

12. TRANSIENT ELECTROMAGNETICS PROGRAM

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12.1 INTRODUCTION

The transient electromagnetics or TEM program is a versatile electromagnetics program using standard phase-lock stacking and averaging methods for signal-to-noise enhancement.

The standard frequency range (repetition rate) of the TEM program is from 0.0625 (16 second period) to 32 Hz (0.03125 second period). The sample rate and window centers are controlled by changing the frequency or pulse repetition rate.

Windows acquired at various repetition rates are as follows:

Frequency (Repetition Rate)	WINDOWS					
	Nr.	50% Duty Cycle		Nr.	100% Duty Cycle	
		First	Last		First	Last
32 Hz	22	30.5 μ s	6.07 ms	25	30.5 μ s	12.1 ms
16 Hz	25	30.5 μ s	12.1 ms	28	30.5 μ s	24.2 ms
8 Hz	28	30.5 μ s	24.2 ms	34	30.5 μ s	48.4 ms
4 Hz	31	30.5 μ s	48.4 ms	34	30.5 μ s	96.7 ms
2 Hz	31	61.0 μ s	96.7 ms	34	122.1 μ s	193.5 ms
1 Hz	31	122.1 μ s	193.5 ms	34	244.1 μ s	387.0 ms
0.5 Hz	31	244.1 μ s	387.0 ms	34	488.3 μ s	773.9 ms
0.25 Hz	31	488.3 μ s	773.9 ms	34	976.6 μ s	1,548 ms
0.125 Hz	31	976.6 μ s	1,548 ms	34	1.953 ms	3,096 ms
0.0625 Hz	31	1.953 ms	3,096 ms	34	3.906 ms	6,191 ms

Note: The default value for the first window will always be equal to or greater than the value shown above (e.g., 30.5 μ s for 32 Hz) and less than two times that amount. See **Section 12.14** and **Section 12.7, Delays**.

A magnitude calibrate buffer, labeled **Time Domain Cal**, is included in the main data cache.



All versions have a digital telluric filter, which we call a moving average or MAV filter, for rejection of low frequency tellurics. This filter is active for 0.5 Hz and below.

This version of the program permits the use of a maximum of three analog channels for repetition rates of 4 through 32 Hz, and up to eight analog channels for repetition rates of 2 Hz or lower.

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

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

12.2 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 ( through ) 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:



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 *DATA Section 7* for more details.



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




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



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

Note: G0 is not enabled for the TEM programs, but can be turned on manually by entering the GAIN program.



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



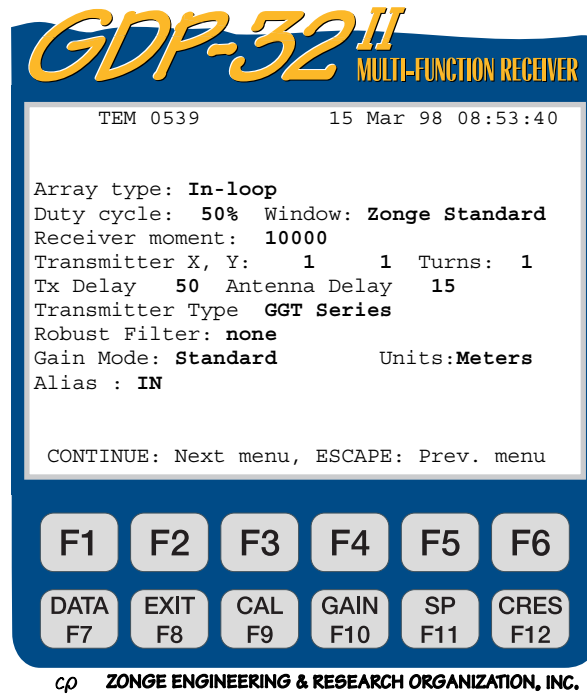
Press this key to measure the contact resistance or coil output resistance. See *GDP Section 6.3, Measuring Contact Resistance* for more details.

12.3 TEM PROGRAM OPERATION

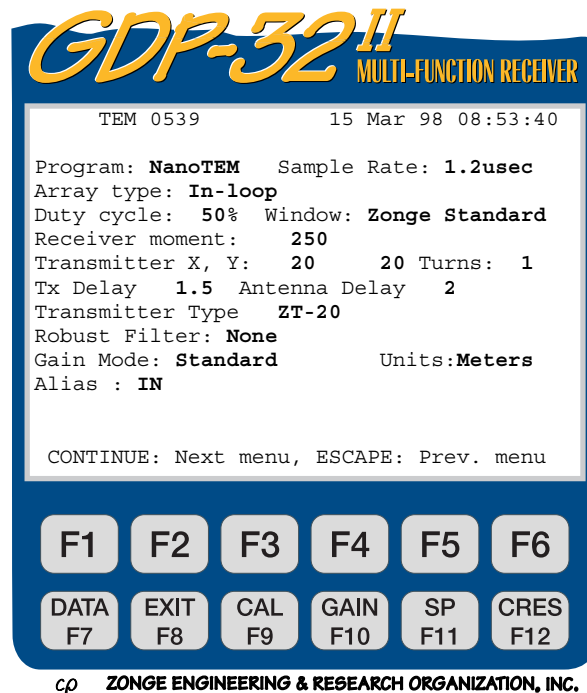
MENU 1:


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

Display screen with regular analog cards installed:



Display screen with both regular analog cards and NanoTEM cards installed:





The  function key is active.

TEM 0539. Program name and version.
15 Mar 98. Date.
08:53:40. Time.

Program: This line shows up on the menu only when a high speed NanoTEM card is installed, and the NanoTEM program is selected. The two selections are:

ZeroTEM	TEM	Standard 30.5 μ s sample time for 4 through 32 Hz rep rates
NanoTEM	NANO	1.2 or 1.6 μ s sample time TEM. See Section 12.18 .

Sample Rate: This line is displayed in the menu only when the NanoTEM program has been selected. The operator can choose between 1.2 and 1.6 microsecond sample rate.

Array type: Five types of arrays are selectable with the  or  keys. (See **Section 12.13, Arrays**):

In Loop	INL
Fixed Loop	FXL
Moving Loop	MVL
LOTEM	LOT
Coincident Loop	COL
Continuous	CNT

The three letter designators are the mode labels added to the data storage listings. The coincident loop, in loop (central loop), moving loop and fixed loop (moving receiver) systems are configured for a loop transmitter and receiver. The LOTEM type survey is usually run with a large dipole transmitter and a loop or combined loop and dipole receiver setup.

In Loop and **Coincident Loop** arrays are used mainly for vertical sounding applications. Resistivities are calculated for Hz channels.

Fixed Loop is used for profiling, and **Moving Loop** is used for both profiling and vertical sounding. Resistivities are not calculated for these configurations.

LOTEM, or large offset TEM, is a method that uses a grounded current dipole for the transmitter (rather than a loop) and gathers magnetic field (and occasionally electric field) data with a large separation between the transmitter and receiver. It is included here mainly as a label for data acquisition. Resistivities are not calculated.

Continuous mode is an experimental program developed for continuous logging for surface, downhole, underwater and airborne applications. Once started, the program will continue to acquire data continuously, in bursts specified by the number of cycles in Menu 4,

until the  key is pressed.

Duty cycle. Two different TEM options are accessed in Menu 1:
50% (default): bipolar 1/4 period on, 1/4 period off, standard time domain waveform.
100% Frequency domain waveform for LOTEM and experimentation.

Windows. Three choices are available:

Zonge Standard: logarithmic window spacings as shown in *Sections 12.8 and 12.9* for TEM and *Sections 12.23.1 and 12.23.2* for NanoTEM

Shallow: higher density early time window spacing for NanoTEM only. See *Section 12.23.3*.

Equal Interval: data are acquired on an evenly spaced time sample and stored on disk. The first 31 samples are also stored in the data cache. See *Section 12.16*.

Receiver Moment. Receiver antenna moment in square meters. The default value is 10,000 m², which is the moment of the TEM/3 antenna.

Note: The NanoTEM boards have an extra gain of 10 installed, so the equivalent area for the receiver moment is 10 times the physical size. For example, a 5 x 5 meter receiver loop would have a moment of 25 x 10, and the value input for the Receiver Moment would be 250.

Transmitter X, Y. Dimensions of the transmitter loop (or dipole) in meters.

Turns. Number of turns in the transmitter loop. Default is 1.

Tx Delay. Turnoff time of the transmitter, in microseconds.

Antenna Delay. Inherent delay of the receiver coil and filters, in microseconds. The RVR and TEM/3 coils have delays of approximately 15 microseconds.

Transmitter Type. The options here are GGT Series, NT-20, or NT-32 (for the embedded Tx version). Specifying the NT-20 transmitter permits the receiver to control the transmitter - turning it on for data acquisition and off after acquisition - thus extending the battery life.

Robust Filter. This filter was added at the request of several clients, and has 3 options:

None: standard linear (mean) stacking and averaging.

Median: median averaging

Trimmed mean: mean calculation after rejecting a percentage of the outliers. The rejection limits are selectable between +/- 12.5%, 25% and 37.5%.

Note: Field tests have determined that the best averaging method in the presence of powerline noise is standard linear mean averaging.

Gain Mode. The default mode is **Standard**, which adjusts the gains for a maximum voltage of 2.5 Volts. The other option is **Noisy**, which limits the gains to obtain a maximum voltage of 1.0 Volts. See *GDP Section 6.5, Gains*.

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

Alias. The operator can lock the antialias filter out - for experimental use only. The antialias filter should always be **IN** for normal operation.

MENU 2:

GDP-32 II
MULTI-FUNCTION RECEIVER


TEM 0539 15 Mar 98 08:53:45

OPER JOHN.DOE TX ID 1 A-SP 100
JOB 94001 LINE 1 N SPREAD 1

CONTINUE: Next menu, ESCAPE: Prev. menu

F1 F2 F3 F4 F5 F6
DATA F7 EXIT F8 CAL F9 GAIN F10 SP F11 CRES F12

cp ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.



The  function key is active.

OPER. User defined identification. Alphanumerics permitted.

TX ID. User defined identification. Alphanumerics permitted.

A-SP. E-field dipole size in meters. Used only for LOTEM.

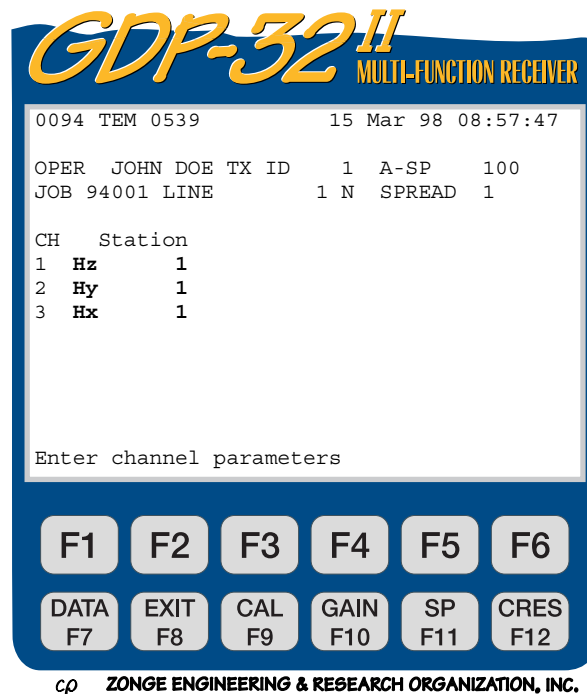
JOB. User defined identification number.

LINE. Two fields available: **xxxxxxxx** defines the line number and **N, E, S, W, NE, SE, SW, NW** designators are available by using the  and  keys.

SPREAD. User defined identification number, subdivision of the **LINE** designator above.

MENU 3:

For this example we will assume a 3-axis measurement at a single station.



DATA
F7

The **DATA** function key is active.

CH. Selections are Hx, Hy, Hz, Ex, Ey, Ez, Ref and OFF. Resistivities are calculated for Hz channels only, when using the in-loop or coincident loop configuration. The total number of channels are presently limited to 3 for sample rates of 4 through 32 Hz. Eight channels can be used for sample rates of 2 Hz and below.

CAUTION - Channels must be turned on in sequence. For single channel operation use channel 1; for two channel operation use channels 1 and 2, etc. Turning on channel 2 only for single channel operation is not valid.

Station. Station identifier, used mostly for multiple station surveys.

F5

Ch Info. Press **F5** for data on the analog cards that have passed QC. For example:

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

Here **DiffAmp** indicates the input plug-in card is a differential amplifier, 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.


If NanoTEM cards are installed, an example would be:

```
4 NanoTEM A/D 1.2usec S/N 31 Passed
5 NanoTEM A/D 1.2usec S/N 42 Passed
```

Note that a number (0094) is visible before the program designator (**TEM 0539**). 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 0095.

MENU 4:



Upon pressing  after the parameters are set up in Menu 3, the following screen will be displayed. This is a combination of Menu 3 and Menu 4.

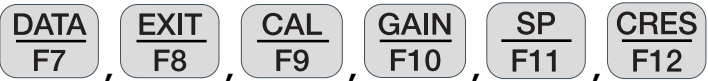
0094 TEM 0539 12.3 15 Mar 98 08:57:49
Survey INL
Tx 1 Rx 3 10 sec
32 Hz / 32 Cycles Tx Curr 1
Window 1.549m Delay 122.1u Alias 26 u
CH Station G0 G1 G2 Atn SP GGGA
1 Hz 1 1 1 1 OU* 0.00 0000
2 Hy 1 1 1 1 OU* 0.00 0000
3 Hx 1 1 1 1 OU* 0.00 0000
CONT-Set Gains, ESC-Prev Menu

F1 F2 F3 F4 F5 F6
DATA F7 EXIT F8 CAL F9 GAIN F10 SP F11 CRES F12

cp ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.

- ← We have selected the In-Loop array
- ← 10 sec indicates that sampling will occur every 10 seconds in Continuous mode. Not displayed for other configurations

All function keys are active:





Tx. Transmitter location. The field for Tx designation is \pm NNNNNNNN with a floating decimal point. Used for bookkeeping purposes in TEM.



Rx. Receiver location. The field for Rx is \pm NNNNNNNN with a floating decimal point. Used for bookkeeping purposes in TEM.

Note: The powerline notch filter switch is DISABLED for TEM.

10 sec. If **Continuous** mode is selected, this field controls the sample interval. Here sampling will take place every 10 seconds, and 32 cycles of 32 Hz data will be acquired every 10 seconds. The operator must be careful to make sure that the sampling interval is large enough or the number of cycles are small enough so that all of the cycles can be obtained in the interval specified.

Hz. Frequency or repetition rate selection - use  or  to change. Changes both repetition rate and sample rate according to the chart in **Section 12.7**.

Cycle. Specify the number of cycles to average. Increments are in binary steps from 1 to

16,384. Use  or  to change. As the system acquires data, the cycle count will be updated in real-time to the left of the number input by the operator.

Tx Curr. Transmitter current in amperes.

Window. The default is window number 16, which in this case occurs at 1.549 ms, for the given transmitter turnoff time, antenna delay, and alias filter delay. This window is monitored for run-time statistics and is user-selectable. Window center times are defined as the time interval occurring after the turnoff of the transmitter current (Tx current is zero).

Delay. Delay in sampling to allow for turnoff time of the transmitter and delays in the antenna and anti-alias filter.

