

6. RECEIVER SETUP

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6.1 CALIBRATION

Calibration routines are generic for all *Field Survey Programs*. Calibrations are initiated from each Survey Program's *Data Acquisition Screen*. Calibration data are stored in the survey program's calibration cache and automatically applied to all acquired survey data.

Calibrations are made for two reasons:

- To remove amplitude change and phase shift from the measured results due to anti-alias and powerline notch filters.
- To correct for gain differences between channels.

With frequency domain signals, amplitude and phase variations due to filters are removed by dividing field voltages by the normalized calibration magnitude then subtracting calibration phase from measured field phase. This is done on a frequency-by-frequency basis.

For time domain signals, only the amplitudes are corrected for filtering distortion.

In the field, calibration should be done at the operator's convenience; one calibration every few days is usually sufficient, with daily system checks over the frequency range of interest. An average calibration takes about 15 minutes.

When in doubt, recalibrate, except when having problems with the receiver. Recalibrating a malfunctioning analog card may tend to compensate for some problems and make it difficult to diagnose the problem in the field.

NOTE: A single calibration for each Field Survey Program (e.g. RPIP) is stored in memory at any one time. When performing a calibration, the calibration data is automatically stored in memory. This overwrites all previous calibration data for that Field Survey Program and any other Survey calibrations stored in the same calibration cache.

If the data are not to be corrected for calibration, the *Calibration Cache* must be initialized. For instructions on initializing see below.

SPECIAL INSTRUCTIONS FOR MT/AMT

Calibrations for the present version of the MT/AMT program require the following:

The hard disk must be turned off. This is done in the initial program screen for the MT/AMT program.

For a full frequency calibrate (low band to very high band) start the calibration at the 5th level of decimation in the low band (0.1875-4Hz).

These conditions must be set up before the calibration routine is entered.




INITIALIZING THE CALIBRATION CACHE

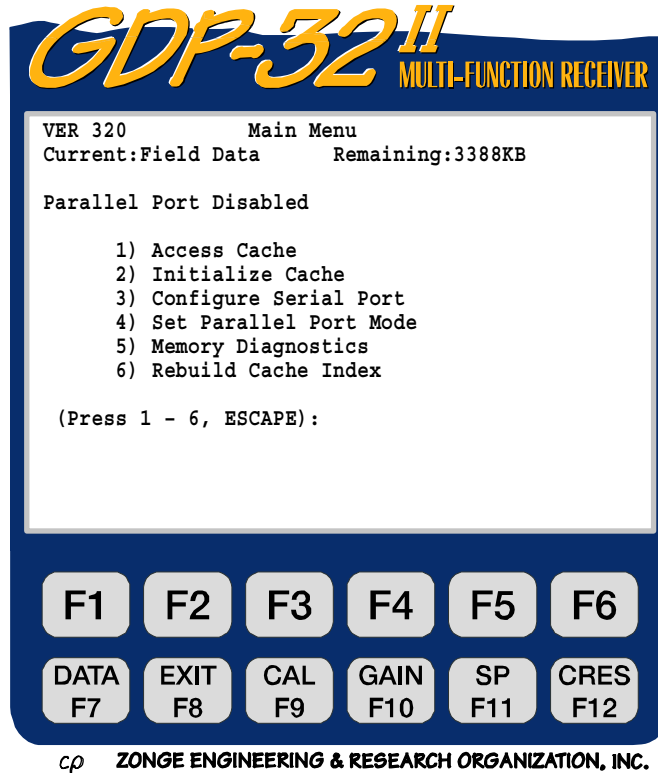
It is good field practice to initialize the Survey Program Calibration Cache before performing a calibration. This avoids confusion about the most recent calibration.

For example:

- Yesterday, a calibration was run from 0.125 to 8192 Hz.
- Today, a calibration was run from 1 to 8192 Hz.
- Today's calibration from 1 to 8192 Hz data is current (since the most previous calibration data will overwrite previous values at those frequencies); however, the old 0.125 to 0.5 Hz calibration data remains in the cache. This problem can be avoided by performing each calibration over the same frequency range.

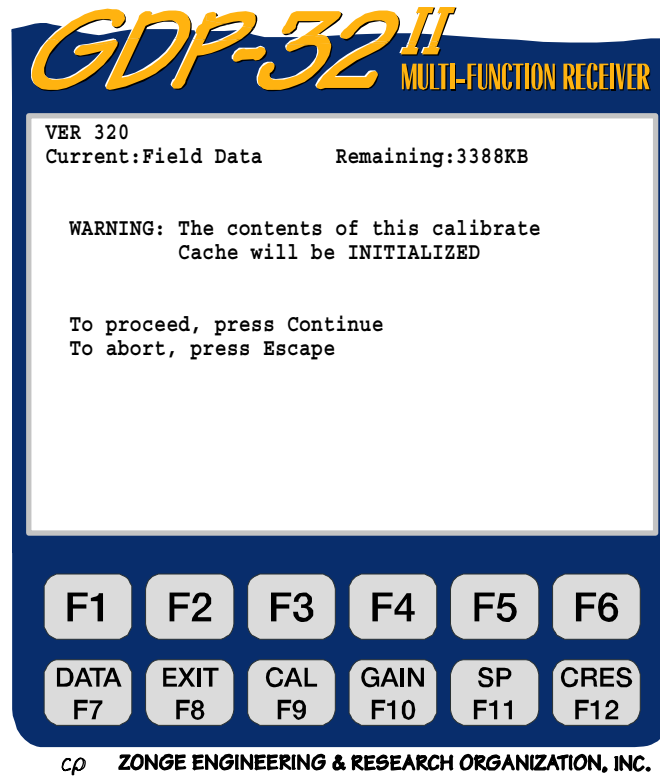
To initialize the Calibration Cache:

1. Press  to enter Data Mode.
2. Press  to bring up the Field Data Menu.
3. Press  a second time to bring up the Cache Utilities Menu.




4. Press , "Initialize Cache".

5. Select the survey program calibration cache to be initialized.
6. The following warning appears:



7. Press .


8. The survey program calibration cache is now empty. Press .

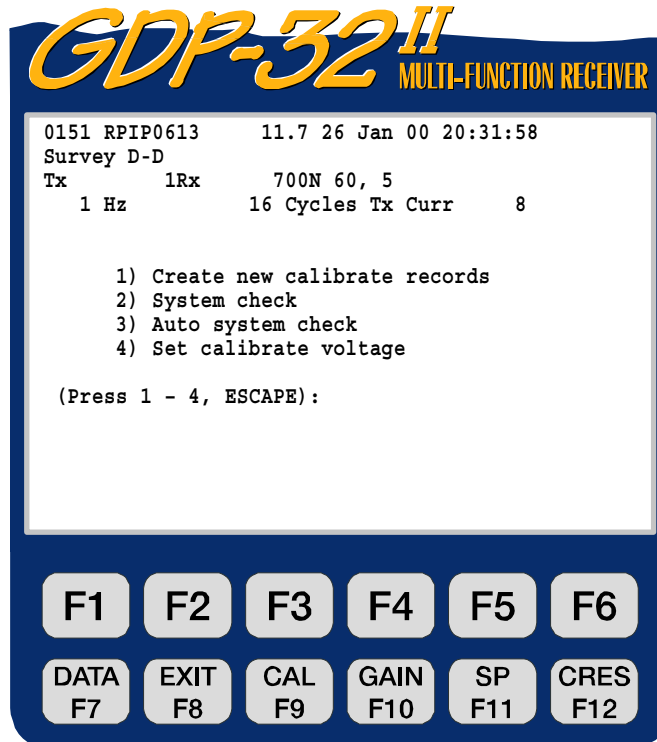
STARTING A CALIBRATION

NOTE: A summary of the Calibration procedure is located in the Section 4 - Quick Start.

From the Program Menu, select the Survey Program to calibrate. Proceed to the Data Acquisition Screen. Select the lowest frequency, cycles and the notch filter.

NOTE: The notch filter to be used for the survey must be selected before starting the calibration. Perform the calibration using that filter setting, and then acquire the field data with the same filter setting. If a different setting is required, either recalibrate at the new filter setting, or input new calibrations into the GDP-32^{II} using a calibration data set stored previously on a field computer.

Press  to enter Calibration mode. The following message appears:




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Only the first option performs an automatic calibration and loads the results into the **Calibration** and **Field Data** caches. The second and third options are system checks, useful for checking calibrations and general machine operation. Data from system checks are automatically stored in the **Field Data** cache.

AUTOMATIC CALIBRATION

Ensure that the starting frequency is set at the desired values for the calibration. The calibration can be started at any frequency. Zonge recommends beginning the calibration at the lowest survey frequency to be used. The purpose of the calibration is to remove the effects of filtering, stray capacitance and inductance in the system.




Press  to begin automatic calibration. Below the Data Acquisition Screen the following warning is displayed:

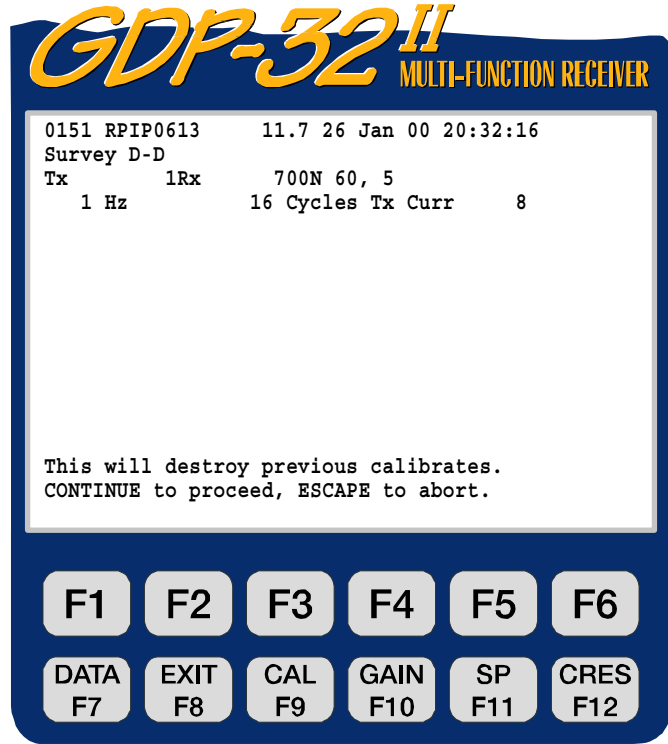
This warning underscores the fact that previous calibration data will be



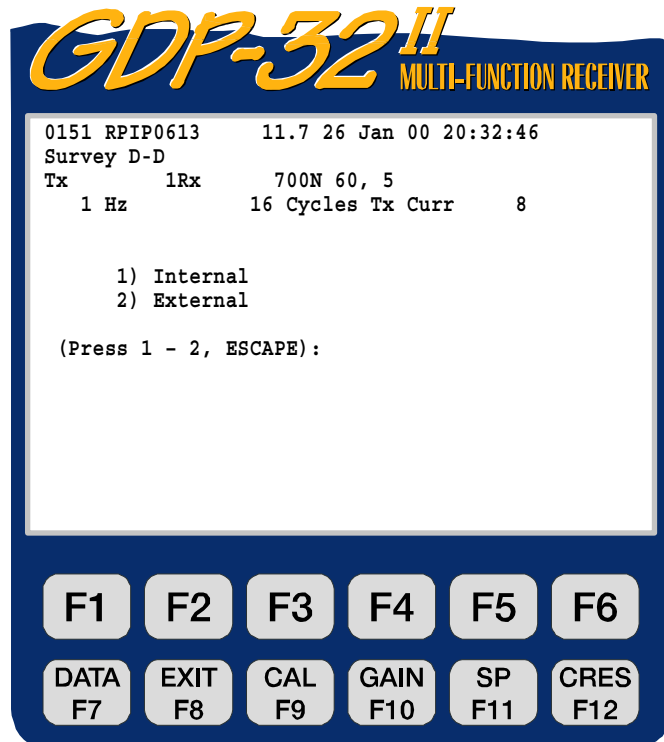
overwritten. Press  to return to the Data Acquisition Screen.



