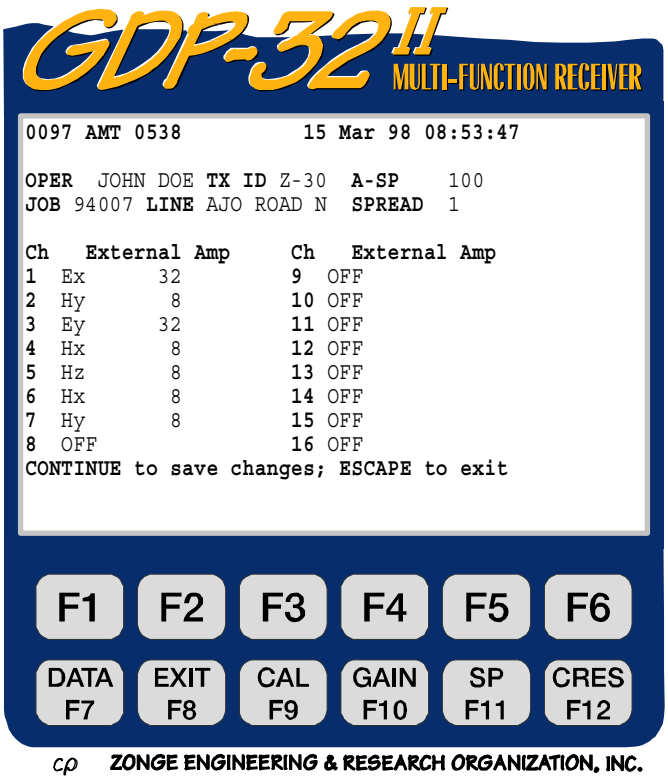
MENU 3B

ExtAmp. Pressing F3 enables input for preamplifier gains, such as the SC-8 Signal Conditioning box. In this example we have set all of the E-field channels to a gain of 32 and the H-field channels to a gain of 8.



MENU 3C

NOTE: For best results, always use an external signal conditioner with low noise preamplifiers and frequency bandwidth limiting capability, such as the SC-8 Signal Conditioning unit.



Ch Info. By pressing F5, you can access data on the analog cards that have passed QC. For example:

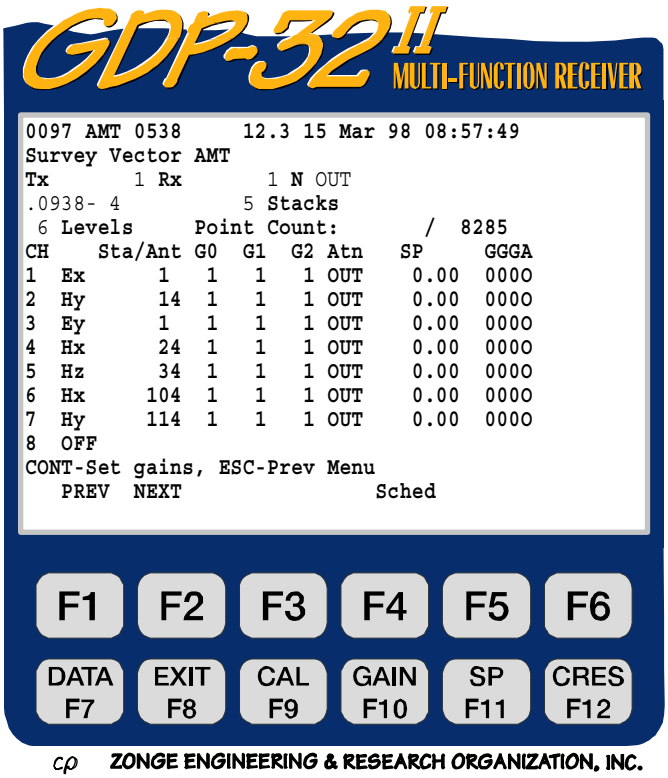
```
1 LoPass  Notch+60,3-5,9  S/N   67 Passed
2 LoPass  Notch+60,3-5,9  S/N  127 Passed
3 LoPass  Notch+60,3-5,9  S/N  256 Passed
```

Here **LoPass** indicates the input amplifier configuration, the powerline notch filter is a **60/180/300/540** Hz filter, (the **+** indicates a modification level), and the three board serial numbers are **67**, **127**, and **256**.

Note that a number (**0097**) is visible before the program designator (**AMT 0538**). This number is the label of the last data block written to the data cache. The next time a block of data is written to the cache, it will be numbered **0098**.

MENU 4:

Upon pressing CONTINUE Enter after the channels are set up in Menu 3, the following screen will be displayed:



Tensor configuration selected with channels 6 and 7 used as remote reference

<– H-fields as shown above in Menu 3B.

<– Point Count - only displayed for the low frequency band

Soft function keys F1 and F2 are active:

PREV/NEXT Pressing F1 and F2 permits the operator to scroll the channel parameters up and down, so that all 16 channels can be accessed. These labels will not be displayed if the receiver has 8 channels or less.

Sched. By pressing F5 you enter the automatic time schedule mode, for automatic control of data acquisition. If you are using an SC-8 signal conditioner box, the same schedule can be entered into the box for control of gains and filter settings as a function of time. **See *Section 13.13*.**

All function keys are active: DATA F7, EXIT F8, CAL F9, GAIN F10, SP F11, CRES F12.

Tx. Transmitter location. The field for **Tx** designation is ±NNNNNNN with a floating decimal point. **Tx** is not used for AMT calculations, but could be used as a location or survey designator.

Rx. Receiver location. The field for **Rx** is ±NNNNNNN with a floating decimal point. For multiple E-field surveys, we normally set **Rx** equal to the station location at which the receiver is set up. In this example, we are occupying one station, so the station number (**Sta**) and **Rx** are the same.

N. Powerline notch filter switch. You have several possible selections here, depending upon the configuration of your receiver. For this example, we have two options.

Use SELECT UP Home or SELECT DN End to change.

`OUT` - All notch filters bypassed.
`60` - 60 and 180 Hz notch filters enabled.
`60,5` - 60, 180, 300 and 540 Hz notch filters enabled.

Other standard selections are:

`50` - 50 and 150 Hz notch filters enabled.
`50,5` - 50, 150, 250 and 450 Hz notch filters enabled.
`50/60` - 50, 150, 60 and 180 Hz notch filters enabled.

Remember that powerline notch filters inject noise into the system, and should only be used when absolutely necessary.

`.0938- 4` Frequency band selected. Use SELECT UP Home or SELECT DN End to change bands. Options are:

384 - 8192
48 - 1024
3 - 64
.0007 - 4 (.0938- 4 is the 6th level of this band)

`Point Count` This indicator is displayed for the low frequency band only, and provides an indicator to the operator as how far along the program is in its data acquisition. For the 6th level of decimation shown here, the total number of points acquired for each time series is 8285. For the 13th level, this increases to 1.061 million points.

`Stacks.` The total number of time series records specified to be acquired and processed at this frequency band. Here the setting is for 5 time series of 8285 data points each.

`6 Levels.` The number of decimation levels selected for the low frequency band. Levels of decimation available are as follows:

Level	Frequency band
2	1.5 - 4 Hz
3	.75 - 4
4	.375 - 4
5	.1875 - 4
6	.0938 - 4
7	.0469 - 4
8	.0234 - 4
9	.0117 - 4
10	.0059 - 4
11	.0029 - 4
12	.0015 - 4
13	.0007 - 4

Only the low frequency band permits selection of decimation levels. All of the rest are fixed at 5 levels. Accordingly, the level prompt only appears for the low frequency band. Refer to the Introduction to this chapter for the frequency content of the medium, high and very high bands.

Sta/Ant.The **Sta**(tion) field (station numbers for individual E-fields) can be changed in Menu 4, but the **Ant**(enna) numbers are accessible only in Menu 3. In Menu 4, the cursor will skip over any channels labeled with an H-field designator.

NOTE: *Our standard data processing programs sort first on station number, second on Rx and third on Tx. To ensure proper sorting in data processing the operator must make sure the station numbers are entered properly.*

G0, G1, G2. Gain stages 0, 1 and 2. In this example, all gain stages are set to unity gain by default. Upon pressing CONTINUE Enter, the program will automatically set the gains and SP buckout if the auto-gain mode is selected as denoted by the message at the bottom of the screen: **CONT- Set gains, ESCAPE-Prev menu**. (This is the default mode).

Atn. The attenuator is bypassed (set to **OUT**). The other option is **IN**. The attenuator should not normally be used for natural source methods.

SP. Self Potential or offset in millivolts. Initially set to 0.00. Will be set to the actual value upon pressing CONTINUE Enter.

GGGA. Gain settings for stages 0, 1 and 2 (in powers of 2). The attenuator setting is **A**, **I** for **IN**, **O** for **OUT**.

CAUTION: Some values are not registered in the computer memory until you exit the parameter field by pressing PREV FIELD Pg Up, NEXT FIELD Pg Dn, or CONTINUE Enter. The exceptions to this rule are the frequency band and the powerline notch filters. Frequency band is used as the sample rate selection. Whenever you change the frequency the sample rate is automatically changed through the timing card. However, the anti-alias filter is not changed until just prior to data acquisition. Upon pressing CONTINUE Enter to gather data or set gains, the receiver will automatically set the anti-alias filter as defined by internal look-up tables.

Notice also that the battery voltage (12.3) has now been inserted between the program version number and the date.

13.4 GATHERING DATA

Upon pressing CONTINUE Enter after the parameters are set up in Menu 4 the following screen display is an example of what you will see with a signal connected to channels 1 through 4. The battery voltage is measured and the A/D converter is automatically calibrated before each measurement cycle.

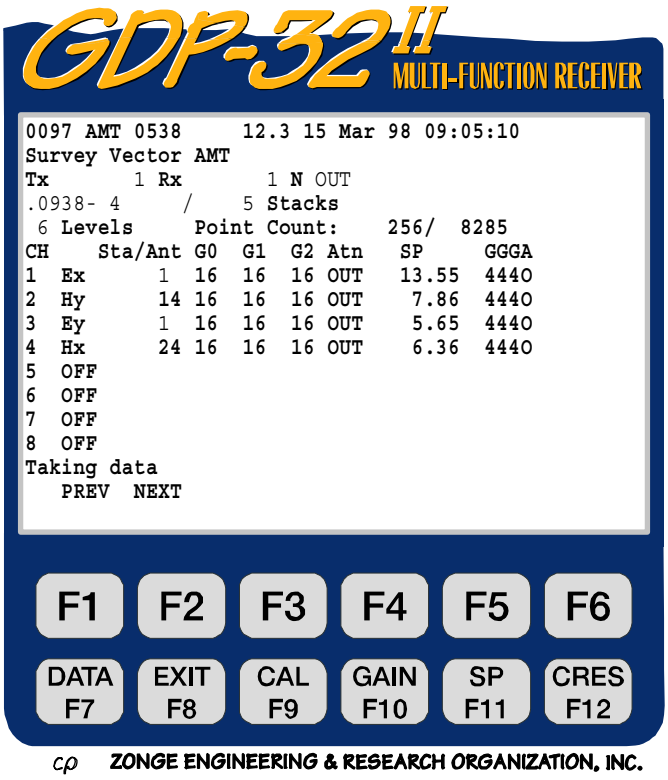
For this example, we will set the frequency band to .0938 - 4 Hz, set the number of stacks to acquire to 5, set the external preamplifier gains to 1, and just turn on the first four channels in a vector configuration. The signal source for the following examples is the pseudorandom noise source from a Tektronix 2642A Fourier Analyzer set to 1 mV RMS output with a 1 KHz bandwidth and an additional RC network to modify the signals to Ch 3 and 4 (Ey, Hx).