Delay increments are in multiples of the sample period. In this example, using a 32 Hz repetition rate, the sample period is 30.5 μ s. The default program adjusts the delay time so that the first window is at least one sample period after transmitter turnoff (loop current equals zero amps). Hence in the Menu 4 example above, using default values of 50 μ seconds delay for the transmitter to turnoff, 15 μ sec for the antenna delay and 26 μ sec for the anti-alias filter delay, we have a total delay of 91 μ sec. Now add 30.5 μ sec to that for one sample period for a total of 121.5 μ sec. This means that we want the first sample (first window) to occur at least 121.5 μ sec after the beginning of the turnoff ramp.

If we delay 4 sample periods (4 times 30.5 μ s) the first window will occur 122.6 μ sec after the beginning of transmitter turnoff ramp, and 31.6 μ sec (122.6 - 91) after the end of the ramp. Thus, the first window will occur at 31.6 μ sec in the data printout.





The delay time can be user adjusted for various tests and for measuring the complete transient during transmitter turnoff.


See **Section 12.14** for a graphic display of the combination of turnoff time and delays.


Alias. The antialias filter delay is fixed by the corner frequency and is displayed for the operator's convenience. See **Section 12.7**.

Station. Station number. Can be accessed in either Menu 3 or 4 for ease in changing values during a survey. Our data processing programs sort first on **Station**, second on **Rx** and third on **Tx**.

TxON. If the Transmitter Type is set to NT-20 in Menu 1, and the transmitter is being controlled by the receiver, the transmitter will be automatically turned on and off by the

program when acquiring data. The  key gives the operator manual control for checking gains, etc. If the label above  is **TxON**, pressing  will turn the transmitter **ON**; if it is labeled **TxOFF** pressing  will turn the transmitter **OFF**. Any operator keystroke will be overridden by the program during data acquisition.

If the Transmitter Type is set to **GGT series**, the display above  will be blank, and the operator will not have control of the transmitter off/on states.

G0, G1, G2. Gain stages 0, 1 and 2. Initially all gain stages are set to unity gain. Upon pressing , 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) and fixed in the OUT position, as indicated by OU*. This is the default setting, since it is not advisable to use the attenuator in the TEM mode.




SP. Self Potential or offset in millivolts. Initially set to 0.00. Will be set to the actual

value upon pressing .

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

NOTE:

Some values are not registered in the computer memory until you exit the parameter field by

pressing , , or . An exception to this rule is the Hz (frequency) field. Whenever you change the frequency it is automatically changed through the timing card. However, the anti-alias filter is not changed until just prior to data acquisition. Upon pressing continue to gather data, the computer 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.

12.4 POWERLINE NOISE REJECTION

Field tests have demonstrated that in general the new binary crystals (4.980736 MHz) provide superior powerline noise rejection over the original 5 MHz crystals. The new crystals provide an exact binary frequency range so that stacking and averaging can be synchronous with the powerline frequencies.

Following are the test results for the old (5 MHz) crystals for various repetition rates (frequencies):

50 Hz		60 Hz	
Freq	Rejection	Freq	Rejection
32 Hz	2000:1	32 Hz	2000:1
16	140:1	16	700:1
8	250:1	8	20:1
4	250:1	4	50:1
2	80:1	2	700:1
1	250:1	1	333:1

For the new (4.980736 MHz) crystals:


50 Hz		60 Hz	
Freq	Rejection	Freq	Rejection
32,16, 8,4,1 Hz	10,000:1	32,16, 8,2,1 Hz	10,000:1
2 Hz	NONE	4 Hz	NONE

With the new crystals (4.980736 MHz), the powerline rejection is nominally greater than 10,000:1 for all frequencies *EXCEPT 2 Hz for 50 Hz noise and 4 Hz for 60 Hz noise*.

FOR THESE TWO REPETITION RATES THERE IS NO EFFECTIVE REJECTION, SO THE 2 Hz REPETITION RATE SHOULD NOT BE USED AROUND 50 Hz POWER SYSTEMS, AND 4 Hz SHOULD NOT BE USED WHEN YOU HAVE 60 Hz POWER SYSTEMS.

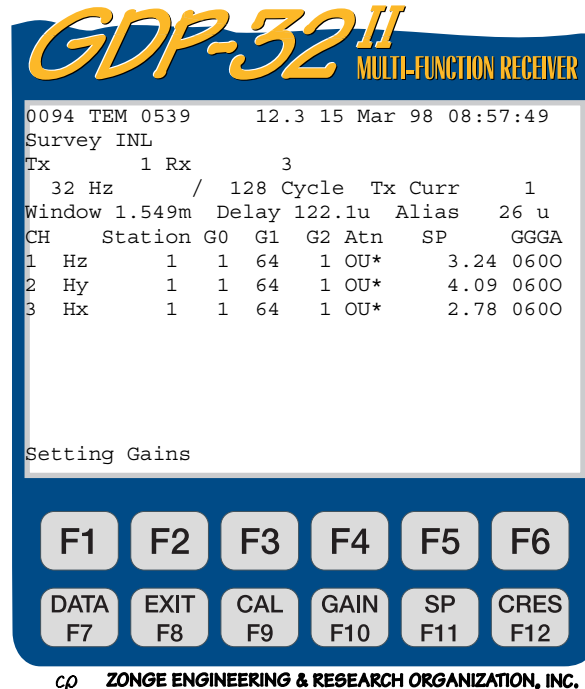
12.5 GATHERING DATA



Upon pressing  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, 2 & 3. 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 to 32 Hz, set the number of cycles to acquire to 128, Transmitter current to 1 amp, and leave the rest of the parameters with the default values. The signal source for this example is an RC network driven by an NT-20 transmitter with a 1 ampere output.

The program will first set up the gains, buck out the SP automatically and then continue to gather data. Since "standard" gain is the default gain mode, the gain is put into G1 and then G2, and the input signal is amplified to a maximum of 3.0 volts. See **GDP Section 6.5, Gains**, for additional information.




The display is self explanatory, but the following comments elaborate on some of the details.

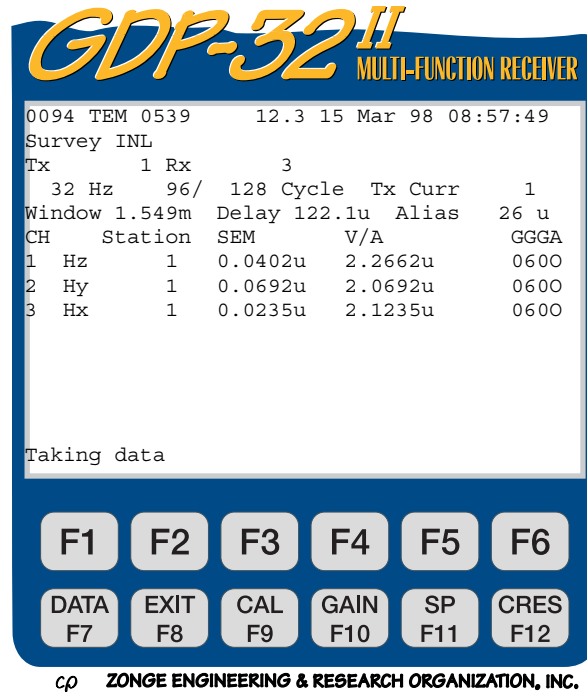
G0, G1, G2. Gain stages 0, 1 and 2. The first gain stage (G0) is set to a gain of 1, the second gain stage (G1) is set to 64 and the third (G2) is set to 1.

Atn. The attenuator is bypassed (set to OUT). The designation of OU*, indicates that the attenuator is fixed in the OUT position.

SP. The values of SP that have been bucked out are 3.24 mv for channel 1, 4.09 mv for channel 2, etc.

GGGA. Gain settings for stages 0, 1 and 2 (in powers of 2). For this example, gain stages 0 and 2 = $2^0 = 1$, gain stage 1 = $2^6 = 64$ and the attenuator is locked **OUT**, unless enabled by the operator.


The program will acquire 128 cycles of data for all enabled channels (unless the  key is pressed before completion) and the results will look similar to the following for real-time displays (while data are being acquired).

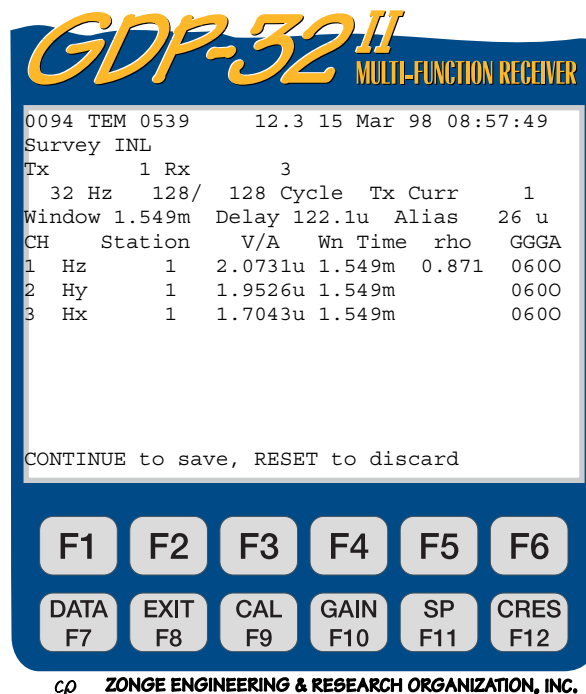


SEM. Standard error of the mean, in volts per ampere calculated after each cycle, or burst of cycles, and based on the average value. Averaging should continue until SEM values are considerably less than the corresponding V/A value.

V/A. Average window value in volts per ampere. The window selected for monitoring in this example is number 16 (1.549 ms), as displayed above.

Notice that we have taken 96 of 128 cycles so far.

After the selected number of cycles have been acquired (or  is pressed), the final display will appear as follows:



GDP-32 II MULTI-FUNCTION RECEIVER

```

0094 TEM 0539      12.3 15 Mar 98 08:57:49
Survey INL
Tx      1 Rx      3
  32 Hz  128/   128 Cycle Tx Curr    1
Window 1.549m Delay 122.1u Alias   26 u
CH      Station  V/A   Wn Time  rho  GGGA
1  Hz      1    2.0731u 1.549m  0.871 0600
2  Hy      1    1.9526u 1.549m         0600
3  Hx      1    1.7043u 1.549m         0600

CONTINUE to save, RESET to discard
  
```

cp ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.

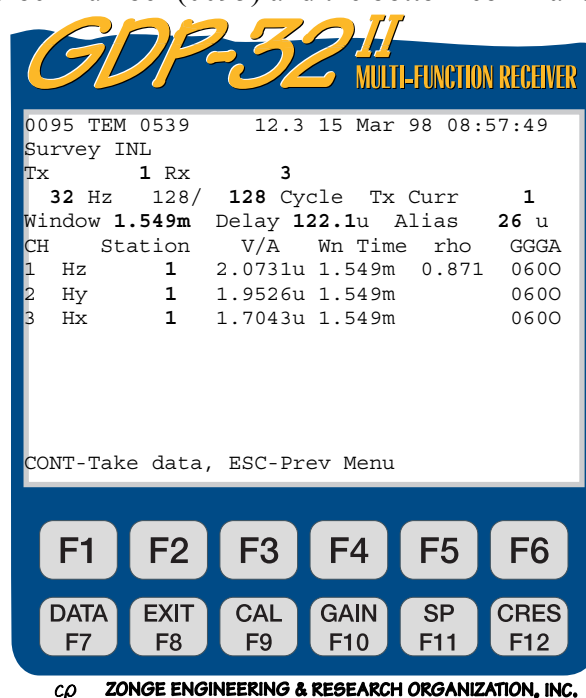
All function keys are active:



V/A. Value of window magnitude for window number displayed.

rho. Apparent resistivity in ohm-meters for Hz component for window time displayed.

Upon pressing  to save the data (or  to discard the data), the only difference in screens is the change in block number (0095) and the bottom command line.



GDP-32 II MULTI-FUNCTION RECEIVER

```

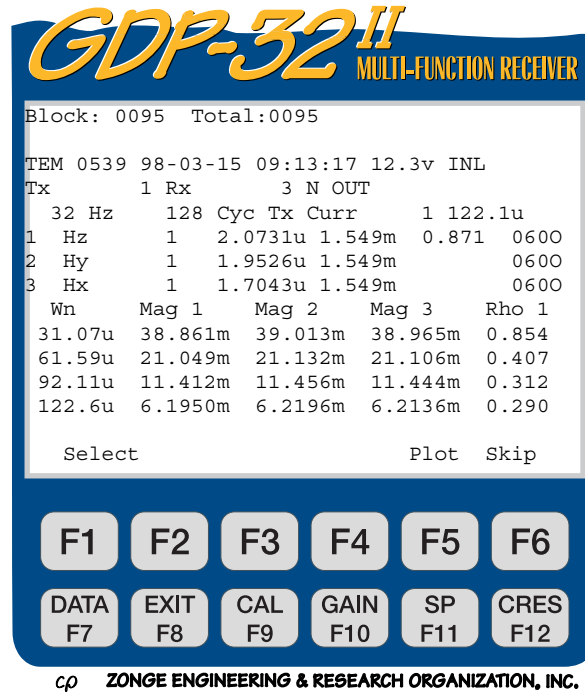
0095 TEM 0539      12.3 15 Mar 98 08:57:49
Survey INL
Tx      1 Rx      3
  32 Hz  128/   128 Cycle Tx Curr    1
Window 1.549m Delay 122.1u Alias   26 u
CH      Station  V/A   Wn Time  rho  GGGA
1  Hz      1    2.0731u 1.549m  0.871 0600
2  Hy      1    1.9526u 1.549m         0600
3  Hx      1    1.7043u 1.549m         0600

CONT-Take data, ESC-Prev Menu
  
```

cp ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.

DATA
F7

Press the **DATA F7** function key to view the data. It will display the last stack taken. See **DATA Section 7.2, Viewing Data** for explanations. The data display is in the following format:



Notice that all of the decay data have not have been displayed. The apparent resistivity data, if calculated, will be to the right of the decay data.



NEXT FIELD
Pg Dn

To view the rest of the data press **NEXT FIELD Pg Dn** several times as needed.


PREV FIELD
Pg Up

To return to the first part of the display press **PREV FIELD Pg Up**.

Again, you may have to press it several times. If we were running with more than one Hz channel in the above example, some of the data would have been off the screen to the right. The SEM, SP and contact resistance values have also been saved to the right of the screen.

To view these numbers press  several times to move to the right,
or press  to move to the left.

The Window data are a combination of point and integrated values, normalized by the transmitter current. See the following section for window specifications. When you first enter the data mode, only the first few windows appear because all data will not fit onto the screen at

one time; use the  or **NEXT FIELD Pg Dn** to see the rest.

Plot Data. By pressing **F5** you get into the plot routines. See *Plot Routines, Section 14* for more information. Standard plots for this TEM program are transient voltage vs. time, and resistivity vs. image depth.

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'.

12.6 A NOTE ON SCALING

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

TEM magnitudes, displayed in volts per ampere (V/A).

Current, displayed in amperes.

Apparent resistivity, displayed in ohm-meters.

Dipole spacings, displayed in meters. (Values not used in TEM).