Press  to complete the calibration. The following message appears:



cp ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.



cp ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.

These options select how to route the calibration signal to the analog boards. The **INTERNAL** option routes the signal from the Calibration Board to the analog boards via internal wiring. The **EXTERNAL** option routes a calibration signal of known voltage amplitude to the output jacks of the Analog I/O Panel.

Jumper wires are required to patch the signal from these jacks to the signal input jacks located on the Analog I/O Panel, the Patch Panel, (See Figure 6.1) and any amplifiers or other external devices in the signal stream.

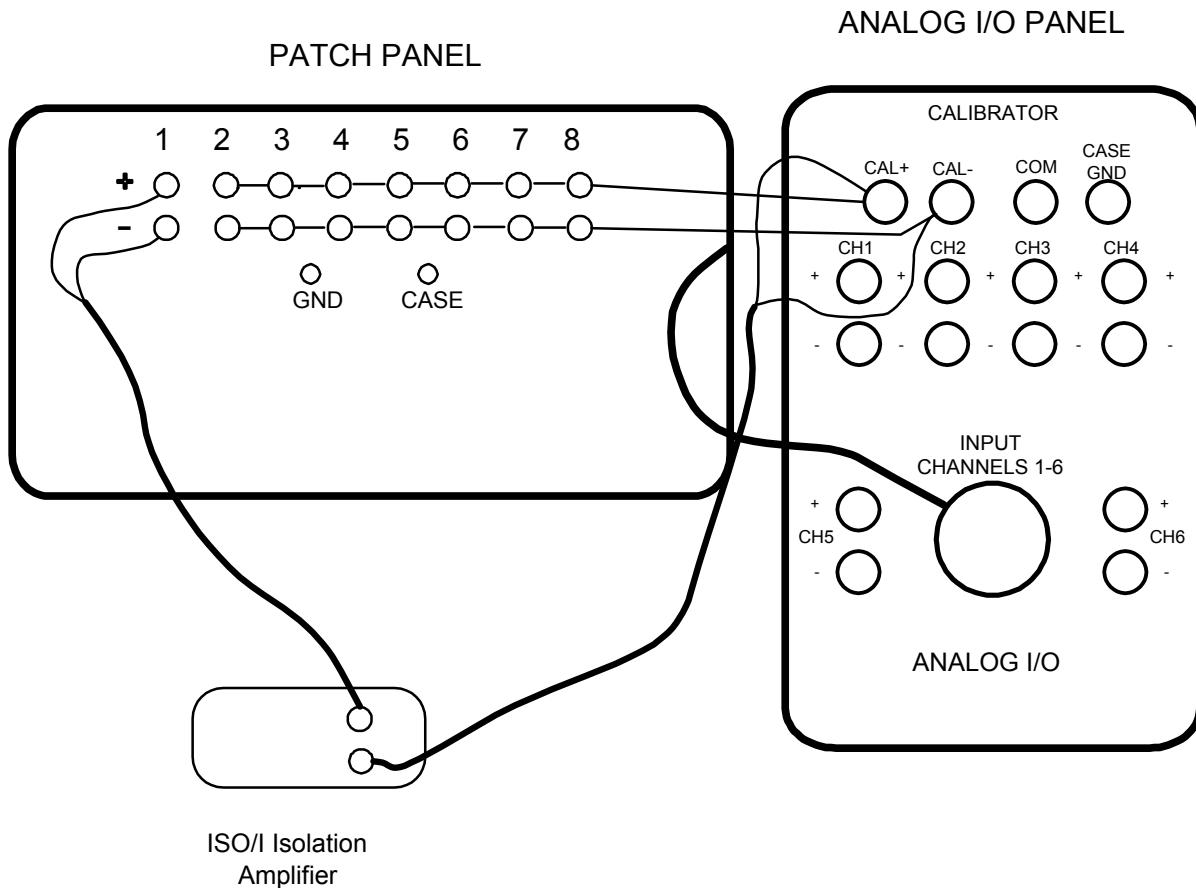


Figure 6.1 - Wiring for an external calibration – large case with Patch Panel using an isolation amplifier on the reference channel.

Use an internal calibration for standard operations. Use an external calibration if there are active auxiliary electronics such as preamplifiers or isolation amplifiers whose effects must be included in the calibration, or if the analog input section needs to be checked.

After selecting an internal or external signal source, the cursor goes to the end of the third line on the display, where the display reads:

ICal = 1v

This is the “calibration signal voltage” (i.e. the amplitude of the voltage signal that is supplied by the Calibration Board for calibration.) The default selection amplitude is 1 volt. Generally speaking, there will be no need to change it. The Instruction line displays:

**Change Calibration voltage or press
CONTINUE to proceed, ESCAPE to abort.**



exits the calibration mode and returns to the Data Acquisition Screen.



begins an automatic calibration. Press . The Instruction Line reads:

CONT when gains are set, ESCAPE to exit.

The program pauses here to permit the operator to manually set the gains, if desired. Press



to use the default gains, or change gains (see Section 6.5 below) and then press



The GDP-32^{II} begins the calibration at the starting frequency specified in the Data Acquisition Screen. The message:

Taking Data

is displayed at the bottom of the screen. When the first stack is complete, the message:

Processing

appears and the screen displays the un-normalized results. However, these results are quickly erased. Review the data in Data Mode after the calibration. The internal beeper sounds an alert at the completion of the calibration of the first frequency. The receiver then:

- Increments the frequency by a factor of two
- Increments the cycles by a factor of two
- Performs a calibration at the new frequency
- Displays the results

This process is repeated until the maximum frequency has been calibrated. The program then returns to the starting frequency and exits the automatic calibration mode.

Zonge recommends immediately performing a system check (see Section 6, page 10) at any frequency to spot-check the automatic calibration.




STOPPING A CALIBRATION WHILE IN PROGRESS

NOTE: To avoid confusion, Zonge strongly recommends that the entire calibration be performed in one continuous sequence, rather than in segments. If a problem arises that requires the calibration to be prematurely aborted, it is recommended that the entire sequence be repeated after resolving the issue.


At times it may be necessary to stop the calibration process (i.e. to change the number of cycles).

To stop the calibration process, press . The Instruction Line now displays:

Exit autocal mode? (1 - yes, 2 - no)

Press  to exit. Press  to change parameters. Upon pressing  the Instruction Line displays:

Press CONTINUE when values are correct

The cursor appears in the “cycles” field of the Data Acquisition Screen. After changing parameters, press  to resume the calibration.

To view calibrates, see section 7.3 for instructions about how to access board calibrate caches. Calibrations are written to the **Field Data** cache as well as the **Calibration** cache so that there is a permanent record of the calibration values. Access the Calibration cache of interest and you will notice that the date, time and condition of the power line notch filter at the time of the calibration are all recorded in the Calibration header.

SYSTEM CHECK


NOTE: A summary of the System Check procedure is located in the Quick Start Section.


Perform a system check to check the quality of a calibration. This process is similar to a system calibration except that the results are NOT stored in a **Calibration** buffer, only in the **Field Data** buffer. Calibration corrections are applied to the results, which are then displayed to the screen. Hence, the system check is a good way to look at the quality of a calibration. The ideal result in phase should be zero milliradians.

Following is a typical reason for using the system check utility:

Assume that three-frequency RPIP data are being acquired, and late in the day you discover that the phase data all decrease suspiciously at the high frequency. A bad calibration or a receiver problem is possible and can be quickly confirmed or rejected by doing a system check at the suspect frequencies. If the phase differences in the decalibrated system check display are zero or nearly zero, the present calibration is the same as the earlier one. So long as the calibration procedure is correct and the calibration agrees with earlier calibrations, the explanation for the problem must be found elsewhere (i.e. faulty analog card, field wire problem, etc.).


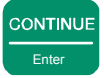
1. Set the frequency value to check (e.g. 0.125 Hz)

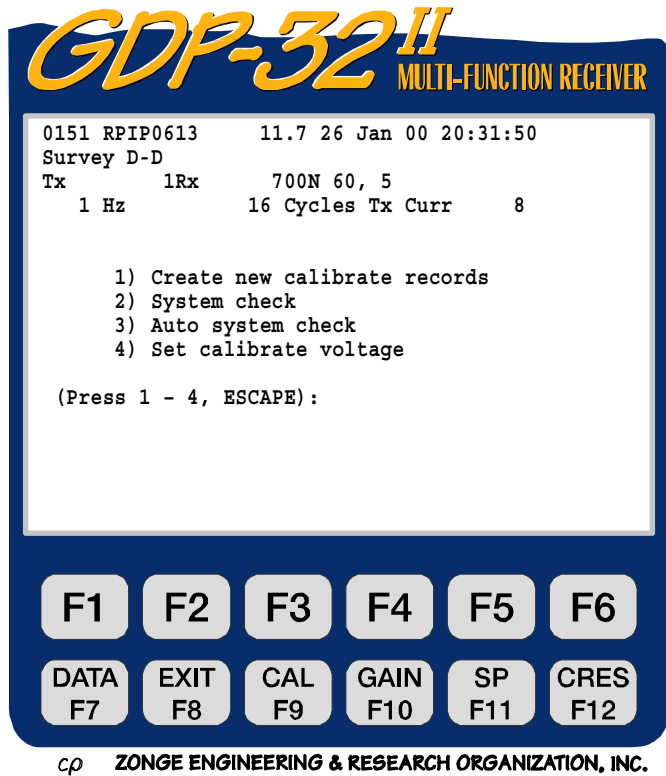
2. From a survey program’s Data Acquisition screen, press . Select the Calibrate or the System Check Mode.







3. To check the calibration for a single frequency, select , “System check” from the Calibration Screen. The system check is performed one frequency at a time. After each check, the operator has the option of continuing or exiting. Before continuing, the frequency must be incremented manually.

NOTE: When checking multiple frequencies select option

, “Auto System Check”.

4. Press  for “Internal” voltage source.
5. Press  to set the default calibration voltage (ISys=1v.)



6. Press  to begin data acquisition. If this is the first time data have been acquired at this frequency, the automatic gain adjust program takes over. Watch the screen to see how it adjusts the gains. The program goes directly from automatic gain setting to data acquisition.
7. The GDP-32^{II} receiver:
- Stacks and averages the calibration signal
 - Calculates a standard error of the mean (SEM) on the real- time parameter displayed
 - Calculates the resistivity and IP parameters, displays them, and asks if you want to save or discard your data.
8. Press  to store the data in the Field Data cache, or press  to discard the data.
9. Press  or  to stay in the System Check mode, or press  to exit.

QUALITIES OF A GOOD CALIBRATION

Since all data will be normalized by the system calibration, it is important to ensure that the calibration is reasonable immediately after it is acquired. (All calibrations are written to memory. If the operator does not verify the calibrations, a bad calibration can be replaced later during data processing; but it's always better to catch the problem in the field.)