The program will first set up the gains using all three gain stages, buck out the SP automatically and then continue to gather data. The very "noisy" gain mode in MT/AMT adjusts the gains until a signal level of 0.5 volts is obtained, starting with gain stage 0 (G0).

The program will acquire and save one stack of time series data at a time (8285 data points in this example) until the stack count is complete or until the STOP AVG Escape key is pressed.

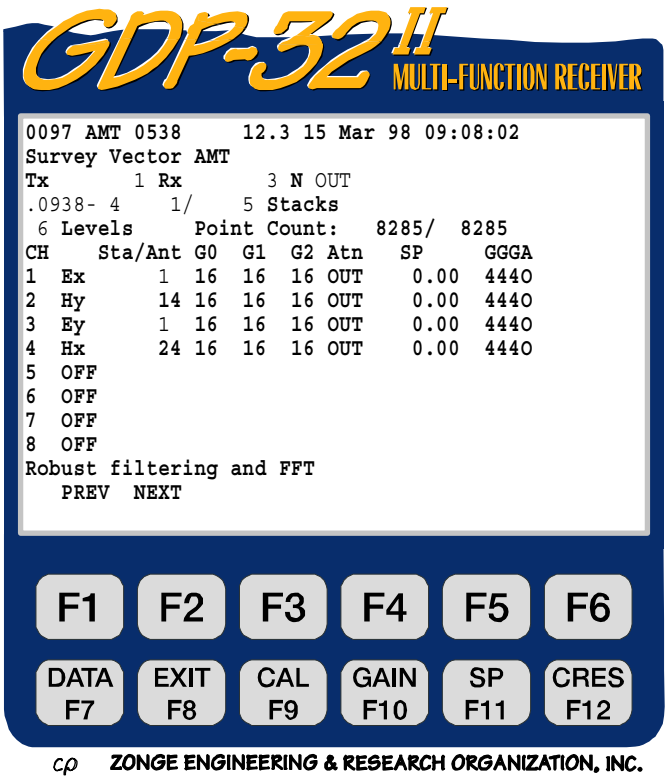
The display during data acquisition will appear as the following figure. The gains will be displayed, but no data will appear until a complete time series is acquired or STOP AVG Escape is pressed. For the low frequency band, the point count will change in increments of about 64 points as data are acquired.

ACQUIRING DATA:



DATA ACQUISITION COMPLETE

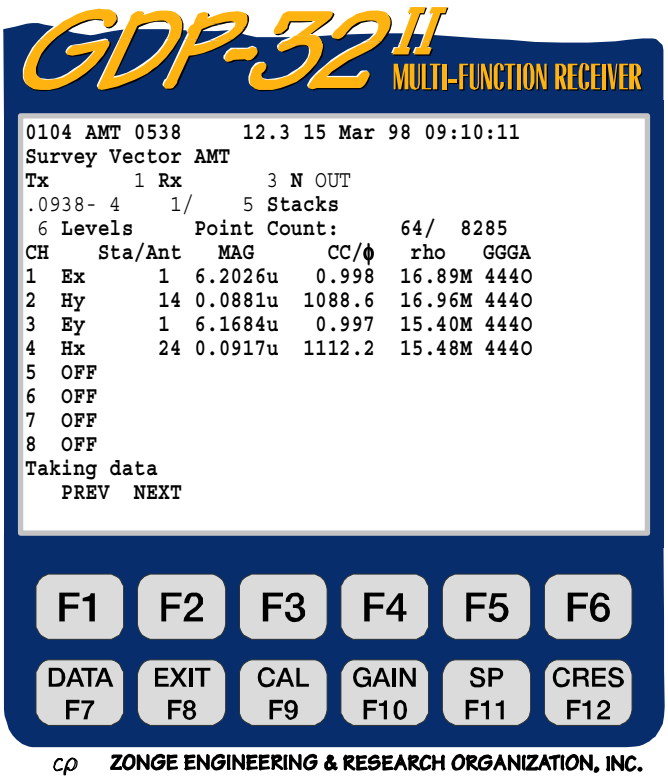
now FILTERING, DECIMATING and FOURIER TRANSFORMING data:



DATA ACQUISITION IS COMPLETE FOR THE FIRST STACK

now acquire the next 4 stacks:

The values displayed at the end of each stack are for the lowest frequency component in the band. Here the lowest frequency is .0938 Hz.



MAG. The square root of the autopower of each component. The E-field channels are not normalized, so the units are volts. The H-field channels are normalized by the antenna calibrates, and the resultant units are microTeslas.

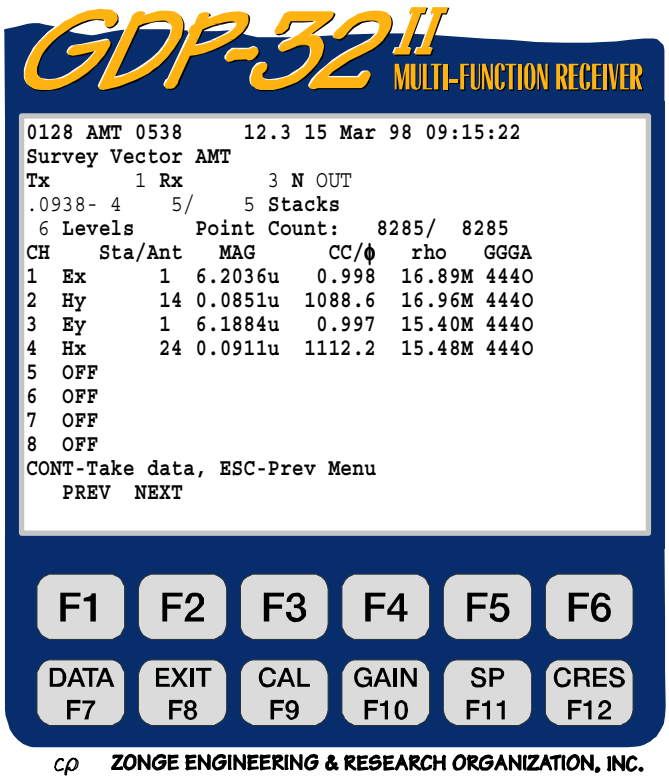
CC/ϕ. Coherency coefficient between the orthogonal E and H components of the 6th harmonic on the E-field lines, or phase difference in milliradians on the H-field lines.

rho. Cagniard or apparent resistivity in ohmmeters for the 6th harmonic. The top value for RHOxy is calculated using $ExHy^{*}/HyHy^{*}$, the bottom value is $ExEx^{*}/HyEx^{*}$. The same logic is used for EyHx.

FINISHED TAKING DATA

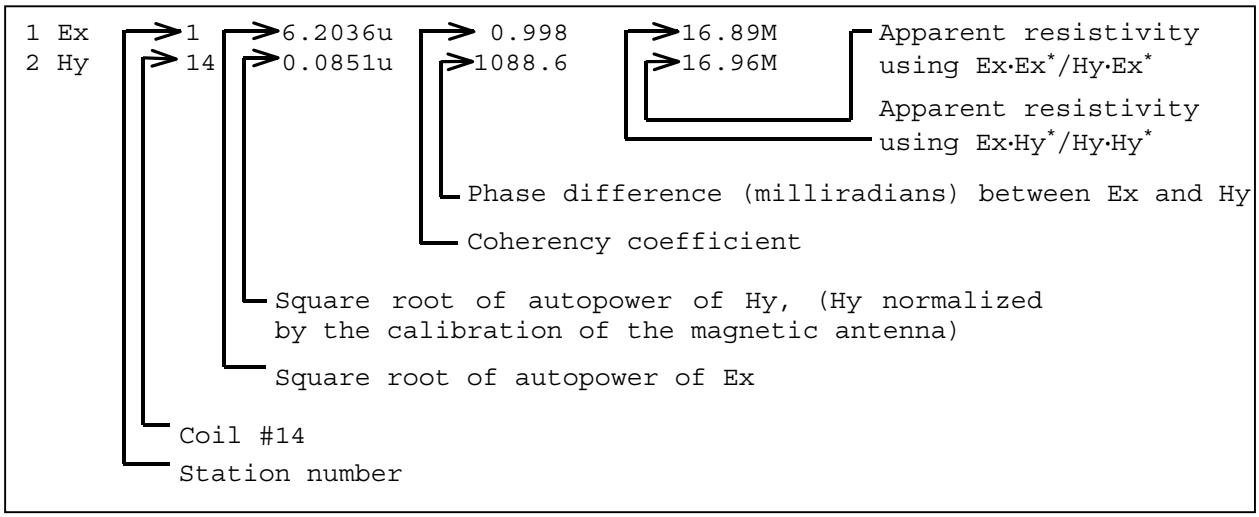
(or 

was pressed):

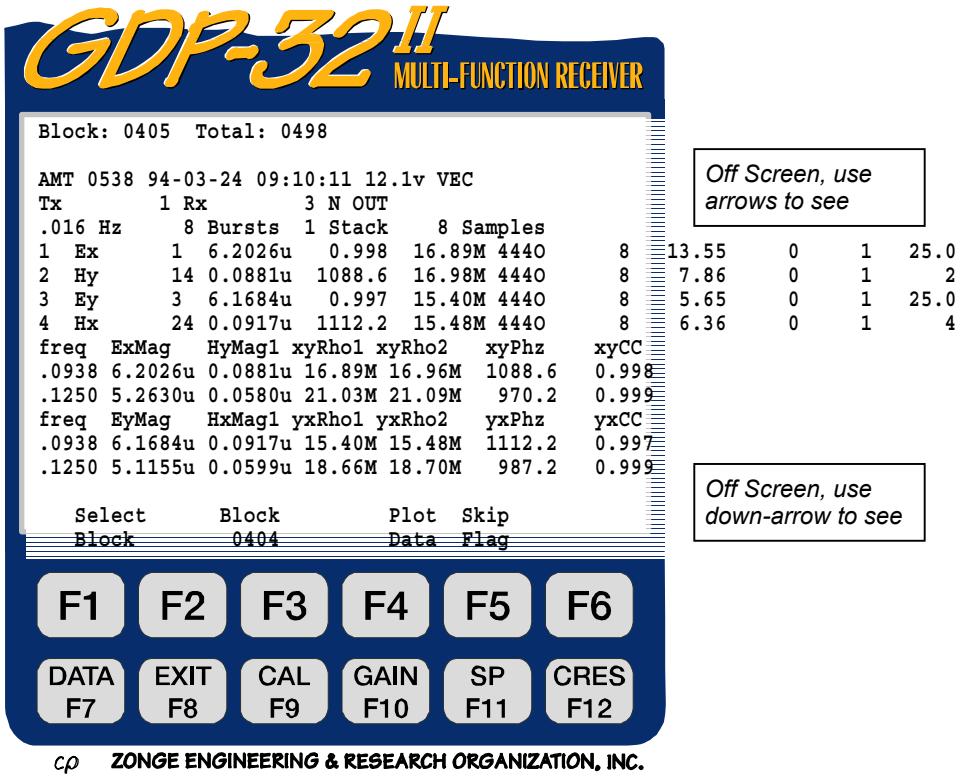


All function keys are active: DATA F7, EXIT F8, CAL F9, GAIN F10, SP F11, CRES F12 at the end of data acquisition.