SEM, displayed in volts per ampere (V/A)

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

12.7 SAMPLE RATES AND ANTIALIAS FILTER DELAYS

FREQ Fo	SAMPLE RATE	SAMP'S /CYCLE	NYQUIST Fn	LOW PASS FILTER Fc	FILTER Delay	SAMPLE INTERVAL
32	32768	1024	16384	24.8 KHz	26 μ s	30.5 μ S
16	32768	2048	16384	24.8	26 μ s	30.5 μ S
8	32768	4096	16384	24.8	26 μ s	30.5 μ S
4	32768	8192	16384	24.8	26 μ s	30.5 μ S
2	16384	8192	8192	12.4	39 μ s	61.0 μ S
1	8192	8192	4096	6.4	64 μ s	122.1 μ S
.5	4096	8192	2048	3.2	118 μ s	244.1 μ S
.25	2048	8192	1024	1.6	226 μ s	488.3 μ S
.125	1024	8192	512	0.8	440 μ s	976.6 μ S
.0625	512	8192	256	0.4	880 μ s	1,953 μ S

12.8 TEM WINDOW CENTERS FOR ZERO DELAY

WINDOW #S	32, 16, 8 and 4 Hz	2 Hz	1 Hz	.5 Hz	.25 Hz	.125 Hz	.0625 Hz
1	0.0 μ s	0.0 μ s	0.0 μ s	0.0 μ s	0.0 μ s	0.0 ms	0.0 ms
2	30.5	61.0	122.0	244.1	488.3	976.6	1.953
3	61.0	122.1	244.1	488.3	976.6	1.953	3.906
4	91.6	183.1	366.2	732.4	1.465 ms	2.930	5.859
5	122.1	244.1	488.3	976.6	1.953	3.906	7.813
6	152.6	305.2	610.4	1.221 ms	2.441	4.883	9.766
7	197.8	395.6	791.1	1.582	3.164	6.329	12.66
8	259.0	517.9	1.036 ms	2.072	4.143	8.287	16.57
9	320.1	640.2	1.280	2.561	5.121	10.24	20.48
10	395.6	791.1	1.582	3.164	6.329	12.66	25.32
11	487.3	974.7	1.949	3.899	7.797	15.59	31.19
12	607.3	1.215 ms	2.429	4.858	9.717	19.43	38.87
13	774.5	1.549	3.098	6.196	12.39	24.78	49.57
14	972.3	1.945	3.889	7.778	15.56	31.11	62.23
15	1.215 ms	2.429	4.858	9.717	19.43	38.87	77.73
16	1.518	3.037	6.073	12.15	24.29	48.58	97.17
17	1.911	3.821	7.643	15.29	30.57	61.14	122.3
18	2.426	4.852	9.704	19.41	38.82	77.63	155.3
19	3.064	6.128	12.26	24.51	49.02	98.05	196.1
20	3.852	7.704	15.41	30.82	61.63	123.3	246.5
21	4.838	9.676	19.35	38.71	77.41	154.8	309.6
22	6.094	12.19	24.38	48.75	97.50	195.0	390.0
23	7.687	15.37	30.75	61.50	123.0	246.0	492.0
24	9.659	19.32	38.64	77.28	154.6	309.1	618.2
25	12.14	24.29	48.57	97.15	194.3	388.6	777.2
26	15.30	30.59	61.18	122.4	244.7	489.5	978.9
27	19.25	38.51	77.02	154.0	308.1	616.1	1232.3
28	24.24	48.48	96.96	193.9	387.8	775.6	1551.3
29	30.53	61.06	122.1	244.2	488.5	977.0	1954.0
30	38.42	76.83	153.7	307.3	614.7	1229.3	2458.6
31	48.38	96.76	193.5	387.1	774.1	1548.2	3096.4

For 32 Hz we get 22 windows for 50% duty cycle

25 windows for 16 Hz

28 windows for 8 Hz

31 windows for 4 Hz and below

Window center times saved in the cache during data acquisition will be the above values plus the delay after turnoff. See **Section 12.10** for sample data blocks.

12.9 WINDOW CENTERS AND WIDTHS

32, 16, 8 and 4 HZ REPETITION RATES

WINDOW #S	POINTS PER WINDOW	WINDOW CENTERS	WINDOW WIDTHS	
		32, 16, 8 and 4 Hz	BEGINNING	END
1	1	0.0 μ sec	0.0 μ sec	0.0 μ sec
2	1	30.5	30.5	30.5
3	1	61.0	61.0	61.0
4	1	91.6	91.6	91.6
5	1	122.1	122.1	122.1
6	1	152.6	152.6	152.6
7	2	197.8	183.1	213.6
8	2	259.0	244.1	274.7
9	2	320.1	305.2	335.7
10	3	395.6	366.2	427.3
11	3	487.3	457.8	518.8
12	5	607.3	549.3	671.4
13	6	774.5	701.9	854.5
14	7	972.3	885.0	1.068 m sec
15	9	1.215 m sec	1.099 m sec	1.343
16	11	1.518	1.373	1.678
17	15	1.911	1.709	2.136
18	19	2.426	2.167	2.716
19	23	3.064	2.747	3.418
20	29	3.852	3.449	4.303
21	36	4.838	4.334	5.402
22	47	6.094	5.432	6.836 — 32 Hz
23	58	7.687	6.867	8.606
24	72	9.659	8.637	10.803
25	92	12.14	10.834	13.611 — 16 Hz
26	116	15.30	13.642	17.151
27	145	19.25	17.182	21.576
28	184	24.24	21.607	27.192 — 8 Hz
29	231	30.53	27.222	34.241
30	289	38.42	34.272	43.061
31	369	48.38	43.091	54.322 — 4 Hz

To find the window centers or beginning and ending sample points for the windows, just take these values and multiply them by the ratio of 4 Hz divided by the frequency of interest. For example to determine the window widths for a 2 Hz repetition rate, multiply the above numbers by $4/2 = 2$, so for the 20th window the center would be $2 \times 3.852 = 7.704$ ms, and the beginning of the window would be at $2 \times 3.449 = 6.898$ ms, and ending at 8.606 ms.

12.11 FIELD CONFIGURATIONS AND MAGNETIC ANTENNAS

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

The **CASE GND** to **COM** connection is recommended for receivers making only magnetic measurements, since this tends to reduce noise in most environments. The REFERENCE ELECTRODE is optional for magnetic measurements.

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

TEM/3 magnetic coils with an active, differential (3-wire) output, should have the two signal wires connected to the red and black input terminals and the ground wire connected to **COM** on the analog side-panel.

Magnetic coils with a single-ended (2 wire) output (older TEM/3), should have the signal wire connected to the red input and the ground wire (or shield, if it is a coaxial cable) connected to the black input. If the coils have a separate power supply, you may want to consider connecting a common line from the power supply to the **GDP COM** connector, to avoid common mode problems.

Passive magnetic coils such as the TEM/1 cable-coil should be loaded with a 1000 ohm resistor across the two output signal wires, and these two wires connected to the red and black signal inputs on the GDP. The shield wire should then be connected to the analog ground (**COM**) on the analog side panel.

12.12 ESTIMATING RAMP-OFF TIME

For those clients that do not have the ramp turnoff meter for the GGT-Series transmitters, the following equation will provide a good estimate of the ramp turnoff time:

L = length of loop side (meters)

R = loop resistance (ohms)

T = ramp turnoff time (microseconds)

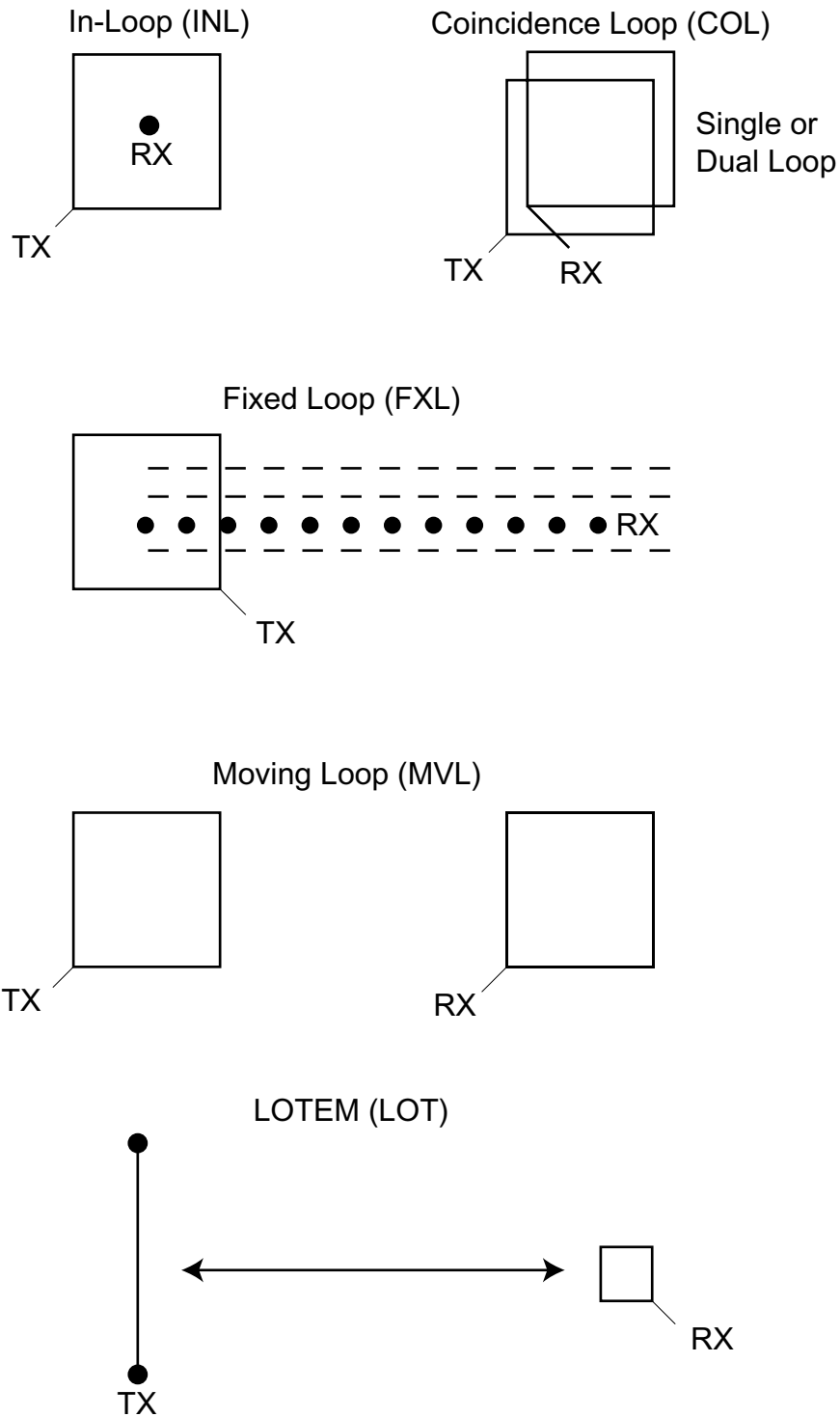
$$T = \frac{2 * L^{1.25}}{5 + R}$$

For example, the turnoff time for a 100 x 100 meter loop with 4 ohms total resistance would be:

$$T = 2 * 100^{1.25} / (5 + 4) = 70 \text{ } \mu\text{seconds}$$

If you are using a rectangular loop, use the average length of a side for L. Example: if you are running with a 300 x 600 meter loop, use $(300 + 600)/2 = 450$ meters for L.

12.13 TEM RECEIVER / TRANSMITTER ARRAYS

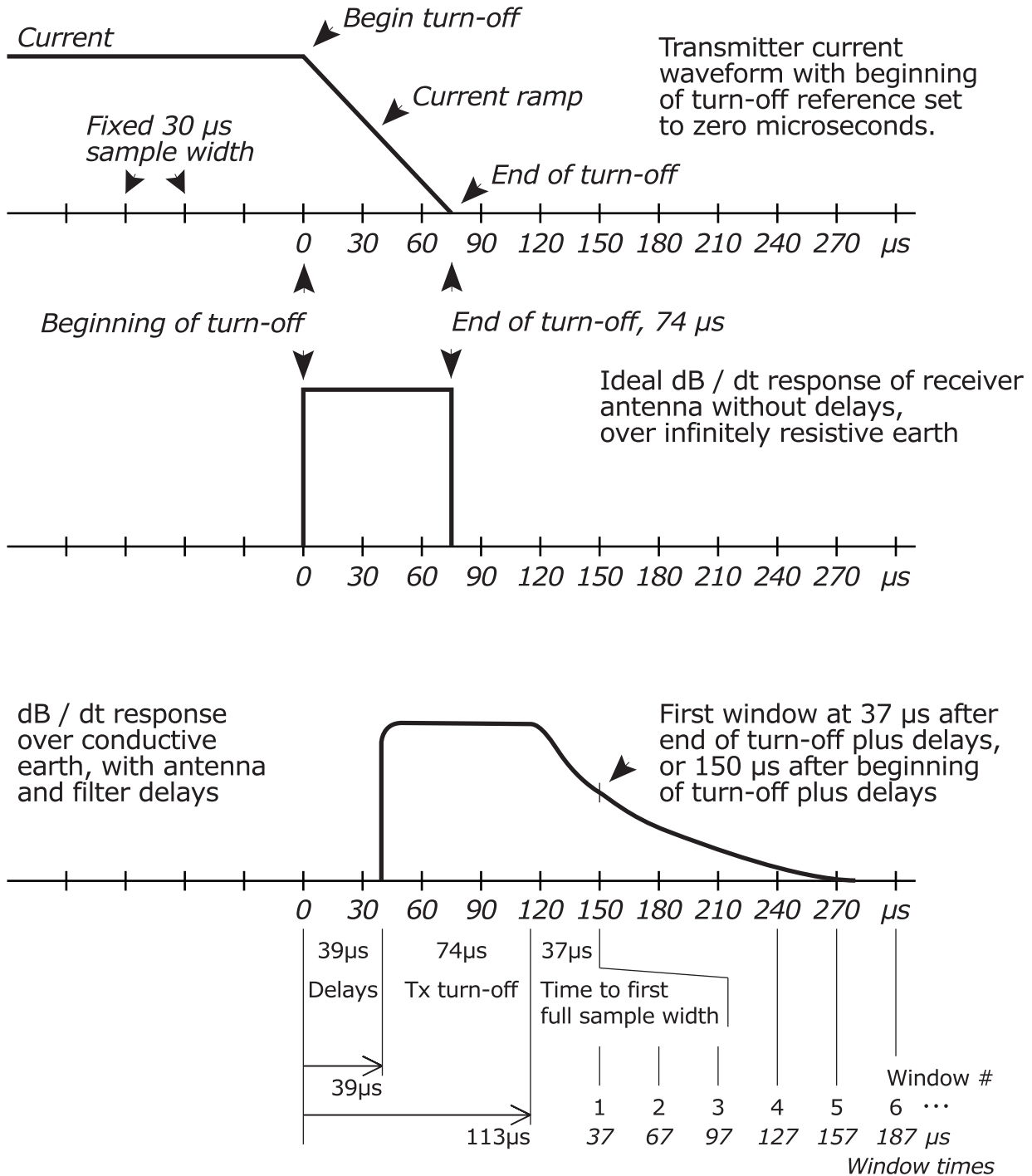


12.14 EXAMPLE: FIRST WINDOW TIME DETERMINATION

Assume for this example:

Fixed sample width = $30\ \mu\text{s}$
Current turn-off = $74\ \mu\text{s}$

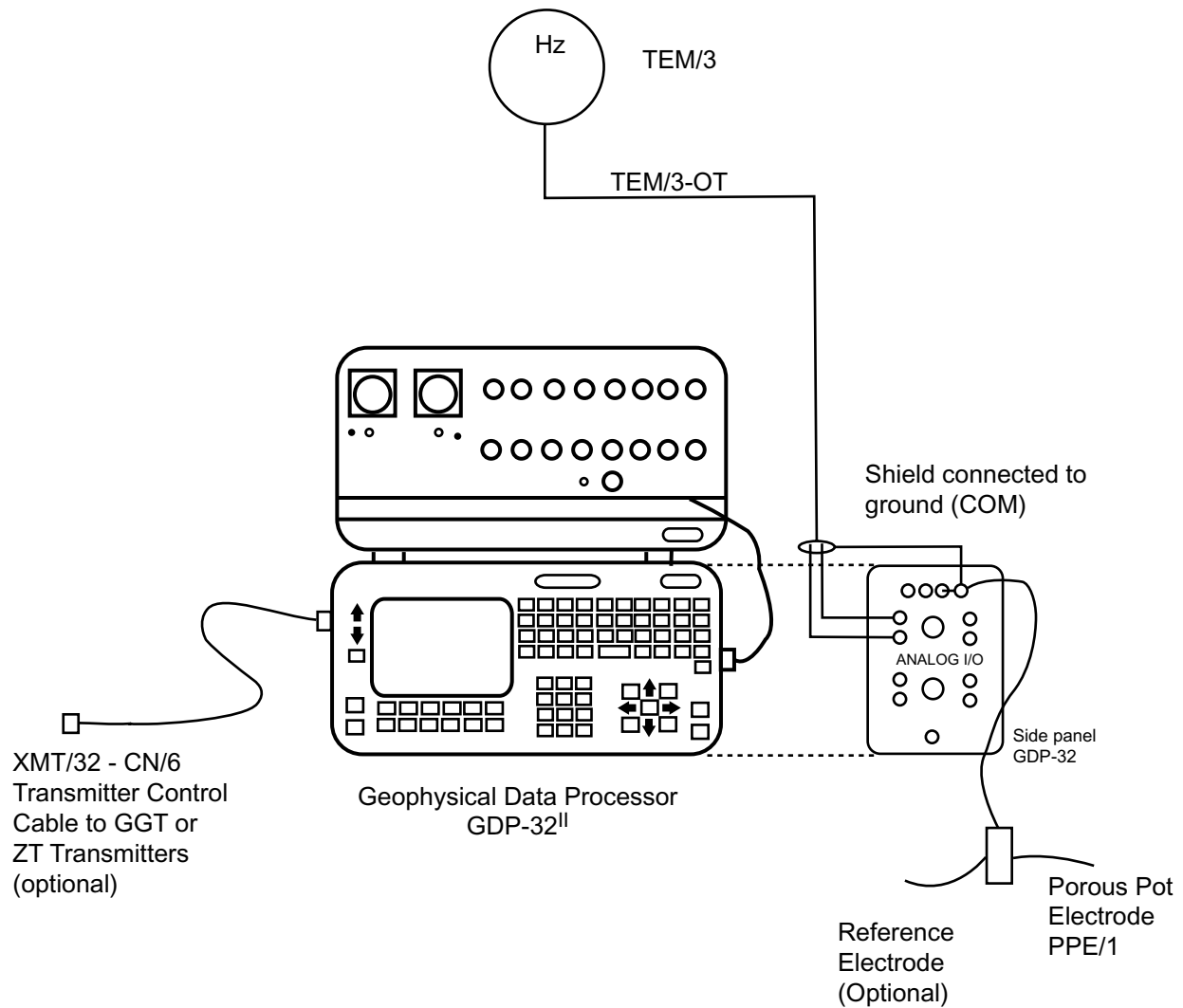
Antenna delay $15\ \mu\text{s}$
Filter delay $24\ \mu\text{s}$
Total delays $39\ \mu\text{s}$



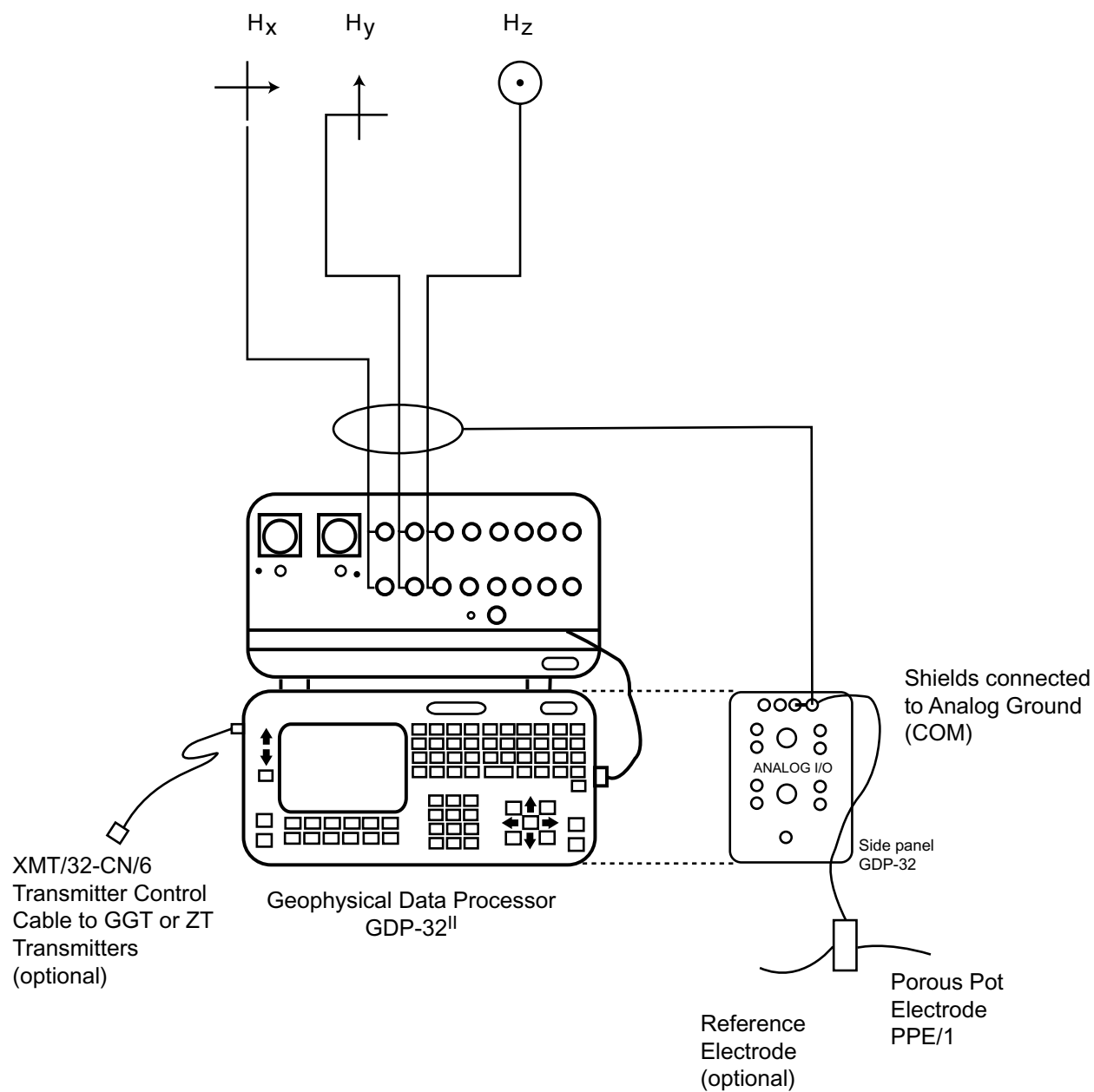
The software is set so that the first window time is always equal to or greater than one sample width, or in this case greater than $30\ \mu\text{s}$.

12.15 FIELD CONFIGURATIONS

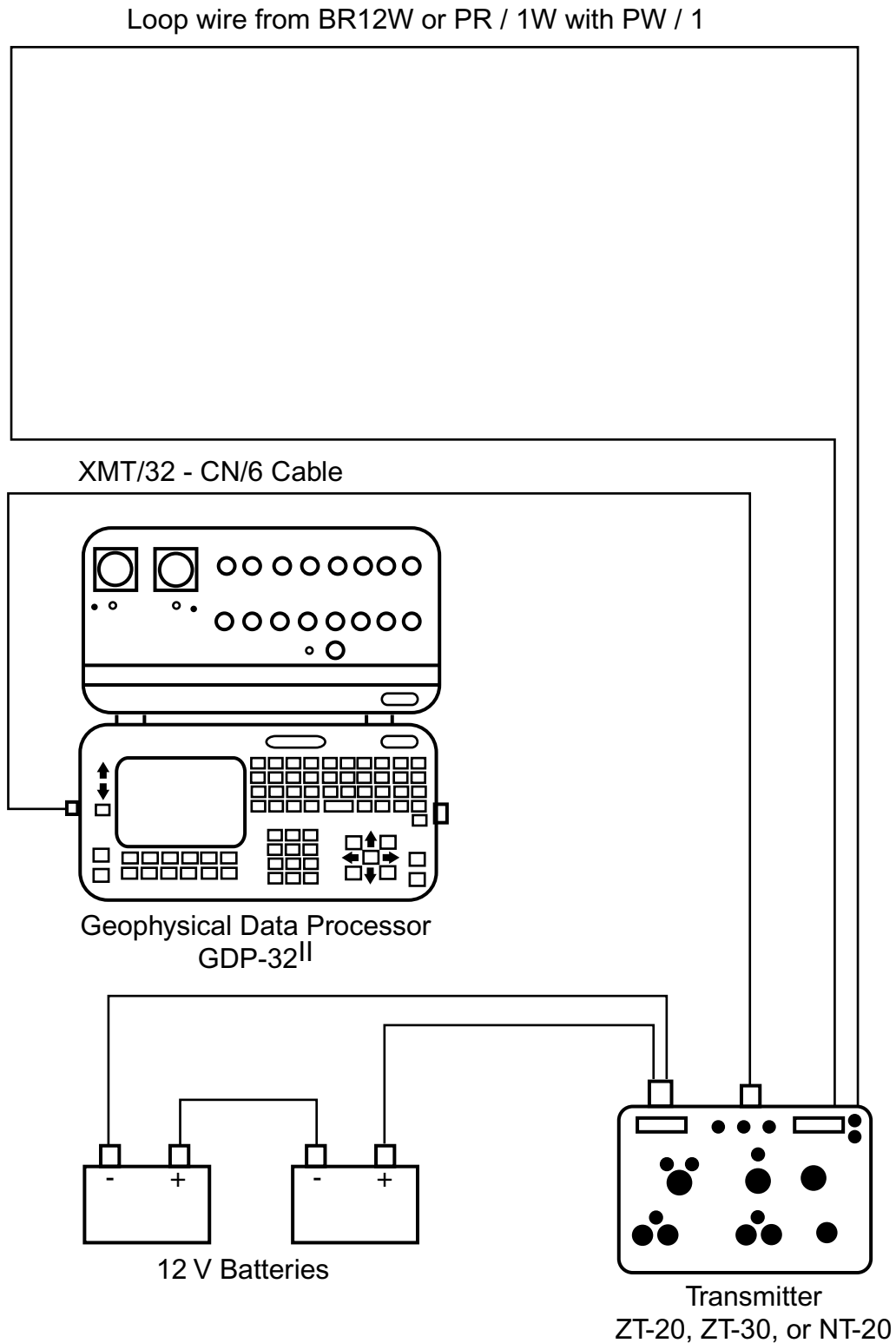
12.15.1 TEM Receiver Setup with Z-Axis Coil



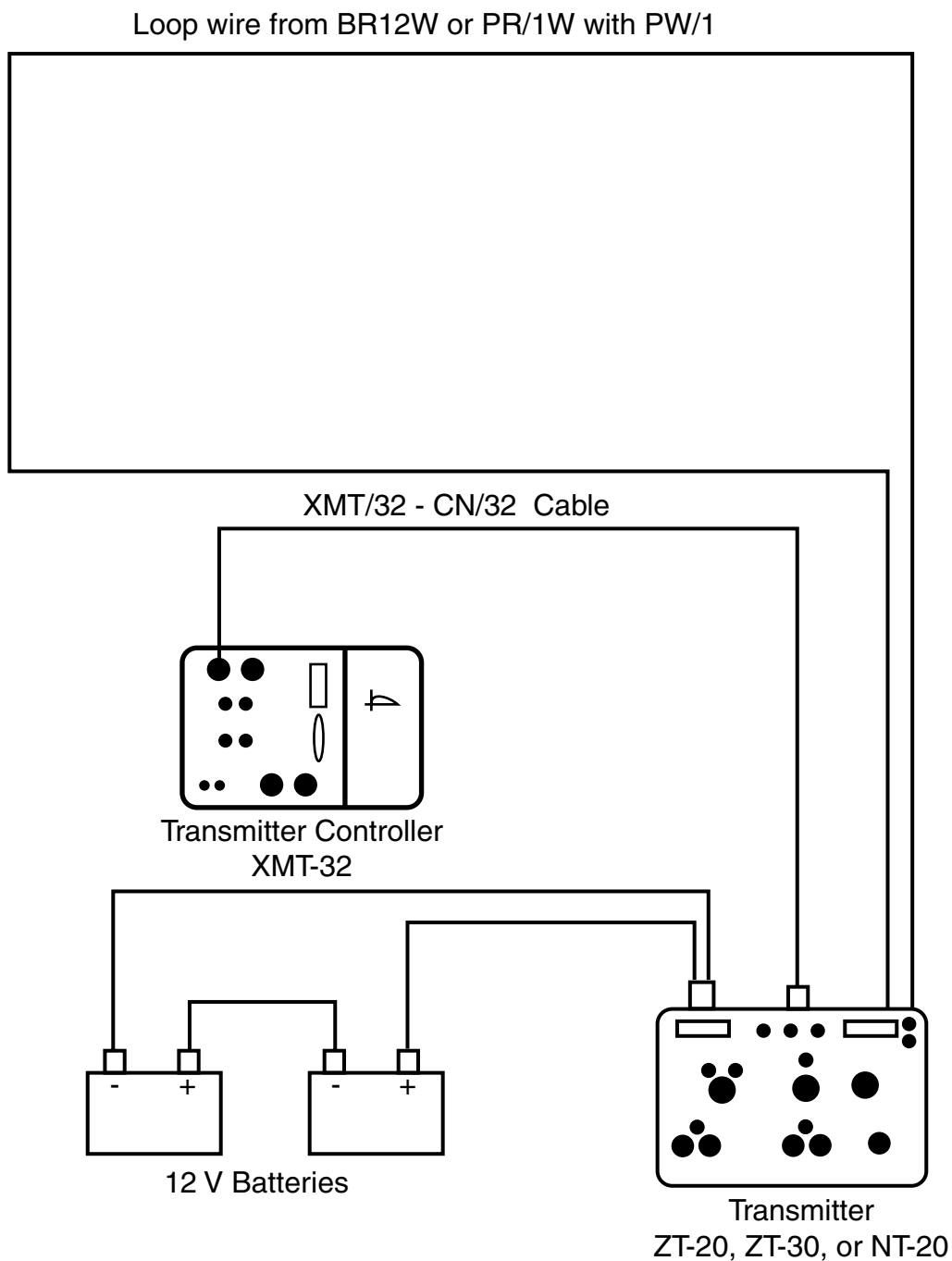
12.15.2 TEM Receiver with 3-Axis (X,Y,Z) Coils