Table 6.1 (below) lists values from a typical RPIP calibration. Remember calibrations incorporate the electronic characteristics of each individual receiver, so the numbers may vary depending upon the filters and other components in a particular receiver.

The magnitudes in the Calibration Cache will differ from the magnitudes shown on the display while the calibration is in progress. This is because the initial magnitudes are raw values, while the values stored in the caches have been normalized to the calibration voltage and have been corrected for any gain differences in the individual channels.

QUESTIONABLE CALIBRATIONS

If a calibration differs significantly from a known, correct value for a particular instrument, and that difference cannot be due to recent hardware modifications, there may be a system problem. Consult Section 15 - Maintenance for trouble-shooting. Otherwise, an error may have been made in the calibration set-up. Re-check the set-up procedure. Common errors include:

- Incorrect wiring to the input channels for an external calibration.
- Checking the calibrations using a notch filter setting different from the calibration setting.

If a bad calibration is discovered before any data is taken, simply re-run the calibration. This replaces the old values with the new ones. Either erase (initialize) the old calibration first or run the new calibration at the same frequencies. This avoids the problem of combining old calibration data with new.

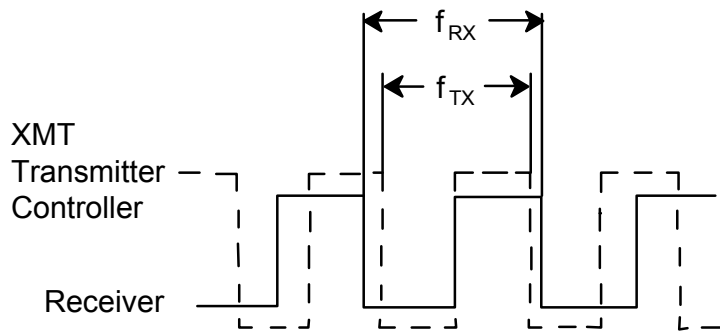
If an invalid calibration is discovered after taking data, the data can be saved.

1. Dump the bad calibration file into a file on a personal computer (See Section 7.6).
2. Recalibrate the receiver, and dump this file to the personal computer (See Sections 6.1, 7.6).
3. Process the data through the Zonge SHRED program, and provide both the good and bad calibration files. SHRED will remove the bad calibration and renormalize the data with the good calibration.

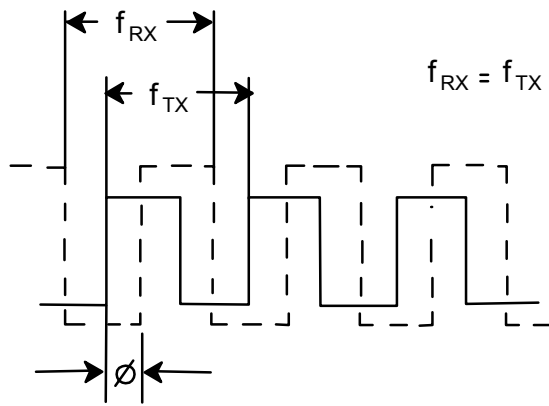
Table 6.1 - Examples of Good RPIP Calibration Values

Note: Values vary from board to board, depending upon components and filters. Magnitudes are normalized to the magnitude at the lowest calibration frequency; phases are in milliradians.

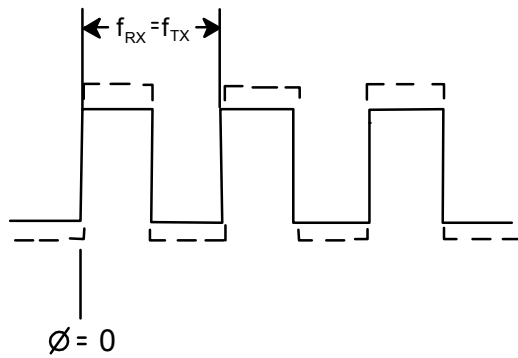
Frequency (Hz)	NOTCH FILTER SELECTION							
	None		60/180 Hz		50/150 Hz		50/60 Hz	
	Mag	Phase	Mag	Phase	Mag	Phase	Mag	Phase
8192	.14	1370	.14	1347	.14	1347	.14	1322
4096	.40	2792	.40	2789	.40	2787	.40	2783
2048	.59	-2597	.59	-2581	.60	-2585	.60	-2570
1024	.60	-2469	.59	-2426	.60	-2434	.60	-2392
512	.82	-1557	.81	-1460	.82	-1479	.82	-1381
256	.83	-1536	.78	-1229	.81	-1327	.78	-1019
128	.86	-1389	.81	-1551	.72	-1862	.68	-2024
64	.86	-1384	.46	-508	.79	-1114	.45	-239
32	.97	-697	.95	-878	.94	-954	.93	-1136
16	1.00	-349	.99	-423	.99	-451	.99	-515
8	1.00	-174	1.00	-210	1.00	-218	1.00	-254
4	1.00	-174	1.00	-192	1.00	-196	1.00	-213
2	1.00	-181	1.00	-190	1.00	-192	1.00	-201
1	1.00	-181	1.00	-184	1.00	-186	1.00	-190
.5	1.00	-90	1.00	-92	1.00	-93	1.00	-95
.25	1.00	-90	1.00	-91	1.00	-92	1.00	-93
.125	1.00	-90	1.00	-91	1.00	-92	1.00	-92



a) Initial State:
signal frequency from
receiver and controller
crystals are different



b) After Trimming Oscillator:
signal frequencies are
now the same but are
out of Phase by ϕ



c) After Pressing RESET
on XMT:
receiver and controller divider
chains are now at same
frequency and in phase
synchronization

Figure 6.2 - Pictorial description of the Frequency Adjustment and Synchronizing operations.

6.2 SYNCHRONIZING TIMING CIRCUITS

FREQUENCY ADJUST AND SYNCHRONIZING OPERATIONS

The timing circuits of the XMT-32 and the GDP-32^{II} are comprised of an ultra-stabilized 4.980736 MHz oscillator and a digital counter chain providing a binary sequence of frequency divisions. Frequencies on the XMT-32 Transmitter Controller are selectable from a push-button panel switch. Frequencies on the GDP are selectable from a menu screen under the control of the on-board computer.

To ensure that the timing edge of the transmitter controller (i.e. the transmitter output) and the receiver waveforms coincide exactly throughout the day, two adjustments must be made:

- First, the two 4.980736 MHz crystals must be adjusted to EXACTLY the same frequency to prevent the phase drift.
- Second, the counter chains in the XMT-32 and GDP-32^{II} must be reset so that the switching edges of both occur simultaneously (i.e. the waveforms are synchronized.)

The GDP uses the counter waveform to determine the polarity of the transmitted waveform and the on/off cycle in the case of time domain. Both of these adjustments require that the synchronization cable be connected between the XMT-32 and GDP-32^{II}.

The synchronization cable connects the GDP-32^{II}'s 4.980736 MHz oscillator output to the XMT-32 phase detector. The detector displays the frequency difference between the two oscillators on the XMT-32 phase meter. Each complete swing of the meter represents one cycle of 4.980736 MHz or 0.2 microseconds (μ sec) of time shift.

The following table shows the phase shift in milliradians (mr) per meter swing that occur at various frequencies, where:

$$\text{Period} = 1/\text{Frequency}$$

$$\text{Period/mr} = \text{Period}/(6.283*1000)$$

<u>Freq</u>	<u>Period</u>	<u>Period/mr</u>	<u>mr/swing</u>
8192 Hz	122.0 μ sec	0.019 μ sec/mr	10.5mr/swing
512	1953.0	0.31	0.62
64	15.6msec	2.5	0.08
8	125.0	19.9	0.01
1	1.0sec	159.0	0.00125
0.125	8.0	1.3 msec/mr	0.00016

The above list shows the importance of accurate frequency adjustments for the acquisition of accurate high frequency phase measurements. The frequency match is obtained by performing a **Frequency Adjustment** as outlined in the section below. Typically, the frequency should be adjusted so that meter drift is less than one division over a 30 second interval. Drift rates of this magnitude yield phase drifts of less than one hundredth of the above values.

The synchronization cable also connects and enables the counter chain reset circuitry in both the GDP-32^{II} and XMT-32.

Refer to Figure 6.3 and 6.4a,b for a pictorial description of the frequency adjust and synchronization operations.

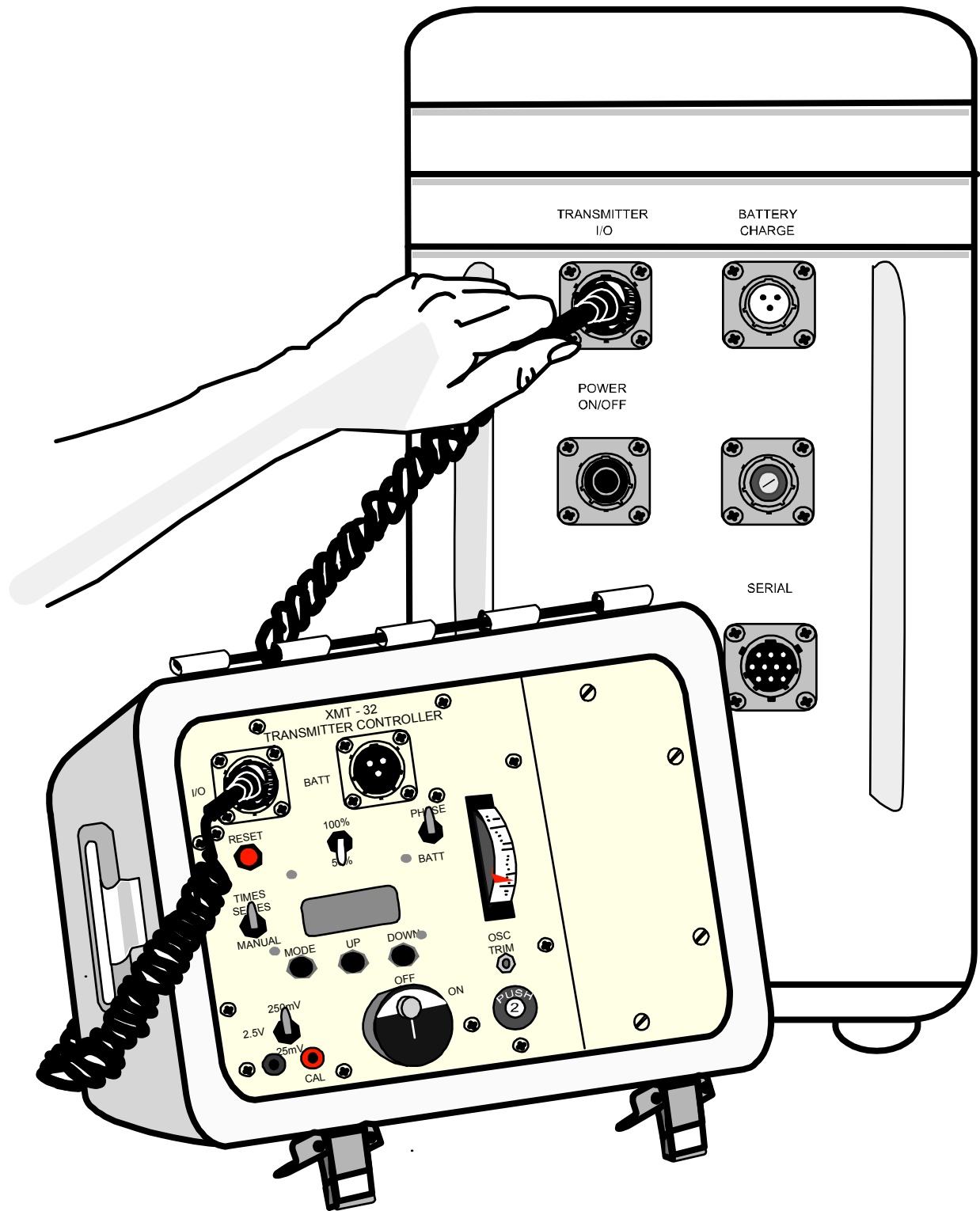


Figure 6.3 – Connecting the GDP-32^{II} Receiver and XMT-32 Transmitter Controller for synchronization.