Additional explanation of output:



If you want to view the stored data, press the DATA F7 key. It will display the last stack taken. See ***Section 7*** for an explanation of the data mode. The data display is in the following format:



The BURSTS saved, SP, contact resistance values, pre-amp gain, variable A-spacing and reference channel have been saved, but are off of the screen to the right.

To view these numbers press → several times to move to the right,

or press ← to move to the left.

Some of the data for coherencies and phase are off the screen towards the right, and frequency, magnitudes and resistivities are off the screen toward the bottom. Use → and ↓ or NEXT FIELD Pg Dn to view these data.

Plot Data. By pressing F5 you get into the plot routines.

Skip Flag. By pressing F6 an '**x**' is placed 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 will be skipped when averaging multiple blocks for plotting. Repeated pressing of F6 will remove and replace the '**x**'.

13.5 A NOTE ON VARIABLE A-SPACING

When using variable A-Spacings, the key to getting the correct A-Spacing entered and used, is to remember two things: 1) the last field changed controls the A-Spacing value that is used, and 2) the A-Spacing that is used is ALWAYS the value in the Variable A-Spacing list.

For example, if the operator sets the A-Spacing value in the header to 50 M, then all of the numbers in the Variable A-Spacing list are set to 50 M. If the operator then gets into the Variable A-Spacing list and changes all of the values to, say, 25 M, then the A-Spacing value left in the header will still be 50 M but the actual values used will be 25 M - as shown in the Variable A-Spacing list.

The computer remembers where the latest changes were made and upon startup of the program. The A-Spacing in the header will still be 50 M, and the values in the Variable A-Spacing cache will still be 25 M. However, if the operator sets the A-Spacing in the header to, say, 100 M on startup, then the Variable A-Spacing values will all be set to 100 M.

13.6 A NOTE ON PHASE

For scalar operations the phase difference between Ex and Hy should be between 200 and 1500 milliradians. In the presence of 2 and 3-D features, or when measuring fields in an anisotropic environment, the phase values can approach π radians (3141.6 mr), but this is unusual.

For vector operations, keep the phase differences positive for both sets of measurements by orienting Ex positive north, Hy positive east, and Ey positive east, Hx positive south.

For tensor measurements orient Ex positive north, Hy positive east and then Ey positive is oriented east and Hx positive north. For this configuration the phase difference will be positive for Ex Hy and negative for Hx Ey, which is the standard tensor setup.

If the phase differences are coming out negative when they should be positive (and vice versa), this means that you have either the E-field or H-field orientations wrong. To correct this, just switch one of the connections at the receiver, or rotate the H-field sensor by 180 degrees.

13.7 A NOTE ON SCALING

The following convention is used for all measured and calculated parameters:

- Voltage (magnitudes), displayed in volts.
- Phase, displayed in milliradians.
- Apparent resistivity, displayed in ohm-meters.
- Dipole spacings, displayed in meters.
- Coil calibrate magnitudes, entered and displayed in millivolts per gamma.
- SP, displayed in millivolts
- CC, displayed in units from 0.00 to 0.99
- E-field (magnitudes), displayed in volts.
- H-field(magnitudes), displayed in kilo-gammas

If scaling is necessary on these values, the following labels are appended to the end of the number string:

M - Mega units
K - Kilo units
m - milli units
u - micro units

13.8 RESTRICTIONS

The main restriction on setting up the channels and using this program is to ***make sure the E-field channels always precede the corresponding orthogonal H-field channels***. In calculating Cagniard resistivities, the program first looks for an E-field channel, and then matches it up with the ***first orthogonal H-field channel that it finds when going down the channel list***.

Following is an example for connecting and defining the channels for scalar measurements on 7 separate stations:

```
CH    Sta/Ant    MAG     CC/ϕ   rho  GGGA
 1 Ex      1
 2 Ex      2
 3 Ex      3
 4 Ex      4
 5 Ex      5
 6 Ex      6
 7 Ex      7
 8 Hy      14
```

This example is similar to scalar CSAMT, measuring E-fields at 7 different stations, with the H-field antenna placed near the center of the array. This array is normally used for reconnaissance or E-Map applications.

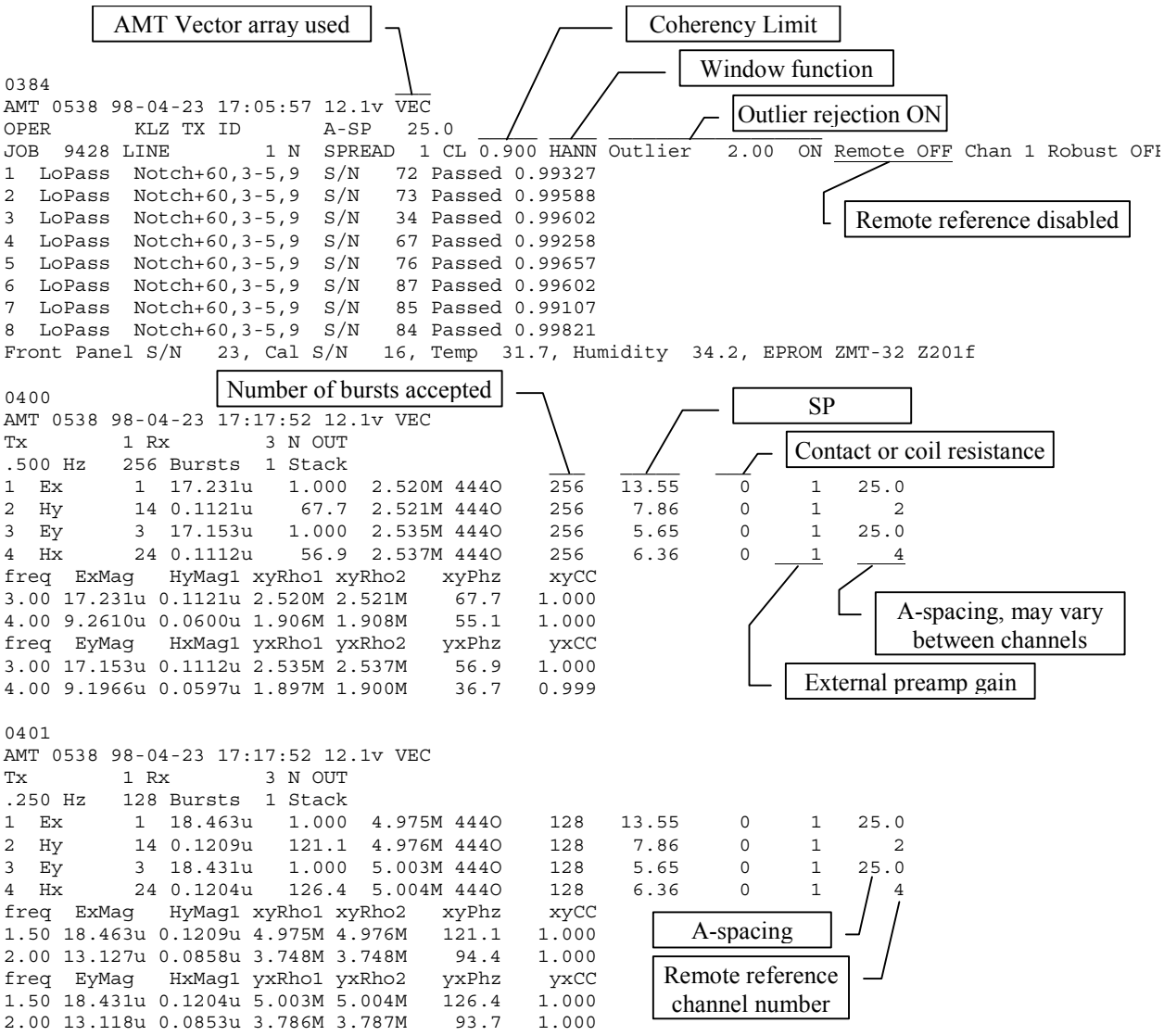
The numbers 1 through 9 in the **ANT** field are used as station identifiers for data processing. The Rx value (not shown above) is commonly used to indicate the location of the GDP. These numbers can be any value from 0 to 9999999. The number 14 on the **CH 8 Hy** line indicates that the calibrates for AMT antenna Serial Number 1 are to be used. This exact number must identify the calibrates in the AMT antenna calibrate cache.