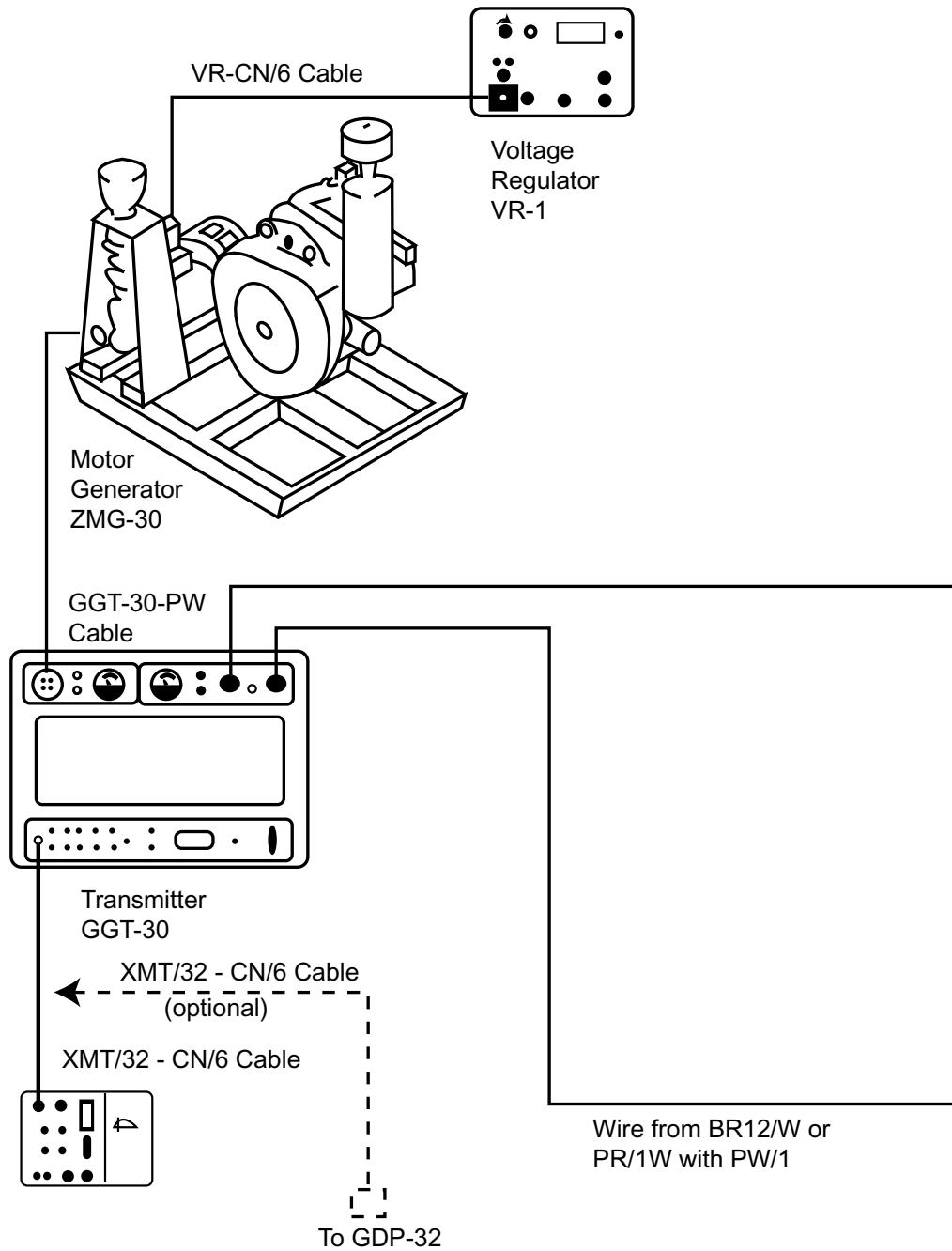
12.15.3 ZT-20 ZeroTEM Transmitter Setup (Standard)



12.15.4 ZT-20 ZeroTEM Transmitter Setup (XMT-32)



12.15.5 High-Power TEM Transmitter Setup



12.16 EQUAL-INTERVAL MODE, TEM

General

A version of the TEM program that runs on the Zonge GDP-32^{II} receiver permits TEM transients to be uniformly sampled and stored as time series to the hard disk. The window parameter may be toggled between ZONGE STANDARD, SHALLOW and EQUAL INTERVAL acquisition modes. The ZONGE STANDARD TEM data acquisition modes are described in the TEM sections of this manual. When the TEM program is operating in the EQUAL INTERVAL mode, it writes the program name TEME to each of the data blocks stored to the data cache.

The program stores the first 31 samples of the transient time series to the data cache using a format identical to that of the TEM program. However, the entire transient waveform that usually contains many more samples is written to a disk file whose name is **BLKnnnn.TEM** where **nnnn** is a 4-digit integer corresponding the GDP32^{II} block number of the data measurement. The transient data files are written in binary for efficient storage and data transfer. But they are easily transformed into ASCII text format using one of DOS executable utilities furnished when a receiver is purchased with this version of the TEM program.

The TEM Equal Interval program can handle a maximum of 65536 bytes of data. Since each sample point takes 4 bytes, the maximum number of sample points that can be acquired is 16384. Divide this number by the number of channels to determine the number of samples per channel that can be acquired.

Operating Instructions

With a few minor differences as explained below, the TEME program operates the same as the TEM program.

MENU 1:

Select the EQUAL INTERVAL option by moving the cursor to the WINDOWS field and toggling between EQUAL INTERVAL, SHALLOW, and ZONGE STANDARD options. The remaining parameters are the same as in the standard TEM program.

MENU 4:

In MENU 4 (the last menu before data are acquired) there are three selectable parameter fields:

Width: This field selects the sample interval. The minimum sample interval is governed by the frequency selected in the Frequency parameter field of this menu (see page TEM-16 of the GDP-32^{II} manual). Sample intervals ranging from 30.4 μ s to 1.946 ms are selectable. At frequencies below 4 Hz, the minimum sample interval changes on binary increments from 60.8 μ s up to 1.946 ms.

Start: This field specifies the delay time in sample intervals from the logic time of current turn-off to the first sample of the transient. No corrections for transmitter delay filter delays antenna delays, or current turnoff times are applied. Delays of up to a quarter of a period are permitted (i.e., $\text{Start} \leq T/(4\Delta t)$).

Count: This field specifies the number of samples to be acquired. Note there will be a maximum number of samples that can be acquired that is equivalent to a time period of $T/4$ (i.e. $\text{Count} \leq T/(4\Delta t)$).

Data Inspection and Downloading

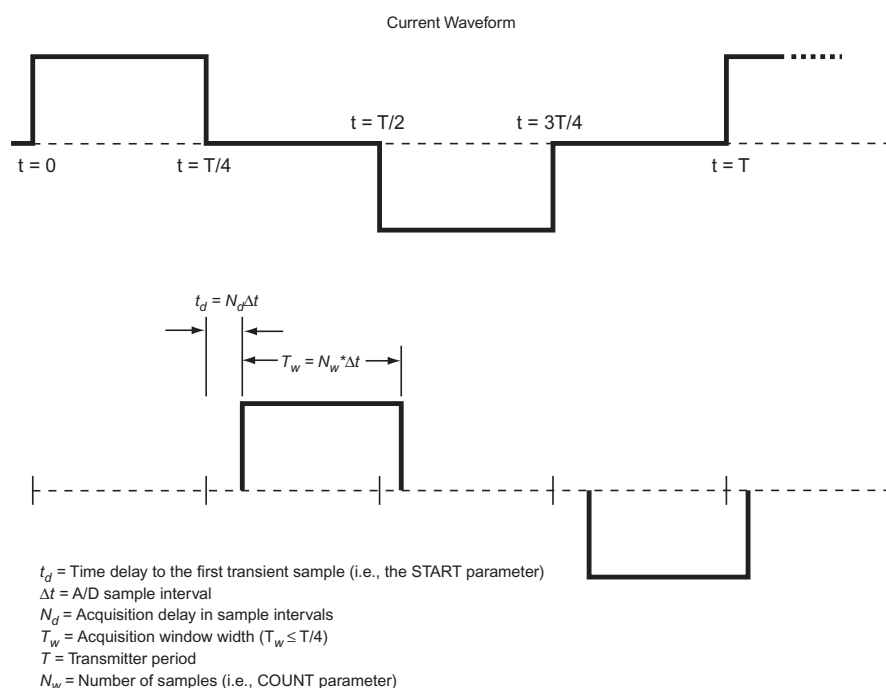
The sampled data falling within the gates as defined above and illustrated in the accompanying figure are rectified and stacked. These data are stored both in the data cache and as binary files on the hard disk. Only the first 31 data points are stored in the cache. They may be viewed and/or dumped from the DATA menu using procedures common to all the programs. The binary files are stored on the hard disk with the name **BLKnnnnn.TEM**, where **nnnn** is an integer corresponding to the block number of the corresponding partially complete data set stored in the data cache.

The binary data may be downloaded using either the LAN connection or the serial port. The steps for downloading are listed below:

1. While the GDP-32^{II} power is off, connect it to either a LAN or to the serial port of another computer (a null modem must be used).
2. Turn on the GDP-32^{II} and run Windows.
3. If using the LAN, you may have to re-configure the network parameters in the GDP-32^{II} to be compatible with your network.
4. If using the serial port, HyperTerminal is the recommended program to use. You will have to ensure that the two serial ports are configured identically.
5. The data files are stored in **d:\data**.

Binary data files with the extension IGG may be inspected by converting them to ASCII format. The utility program **iggascii.exe** converts a binary file to an ASCII text file of the same name with extension **PRN**.

The source code for this utility program is included so that users or customers have prototype C code for reading a binary file containing uniformly sampled transient data.



Explanation of the EQUAL INTERVAL mode data acquisition mode in the GDP-32^{II} TEM program

12.17 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**.

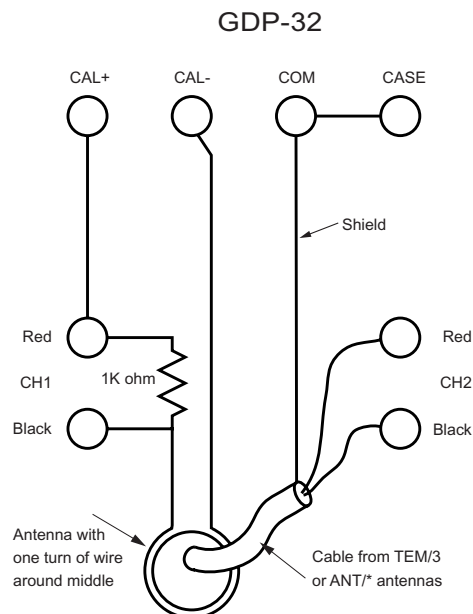
13. Enter the starting channel number = 2 and press

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.



12.18 THE NanoTEM SYSTEM

The NanoTEM system is a very fast turnoff and sampling TEM option available for the GDP-32^{II} receivers. The equipment consists of a high-speed sampling card (Board 194) for the GDP, a battery powered NanoTEM transmitter and a few loading resistors.

The receiver board samples the decay waveform at either 1.2 or 1.6 microsecond intervals, and then stores the data in an on-board memory buffer. Then the data are transferred to the main GDP memory where the samples are combined to form time windows on a logarithmic scale.

The NanoTEM transmitter is configured for very fast turn-off, is powered by a 12-volt battery, and can output up to 4 amperes. Two versions of the NanoTEM transmitter are available. The first, the NT-20, is an external transmitter system, and the second is the NT-32 that utilizes a transmitter integrated within the GDP-32^{II} case.

Operating instructions for the NT-20 transmitter are included in a separate manual included with the NT-20. Instructions for effective operation of the NT-32 system are included in **Section 12.20**.

*NOTE: Board 194 has a fixed gain stage of x10, which cannot be changed. Therefore, the receiver moment must be multiplied by a factor of 10 (as shown in **Section 12.19**, step 9) to get the correct resistivity numbers. There is also a variable gain stage with selections of 1, 2, 4, 8 and 16, which can be set automatically with the NanoTEM program.*

12.18.1 NanoTEM Configuration

NanoTEM Card for the GDP-32^{II}

NT-20 Transmitter

Wire for TX loop - 10 x 10 m, 20 x 20 m, etc.

Wire for RX loop - presently using 5 x 5 m by 1 turn for 20 m TX loops and 10 x 10 m for 40 m TX loops.

Battery for NT-20

Battery charger

Cable: RX loop to GDP - twisted pair with 150 ohm load resistor with alligator clips on the receiving antenna end and a 1 k Ω balanced bridge resistor on the other end, which plugs into the GDP. The cable should be approximately 14 meters long for a 20 x 20 m loop.

Cable: transmitter control - from NT-20 to GDP

Cable: battery power for NT-20

Two options:

- a) cable for using two 12 Volt car batteries
- b) cable for using 12/24 Volt 10 amp-hour battery pack

CAUTION: *NanoTEM operation requires 12-volt supply only.*

12.19 NanoTEM HOOKUP DIRECTIONS

Using a 20 X 20 m Transmitter Loop and NT-20 or NT-32 Transmitter

1. Use the 1 K-ohm bridge that is supplied. Plug it into the input for the channel that has the NanoTEM card (channel 3 in this example), and connect the ground wire to COM.
2. The 150 ohm resistor mounted on the Pomona plug must be connected across the receiver coil as shown in **Section 12.26**.
3. Observe the color-coded hookups as shown to get the proper polarity for received data.
4. VERY IMPORTANT: Upon turn-on, the NT-20 or NT-32 transmitter may come up on a setting other than a 20 meter loop. You MUST set it to the proper loop size to get the proper turn-off time.
5. For 20 meter loop operation, run the TX at 3 amps. Maximum current is about 4 amps.
6. Insulate the clips on the ends of the 20 meter TX loop sections to make sure you do not have leakage. This is not necessary in very dry conditions.
7. Do the same for the resistor load on the RX antenna, which is 5x5 meters for this example.
8. Header information from **Menu 1**:
 - Array Type : NanoTEM
 - Duty cycle : 50%
 - Receiver moment : 250
 - Transmitter X,Y : 20 , 20 Turns: 1
 - TX delay : 1.5 microseconds
 - Antenna delay : 2 microseconds
 - Transmitter type : NT-20 (NT-32 if available in instrument)
 - Automatic gain mode
 - Alias filter IN
9. Note that the receiver moment is set to 250 meters squared even though the RX loop is 5 x 5 meters. The extra factor of 10 compensates for a gain of 10 on the NanoTEM card.
10. If using the NT-32 transmitter, pressing the GAIN/F10 key, then entering 8 from the data collection menu will accesses configuration of the NT-32 internal transmitter. The damping resistor should be set to 250 and transmitter loop size set to 20.
11. Take two stacks of 1024 cycles, unless the data are coming in clean with shorter stacks.