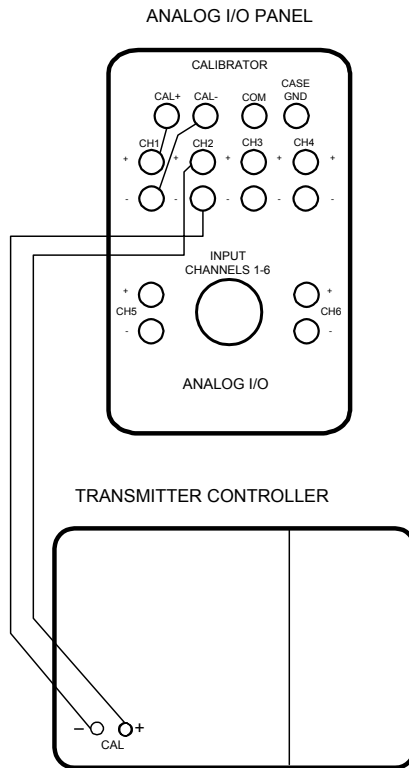


Figure 6.4(a) - Wiring for verifying synchronization to a small case GDP-32^{II}.

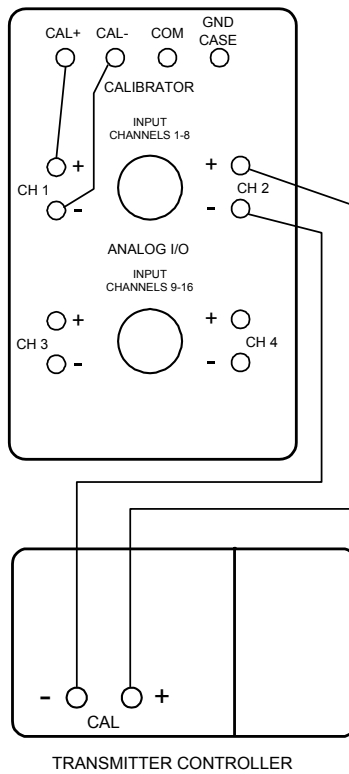


Figure 6.4(b) - Wiring for verifying synchronization to a large case GDP-32^{II}.

SYNCHRONIZING THE TRANSMITTER AND RECEIVER

The GDP-32^{II} receiver and XMT-32 Transmitter Controller have identical crystal oscillators and circuitry for dividing the crystal frequency into a set of precise, selectable, operational frequencies. For synchronous operation, the two oscillators must be equal in frequency to provide an absolute phase reference.

NOTE: For surveys such as complex resistivity (CR), roll-along IP, and NanoTEM where the receiver is linked to the transmitter directly, synchronization is not required. The receiver clock controls both the transmitter and the receiver.

At least one hour prior to adjusting the frequency:

1. Press the Power On/Off Button on left side panel of the GDP-32^{II} to apply power to the crystal oscillator. Make sure that the red LED marked CRYSTAL ON is illuminated.
2. Turn the XMT-32 Power Switch to ON.

NOTE: During continuous field operations, power to either the GDP-32^{II} or the XMT-32 crystals should rarely be turned off. Crystals can remain on during charging. This practice eliminates the wait for the crystal ovens to warm.

NOTE: Before using the "Synchronize to XMT" routine or the manual synchronization routine, make sure you have a good calibration for the RPIP exists (FDCALS in the CALIBRATION cache) as that program is used in the synchronization routine.

After the crystal ovens have heated for at least 60 minutes:

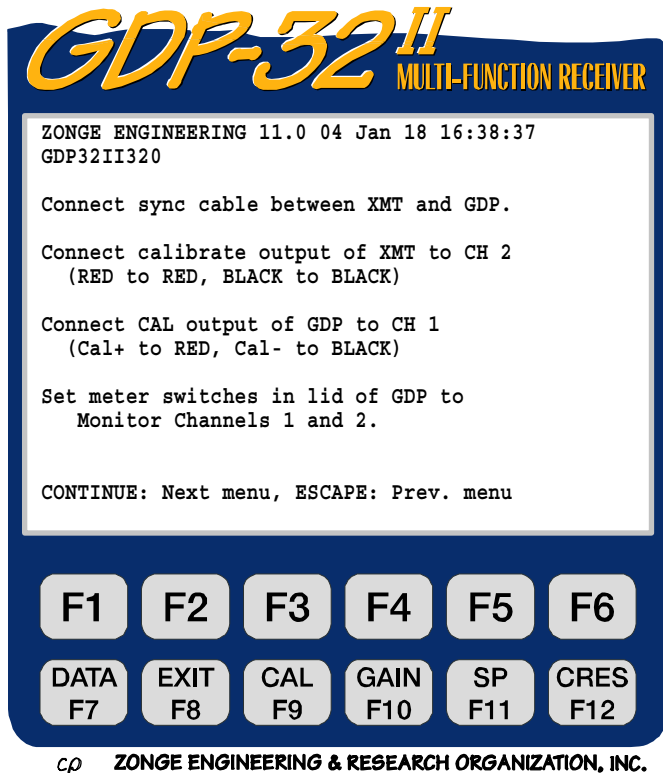
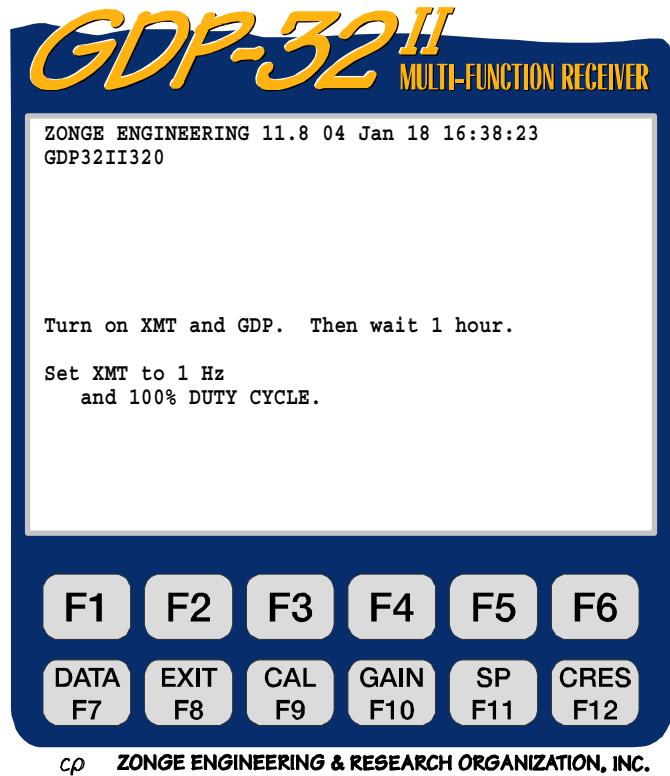
1. Disconnect the Battery Charger.
2. Connect the synchronization cable between the I/O port on the XMT-32 Transmitter Controller and the TRANSMITTER I/O port on the Control I/O panel of the GDP-32^{II} receiver (Figure 6.3.)
3. Switch the PHASE/BATT switch to the BATT position to check the transmitter controller battery voltage. The voltage should read at least 12.5 volts. If lower, there is either a poorly charged battery or a problem with the power system (see Section 15 - Maintenance.)
4. Switch the PHASE/BATT switch to the PHASE position. Observe the needle on the PHASE/BATT analog meter. Any needle movement indicates that some frequency difference exists between the GDP-32^{II} and the XMT-32 oscillators.

The faster the needle is swinging, the greater the frequency difference. If there is absolutely no swinging over a period of a minute, the oscillators are either adjusted to the exact same frequency (skip to step 10), or the oscillators are very different in frequency and the resultant beat frequency is beyond the response of the meter (see Section 6 to manually trim the XMT-32).

Frequency adjustment and synchronization are accomplished with the GDP-32^{II} by executing the "Synchronize to XMT" function (Utilities Menu - Option 4.)

5. Follow the directions given on the screen:

6. Press .



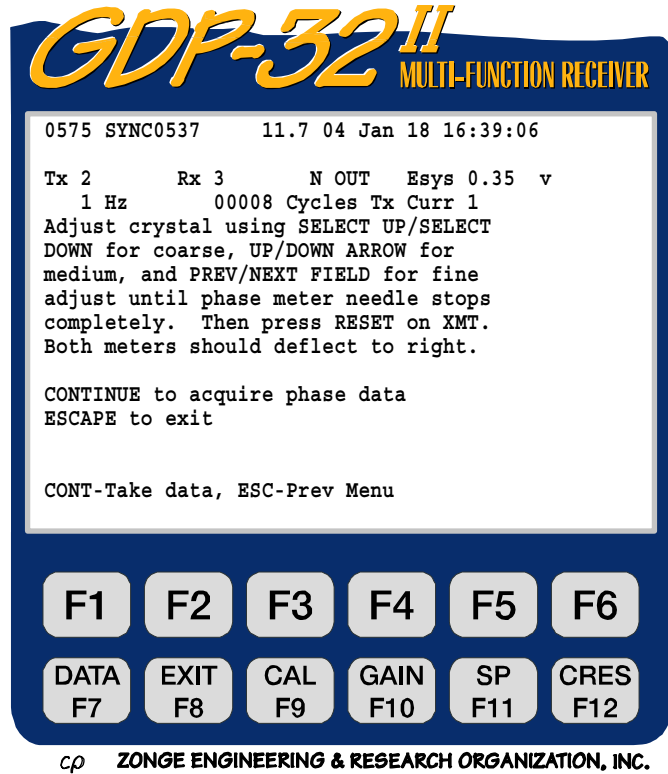
7. Continue to follow screen instructions for external connections: (see Figure 6.4)

8. Press  when the connections have been completed.

- To electronically adjust the crystal frequency of the GDP-32^{II} to match that of the XMT-32 use the cursor control keys and follow the instructions on the display:

While adjusting the frequency of either instrument, the XMT-32 phase meter needle should come to rest near the center of the meter, where it is most sensitive to movement. Use the cursor control keys to adjust the frequency up or down slightly until the needle roughly stabilizes near the center of the scale.

- Press **RESET** on the XMT-32 to synchronize the counter chains of the two instruments. RESET places the counters in both instruments in the reset mode with the needles on the analog meters steady and deflected towards the right. When RESET is released, both counters simultaneously start to count, thereby providing synchronized frequency waveforms that can be selected from the GDP-32^{II} and XMT-32.



- Press **CONTINUE**. The GDP-32^{II} automatically measures the phase difference between the external calibration signal generated by the GDP-32^{II} and the corresponding signal generated by the XMT-32. If the two instruments have been properly synchronized, the measured phase difference is close to 0.0 mr.
- Repeat step 11 several times to check the synchronization. The measured phase difference should remain close to 0.0 mr.
- Ensure that synchronization can be maintained without the synchronization cable. First, disconnect the cable from the XMT-32, then from the GDP-32^{II}, then repeating the phase measurement.