These two hookup configurations are identical as far as the AMT program is concerned but the display of the results will be different:

```
CH    Sta/Ant    MAG     CC/ϕ   rho  GGGA
 1 Ex      1
 2 Hy      14
 3 Ey      1
 4 Hx      24
 5 OFF
 6 OFF
 7 OFF
 8 OFF
```

```
CH    Sta/Ant    MAG     CC/ϕ   rho  GGGA
 1 Ex      1
 2 Ey      1
 3 Hx      14
 4 Hy      24
 5 OFF
 6 OFF
 7 OFF
 8 OFF
```

AN EXAMPLE OF FIELD DATA




```
0384
AMT 0538 98-04-23 17:05:57 12.1v VEC
OPER       KLZ TX ID       A-SP   25.0
JOB  9428 LINE        1 N  SPREAD  1 CL 0.900 HANN Outlier   2.00  ON Remote OFF Chan 1 Robust OFF
1  LoPass  Notch+60,3-5,9  S/N   72 Passed 0.99327
2  LoPass  Notch+60,3-5,9  S/N   73 Passed 0.99588
3  LoPass  Notch+60,3-5,9  S/N   34 Passed 0.99602
4  LoPass  Notch+60,3-5,9  S/N   67 Passed 0.99258
5  LoPass  Notch+60,3-5,9  S/N   76 Passed 0.99657
6  LoPass  Notch+60,3-5,9  S/N   87 Passed 0.99602
7  LoPass  Notch+60,3-5,9  S/N   85 Passed 0.99107
8  LoPass  Notch+60,3-5,9  S/N   84 Passed 0.99821
Front Panel S/N   23, Cal S/N   16, Temp  31.7, Humidity  34.2, EPROM ZMT-32 Z201f

0400
AMT 0538 98-04-23 17:17:52 12.1v VEC
Tx        1 Rx        3 N OUT
.500 Hz   256 Bursts  1 Stack
1  Ex      1  17.231u   1.000  2.520M 444O    256   13.55     0     1   25.0
2  Hy     14 0.1121u    67.7  2.521M 444O    256    7.86     0     1      2
3  Ey      3  17.153u   1.000  2.535M 444O    256    5.65     0     1   25.0
4  Hx     24 0.1112u    56.9  2.537M 444O    256    6.36     0     1      4
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
3.00 17.231u 0.1121u 2.520M 2.521M    67.7   1.000
4.00 9.2610u 0.0600u 1.906M 1.908M    55.1   1.000
freq  EyMag   HxMag1 yxRho1 yxRho2   yxPhz    yxCC
3.00 17.153u 0.1112u 2.535M 2.537M    56.9   1.000
4.00 9.1966u 0.0597u 1.897M 1.900M    36.7   0.999

0401
AMT 0538 98-04-23 17:17:52 12.1v VEC
Tx        1 Rx        3 N OUT
.250 Hz   128 Bursts  1 Stack
1  Ex      1  18.463u   1.000  4.975M 444O    128   13.55     0     1   25.0
2  Hy     14 0.1209u    121.1  4.976M 444O    128    7.86     0     1      2
3  Ey      3  18.431u   1.000  5.003M 444O    128    5.65     0     1   25.0
4  Hx     24 0.1204u    126.4  5.004M 444O    128    6.36     0     1      4
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
1.50 18.463u 0.1209u 4.975M 4.976M   121.1   1.000
2.00 13.127u 0.0858u 3.748M 3.748M    94.4   1.000
freq  EyMag   HxMag1 yxRho1 yxRho2   yxPhz    yxCC
1.50 18.431u 0.1204u 5.003M 5.004M   126.4   1.000
2.00 13.118u 0.0853u 3.786M 3.787M    93.7   1.000
```

AN EXAMPLE OF SCALAR FIELD DATA

```
0384
AMT 0538 98-04-09 18:38:39 11.8v VEC
Tx        1 Rx        4 N 60
32 Hz    32 Bursts  1 Stack
1  Ex      1  13.085u   0.907  10.73  023O     25   -0.06     0    32    100
2  Ex      2  17.443u   0.978  20.56  023O     25    0.00     0    32    100
3  Ex      3  20.851u   0.940  28.22  023O     25    0.20     0    32    100
4  Ex      4  20.399u   0.976  28.04  023O     25   -0.14     0    32    100
5  Ex      5  24.703u   0.973  41.02  022O     25   -0.06     0    32    100
7  Hy     34 1.2281u   848.4  43.31  020O     25    0.00     0     8      7
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
192 13.085u 1.2281u 10.73  13.03    755.9   0.907
256 41.456u 3.1088u 13.72  14.06   1061.2   0.988
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
192 17.443u 1.2281u 20.56  21.48    789.1   0.978
256 49.744u 3.1088u 19.82  20.19   1033.4   0.991
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
192 20.851u 1.2281u 28.22  31.95    838.1   0.940
256 56.068u 3.1088u 25.22  25.60   1000.8   0.992
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
192 20.399u 1.2281u 28.04  29.46    835.7   0.976
256 66.029u 3.1088u 35.00  35.49    986.6   0.993
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC
192 24.703u 1.2281u 41.02  43.31    848.4   0.973
256 89.405u 3.1088u 64.05  65.18    904.8   0.991
```

AN EXAMPLE OF SCALAR DATA WITH A REMOTE REFERENCE

```
0468
AMT 0538 98-04-09 19:41:57 11.6v VEC
Tx        1 Rx        5 N 60
32 Hz    20 Bursts  1 Stack
1  Ex      1  4.5206u   0.849  3.616  004O     20   -0.06     0    32    100
2  Ex      2  10.468u   0.950  21.71  004O     20    0.00     0    32    100
3  Ex      3  15.732u   0.915  47.19  004O     20    0.19     0    32    100
4  Ex      4  12.521u   0.941  30.77  004O     20   -0.14     0    32    100
5  Ex      5  14.123u   0.938  39.01  004O     20   -0.06     0    32    100
7  Hy     34 0.7261u   853.0  40.41  012O     20    0.53     0     8      8
8  Hy     34 0.0788u     0.0      0  042O     20    0.00     0     8      8
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC  HyrMag
192 4.5206u 0.7261u 3.616  5.442    592.7   0.849  .0788u
256 37.830u 2.9825u 12.49  12.75   1077.5   0.987  .2800u
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC  HyrMag
192 10.468u 0.7261u 21.71  22.30    796.0   0.950  .0788u
256 45.367u 2.9825u 17.99  18.30   1052.8   0.989  .2800u
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC  HyrMag
192 15.732u 0.7261u 47.19  50.78    863.9   0.915  .0788u
256 51.542u 2.9825u 23.29  23.54   1027.3   0.992  .2800u
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC  HyrMag
192 12.521u 0.7261u 30.77  31.86    814.3   0.941  .0788u
256 62.164u 2.9825u 33.92  34.18   1021.4   0.993  .2800u
freq  ExMag   HyMag1 xyRho1 xyRho2   xyPhz    xyCC  HyrMag
192 14.123u 0.7261u 39.01  40.41    853.0   0.938  .0788u
256 87.352u 2.9825u 67.14  67.39    963.6   0.996  .2800u
```

AN EXAMPLE OF TENSOR DATA

```
0120
AMT 0538 98-04-09 16:19:12 12.1v TEN
Tx        1 Rx        3 N 60
   32 Hz    32 Bursts  1 Stack
1  Ex      1  6.6429u   0.896  6.238  023O     32   -0.02     0    32    100
2  Hy      34 1.6298u  -404.6      0  231O     32   -0.97     0     1      2
3  Ey      3  4.7596u   0.003  8.606u 031O     32    0.19     0    32    100
4  Hx      34 8.8842u   675.3      0  041O     32   -2.74     0     1      4
 freq  ExMag   HyMag  xyRho    xyPhz    xyCC  ExEy*   ExEy*   ExHx*   ExHx*   ExHy*   ExHy*
  192 6.6429u 1.6298u 6.238    675.3   0.896  138.4u -106.6u  7.762u -7.922u  10.04u  7.959u
  256 6.6429u 1.6298u 21.20    932.9   0.995  0.119   66.12m -66.47u -709.3u  168.8u  273.3u
 freq  EyMag   HxMag  yxRho    yxPhz    yxCC  EyHx*   EyHx*   EyHy*   EyHy*   HxHy*   HxHy*
  192 4.7596u 8.8842u 10.64  -2341.4   0.003  2.610u  0.652u -0.195u  2.488u  0.043u  0.151u
  256 4.7596u 8.8842u 10.64  -2341.4   0.982 -994.8u -1.423m  657.0u  370.6u -3.547u  1.732u
```

Real, Imag — Real, Imag

AN EXAMPLE OF TENSOR DATA WITH HZ

```
0220
AMT 0538 98-05-07 12:54:55 13.2v TEN
OPER         1 TX ID     1 A-SP    100
JOB     1 LINE        1 N  SPREAD  1 CL 0.900 HANN Outlier   2.00  ON Remote OFF
1  LoPass  Notch+60,3-5,9  S/N   52 Passed 1.00069
2  LoPass  Notch+60,3-5,9  S/N   31 Passed 1.00151
3  LoPass  Notch+60,3-5,9  S/N   53 Passed 0.99986
4  LoPass  Notch+60,3-5,9  S/N   51 Passed 1.00055
5  LoPass  Notch+60,3-5,9  S/N   68 Passed 0.99986
6  LoPass  Notch+60,3-5,9  S/N   36 Passed 1.00110
7  LoPass  Notch+60,3-5,9  S/N   25 Passed 0.99890
Front Panel S/N   16, Cal S/N    5, Temp -450.0, Humidity -450.0, EPROM ZMT-32 Z201h

0221
AMT 0538 98-05-07 12:55:29 13.2v TEN
Tx        1 Rx        3 N OUT
  128 Hz   129 Bursts  1 Stack
1  Ex      1  430.33u   0.016  164.7u 000O    129    0.00     0     1    100
2  Hy       1 686.04u   575.0      0  000O    129    0.00     0     1      2
3  Ey      3  447.40u   0.030  1.337m 000O    129    0.00     0     1    100
4  Hx       1 345.18u  1880.2      0  000O    129    0.00     0     1      4
5  Hz       1 367.28u     0.0      0  000O    129    0.00     0     1      5
 freq  ExMag   HyMag  xyRho    xyPhz    xyCC  ExEy*   ExEy*   ExHx*   ExHx*   ExHy*   ExHy*
  768 430.33u 686.04u 164.7u   575.0   0.016 -0.259  -0.278   27.88m -8.883m  76.89m  51.44m
 1024 421.40u 357.52u 62.68u  2741.7   0.003  0.185   0.410   28.77m  6.017m -16.94m  8.706m
 freq  EyMag   HxMag  yxRho    yxPhz    yxCC  EyHx*   EyHx*   EyHy*   EyHy*   HxHy*   HxHy*
  768 447.40u 345.18u 1.337m  1880.2   0.030 -20.32m  63.18m -10.59m  72.01m -1.721m  84.78u
 1024 361.67u 270.09u 470.6u  2067.5   0.013 -11.99m  24.73m  4.761m  44.74m  33.63u  1.052m

 HzHy*   HzHy*   HzMag
 876.6u -6.042m  367.28u
 3.479m  49.68u  414.76u
 HzHx*   HzHx*
 5.315m  4.018m
 4.123m  636.4u
```