Using Transmitter Loops Other Than 20 Meters

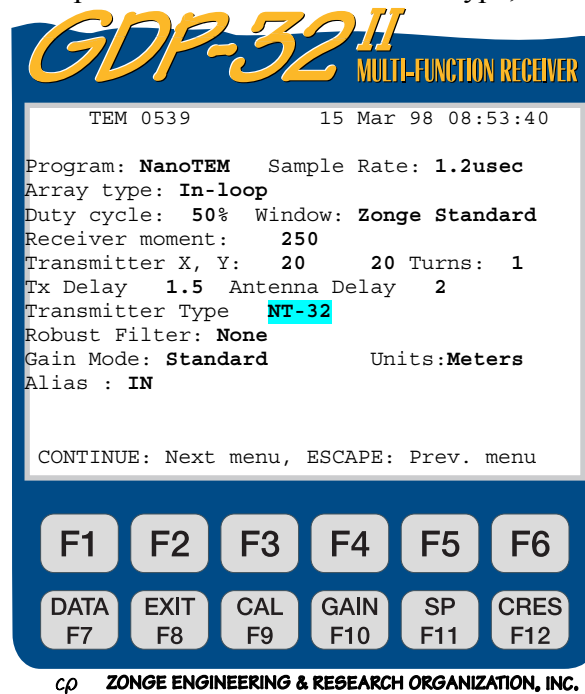
If you are using an NT-20 transmitter, be sure to set the **LOOP SIDE** switch on the NT-20 to the closest smaller value for the transmitter loop being used. For example, a 61-meter loop should be set to 50 meters on the NT-20. The new loop dimensions should also be entered in Menu 1.

If you are using the NT-32 transmitter, the damping resistor value may be changed to correspond to the loop dimensions. A chart for estimated damping resistor values is included at the end of **Section 12.20**.

12.20 NT-32 TRANSMITTER SYSTEM

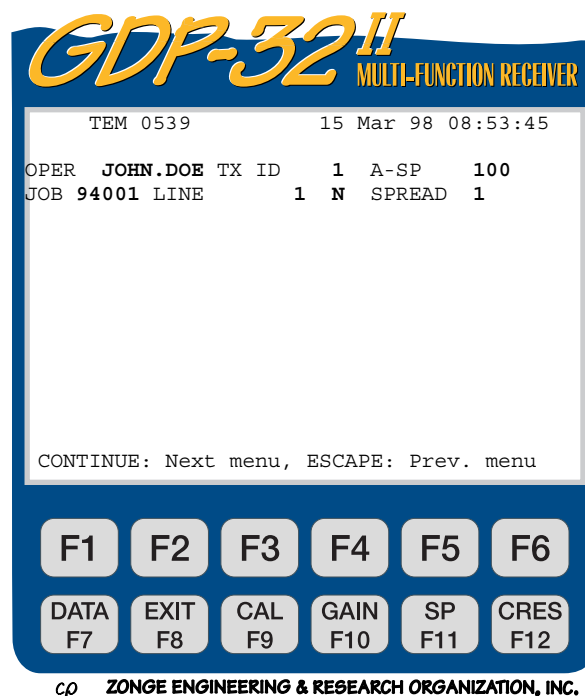
Setup of the NanoTEM system using the NT-32 transmitter is similar to the steps used when using all of the other Zonge Transmitter systems.

Configuration information is entered into Menu 1 in the GDP-32^{II} data program as outlined in *Section 12.5*. Of particular importance are the Transmitter Type, which should be set to **NT-32**.



After initializing the NT-32 Transmitter, the data collection program continues on to menu 2 allowing entry of record keeping information such as line number, operator name, etc. A-Spacing (**A-SP**) is displayed in this menu, but it is not used for NanoTEM.

Menu 2



Menu 3, as with all of the data collection programs in the GDP-32^{II}, allows individual channels to be enabled, station numbers to be entered for each channel, and configuration information for the channels (Hx, Hy, or Hz) to be entered. Below is a configuration for making vertical magnetic field measurements at three separate stations.

Menu 3

GDP-32^{II} MULTI-FUNCTION RECEIVER

```


0094 TEM 0539          15 Mar 98 08:57:47

OPER  JOHN DOE TX ID   1  A-SP   100
JOB 94001 LINE         1  N   SPREAD  1

CH  Station
1  Hz      1
2  Hz      2
3  Hz      3

Enter channel parameters
  
```

cp **ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.**

Menu 4 is the primary data collection screen. Control over the configuration of the NT-32 transmitter is gained though pressing  key while in this menu. The other portions of this menu are described in detail in *Section 12.5*.

Menu 4

GDP-32^{II} MULTI-FUNCTION RECEIVER

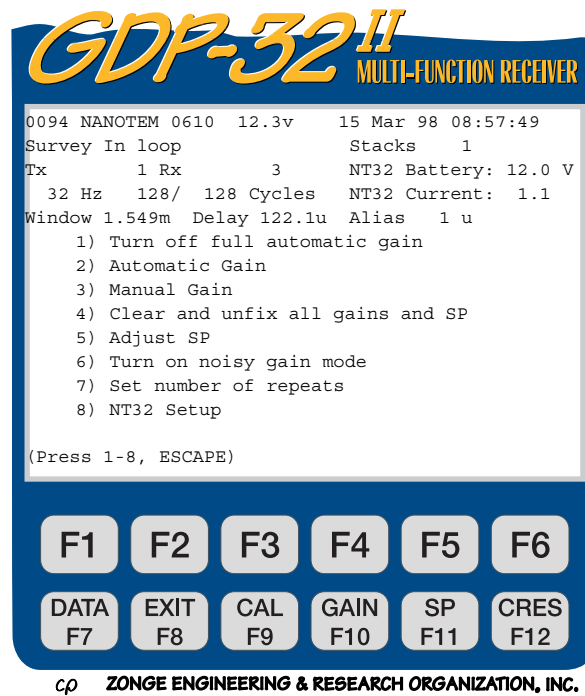
```

0094 NANOTEM 0610 12.3v 15 Mar 98 08:57:49
Survey In loop          Stacks  1
Tx      1 Rx           3  NT32 Battery: 12.0 V
  32 Hz 128/ 128 Cycles NT32 Current: 1.1
Window 1.549m Delay 122.1u Alias 1 u
CH  Station  V/A  Wn Time rho  GGGA
1  Hz      1  2.0731u 1.549m 0.871 0600
2  Hy      1  1.9526u 1.549m      0600
3  Hx      1  1.7043u 1.549m      0600

CONTINUE-Set Gains, Esc-Prev Menu
  
```

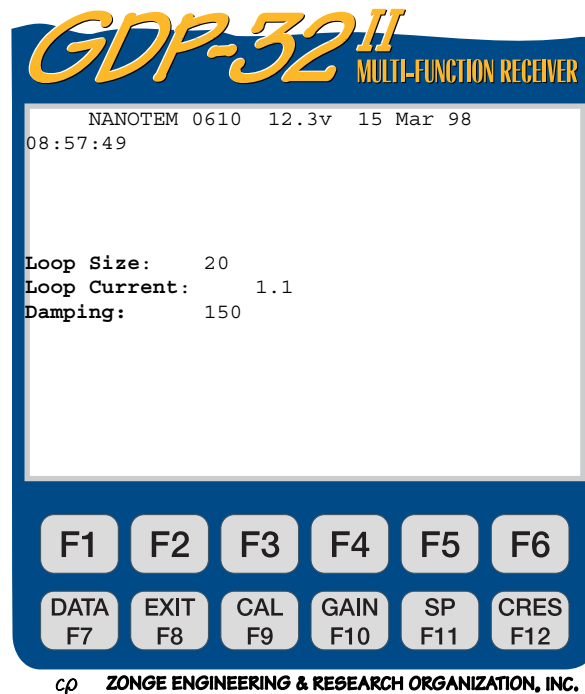
cp **ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.**

Gain/F10 SubMenu



The setup menu for the NT-32 transmitter can be accessed by pressing **8**. This will bring up the NT-32 configuration menu.

NT-32 Configuration Menu



Loop Size: Transmitter loop side in meters

Loop Current: Adjust output current (measured in Amperes)

Damping: Adjustment for transmitter damping resistors. Damping resistance values are available from 50 to 1550 ohms in steps of 50 ohms. These values can be changed by pressing



and



. The best choice for damping resistors is a complex function of the loop size and the electrical resistivity of the area in which measurements are being made. The chart below offers estimates of damping values for different transmitter geometries.

Tx Loop Size	Damping Resistance
5	100
10	150
20	250
40	450
80	850
100	1000

12.21 NanoTEM TURNOFF TIMES

Following are some approximate turnoff times for a selection of transmitter loop sizes:

Loop Size	Turnoff Time
10 x 10 meter loop	1.2 μ s
20 x 20 meter loop	1.5
40 x 40 meter loop	3.0
100 x 100 meter loop	6.0

The NanoTEM program has been used successfully in highly conductive as well as highly resistive environments.

12.22 Initializing the NanoTEM Field Data Cache

At this time, all of the GDP-32^{II} programs, except for the NanoTEM program, initialize the data cache according to the outline in Chapter 7.4. Initialize the NanoTEM data cache as follows:


If you are in the NanoTEM program, get into the first menu and

Press 2 Utilities then


Press 6 Turn off power, then

Press 

The LOGO screen will now be displayed. This is also where you will enter the program if you have just turned the receiver on.


Press  to get into WINDOWS


If you do not have a mouse attached, press  (OK) for Mouse Support display box.


Press  (YES) for the DHCP box
Windows EXPLORER is now activated



Press  -  to see the bottom of the display and the file listings

Press  until you highlight the file NTDATA.CAC

Press . The following message will appear
Are you sure you want to send NTDATA.CAC to the recycle bin?

If YES is not highlighted, press  to highlight YES



Press . NTDATA should be deleted from the screen

Press  -  to view the lower left-hand part of the screen

Press  - 
Press the down arrow to highlight SHUT DOWN

Press 
Press  and  to RESTART the computer, if desired,

Otherwise press  to turn the computer off.

Press  -  to get back to the original position of the screen

12.23 NanoTEM WINDOW CENTERS

12.23.1 Sample Period: 1.6 Microseconds Zero Delay After Current Turnoff

WINDOW #S	POINTS PER WINDOW	WINDOW CENTERS	WINDOW WIDTHS BEGINNING	END
1	1	0.0 μ sec	0.0 μ sec	0.0 μ sec
2	1	1.6	1.6	1.6
3	1	3.2	3.2	3.2
4	1	4.8	4.8	4.8
5	1	6.4	6.4	6.4
6	1	8.0	8.0	8.0
7	2	10.4	9.6	11.2
8	2	13.6	12.8	14.5
9	2	16.8	16.1	17.7
10	3	20.8	19.3	22.5
11	3	25.6	24.1	27.3
12	5	32.0	28.9	35.3
13	6	40.8	36.9	45.0
14	7	51.2	46.6	56.2
15	9	63.9	57.8	70.7
16	11	79.9	72.3	88.3
17	15	100.6	89.9	112.4
18	18	127.7	114.0	142.9
19	23	161.2	144.5	179.9
20	29	202.7	181.5	226.4
21	36	254.6	228.1	284.3
22	47	320.7	285.9	359.7
23	58	404.5	361.4	452.9
24	72	508.3	454.5	568.5
25	92	639.0	570.1	716.3
26	116	804.9	717.9	902.6
27	145	1.013 m sec	904.2	1.135 m sec
28	184	1.276	1.137 m sec	1.431
29	231	1.607	1.433	1.802
30	289	2.022	1.804	2.266
31	369	2.546	2.268	2.859

To demonstrate how to determine the actual window times, we will use the 20 meter loop parameters as an example: add the Tx delay (1.5 μ s) plus the antenna delay (2.0 μ s) plus the antialias filter delay (1.0 μ s) = 4.5 μ s. The first sample point after the Tx turnoff and delays is at 4.8 μ s (3 x 1.6), so the first window will be at 4.8 - 4.5 = 0.3 μ s. The next window will be 1.6 + 0.3 = 1.9 μ s, then 3.2 + 0.3 = 3.5 μ s, for the next window, etc.

12.23.2 Sample Period: 1.2 Microseconds
Zero Delay After Current Turnoff

WINDOW #S	POINTS PER WINDOW	WINDOW CENTERS	WINDOW WIDTHS	
			BEGINNING	END
1	1	0.0 μ sec	0.0 μ sec	0.0 μ sec
2	1	1.2	1.2	1.2
3	1	2.4	2.4	2.4
4	1	3.6	3.6	3.6
5	1	4.8	4.8	4.8
6	1	6.0	6.0	6.0
7	2	7.8	7.2	8.4
8	2	10.2	9.6	10.8
9	2	12.6	12.1	13.3
10	3	15.6	14.5	16.9
11	3	19.2	18.1	20.5
12	5	24.0	21.7	26.5
13	6	30.6	27.7	33.7
14	7	38.4	34.9	42.2
15	9	48.0	43.4	53.0
16	11	59.9	54.2	66.3
17	15	75.4	67.5	84.4
18	19	95.8	85.6	107.2
19	23	121.0	108.5	135.0
20	29	152.1	136.2	169.9
21	36	191.0	171.1	213.3
22	47	240.6	214.5	269.9
23	58	303.5	271.1	339.8
24	72	381.4	341.0	426.6
25	92	479.5	427.8	537.4
26	116	604.0	538.6	677.2
27	145	760.2	678.4	851.9
28	184	957.1	853.1	1,074
29	231	1,205	1,075	1,352
30	289	1,517	1,353	1,700
31	369	1,910	1,701	2,145

To demonstrate how to determine the actual window times, we will use the 20 meter loop parameters as an example: add the Tx delay (1.5 μ s) plus the antenna delay (2.0 μ s) plus the antialias filter delay (1.0 μ s) = 4.5 μ s. The first sample point after the Tx turnoff and delays is at 4.82 μ s (4 x 1.205), so the first window will be at 4.82 - 4.5 = 0.32 μ s. The next window will be 1.2 + 0.32 = 1.52 μ s, then 2.41 + 0.32 = 2.73 μ s, for the next window, etc.

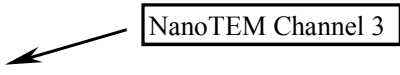
12.23.3 Sample Period: 1.2 Microseconds, Shallow Applications
Zero Delay After Current Turnoff

WINDOW #S	POINTS PER WINDOW	WINDOW CENTERS	WINDOW WIDTHS	
			BEGINNING	END
1	1	0.0 u sec	0.0 u sec	0.0 u sec
2	1	1.2	1.2	1.2
3	1	2.4	2.4	2.4
4	1	3.6	3.6	3.6
5	1	4.8	4.8	4.8
6	1	6.0	6.0	6.0
7	1	7.2	7.2	7.2
8	2	9.0	8.4	9.6
9	2	11.4	10.8	12.0
10	2	13.8	13.3	14.5
11	2	16.3	15.7	16.9
12	3	19.2	18.1	20.5
13	3	22.9	21.7	24.1
14	4	27.0	25.3	28.9
15	5	32.4	30.1	34.9
16	6	39.0	36.1	42.2
17	7	46.8	43.4	50.6
18	8	55.9	51.8	60.2
19	9	66.1	61.4	71.1
20	11	78.1	72.3	84.3
21	14	93.0	85.6	101.2
22	17	111.6	102.4	121.7
23	20	133.8	122.9	145.8
24	24	160.2	147.0	174.7
25	29	192.0	175.9	209.7
26	35	230.4	212.3	251.8
27	42	276.6	253.0	302.4
28	50	331.8	303.7	362.7
29	59	397.3	363.9	433.8
30	70	474.7	435.0	518.1
31	85	567.7	519.4	620.6

To demonstrate how to determine the actual window times, we will use the 20 meter loop parameters as an example: add the Tx delay (1.5 us) plus the antenna delay (2.0us) plus the antialias filter delay (1.0us) = 4.5us. The first sample point after the Tx turnoff and delays is at 4.8us (4 x 1.2), so the first window will be at 4.8 - 4.5 = 0.3us. The next window will be 1.2 + 0.3 = 1.5us, then 2.4 + 0.3 = 2.7us, for the next window, etc.