MANUALLY TRIM THE XMT

In extreme cases, the frequency difference between the two oscillators is too large to adjust out electronically. In this case, manually trim the oscillator on the XMT-32 using a plastic trimming tool or a small, insulated, flat-bladed screwdriver.

NOTE: The GDP-32^{II} crystal adjustment potentiometer is not externally accessible. It is unlikely that a customer would need to trim both oscillators.

There are approximately 70 coarse divisions for crystal adjustment of the GDP-32^{II}. Before adjusting the trim pot in the XMT-32, set the coarse adjustment on the GDP-32^{II} to mid-range using the following procedure:

Set the Crystal adjustment on the GDP-32^{II} to Mid-Range:

1. Hold down one of the coarse adjustment keys ( or ) until a rapid beep is heard.
2. Press the opposite button ( or ) 35 times (35 beeps) to set the coarse adjustment to mid-range.

Manually trim the oscillator in the XMT-32:

1. Locate the OSC TRIM potentiometer adjustment screw on the panel of the XMT-32 (Figure 6.3.)
2. Make sure the meter function switch is in the PHASE position.
3. Using a plastic adjustment tool, turn the trim pot screw slowly in one direction and observe the response on the XMT-32 meter.
4. If the needle motion slows down, the screw is being turned in the correct direction. If it speeds up, turn it the other direction. Keep turning the screw until the needle movement comes to a stop near the center of the meter.
5. Use the cursor control keys to adjust the frequency up or down slightly until the needle roughly stabilizes near the center of the scale.
6. Using the fine adjustments on the GDP-32^{II}, trim the frequency until the meter movement halts. The oscillator is properly adjusted if the needle drifts less than the distance between two meter marks over a 30 second interval.
7. If the PHASE needle does not stop after setting the crystal adjustment on the GDP-32^{II} to mid-range and manually trimming the XMT-32 oscillator, it is necessary to adjust the crystals in either the GDP-32^{II} or XMT-32. Consult Zonge Engineering before attempting this procedure.





LOSING SYNCHRONIZATION

Synchronization can be **LOST** in the following circumstances:

- Turning off power
- Losing battery power to either the transmitter controller or the receiver
- Re-adjusting the OSC TRIM pot on the transmitter controller
- Malfunction of the timing chain, crystal heater, crystal, timing boards, etc.
- The GDP-32^{II} or XMT-32 receives a sharp jolt

Synchronization is **NOT LOST** under the following circumstances:

- Turning off the receiver using Utilities Menu Option 6 – Turn Off Power.

- Re-booting the machine with  or   .
- Changing frequencies
- Changing from time domain to frequency domain or vice versa.

If synchronization is lost, connect the transmitter controller and the receiver using the synchronization cable and re-synchronize. In certain cases, such as in scalar CSAMT, re-synchronization is not necessary if only the phase DIFFERENCE between the electric and magnetic field components is of interest (the ABSOLUTE phase values require synchronized crystals). Usually, loss of synchronization must be corrected immediately.

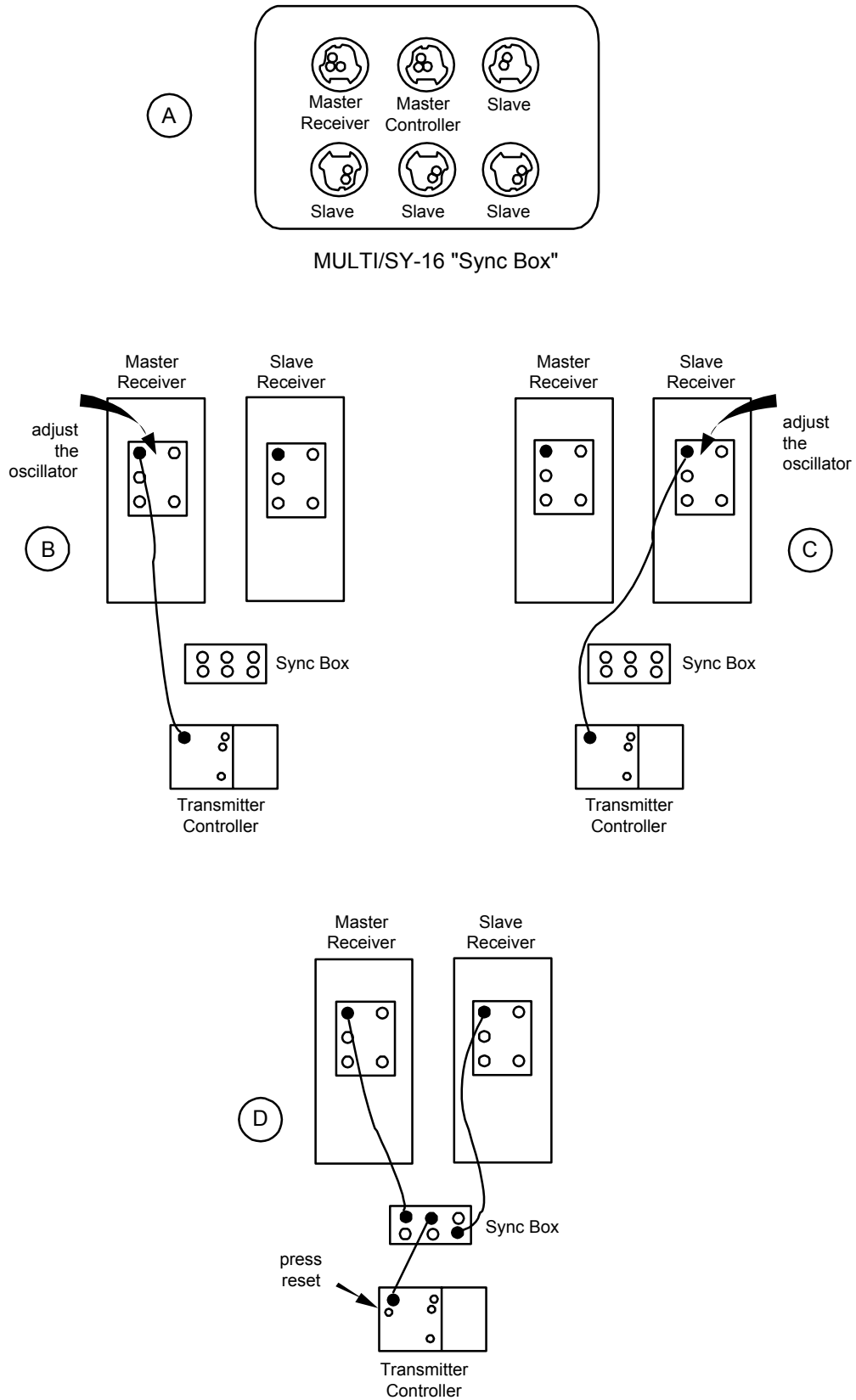


Figure 6.5 - Synchronizing a system of multiple receivers with the older MULTI/SY-16 Synchronization Box.

SYNCHRONIZING MULTIPLE RECEIVERS WITH THE MULTI/SY-16 SYNC. BOX:

Up to five GDP receivers can be synchronized to one XMT by using the MULTI/SY-16 Sync Box. Additional Sync Boxes can be linked for synchronizing an unlimited number of GDP receivers. Two or more receivers can be synchronized to one XMT-32 using the following procedure:

1. Obtain a MULTI/SY-16 Sync Box (Figure 6.5(a)) and extra synchronization cables (one per receiver) from Zonge Engineering. Designate one receiver as master and the rest as slave receivers.
2. Connect a synchronization cable between the Transmitter I/O port of the master GDP receiver and the transmitter controller's I/O port, as shown in Figure 6.5(b).
3. Adjust the oscillator frequency using the "Synchronizing the Transmitter and Receiver" routine (on page 17) on the master receiver, but do not push **RESET** on the transmitter controller.
4. Remove the synchronization cable from the master receiver and attach to the slave receiver.
5. Adjust the oscillator on the slave receiver, but do not push **RESET**. Continue this process until all receivers are adjusted to the same frequency as the XMT-32.
6. Make attachments as shown in Figure 6.5(d), being careful to connect the receivers and transmitter controller to the proper ports on the Sync Box.
7. Press **RESET**. If the receivers and transmitter controller are connected correctly, the needles on the receivers' meters deflect to the right while the **RESET** button is depressed. The meters will begin to move in synchronization when the **RESET** button is released.
8. Disconnect the synchronization cables. Remove the cable from the XMT-32 first, then from the GDP.
9. Verify the synchronization operation by measuring the phase difference between the external calibration signal on a particular receiver and the corresponding signal generated by the XMT-32. (See on page 17 - Synchronizing the Transmitter and Receiver.)

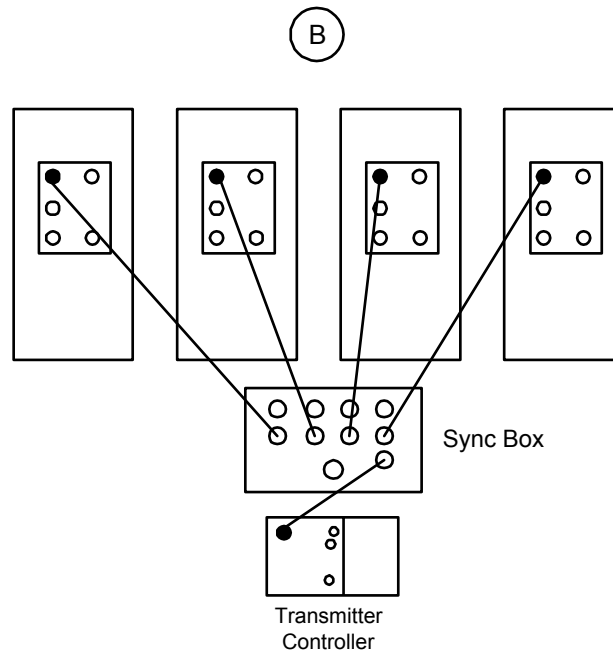
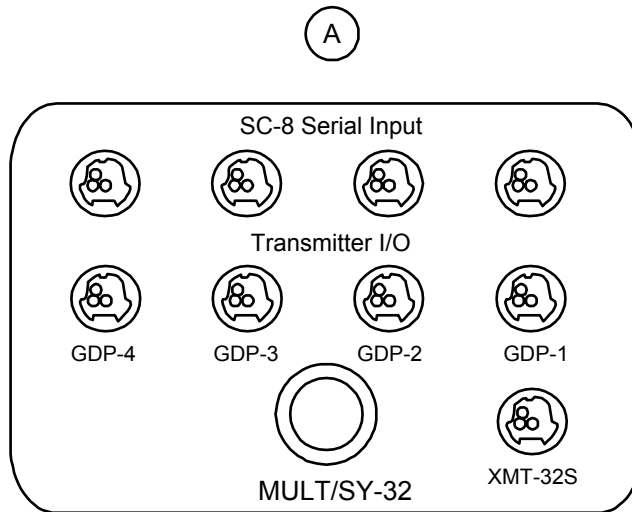


Figure 6.6 (a) - MULT/SY-32 Synchronization Box

Figure 6.6 (b) - Synchronizing a system of multiple receivers

SYNCHRONIZING MULTIPLE RECEIVERS WITH THE MULT/SY-32 SYNC. BOX:

Up to four GDP-32^{II} receivers can be synchronized to a single XMT-32 with the MULT/SY-32 Sync Box using the following procedure:

1. Connect all GDP-32^{II}s to be synchronized to the Transmitter I/O port on the MULT/SY-32 Sync Box (Figure 6.6(a)), using synchronization cables as shown in Figure 6.6(b).
2. Connect the XMT-32 to the XMT-32/S port on the MULT/SY-32 Sync Box using a synchronization cable.
3. Connect the XMT Cal Output to all GDP-32^{II}s:
Red XMT-32 cal output to Red Ch 2 on GDP-32^{II}
Black XMT-32 cal output to Black Ch 2 on GDP-32^{II}
(Connect all GDP-32^{II}s in tandem to XMT-32.)
4. Using the selector switch on the MULT/SY-32 Sync Box, adjust the oscillator on each GDP-32^{II} until the needle on the XMT-32 comes to rest.
CAUTION: DO NOT PRESS RESET ON THE XMT-32 UNTIL ALL GDP-32^{II}S ARE ADJUSTED!
5. After adjusting all receivers, press **RESET**. If the receivers and transmitter controller are connected correctly, the needles on the receivers' analog meters deflect to the right while the **RESET** button is depressed. The needles will begin to move in synchronization when the **RESET** button is released.
6. Disconnect the synchronization cables. Remove the cable from the XMT-32, then from the GDP-32^{II}s.
7. Verify the synchronization operation by measuring the phase difference between the external calibration signal on a particular receiver and the corresponding signal generated by the XMT-32. (See Synchronizing the Transmitter and Receiver)

SYNCHRONIZING AN ADDITIONAL XMT-32 (MULTI/SY-16)

An additional XMT-32 can be synchronized along with the rest of the equipment by using the following procedure:

1. Adjust each receiver individually, using the master transmitter controller as shown in Figure 6.5 (b) and (c).
2. Connect a cable between the master receiver's Transmitter I/O port and the slave transmitter controller's I/O port.
3. Adjust the slave controller using the OSC TRIM pot on the controller. DO NOT adjust the receiver again, since it has already been trimmed to the master controller.
4. Connect an additional cable between the slave controller's I/O port and any slave port on the Sync Box as shown in Figure 6.5(d).
5. Press **RESET** on the slave controller and keep it depressed while **RESET** is pressed and released on the master transmitter controller. (**RESET** on the slave controller may be released any time after releasing **RESET** on the master controller.)

Check the synchronization

To check the synchronization of the two transmitter controllers and one GDP-32^{II} receiver:

1. Enable three channels on the GDP-32^{II}.
2. Connect the cal output on one transmitter controller to channel 2 on the receiver.
3. Connect the cal output on the other transmitter controller to channel 3 on the receiver (red to red, black to black).
4. Connect channel 1 on the receiver to the cal output on the receiver, as shown in Figure 6.4.

NOTE: The timing systems of the GDP-16/XMT-16 and the GDP-32^{II}/XMT-32 are identical. Field operations may be conducted using receivers and/or transmitter controllers from the different families provided they are equipped with matching crystals.

GDP-16's were originally manufactured with either a 5.0 MHz or a 4.980736 MHz crystal. Before mixing components from the two families, it is important to ascertain their crystal frequencies.

6.3 MEASURING CONTACT RESISTANCE

After completing the system calibration, set up the electrode array and connect the field wires to the receiver analog input jacks (Refer to the different survey program sections for instructions on connecting wires to the receiver.)

Zonge Engineering recommends measuring the contact resistance between the potential electrodes (pots) and the ground before acquiring data. A contact resistance measurement provides information on the status of the pots. For example, an “open” contact resistance measurement on a pot may indicate that the pot has not been connected, is drying out, or has been dislodged from the ground.

NOTE: Remember to measure the contact resistance at each new receiver array location.

Make electrode resistance measurements from the Data Acquisition Screen of the appropriate survey program.

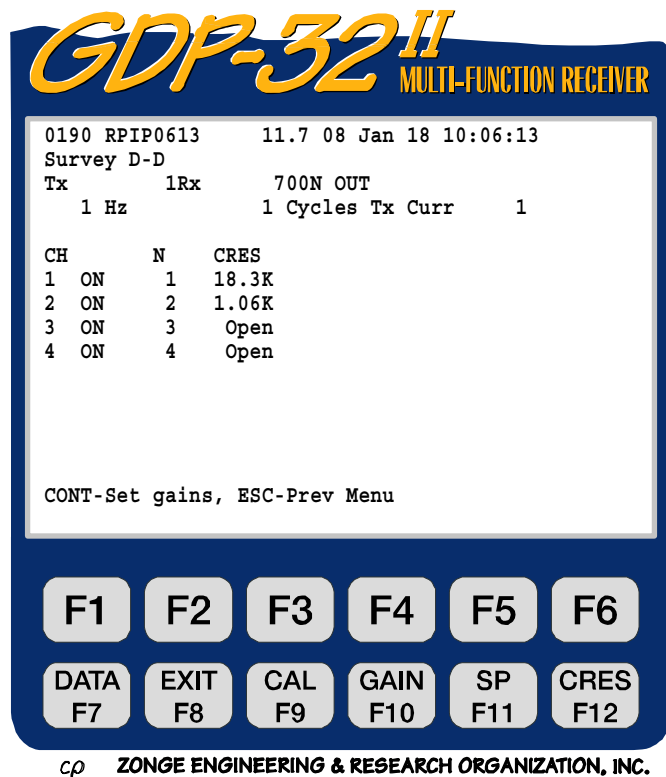
CRES
F12

1. With the transmitter off and all field wires attached to the receiver, press

NOTE: For methods using low signal levels such as CSAMT, it is often unnecessary to turn the transmitter off before to making contact resistance measurements.

2. The receiver sets all gains to unity and offsets any SP potential. It then calculates the sum of the contact resistance for both pots of each dipole. Each channel takes about two seconds. The sound of relays clicking can be heard for each active Analog Board. The contact resistance for each channel is then displayed on the screen, as shown in the screen below.

In the following screen all channels except channels 1 and 2 show reasonable contact resistances (i.e. in the 1 k Ω to 10 k Ω range.) These values are the total dipole resistance. Channels 4 and 5 show “Open”, which indicates open circuits (the pot common to dipoles 4 and 5 is not placed properly, broken wire, faulty connection, etc.), or the contact resistance is in excess of 100 k Ω . If the channel is turned off or is disconnected, no value is displayed.



A “good” resistance is under 2 k Ω . In some areas, however, resistances higher than 25 k Ω are common. Over the Canadian Shield and in the high deserts of South America, contact resistances can be 500 k Ω or higher. If high contact resistances are measured, check to make sure that the pots are properly planted and are filled with saturated electrode solution (e.g., CuSO₄.) In dry ground, it may be necessary to use two pots hooked in parallel to lower the resistance. Zonge also manufactures potential electrode amplifiers (APOT) for use where the contact resistance cannot be reduced sufficiently by passive means.

The status of CSAMT antennas and other types of active sensors can be monitored with the CRES option. For the ANT/1, ANT/2 and TEM/3 antennas, the ON resistance varies from 0 to 200 Ω , and the OFF resistance is usually in excess of 2,000 Ω . Abnormally high CRES values for battery-powered devices (antennas, APOTs, etc.) may indicate a dead battery or mechanical problem.

6.4 SETTING THE POWERLINE NOTCH FILTER

There are several ways to determine if a powerline notch filter is necessary. One of the best ways is to observe the cyclic noise on an oscilloscope and compare its amplitude to the signal amplitude. Engage the filter if the powerline noise amplitude is noticeable. Refer to Section 5, page 14 for a description of available powerline notch filters.

When an oscilloscope is not available, a technique used to estimate powerline noise is as follows:

1. Turn off the transmitter.
2. On the GDP-32^{II}, enter the RPIP survey program and, in the Data Acquisition Screen, select a high frequency (e.g. 512 Hz).
3. Set the Notch Filter OUT.
4. In normal data gathering mode, (i.e. with all dipoles connected) set the gains with the auto-gain option, and note the G1 and G2 values (gain stages 1 and 2). This estimates the ambient background noise **with powerline noise**.
5. Select a Notch Filter and reset all gains with the auto-gain option, and note the new G1 and G2 values. This estimates the ambient background noise **without powerline noise**.
6. If a significant difference in the G1 and G2 values is noted (i.e., a factor of 2 or more), turn on the appropriate notch filters.

NOTE: Although a powerline notch filter may be required for only part of a survey, it is best to complete the entire survey with the same notch filter configuration.

NOTE: If a survey is to be run with the powerline notch filters IN, the system MUST be calibrated with the same powerline notch filters IN (see Section 6.1).

6.5 GAINS

HOW GAINS ARE DEFINED

There are two ways of expressing gains in the GDP-32^{II}: as a multiplier, and as a binary gain number. Gains are expressed by the relation $G = 2^g$ (where “G” is actual multiplicative gain, and “g” is the binary gain number.) For example, if the multiplicative gain “G” is 64, then the binary gain “g” is 6, since $64=2^6$.

The receiver design employs three gain stages, G0, G1 and G2. An input attenuator is also used. Thus, the Gains for each stage are:

$$G0 = 2^{g0}$$

$$G1 = 2^{g1}$$

$$G2 = 2^{g2}$$

$$A = 2^a$$

where gains can be:

$$G0 = \{1, 4, 16\}$$

$$g0 = \{0, 2, 4\}$$

$$G1, G2 = \{1, 2, 4, 8, 16, 32, 64\}$$

$$g1, g2 = \{0, 1, 2, 3, 4, 5, 6\}$$

and the attenuator can be:

$$A = \{1 \text{ (“OUT”) } 0.125 \text{ (“IN”)}\}$$

$$a = \{0 \text{ (“OUT”) } -3 \text{ (“IN”)}\}$$

The total receiver gain is $G = G0 \times G1 \times G2 \times A$ (or $=g0+g1+g2+a$.) Hence the gain can vary from $G=0.125$ ($g=-3$) to $G=16,384$ ($g=16$.) The “Bits of Resolution” section (Section 6.6) discusses the various definitions of “gain”.

GAIN-SETTING STRATEGY

Whether done automatically or manually, setting gains should follow a standard approach.

1. The GDP-32^{II} senses the total signal level and automatically sets the Attenuator IN or OUT. If the voltage exceeds ± 3.5 V at unity gain, the Attenuator will be automatically set to “IN”.
2. Any self potential (SP) present in the signal is offset.
3. The receiver bypasses the anti-alias filter and adjusts the first gain stage (G1). *[Note: In the manual mode, bypassing the antialias filter is not possible.]* Since the G1 Gain stage comes before the anti-aliasing filter, this process prevents front-end saturation.

G1 increases as required to adjust the signal amplitude to ± 1.0 V or less for NOISY Gain mode, or ± 2.25 V or less for STANDARD gain mode. NOISY Gain mode provides sufficient headroom so that noise spikes and SP drift should not saturate the system. G1 can be increased to a maximum of 64. (G0 can be set to 1, 4 or 16)

4. The receiver engages the anti-aliasing filter and adjusts Gain stage G2 until the input to the A/D is equal to or less than the maximum voltage permitted for the gain mode selected.

NOTE: Regardless of the frequency being used, the automatic gain setting routine samples a burst of the incoming signal at 32 kHz to check for low frequency radio noise. This prevents input amplifier saturation when using low (IP) frequencies.