AN EXAMPLE OF FULL TENSOR DATA WITH REMOTE REFERENCE

```
0226
AMT 0538 98-05-07 13:02:10 13.2v TEN
OPER         1 TX ID     1 A-SP    100
JOB     1 LINE        1 N  SPREAD  1 CL 0.900 HANN Outlier   2.00  ON Remote  ON
1  LoPass  Notch+60,3-5,9  S/N   52 Passed 1.00069
2  LoPass  Notch+60,3-5,9  S/N   31 Passed 1.00151
3  LoPass  Notch+60,3-5,9  S/N   53 Passed 0.99986
4  LoPass  Notch+60,3-5,9  S/N   51 Passed 1.00055
5  LoPass  Notch+60,3-5,9  S/N   68 Passed 0.99986
6  LoPass  Notch+60,3-5,9  S/N   36 Passed 1.00110
7  LoPass  Notch+60,3-5,9  S/N   25 Passed 0.99890
Front Panel S/N   16, Cal S/N    5, Temp -450.0, Humidity -450.0, EPROM ZMT-32 Z201h

0227
AMT 0538 98-05-07 13:02:49 13.1v TEN
Tx        1 Rx        3 N OUT
  128 Hz   129 Bursts  1 Stack
1  Ex       1  347.46u   0.040  108.7u 000O    129    0.00     0     1    100
2  Hy        1 7.9696m  3126.8      0  000O    129    0.00     0     1      6
3  Ey       3  382.29u   0.023  67.56m 000O    129    0.00     0     1    100
4  Hx        1 244.27u   115.3      0  000O    129    0.00     0     1      7
5  Hz        1 331.13u     0.0      0  000O    129    0.00     0     1      5
6  Hx        1 334.13u     0.0      0  000O    129    0.00     0     1      6
7  Hy        1 312.26u     0.0      0  000O    129    0.00     0     1      7
 freq  ExMag   HyMag  xyRho    xyPhz    xyCC  ExEy*   ExEy*   ExHx*   ExHx*   ExHy*   ExHy*
  768 347.46u 7.9696m 108.7u  3126.8   0.040  0.262  -0.265   24.79m  13.08m -52.25m -0.195
 1024 429.69u 5.0145m 275.8u -1682.5   0.029  0.433  -0.399   5.689m -12.04m -40.66m -0.404
 freq  EyMag   HxMag  yxRho    yxPhz    yxCC  EyHx*   EyHx*   EyHy*   EyHy*   HxHy*   HxHy*
  768 382.29u 244.27u 67.56m   115.3   0.023  13.92m -20.57m  0.699  -0.297   42.74m -20.29m
 1024 265.84u 285.41u 2.908m  -149.9   0.018  19.80m -6.856m -0.160  -0.590   23.01m -141.2u

HzHy*   HzHy*   HzMag   ExHyr*  ExHyr*  EyHyr*  EyHyr*
 14.46m -3.850m  331.13u  57.40m -7.526m  47.09m  11.34m
 20.63m -55.57m  317.06u  54.74m -31.39m  2.441m  1.162m
HzHx*   HzHx*   ExHxr*  ExHxr*  EyHxr*  EyHxr*  HxHxr*
 2.647m  680.4u  11.73m -14.20m  44.87m  6.687m  4.245m
 2.475m -86.54u  69.44m  2.482m  33.96m -16.83m  5.019m

HxHyr*  HxHyr*  HyHyr*  HyHyr* HxrHyr* HxrHyr* HyrHyr*
 145.8u  2.695m -81.68m  41.42m      0       0   27.91m
 1.382m -1.076m -555.7u  16.11m      0       0   29.58m
HxHxr*  HyHxr*  HyHxr* HxrHxr*
 580.3u  32.16m  19.60m  24.38m
 922.0u  20.36m -52.50m  44.66m
```

13.9 NOTES ON FIELD CONFIGURATIONS

When running multiple channel receiver systems, you must be very careful 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.

Common mode levels for the standard configuration of the GDP-32 are ±10 volts. With external isolation amplifiers, this level can be extended to several thousand volts, but in exchange you have to contend with higher noise and a lower overall frequency response.

The best configuration that we have found is to install a **REFERENCE ELECTRODE** (standard copper/copper-sulfate electrode or equivalent), connected to analog ground (**COM** on the analog side-panel) and the case ground (**CASE GND** on the side panel), positioned next to the receiver and at least one meter distant from the nearest receiving electrode.

Another consideration is protection from static discharge and nearby lightning strokes. This protection is maximized by connecting the case ground to the **REFERENCE ELECTRODE** as well.

Additional protection in lightning-prone areas can be afforded 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 by 30 cm.

We have found that for most environments, the best noise rejection is obtained by connecting the analog ground (**COM**) to the case ground (**CASE GND**) on the analog I/O side panel.

The figures at the end of this chapter provide examples of receiver connections using the **REFERENCE ELECTRODE** or **REFERENCE POT** connected to both analog ground (**COM**) and case ground (**CASE GND**).

Note: *For best results for natural source data acquisition, always use an external signal conditioner with programmable gain and frequency band limiting capability, such as the SC-8. Provision is made in Menu 3 to enter external gain factors to be included in the calculation of apparent resistivity.*

13.10 CASCADE DECIMATION OVERVIEW

For the upper three frequency bands (very high, high and medium bands), data are gathered in time series records of 4141 points each (4096 + 45 extra points used in the decimation filter). The data are then processed in 32 point records, for all of the data points for that level.

Decimation Level	Total Bursts	Points per burst	Data points processed
1	128	32	4096
2	64	32	2048
3	32	32	1024
4	16	32	512
5	8	32	256

The low frequency band acquires data on a continuous basis, and filters, decimates and transforms the data real time. The length of the time series record depends upon the level of decimation chosen. If the full 13 levels are selected, the number of points processed range from 256 at 0.0007 Hz to 1.061 million at 4 Hz.

Decimation levels and base frequencies for the four frequency bands are:

Low Frequency Band
Sample Rate = 16 Hz

Decimation Levels	Base Frequency	Frequency Interval	Frequencies Obtained
2	.25 Hz	1.5 - 4 Hz	1.5, 2, 3, 4 Hz
3	.125	.75 - 4	.75, 1. + above
4	.0625	.375 - 4	.375, .5 + above
5	.03125	.1875 - 4	.1875, .25 + above
6	.015625	.0938 - 4	.0938, .125 + above
7	.007813	.0469 - 4	.0469, .0625 + above
8	.003906	.0234 - 4	.0234, .0313 + above
9	.001953	.0117 - 4	.0117, .0156 + above
10	.0009765	.0059 - 4	.0059, .0078 + above
11	.0004882	.0029 - 4	.0029, .0039 + above
12	.0002441	.0015 - 4	.0015, .00195 + above
13	.0001221	.0007 - 4	.0007, .00098 + above

Medium Frequency Band
Sample Rate = 256 Hz

Decimation Levels	Base Frequency	Frequency Interval	Frequencies Obtained
5	.5 Hz	3 - 64 Hz	48, 64 Hz 24, 32 12, 16 6, 8 3, 4

High Frequency Band
Sample Rate = 4096 Hz

Decimation Levels	Base Frequency	Frequency Interval	Frequencies Obtained
5	8.0 Hz	48 - 1024 Hz	768, 1024 Hz 384, 512 192, 256 96, 128 48, 64

Very High Frequency Band
Sample Rate = 32768 Hz

Decimation Levels	Base Frequency	Frequency Interval	Frequencies Obtained
5	64 Hz	384 - 8192 Hz	6144, 8192 Hz 3072, 4096 1536, 2048 768, 1024 384, 512

A 5-point digital, low-pass filter is used on the time series for each level of decimation. The coefficients for this filter are as follows:

$a_0 = a_4 = 1.0$
$a_1 = a_3 = 3.41421356$
$a_2 = 4.87100924$

(From Wight, D.E. and Bostick, F.X., 1980 Proceedings IEEE International Conference on Acoustic Speech and Signal Processing, April 9-11, 1980, Denver CO. pp 626-629.

13.11 DATA DUMP UTILITY

Time series data are stored on the internal hard disk, and MT parameters are calculated and stored in the data cache. Each stack of data will generate one data block for each decimation level. The medium, high, and very high bands will generate 5 data blocks for each stack, and the low band will generate 2 to 13 data blocks, depending upon the decimation levels selected.

13.12 TIME SERIES FILE FORMAT

This section describes the operation of the natural source AMT time series conversion program, **AMTDATA**. The GDP-32^{II} has the ability to save the raw time series data on the optional internal hard disk. A default file name is given to file as **BLKxxxx.OUT**, where **xxxx** is the next field data cache block number.

Below is the data from the field data cache. The GDP-32^{II} generated a time series file called **BLK66.OUT**.

```
0066
AMT 0533 94-10-28 13:30:49 11.5v TEN
Tx        1 Rx       75 N OUT
  128 Hz   129 Bursts  1 Stack
2  Ex     75  3.0822u   0.000  66.63m 406O    129    6.31    0     1  200.0
3  Ey     75  1.9731u   0.004  0.200  425O    129    3.02    0     1  200.0
6  Hx     144 0.3314u -1752.4      0  431O    129    2.89    0     1      6
7  Hy     134 0.2704u  1397.6      0  430O    129    2.61    0     1      7
8  Hz     124 0.3072u     0.0      0  433O    129    0.00    0     1      8
 freq  ExMag   HyMag  xyRho    xyPhz    xyCC  ExEy*   ExEy*    ....
  768 3.0822u 0.2704u 66.63m  1397.6   0.000 -0.527u  1.984u
 1024 2.0111u 0.1124u 20.91  -2137.7   0.012 -0.065u -1.023u -
 freq  EyMag   HxMag  yxRho    yxPhz    yxCC  EyHx*   EyHx*
  768 1.9731u 0.3314u 0.200  -1752.4   0.004  0.092u  0.004u
 1024 1.0510u 0.1388u 1.031    503.6   0.002  0.005u  0.002u
```

And below is the output in the file **BLK66.PRN** after the command **AMTDATA BLK66** is executed.

```
             5          4141            12            47             0
             1             2             5             6             7
             1             2             4             5             6
 7.500000e+001 7.500000e+001 1.440000e+002 1.340000e+002 1.240000e+002
 2.000000e+002 2.000000e+002 6.000000e+000 7.000000e+000 8.000000e+000
 1.351312e-007 6.697244e-008 5.361473e-007 1.076580e-006 1.343134e-007
         -1718         -2079           661          1711         -1157
         -1709         -2002           457          1823         -1065
         -1714         -1983           140          1844          -928
            .             .             .             .             .
            .             .             .             .             .
            .             .             .             .             .
            .             .             .             .             .
            .             .             .             .             .
            .             .             .             .             .
```

The file is setup in lines, across the page, and columns, down the page, format. Each column represents one channel's data. There are 6 lines of header information before the time series data begins.

The first line contains various non-channel specific parameters for the data block. On the first line, the first value (5) is the number of channels of data that was gathered, next is the number of data points (4141) in the time series for one channel. Next, is the sample rate log base 2 (12) and the following value is the field data cache block number. If there are more than 4 channels of data then a 0 will be written in those columns on this line.

The sample rate value determines which of the four frequency bands this time series file represents: very high (384 - 8192 Hz), high (48 - 1024 Hz), medium (3 - 64 Hz), or low which ranges from 4 Hz to a possible low frequency of 0.0007 Hz. Sample rate for the low band is 16 Hz (log base 2 is 4), medium band's sample rate is 256 Hz (8), high band is 4096 (12), and the very high band has a sample rate of 32768 Hz (15).

The second line contains the GDP-32^{II} actual channel number minus 1 that this column of data represents.

The channel designator is on the third line, where 1, 2, 4, 5, 6 represent Ex, Ey, Hx, Hy, and Hz, respectively.