12.24 NanoTEM Sample Data

```
0778
NANO0534 94-12-31 17:58:13 11.7v INL
OPER      SAU TX ID  T-21 A-SP      1
JOB 94118 LINE      4 N  SPREAD  1
50% RxM  10000 TxX    1 TxY    1 #T  1 Ref 0.113
Tx Delay  1.5 Antenna Delay    2 Alias IN
Robust None
1  LoPass  Notch+60,3-5,9  S/N  117 Passed 1.00014
2  LoPass  Notch+60,3-5,9  S/N  114 Passed 0.99794
3  NanoTem A/D  14-bit    S/N    2 Passed 1.00000
Front Panel S/N    21, Cal S/N    15, Temp  20.0, Humidity  51.4, EPROM ZMT-32 Z201s
```



```
0779
NANO0534 94-12-31 18:00:05 11.6v INL
Tx      1 Rx      3 N OUT
32 Hz    512 Cyc Tx Curr  1 4.819u    1u 1.606u
3 Hz      3 59.005u 80.23u 12.97 0400 14.61u    0.00    0
Wn      Mag 3      Rho 3
0.319u  19.863m  2692.5
1.925u  4.8605m  343.38
3.531u  2.8371m  178.83
5.137u  2.0226m  119.96
6.743u  1.4475m  95.275
8.350u  1.1190m  79.222
10.73u  900.31u  60.311
13.95u  611.69u  50.388
17.16u  499.88u  40.790
21.14u  391.33u  33.942
25.97u  294.99u  29.080
32.28u  221.91u  24.461
41.08u  162.99u  20.108
51.49u  118.19u  17.097
64.24u  86.311u  14.580
80.23u  59.005u  12.974
100.9u  51.056u  9.7527
128.0u  38.916u  7.8601
161.6u  30.188u  6.3142
203.1u  22.741u  5.2111
255.0u  20.282u  3.8488
321.0u  18.985u  2.7393
404.9u  14.122u  2.2663
508.7u  12.730u  1.6603
639.4u  8.2726u  1.5116
805.4u  6.1923u  1.2482
1.014m  4.9634u  0.9859
1.276m  3.1665u  0.9065
1.607m  2.7103u  0.6845
2.022m  0.9478u  0.9404
2.547m  0.1911u  1.8622
```

The above data were acquired using a dummy load on an NT-20 transmitter.

12.25 The NanoTEM Calibrate Box

The NanoTEM Calibrate Box is a resistor-capacitor network that provides a load for the NT-20 Transmitter when operating in the NanoTEM mode, which generates a decay transient suitable for measurement in the NanoTEM decay windows.

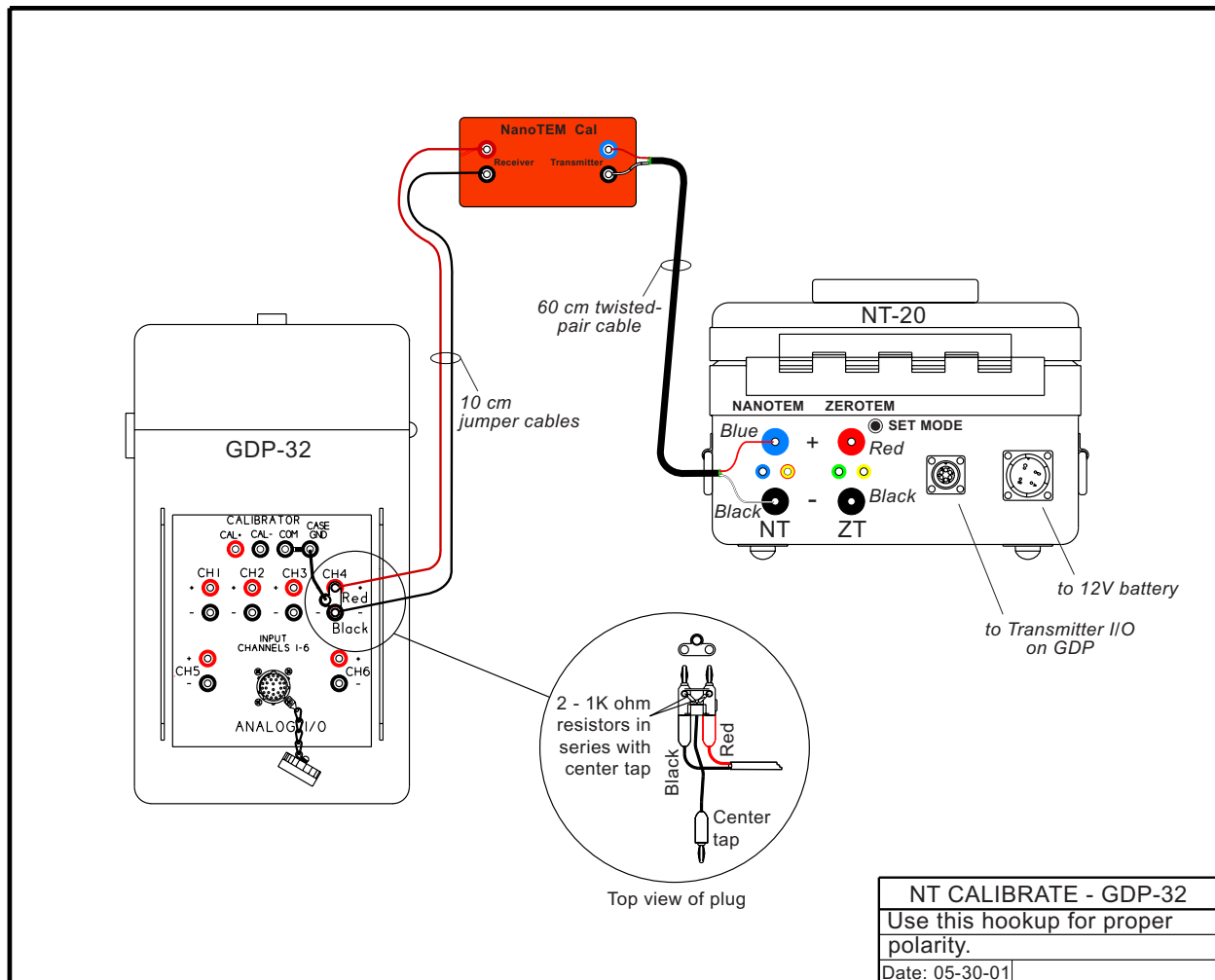
SETUP

Figure 12.25.1 is a schematic diagram showing the setup for testing the GDP-32^{II} with the NanoTEM Calibrate Box. Refer to **Section 12.3** to set up the correct header information for TEM. Follow the steps enumerated below and refer to the figure:

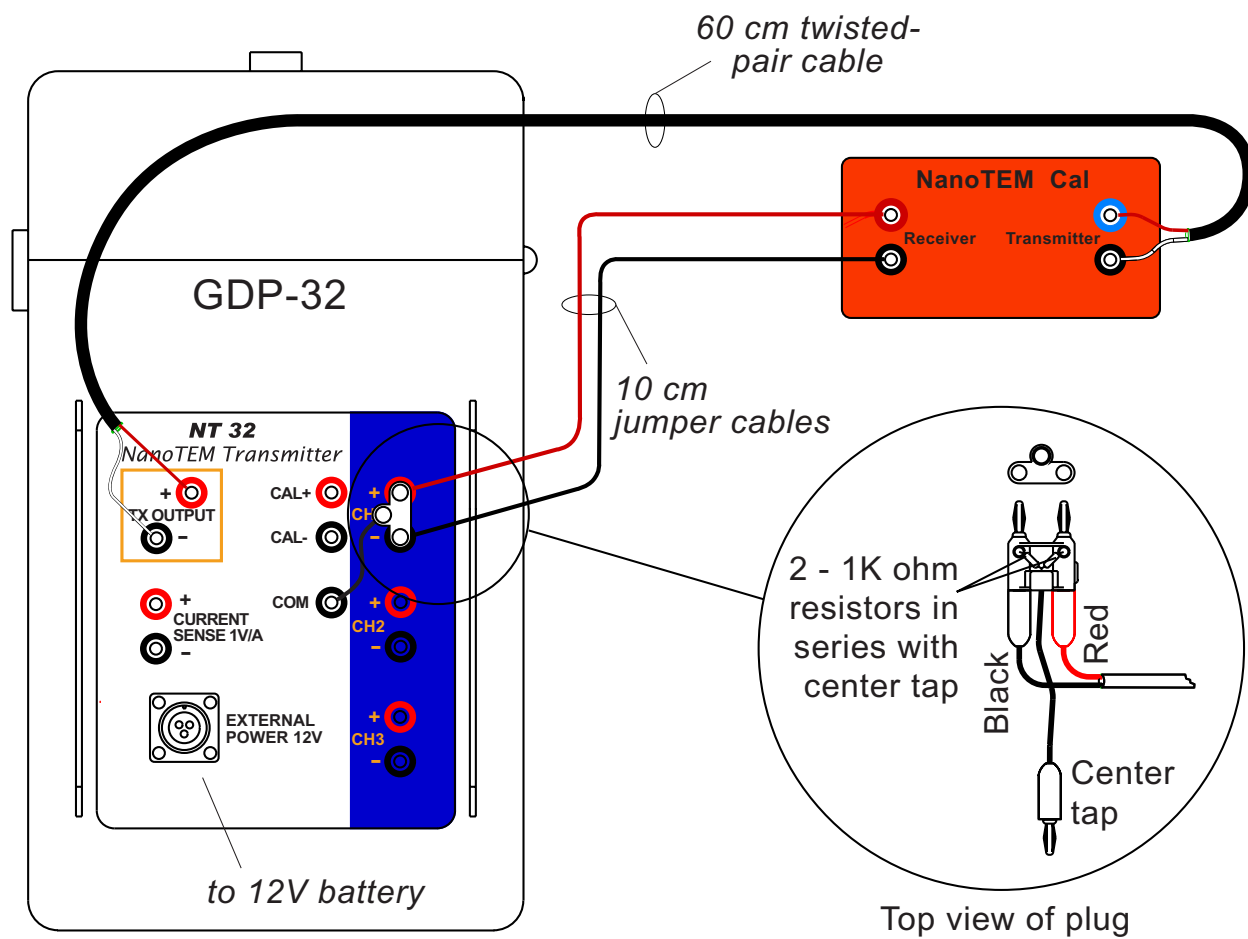
1. Connect the NT-20 transmitter outputs to the corresponding TRANSMITTER jacks (BLUE and BLACK banana jacks) of the NanoTEM Calibrate Box. Use the 60 cm twisted-pair cable provided with the calibrate box.
2. Plug the NT-I terminal connector (i.e., black double banana plug with single banana plug pigtail cable) into a GDP-32^{II} input channel corresponding to a NanoTEM analog card. Plug the pigtail into the COM jack of the GDP-32^{II}.
3. Connect the RECEIVER outputs of the NanoTEM Calibrate Box to input channel containing the NT-I terminator plug, RED to RED and BLACK to BLACK. Use 10 cm jumper cables.
4. Connect the NT-20 power cable to a 12Vdc power source and the Transmitter I/O cable from the GDP-32^{II} to the corresponding cable connector on the NT-20.
5. The results plotted in **Figure 12.25.3** show the transient curve for 1.2 μ s sampling and 1.6 μ s sampling, respectively with the antenna delay set at 2 μ s and the Tx delay set at 1.5 μ s. The ALIAS filter was set to IN. The receiver moment was set for a standard 5mx5m loop (RxM = 250). The output current of the transmitter should be adjusted to 1 A.

The recorded signal levels are normalized by current so it is important that the output current be set to one amp if decay curves are to be compared to those in **Figure 12.25.3**. Also remember that you are comparing curves with the same total delay time.

12.25.1 NT-20 NanoTEM Calibrate Setup

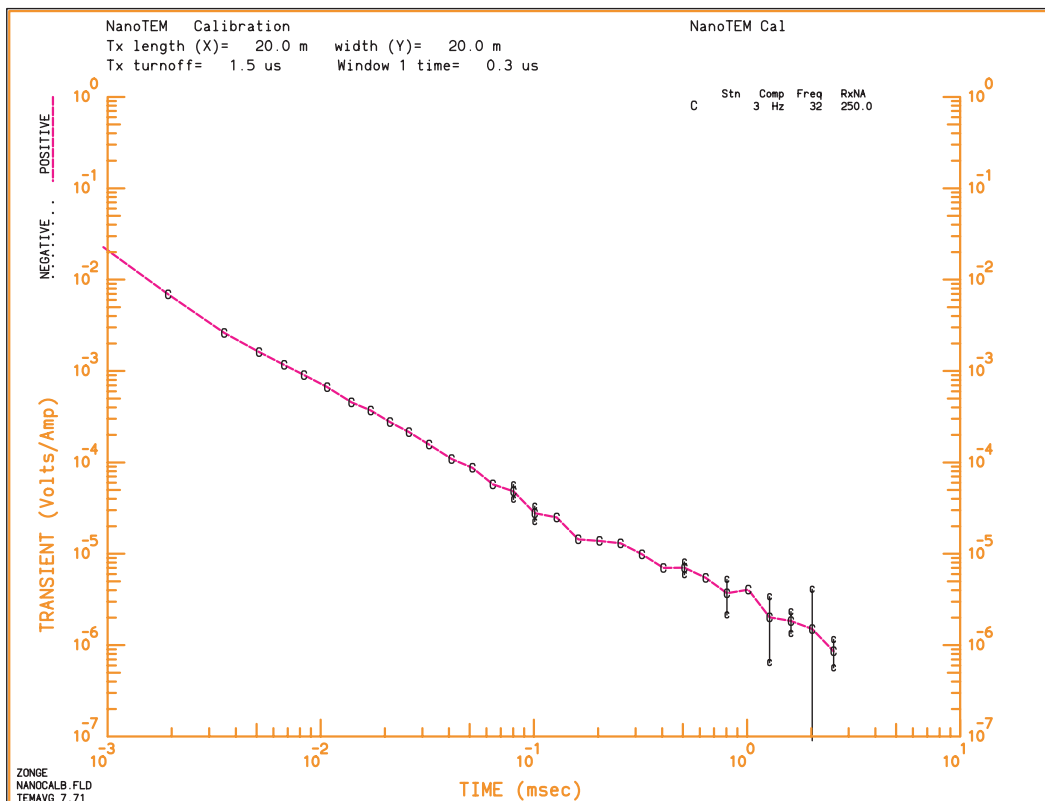
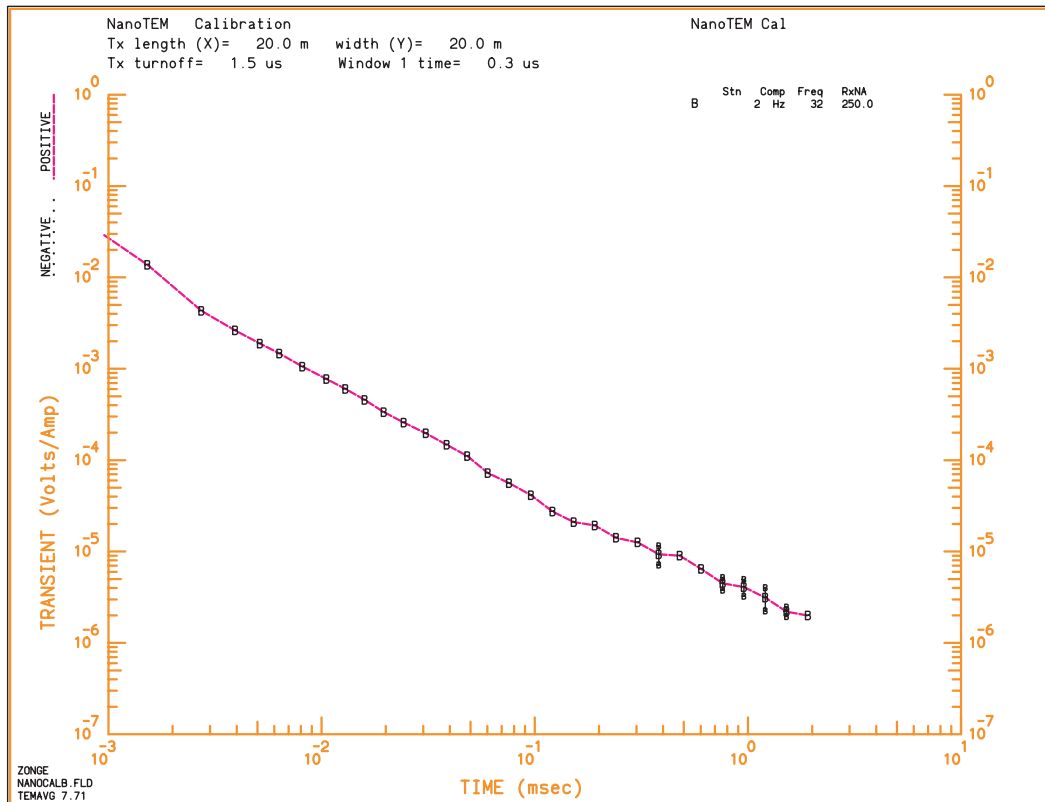