NOTE: The NOISY Gain mode is the default mode for all programs except TEM and MT/AMT, and is used for most applications.

NOTE: The Attenuator should not be used at frequencies above 32 Hz unless an external calibration is made with the attenuators IN.

NOTE: If the front-end gain state (G0) is enabled, then above in paragraph 3, where gain stage G1 is mentioned should read "G0 and then G1"

SETTING GAINS

To set Gains, all receiving wires must be connected to the receiver.

1. Turn on the transmitter.
2. On the GDP-32^{II}, enter the Data Acquisition Screen for the survey program.
3. Select the Frequency and set the Current level.

4. Press **GAIN F10**. The Gain Setting Menu appears (in this case for NanoTEM):

The Gain Setting Menu has six Gain-Setting options, a setting for the number of data stacks to acquire and one Independent SP control. Detailed instructions for using each option are included after the brief descriptions that follow.

Option 1 – Turn OFF (or ON) full automatic mode

Toggles the default setting of Full Automatic Mode between ON and OFF. The receiver automatically adjusts gains each time the frequency, transmitter current, Rx, Tx, N, station number, Powerline notch filter or delay (for TEM) are changed.

Option 2 – Automatic Gain

Automatically determines Gains. The receiver adjusts the gains, then returns to the Data Acquisition screen.

Option 3 – Manual Gain

Allows the operator to manually set and fix Gains and Attenuator. The operator may flip Gains between amplifier stages.

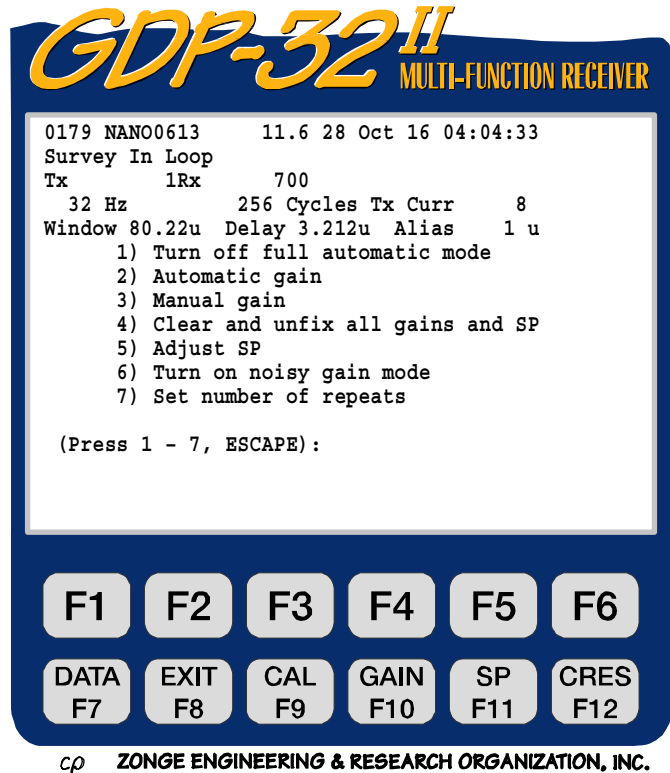
Option 4 – Clear and unfix all gains and SP

Sets all Gains to unity, sets SP buckout to 0.0, and clears any FIX flags.

Option 5 – Adjust SP

Adjusts the SP buckout without changing the gain settings. The operator may adjust SP in environments where it varies rapidly and you do not want to continue adjusting the

gains. Pressing **SP F11** also adjusts the SP.



Option 6 – Turn OFF (or ON) noisy gain mode

Noisy Gain mode: (default setting – except for TEM)

- Works with automatic gain ranging
- Permits a maximum signal of ± 1.0 volts (providing headspace for SP drift)
- Puts the Gains into the second stage first (G2) and then adjusts the Gain of the first stage (G1), if necessary.

Standard gain mode:

- Works with automatic gain ranging
- Permits signal amplification up to ± 2.25 V
- Adjusts G1 first, then G2.

Option 7 – Set number of repeats

Sets the number of repeats for each data stack. Used for quality control and fast acquisition of multiple stacks with the same settings.

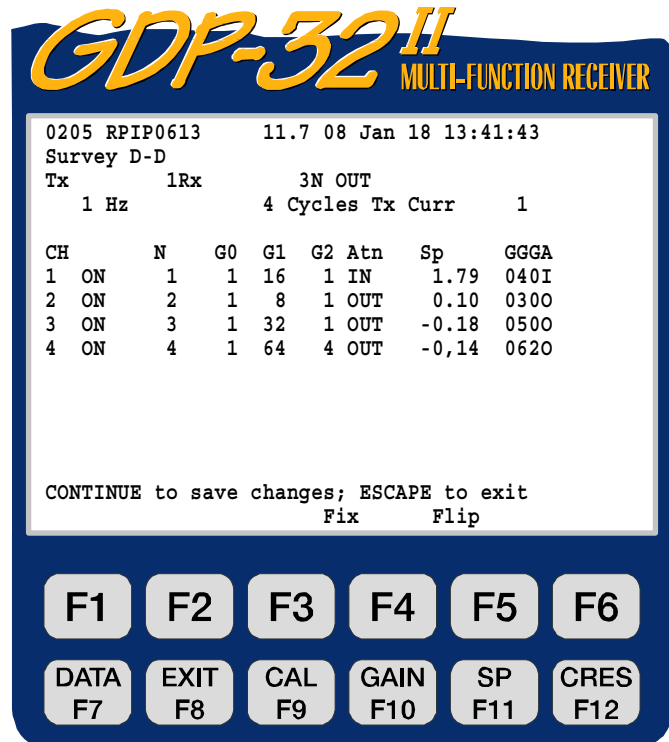
Option 8 – Turn on G0 gain calculation

ON and OFF toggle switch for the G0 gain stage automatic gain calculation.

After setting the gains using one of the above methods, the LCD displays the values in gain stages G0, G1 and G2 and the Attenuator setting.

Screen Description

- **G0, G1, G2** – The three gain stages
- **Atn-x1, x 1/8** Attenuator
- **SP** – Self-potential in millivolts.
- **GGGA** - Gains of G0, G1, and G2 are the values of the exponent where the gain is expressed as a power of 2. “A” is the attenuator setting: I (in) or O (out).



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Definition of Signal Voltage V

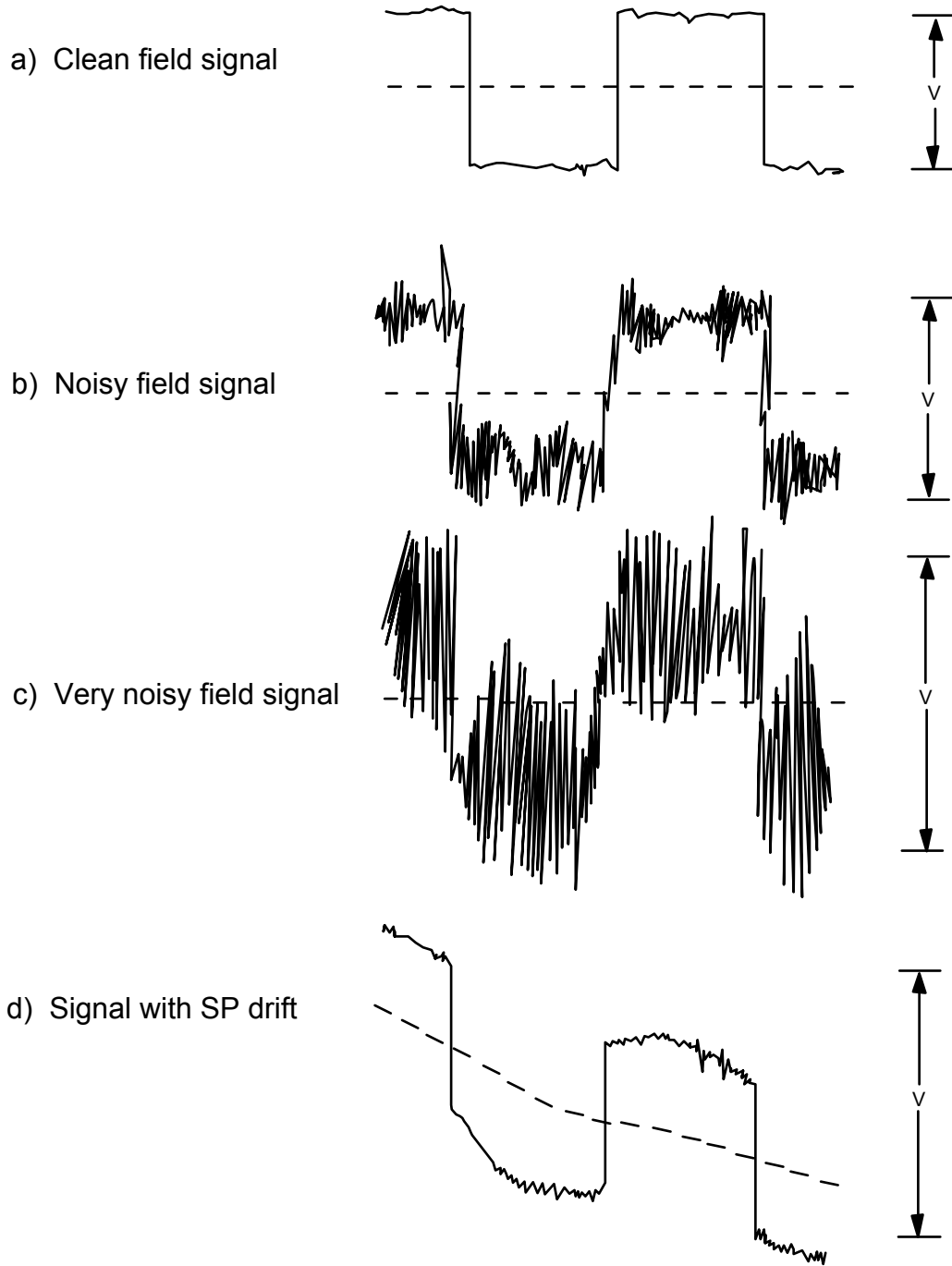


Figure 6.7 - Definition of signal strength for purposes of setting receiver gains.

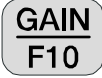
OPTION 1 – FULLY AUTOMATIC GAIN-SETTING

In the fully automatic gain-setting mode, the receiver automatically reviews all parameters and sets gains more efficiently and effectively than any other method. Always use this option for normal field surveys.

Features

- Adjusts SP and sets Gains automatically, without specific instructions, each time frequency, transmitter current, Rx, Tx, N, station number, powerline notch filter or delay (for TEM) are changed and data collection is started. Gains are also saved and reset after checking contact resistance.
- Can be either disabled or overridden on a case-by-case basis. The program first checks the input signals and puts the attenuator IN for signals over ± 3.5 volts, zeroes SP, and adjusts the gains for a signal-plus-noise voltage of ± 1.0 volts maximum for “NOISY” gains or ± 2.25 volts for “STANDARD” gains. The receiver adjusts gain stage G0 first, if enabled, and then Gain stages G1 and G2 if necessary.

Operational Procedures

1. Connect field wires and turn on the transmitter.
2. Set the Frequency on both the controller and the receiver.
3. Ensure that fully automatic mode is enabled by pressing . The fully automatic mode is the default mode. Option 1 will say “turn off full automatic mode” indicating the automatic gain option is selected.
4. Gains are displayed as they are set. Ensure that these values are reasonable.