Station number for Ex and Ey channels or antenna identifier for Hx, Hy, and Hz channels are on the fourth line.

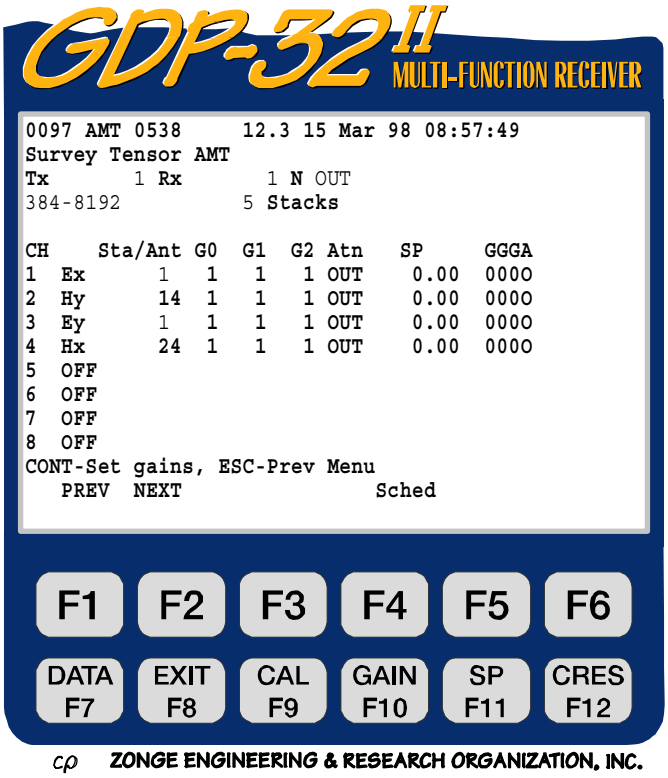
Line number 5 has the A-spacing used for Ex and Ey or the channel number used as the remote reference for Hx, Hy, and Hz channels. In this example, remote reference was not used so default values were written.

The last header line contains the conversion factor from time series data to volts.

Then, line 7 to the end of the file contains the raw time series data for each channel. In this example, there are 4141 data points so there will be 4138 more lines of time series data.

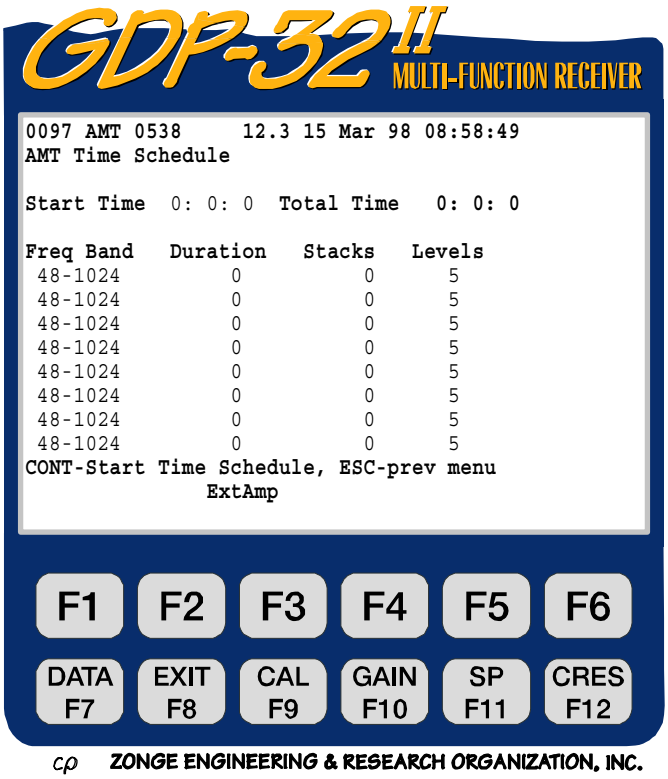
13.13 TIME SCHEDULE

Three programs have an option for automatic data acquisition: MT/AMT, CSAMT, and TDCSMT. For MT/AMT, the automatic time schedule can be entered by pressing F5 in Menu 4 as shown below.



Upon pressing F5 (Sched), the following screen is displayed (assuming the time schedule option has not been used previously):

If the time schedule has been used in the past, the last time schedule entered will be displayed.



There can be up to 8 individual time schedule entries as shown in the above display. All entries are executed in the order shown in the menu.

Start Time. The time entered here determines when the automatic time schedule for data acquisition begins.

Total Time. The sum of the times entered under the **Duration** column. This sum is automatically calculated and inserted as shown below.

Freq Band. Very high, high, medium and low frequency bands, as listed in Section 1 of this manual, are selected by using the SELECT UP Home and SELECT DN End keys. The low frequency band is further selected by changing the number of levels in the **Levels** column.

Duration. This is the time, in minutes, specified for data acquisition for each frequency band. If **Duration** is set to 0 for an entry, that entry will not be run. When the program reaches the last entry, it will automatically go back to the top of the schedule and start over.

Stacks. The number of stacks to be acquired for each frequency band.

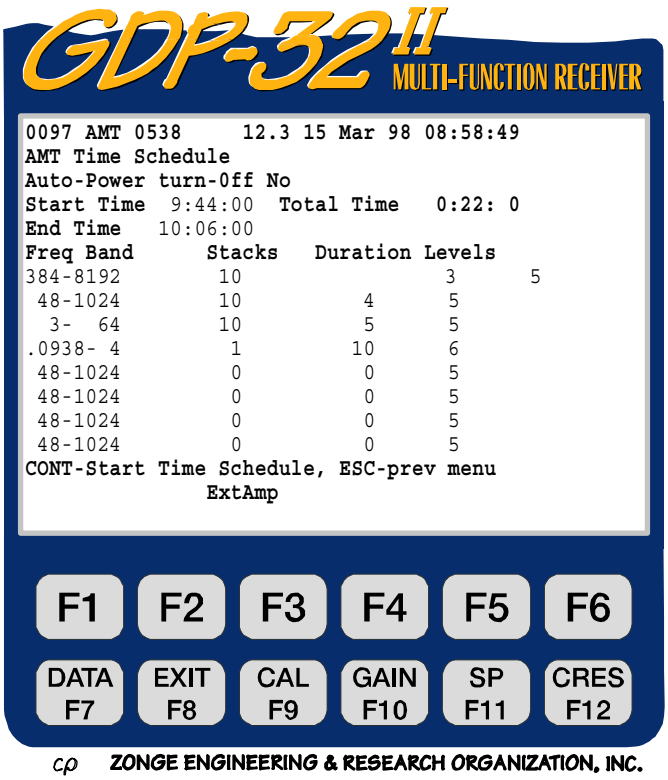
Levels. This column is fixed at 5 for all frequency bands except the lowest. The default value for the low frequency band is 5 also (0.1875 - 4 Hz). Changing the levels for the low frequency band changes the frequency band automatically, and can be done by either using the SELECT UP Home and SELECT DN End keys or by entering the level from the numeric keypad.

ExtAmp. If F3 is pressed while the cursor is in the **Start Time** field, then the default external amplifier menu will be displayed. This allows the user to input external amplifier settings that will be used for ALL TIME SCHEDULE ENTRIES.

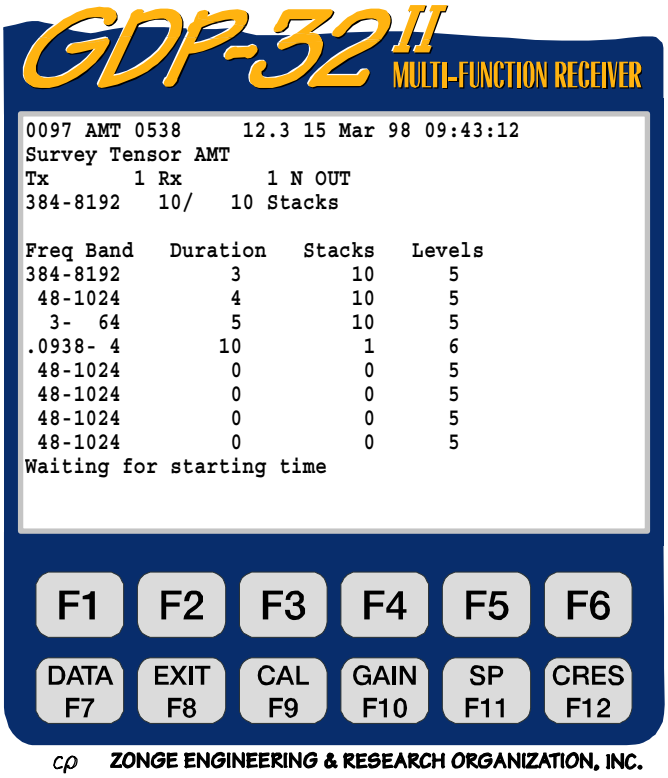
When the time schedule cursor is in any other field, the External Amplifier Menu can be called up by pressing F3. This will permit changing the parameters for external amplifier gains for that particular **Frequency Band** entry only.

Notice that each frequency band entry can have separate external amplifier settings. Make sure the correct gain value is input to obtain the correct resistivity values.

SAMPLE TIME SCHEDULE SETUP:

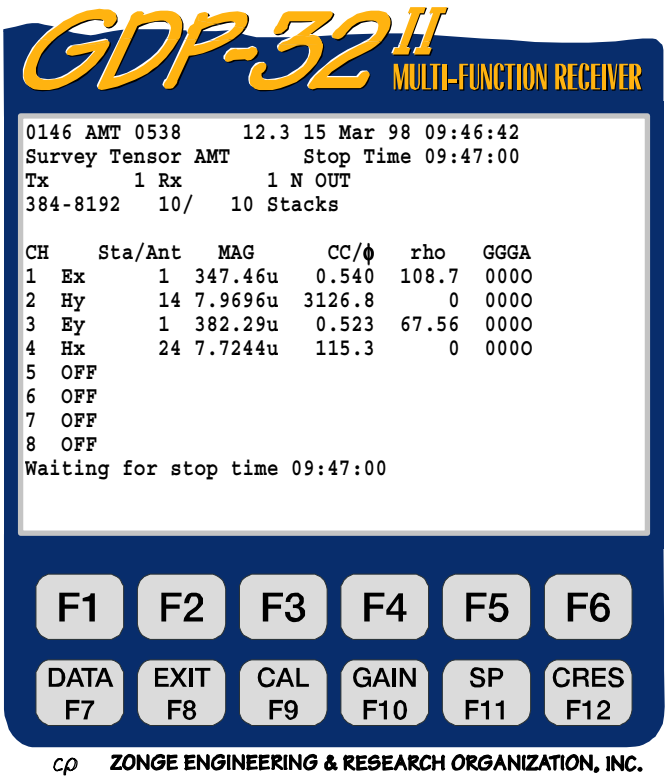


WAITING FOR THE STARTING TIME IN THE TIME SCHEDULE:



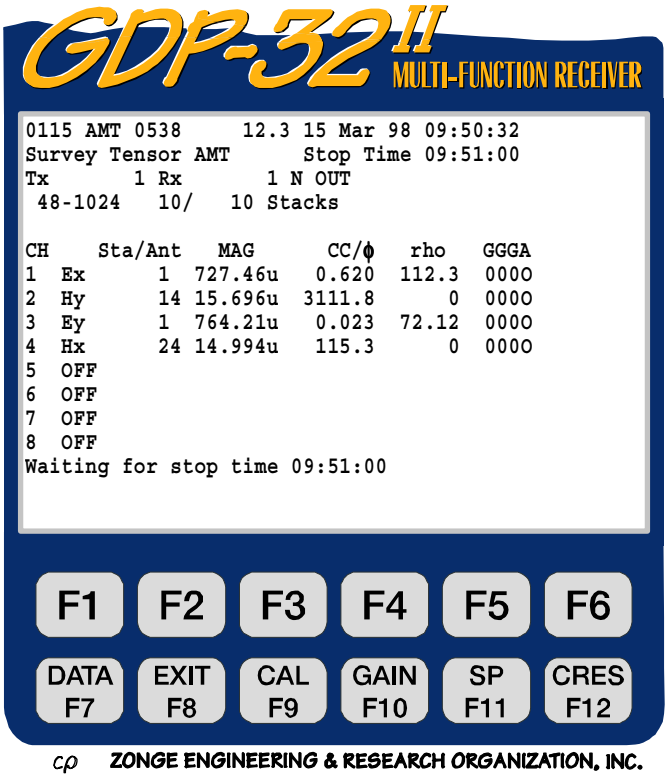
HAVING ACQUIRED DATA, WAITING FOR STOP TIME:

Here we have acquired the specified number of stacks in the very high frequency band, as specified in the time schedule. The operator can continue to acquire data on a single frequency band basis (one stack at a time) until the stop time occurs, and data acquisition in the next frequency band begins.



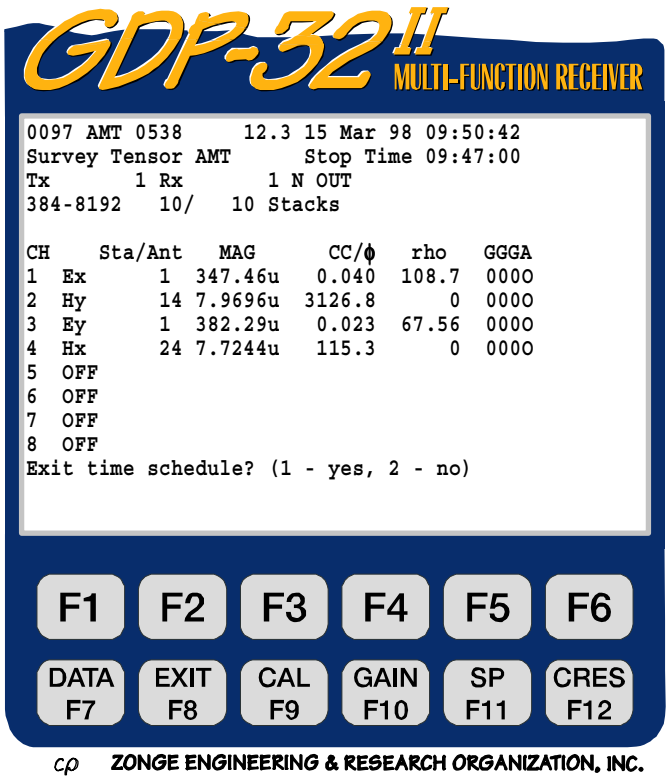
Also, while the "Waiting for starting time" or Waiting for stop time" messages are displayed, the DATA F7 key is active. The operator can exit the data acquisition routine and check the data cache, plot data, etc. When the operator exits the data mode, the time schedule operation will take over.

Data acquisition for the next frequency band is complete - waiting for the stop time and the next frequency band change.



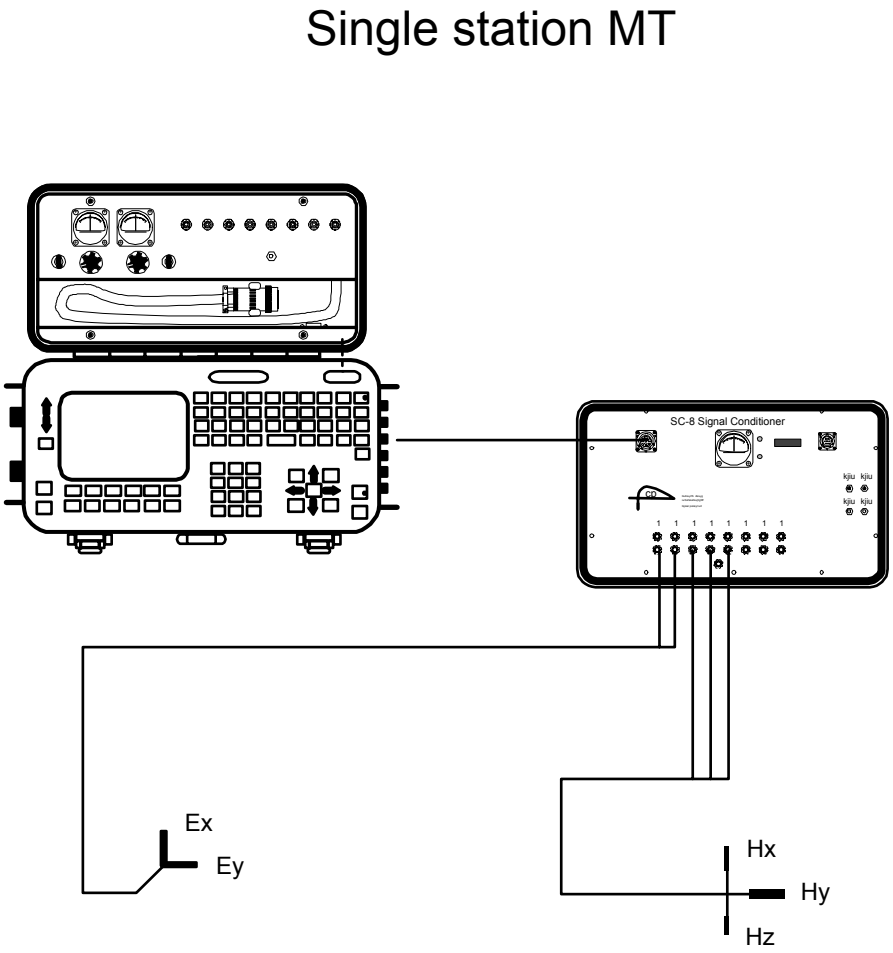
If the operator presses STOP AVG / Escape while the program is acquiring data, the prompt "**Exit time schedule**" will be displayed as above.

If the operator presses STOP AVG / Escape while the program is waiting for the next frequency to start, the program will automatically exit the time schedule mode. Press F5 (**SCHED**) to reenter the time schedule setup table, make any changes desired, and then press CONTINUE / Enter to get back into the automatic data acquisition mode.