12.25.2 NT-32 NanoTEM Calibrate Setup



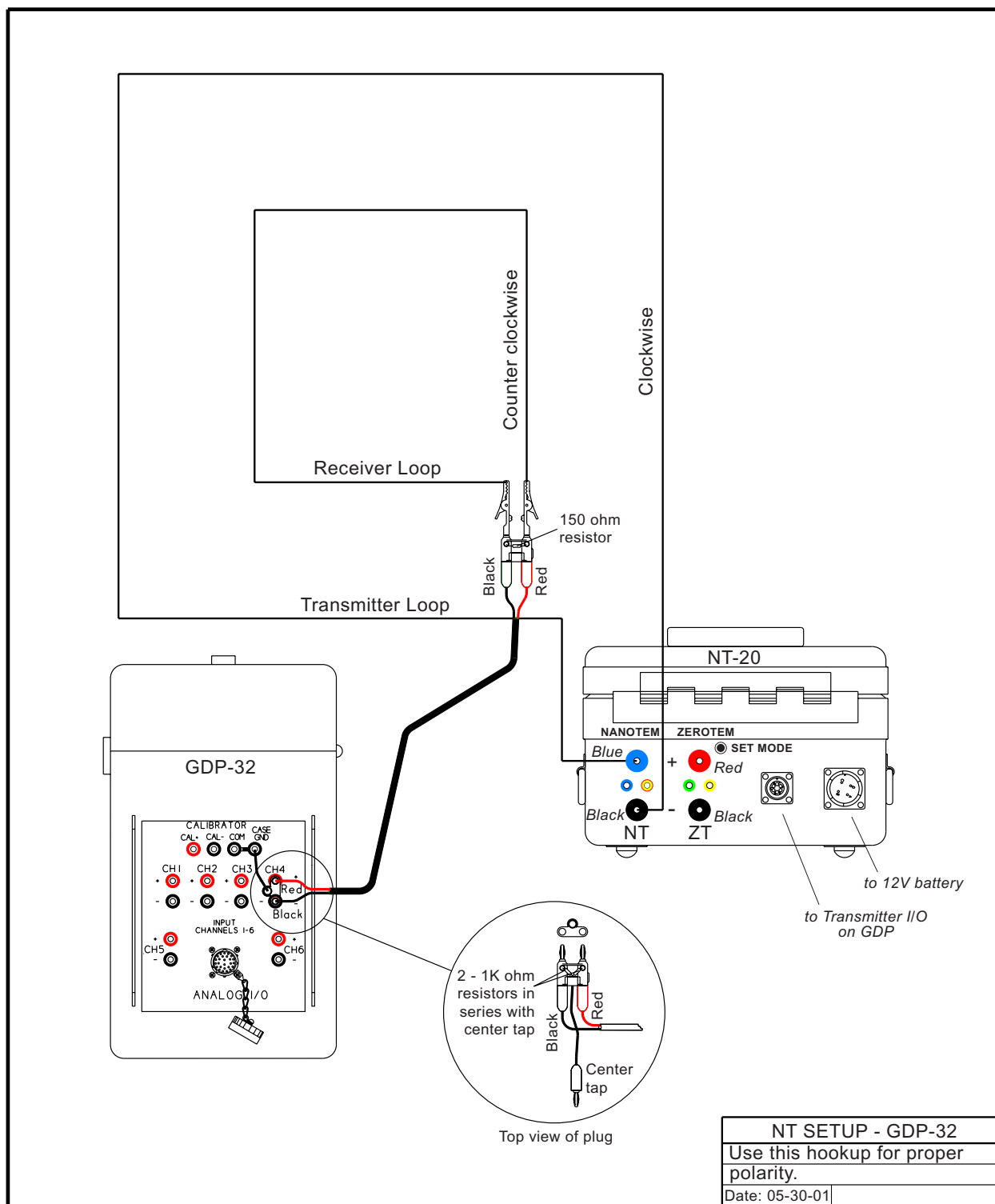
12.25.3 Decay transient observed with NanoTEM calibrator

A (top): 1.2 μ s sample interval, **B** (bottom): 1.6 μ s sample interval.

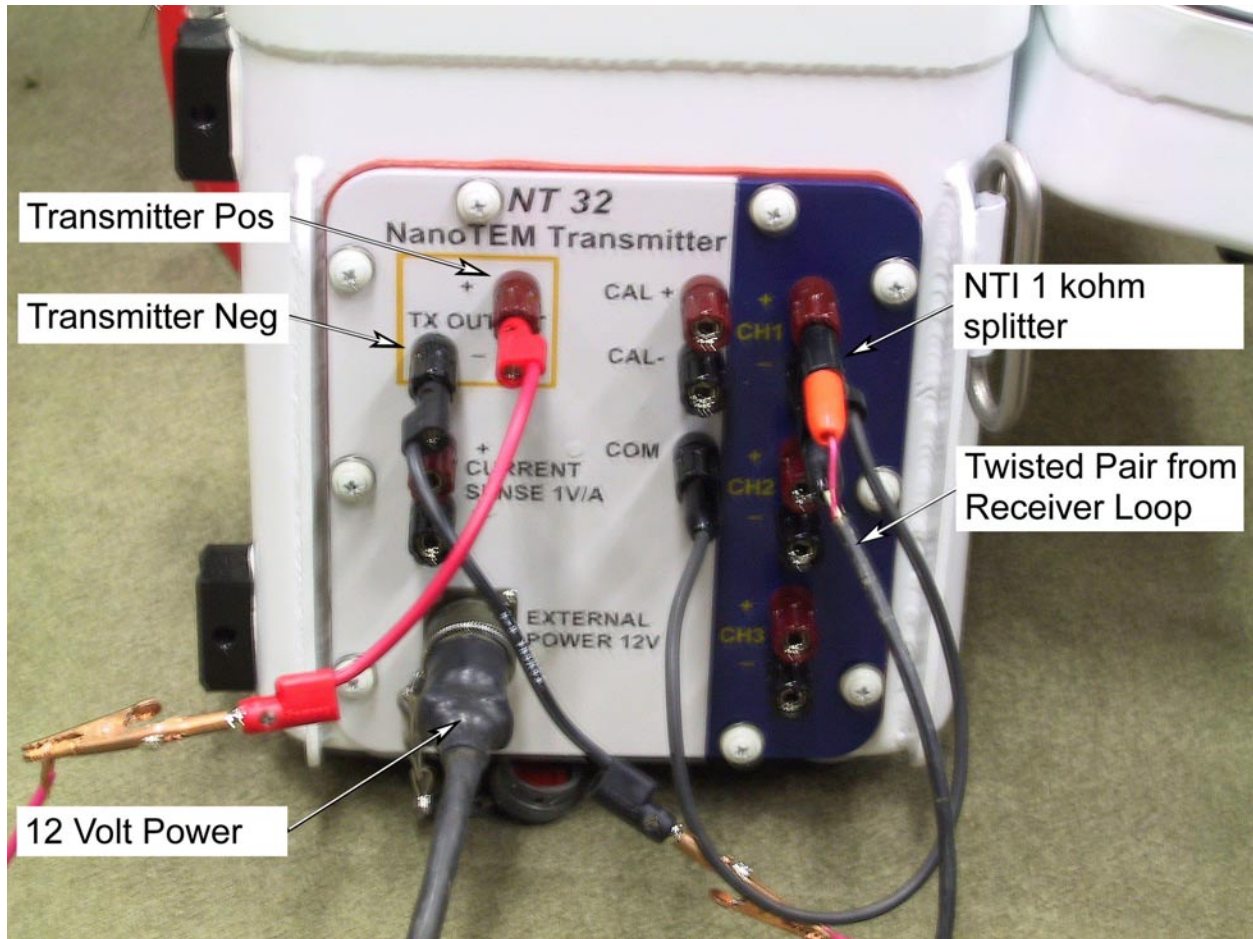


12.26 NanoTEM FIELD SETUP

12.26.1 NT-20 Field Setup



12.26.2 NT-32 Field Setup



12.27 EQUAL-INTERVAL MODE, NanoTEM

General

A version of the NanoTEM program that runs on the Zonge GDP-32^{II} receiver permits NanoTEM transients to be uniformly sampled and stored as time series to the hard disk. The window parameter may be toggled between ZONGE STANDARD, SHALLOW and EQUAL INTERVAL acquisition modes. The ZONGE STANDARD NanoTEM data acquisition modes are described in the NanoTEM sections of this manual. When the NanoTEM program is operating in the EQUAL INTERVAL mode, it writes EQUAL in the window parameter field in the data cache.

The program stores the first 31 samples of the transient time series to the data cache using a format identical to that of the NanoTEM program. However, the entire transient waveform that usually contains many more samples is written to a disk file whose name is **BLKnnnn.NTE** where **nnnn** is a 4-digit integer corresponding the GDP32^{II} block number of the data measurement. The transient data files are written in binary for efficient storage and data transfer. But they are easily transformed into ASCII text format using one of DOS executable utilities furnished when a receiver is purchased with this version of the NanoTEM program.

The NanoTEM Equal Interval program can handle a maximum of 65536 bytes of data. Since each sample point takes 4 bytes, the maximum number of sample points that can be acquired is 16384. Divide this number by the number of channels to determine the number of samples per channel that can be acquired.

Operating Instructions

With a few minor differences as explained below, the EQUAL INTERVAL NanoTEM program operates the same as the NanoTEM program.

MENU 1:

Select the EQUAL INTERVAL option by moving the cursor to the WINDOWS field and toggling between EQUAL INTERVAL, SHALLOW, and ZONGE STANDARD options. The remaining parameters are the same as in the standard NanoTEM program.

MENU 4:

In MENU 4 (the last menu before data are acquired) there are three parameter fields:

Width: This field is set to a sample interval of 1.2 μ s.

Start: This field specifies the delay time in sample intervals from the logic time of current turn-off to the first sample of the transient. No corrections for transmitter delay filter delays antenna delays, or current turnoff times are applied. Delays of 1 through 99 are permitted.

Count: This field specifies the number of samples to be acquired. The maximum number of samples is 4096.

Data Inspection and Downloading

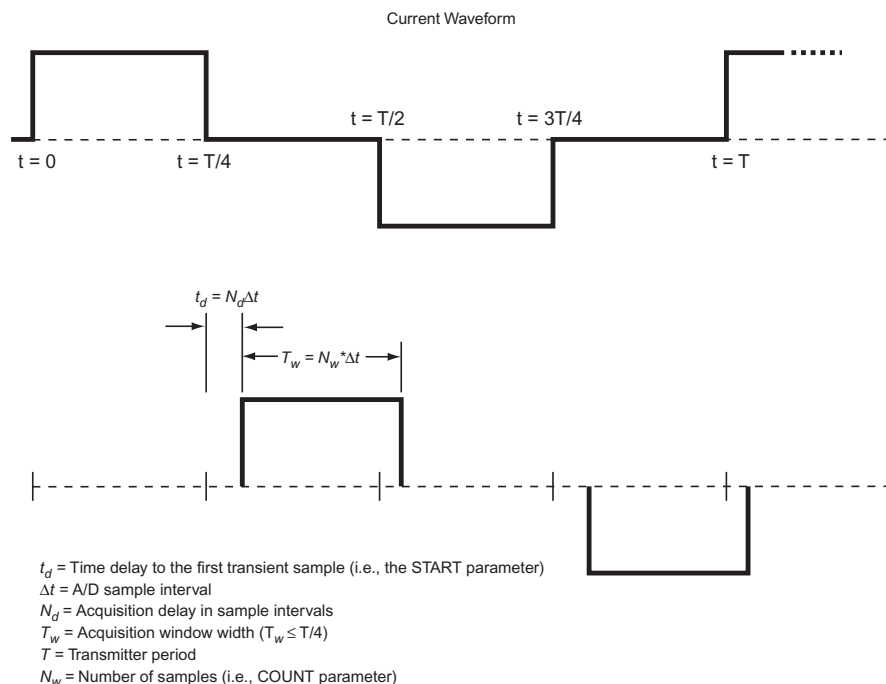
The sampled data falling within the gates as defined above and illustrated in the accompanying figure are rectified and stacked. These data are stored both in the data cache and as binary files on the hard disk. Only the first 31 data points are stored in the cache. They may be viewed and/or dumped from the DATA menu using procedures common to all the programs. The binary files are stored on the hard disk with the name **BLKnnnn.NTE**, where **nnnn** is an integer corresponding to the block number of the corresponding partially complete data set stored in the data cache.

The binary data may be downloaded using either the LAN connection or the serial port. The steps for downloading are listed below:

6. While the GDP-32^{II} power is off, connect it to either a LAN or to the serial port of another computer (a null modem must be used).
7. Turn on the GDP-32^{II} and run Windows.
8. If using the LAN, you may have to re-configure the network parameters in the GDP-32^{II} to be compatible with your network.
9. If using the serial port, HyperTerminal is the recommended program to use. You will have to ensure that the two serial ports are configured identically.
10. The data files are stored in **d:\data**.

Binary data files with the extension **.NTE** may be inspected by converting them to ASCII format. The utility program **iggascii.exe** converts a binary file to an ASCII text file of the same name with extension **PRN**.

The source code for this utility program is included so that users or customers have prototype C code for reading a binary file containing uniformly sampled transient data.



Explanation of the EQUAL INTERVAL mode data acquisition mode in the GDP-32^{II} TEM program