NOTE: The process of automatic gain setting is longer for low frequencies than for high. For example, at 0.125 Hz the process takes about 20 seconds, and only 7 seconds at 1.0 Hz.

NOTE: The fully automatic mode gains can be modified from the gain-setting mode. Select the manual option (explained below.) This overrides the settings made by the fully automatic mode, but does not disable the fully automatic mode. The receiver returns to the fully automatic mode once a survey parameter is changed that affects the signal level (e.g. frequency, transmitter current, notch filter, etc.)


Things to Consider

1. Avoid setting gains during anomalous bursts of noise.
2. See Section 0 above to determine if a powerline notch filter is necessary

Disabling Fully Automatic Mode


When the receiver is turned on, it defaults to Fully Automatic Gain Mode. It remains in this mode until disabled.

To DISABLE the automatic gain mode:

Press  to view the gain setting menu.

Since the receiver is in fully automatic gain mode, Option 1 reads:

- 1) Turn off full automatic mode

Select . The receiver returns to the Data Acquisition Screen.



If the receiver is NOT in fully automatic mode, Option 1 reads:

- 1) Turn on full automatic mode

OPTION 2 – AUTOMATIC GAIN SETTING

Automatic gain setting mode is used primarily to adjust the signal level without actually taking data. Automatic Mode sets gains in the same manner as Fully Automatic Mode.

To set the gains using this routine:

1. Press .
2. Press , “Automatic gain.”

The gains and SP are reset. The receiver then re-calculates and displays the automatically derived gains and SP, and exits the gain-setting program.

This option works whether or not the fully automatic gain setting routine is enabled.

OPTION 3 – MANUAL GAIN SETTING




The manual gain setting mode is used for fixing ALL gain fields (see “Fixing and Flipping Gains” below for fixing only specific gain fields) or for changing the order of the gains between the amplifiers.

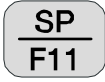
Manual gain setting is an instructive way of learning how the receiver works. But, manual gain setting can be extremely time-consuming and error-prone if used regularly for field production. With a multiple channel receiver in a noisy area, a great deal of time can be spent adjusting SP and gains. Using the manual mode often causes input saturation, thus manual gain setting is seldom used except for troubleshooting or research.


Features

This option permits the manual adjustment of the gains for each channel.

Operational Procedures

1. Connect field wires and turn on the transmitter.
2. Set the frequency on both the controller and receiver (less than 2 Hz).
3. Press .
4. Press  to turn off Full Automatic mode. Disabling the Fully Automatic mode can be justified if the survey entails data collection at very low frequencies. This allows the operator to change frequencies without needing to wait for the gains to be calculated between each frequency reading.
5. Press .
6. Observe field signal levels on analog meters.
7. Set attenuator IN if signal exceeds ± 3 volts. (Needle ± 30 on meter)

8. Zero the SP (press ).
9. Manually gain the GDP-32^{II}. It is best not to manually adjust G1 without an oscilloscope. Confine adjustments to G2. Increment gain stage G2 until the signal level is just below ± 2 volts (needle ± 20 on meter), or until the maximum gain (64) is reached.
10. Observe the analog meters to ensure that the needles swing around zero (if not, repeat step 8).





11. Exit gain-setting mode by pressing .


NOTE: Selectable gains are from 1 to 64 for gain stages G1 and G2. Manual mode is not recommended for regular use, as it is easy to saturate the analog section.

Fixing and flipping gains:

In some types of noisy environments, it is advisable to limit the Gain to the first input amplifier, or set the Attenuator permanently IN or OUT. The Fix Gain option allows the operator to fix only specific gain fields (e.g. G2) while allowing the receiver to automatically set the other gain fields (e.g. G0, G1, A).


1. Connect field wires and turn on the transmitter.
2. Set the frequency on both the controller and the receiver.


3. Press  and then  for the manual gain option. “Fix” and “Flip” keys appear on the screen above  and .
4. Select the G0, G1, G2 or Atn fields, and manually set the gain and/or attenuator values.

Fix the values by pressing . The Fix Flag is represented by an asterisk “*” next to the gain value or attenuator state.

5. To remove the Fix Flag, press .

Gains can be “flipped” only once after each automatic gain setting. This operation, initiated by

pressing , puts all possible gain into the second gain stage and places remaining gain in the first gain stage. For example, after automatic gain ranging the gains were 32 for G1 and 8 for



G2. By pressing  the gains will be rearranged to 4 for G1 and 64 for G2.

Things to Consider

- Avoid setting gains during anomalous bursts of noise.

OPTION 4 – CLEARING GAINS AND SP

In addition to automatic and manual gain setting, the operator can set all gains to unity with the gain-setting routine.

1. From the Data Acquisition Screen, press  to view the gain setting menu.
2. Press , “Clear and unfix all gains and SP.” The receiver then sets the following:
 - Gains to “1”
 - Attenuators to “OUT”
 - SP buckout to 0.0.
 - Removes any Fix Flags on the gain stages and the attenuator.

The receiver displays these values on the screen, and then returns to the Data Acquisition Screen.


OPTION 5 – ADJUSTING SP OFFSET

Figure 6.7(d) shows the signal voltage in an area experiencing SP drift. This can be avoided by adjusting for SP so that a non-zero SP does not restrict the maximum gains and reduce the A/D resolution. This process should be completed before setting gains, when in the manual mode.

SP adjusts for a DC effect, so powerline notch filters can be included at any setting. The SP adjustment can be made with the transmitter on or off, when in the manual mode.

One of the SP-offset options is in the gain-setting routine.

From the Data Acquisition screen, press  to enter gain setting mode.

Press . Wait momentarily until the receiver displays the SP offset parameter (in millivolts) for each channel.

NOTE: SP adjustments can be made at any time by pressing the  key.

OPTION 6 – NOISY/STANDARD GAIN MODE


Figure 6.7(b,c) are examples of noisy and very noisy field signals. Option 6 sets the gain modes to NOISY or STANDARD. NOISY is the default mode for all programs except TEM.

To enable NOISY or STANDARD gain mode:

Press gain to view the Gain Setting menu.


If NOISY gain mode is enabled, Option 6 reads:

6) Turn off noisy gain mode

Press  to enable STANDARD gain mode. The receiver then returns to the Data Acquisition screen.

If STANDARD gain mode is enabled, Option 6 reads:

6) Turn on noisy gain mode

Press  to enable NOISY gain mode. The receiver then returns to the Data Acquisition screen.

The NOISY gain mode can be used with either the fully automatic or manually initiated automatic gain modes (Options 1 and 2.) The receiver adjusts gains automatically as in Options 1 and 2, but the maximum allowable signal is ± 1.0 volt. After the receiver sets gains for the first and second stages, the gains are rearranged by filling gain stage G2, with any additional gain over 64 put into gain stage G1. This prevents input stage saturation due to noise bursts.

For STANDARD gain mode, the maximum allowable signal is ± 2.25 volts and G1 usually contains the highest gain values.

NOTE: In either the STANDARD or NOISY gain modes, the attenuator engages only if the input voltage exceeds ± 3.5 volts.

The AMT/MT program has NOISY and VERY NOISY gain settings (set in the first screen after selecting the AMT/MT program):

- NOISY mode is the same above. It limits the gain for a maximum signal amplitude of ± 1 volt.
- VERY NOISY mode limits the maximum signal amplitude to ± 0.5 volts, providing plenty of headroom for low frequency tellurics.

OPTION 7 – SET NUMBER OF REPEATS

Sets the number of repeats for each data stack. Used for quality control and fast acquisition of multiple stacks with the same settings.

OPTION 8 – TURN ON G0 GAIN CALCULATION

ON and OFF toggle switch for the G0 gain stage automatic gain calculation.

After setting the gains using one of the above methods, the screen displays the values in gain stages G0, G1, G2 and the Attenuator setting.

6.6 BITS OF RESOLUTION

NOTE: This section is provided mainly for those operators that want to use the manual mode for setting gains. The automatic modes provide for maximum resolution in their algorithms.

It is important to utilize as much of the 16-bit A/D resolution as possible when using the GDP-32^{II}. Understanding the bits of resolution helps determine if sufficient signal amplitude exists to acquire quality data.

Table 6.2 shows the number of Bits of Resolution at zero gains at the indicated signal levels. For example, if the input signal is $\pm 34\mu\text{v}$, at unity gains there would be -1 bit of resolution. Such a signal would be unresolved by the A/D without increasing the gains.

Increasing the gains will increase the effective Bits of Resolution. The Gains “G” and “g” and the attenuator setting “A” are defined as:

$$\begin{array}{llll} G0 & = 2^{g0} & g0 & = 0,2,4 \\ G1 & = 2^{g1} & g1 & = 0,1,2,3,4,5,6 \\ G2 & = 2^{g2} & g2 & = 0,1,2,3,4,5,6 \\ A & = 2^a & a & = 0 \text{ (OUT) or } -3 \text{ (IN)} \end{array}$$

The total system gain is $G0 \times G1 \times G2 \times A$, or, in binary terms, $g0+g1+g2+a$. The total bits of resolution, B' , is the sum of the binary gain and the zero-gain bits B from Table 6.2:

$$B' = B + g0 + g1 + g2 + a$$

For example.

- Assume the voltage is $34\mu\text{V}$ (peak) on the oscilloscope, and the receiver's automatic gain function sets the gains at 64 and 16 with the attenuator IN and $G0$ set to 1.
- From Table 6.2, the unity-gain bits value is “-1”.
- $G0=1=2^0$, $G1=64=2^6$ and $G2=16=2^4$, or equivalently, $g0=0$, $g1=6$ and $g2=4$.
- The attenuator is “IN,” so that $a=-3$.
- Hence the total bits of resolution is $B' = -1 + 0 + 6 + 4 + (-3) = 6$ bits.

Bits of Resolution are often limited by signal-to-noise criteria. For example, noise voltage may far exceed signal voltage in some surveys, limiting the maximum gains and hence reducing the Bits of Resolution of the signal itself. Increasing the signal strength (e.g. improving the transmitting electrodes, using a larger transmitter and generator) increases signal-to-noise resolution.

How many bits are enough? Try for as many as possible without saturating the A/D's. Typically 4 or more Bits of Resolution will allow sufficient data quality, depending upon the signal-to-noise ratio. Low signals yielding 1 to 2 bits may cause problems, although acceptable data has been acquired in some areas with zero bits, due to the dithering effect of random noise on the least significant bits in the A/D.

Table 6.2 - Bits of Resolution of the GDP-32^{II} Receiver

$$B' = B + g_0 + g_1 + g_2 + a$$

B' is bits of resolution

B is the unity-gain bits in this Table

g0, g1 and g2 are binary gains of the three gain stages

a =-3 if the attenuator is IN, **a**=0 if it is OUT

V is the peak voltage measured on the oscilloscope

<u>Unity-Gain Bits</u>		<u>Signal Level</u>	
<u>B</u>	<u>V (peak)</u>		
-13		± 0.008	µv
-12		0.017	
-11		0.034	
-10		0.067	
-9		0.13	
-8		0.27	
-7		0.54	
-6		1.07	
-5		2.15	
-4		4.29	
-3		8.58	
-2		17.2	
-1		34.2	
0		68.7	
1		137.	
2		275.	
3		549.	
4		1.10	mv
5		2.20	
6		4.40	
7		8.79	
8		17.6	
9		35.2	
10		70.3	
11		140.	
12		281.	
13		563.	
14		1.13	v
15		2.25	
16		4.5	