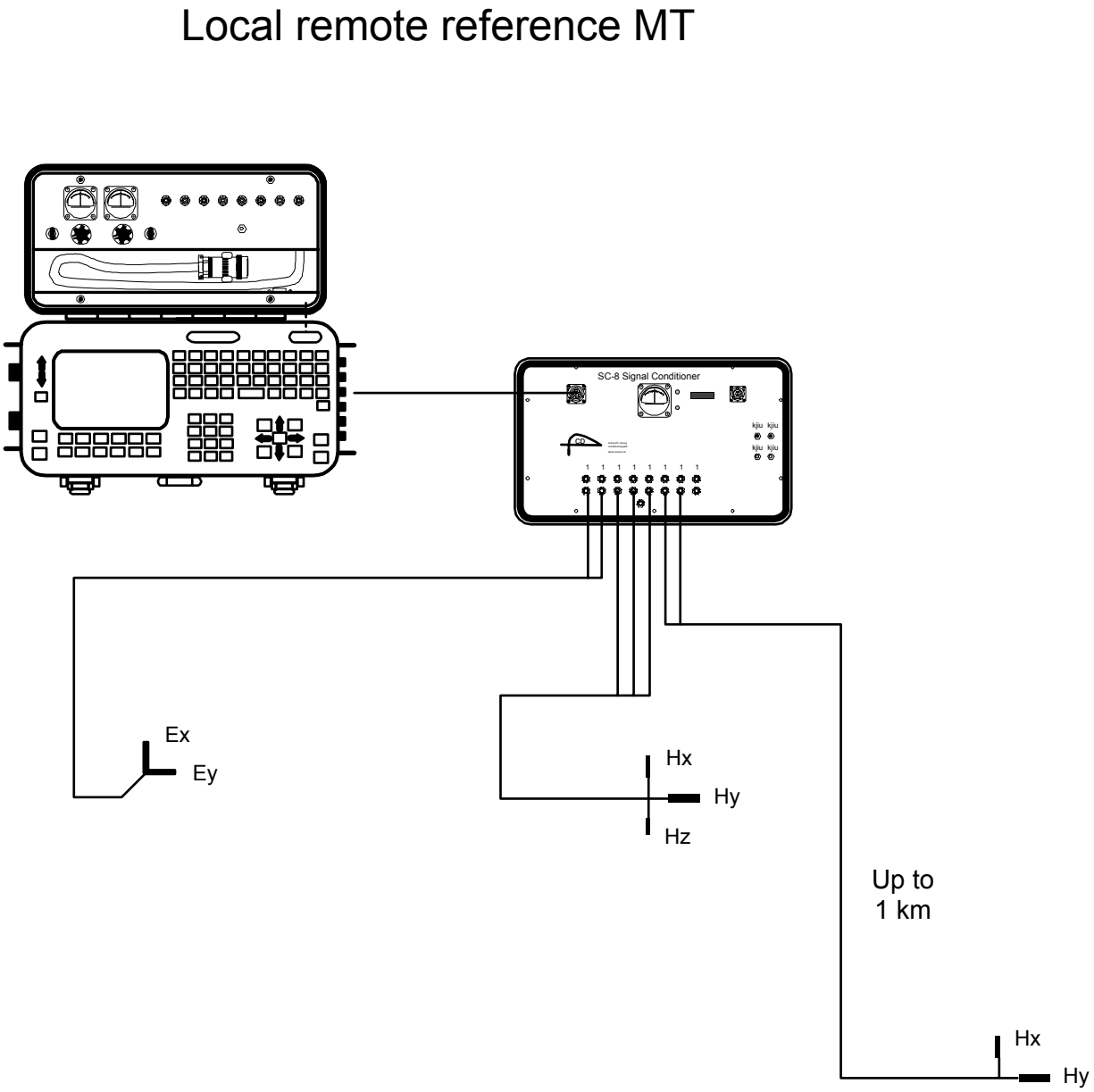


13.14 FIELD CONFIGURATIONS

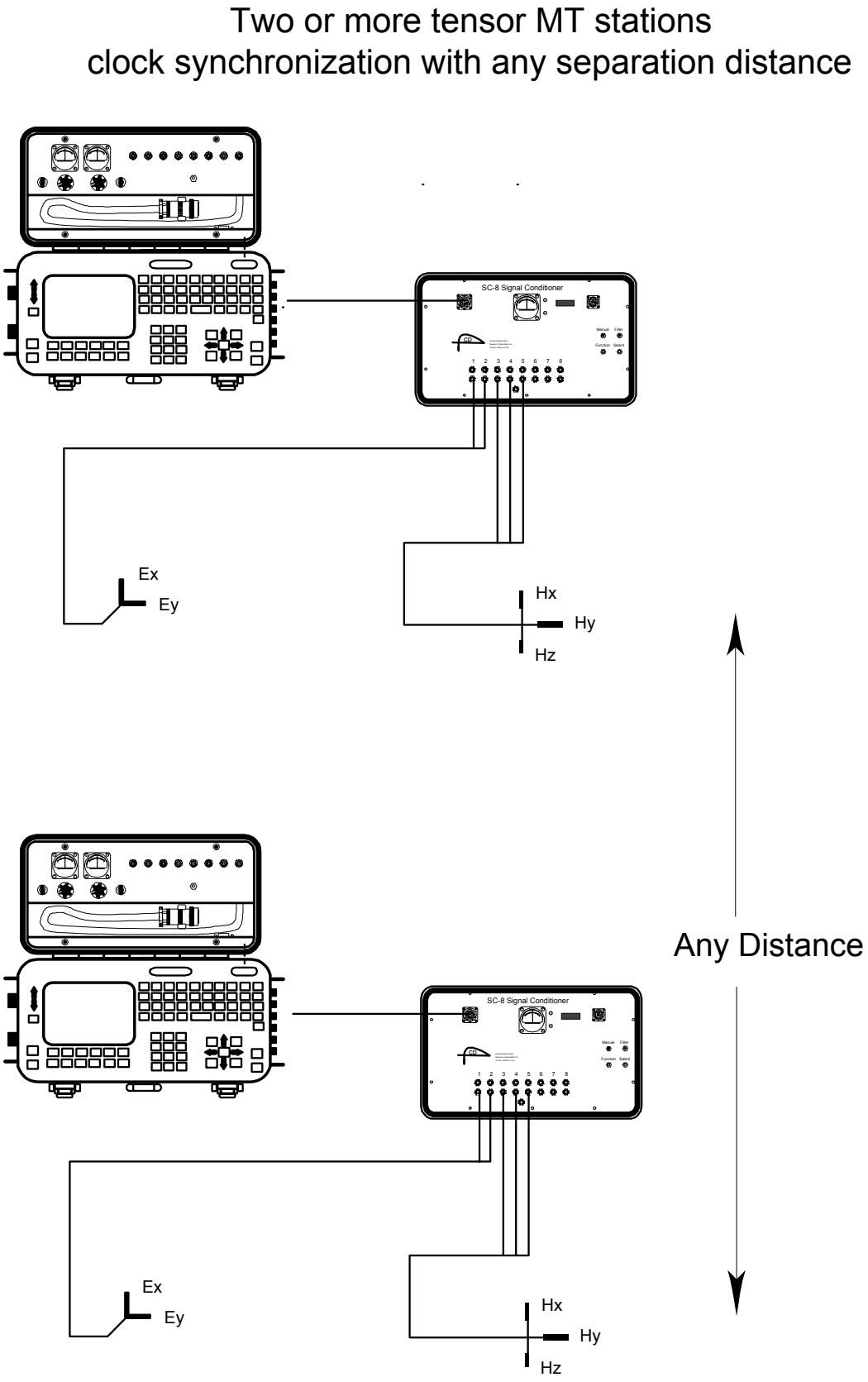
SINGLE STATION MT



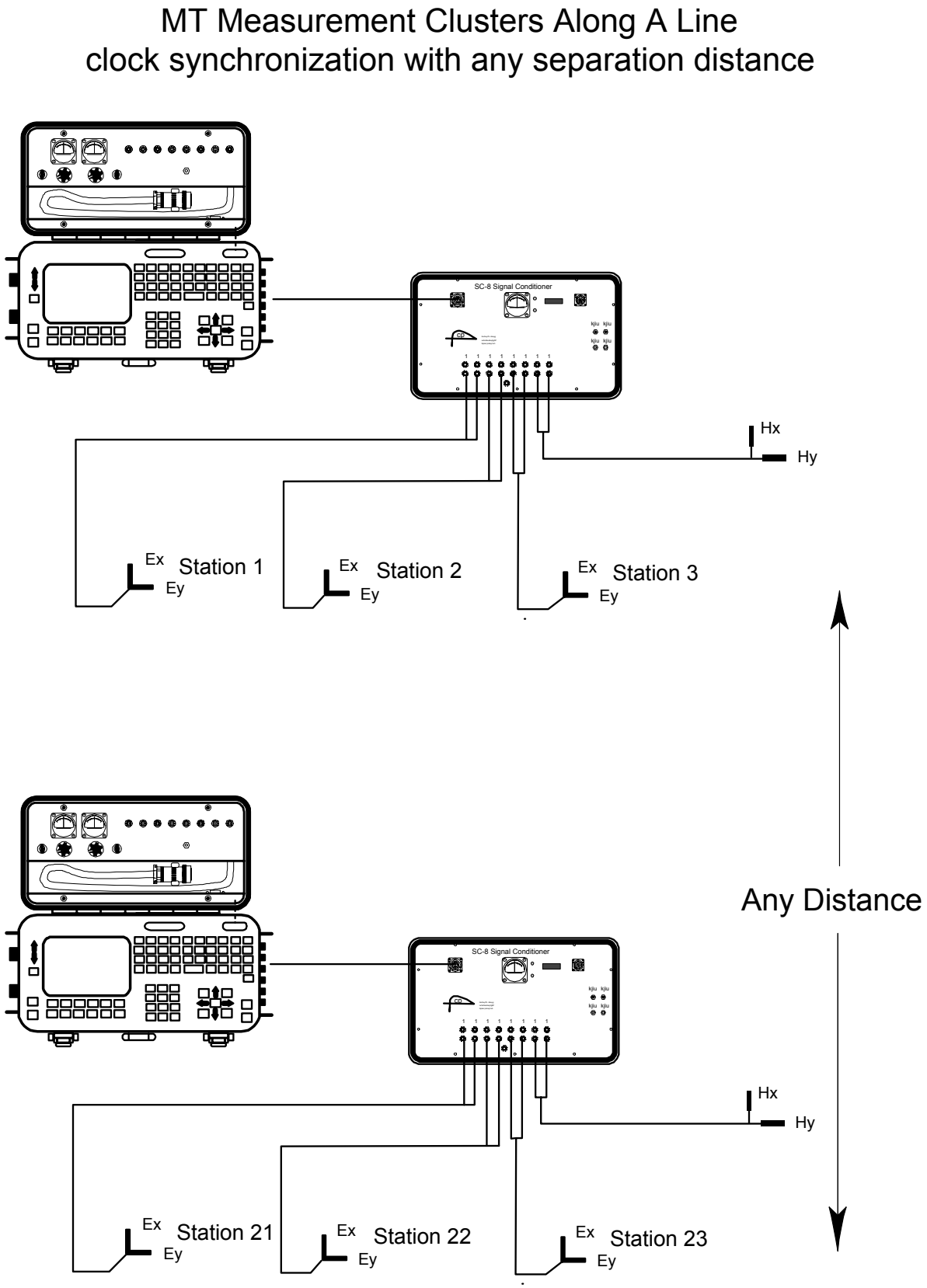
LOCAL REMOTE REFERENCE MT



LOCAL REMOTE REFERENCE MT



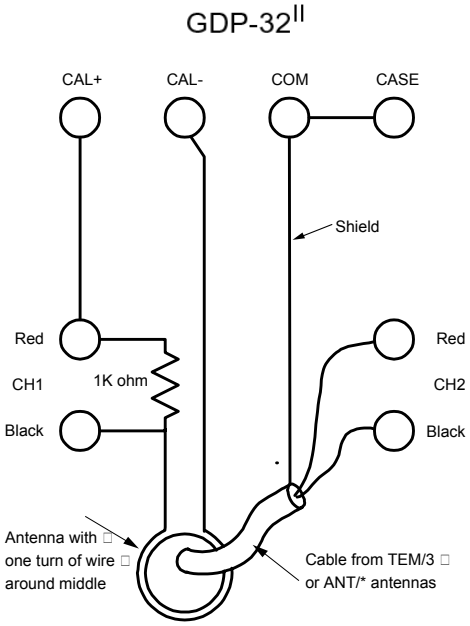
MT MEASUREMENT CLUSTERS



13.15 METHOD TO FIELD-CHECK MAGNETIC SENSORS

It is possible to field check the operation of an antenna by using the GDP calibrator as a signal source as follows:

1. Connect a 1 K ohm resistor between the Black and Red input terminals for channel 1.
2. Take a piece of wire or test lead and make a single turn around the antenna case as shown on the diagram. Connect one end of the wire to the Negative CALIBRATE output and the other end to the Negative (black) input terminal for Channel 1.
3. Connect a test lead from the Red CALIBRATE output to the Red Input for Channel 1.
4. Connect the coil output cable to the Channel 2 inputs as shown on the diagram.
5. Turn on the receiver and enter the CSAMT program. Set Channel 1 to Ex and Channel 2 to Hy with the antenna number set to 1.
6. Set the frequency to the lowest value you want to check - for instance 0.125 Hz.
7. Turn on the antenna.
8. Enter the calibrate program by pressing the CAL F9 key. Then press 3) Auto System Check and then press 2) External. Press CONTINUE Enter to finish setting up the external calibrate system, and to begin taking data.
9. The program will automatically acquire data for each frequency, for example 0.125 Hz through 8192 Hz.
10. Enter the data mode by pressing the DATA F7 key. Check to see the block number of the first data acquired. Then return to the last data block.
11. Enter the plot mode by pressing F5. Press 3) Magnitude Plot.
12. Enter the starting block number and press CONTINUE Enter.
13. Enter the starting channel number = 2 and press CONTINUE Enter.
14. The plot that you get will be the magnitude plot for the coil being tested. It should have the same shape as the calibration done in our test facility.
15. If you want to look at the difference between a calibrate stored in the receiver and the response from this test, go back to step 4 and set the antenna number to the proper value for the antenna under test. Follow the same steps as outlined above. The result when you plot the data will be a straight line.



Note: The reason for monitoring the current through the 1 K ohm resistor is to make sure that the signal level is constant over the frequency range being tested.