

6. RECEIVER SETUP

6.1 CALIBRATION	2
<i>SPECIAL INSTRUCTIONS FOR MT/AMT</i>	<i>3</i>
<i>INITIALIZING THE CALIBRATION CACHE</i>	<i>3</i>
<i>STARTING A CALIBRATION</i>	<i>5</i>
<i>AUTOMATIC CALIBRATION</i>	<i>6</i>
<i>STOPPING A CALIBRATION WHILE IN PROGRESS</i>	<i>9</i>
<i>SYSTEM CHECK</i>	<i>10</i>
<i>QUALITIES OF A GOOD CALIBRATION</i>	<i>12</i>
<i>QUESTIONABLE CALIBRATIONS</i>	<i>12</i>
6.2 SYNCHRONIZING TIMING CIRCUITS	15
<i>FREQUENCY ADJUST AND SYNCHRONIZING OPERATIONS</i>	<i>15</i>
<i>SYNCHRONIZING THE TRANSMITTER AND RECEIVER</i>	<i>29</i>
<i>MANUALLY TRIM THE XMT</i>	<i>22</i>
<i>LOSING SYNCHRONIZATION</i>	<i>24</i>
<i>SYNCHRONIZING MULTIPLE RECEIVERS</i>	<i>26</i>
<i>SYNCHRONIZING AN ADDITIONAL XMT</i>	<i>29</i>
6.3 MEASURING CONTACT RESISTANCE	30
6.4 SETTING THE POWERLINE NOTCH FILTER	31
6.5 GAINS	32
<i>HOW GAINS ARE DEFINED</i>	<i>32</i>
<i>GAIN-SETTING STRATEGY</i>	<i>33</i>
<i>SETTING GAINS</i>	<i>35</i>
<i>OPTION 1: FULLY AUTOMATIC GAIN-SETTING</i>	<i>39</i>
<i>OPTION 2: AUTOMATIC GAIN SETTING</i>	<i>40</i>
<i>OPTION 3: MANUAL GAIN SETTING</i>	<i>41</i>
<i>OPTION 4: CLEARING GAINS AND SP</i>	<i>43</i>
<i>OPTION 5: ADJUSTING SP OFFSET</i>	<i>43</i>
<i>OPTION 6: NOISY/STANDARD GAIN MODE</i>	<i>44</i>
<i>OPTION 7: SET NUMBER OF REPEATS</i>	<i>45</i>
<i>OPTION 8: TURN ON G0 GAIN CALCULATION</i>	<i>45</i>
6.6 BITS OF RESOLUTION	46

6.1 CALIBRATION

Calibration routines are generic for all *Field Survey Programs* and 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 survey data taken.

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 compensate for some problems and hinder diagnosis of 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:

1. The hard disk must be turned off. This is done in the initial program screen for the MT/AMT program.
2. 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.

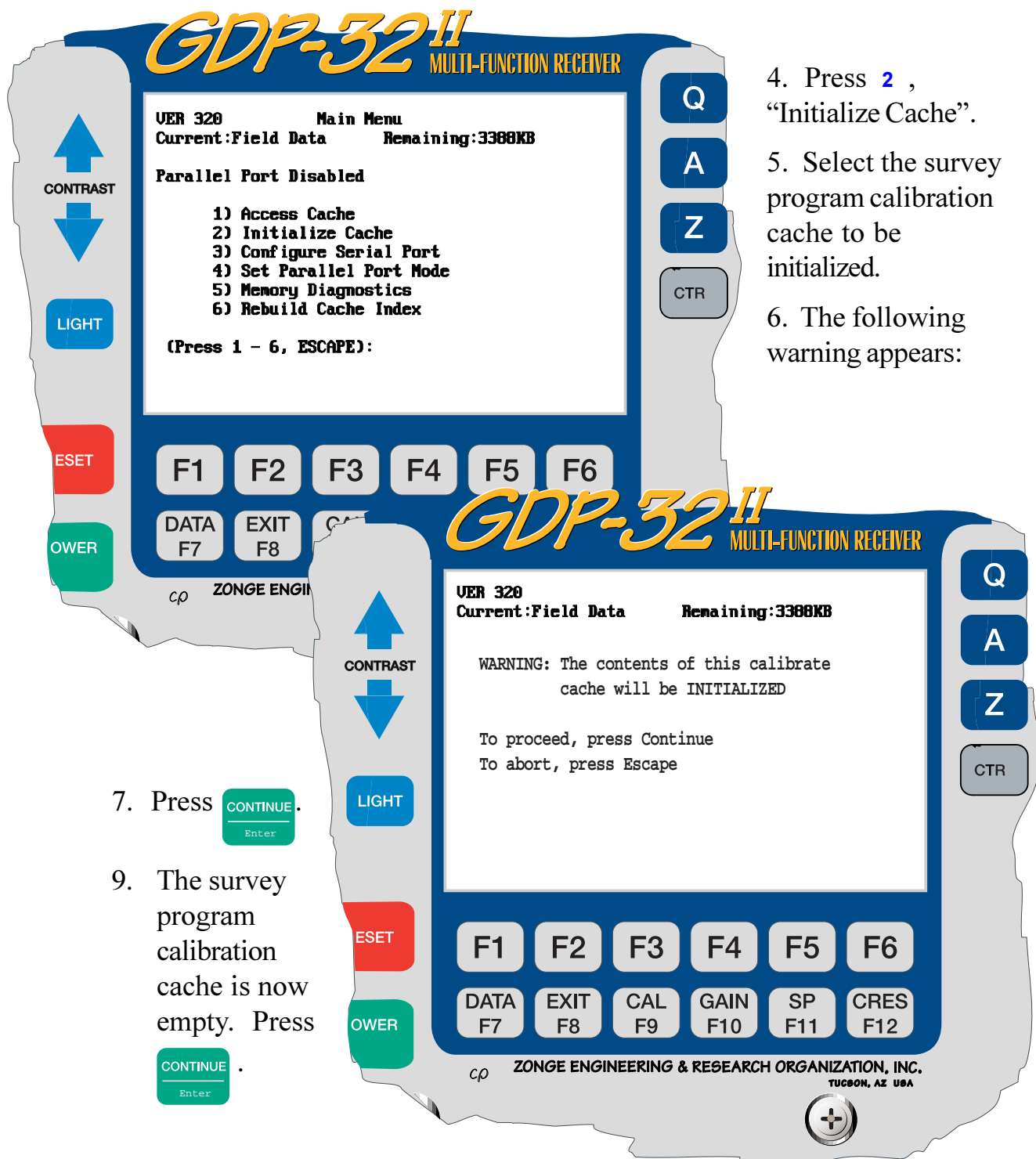
For example:

- 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.

- Press  a second time to bring up the Cache Utilities Menu.




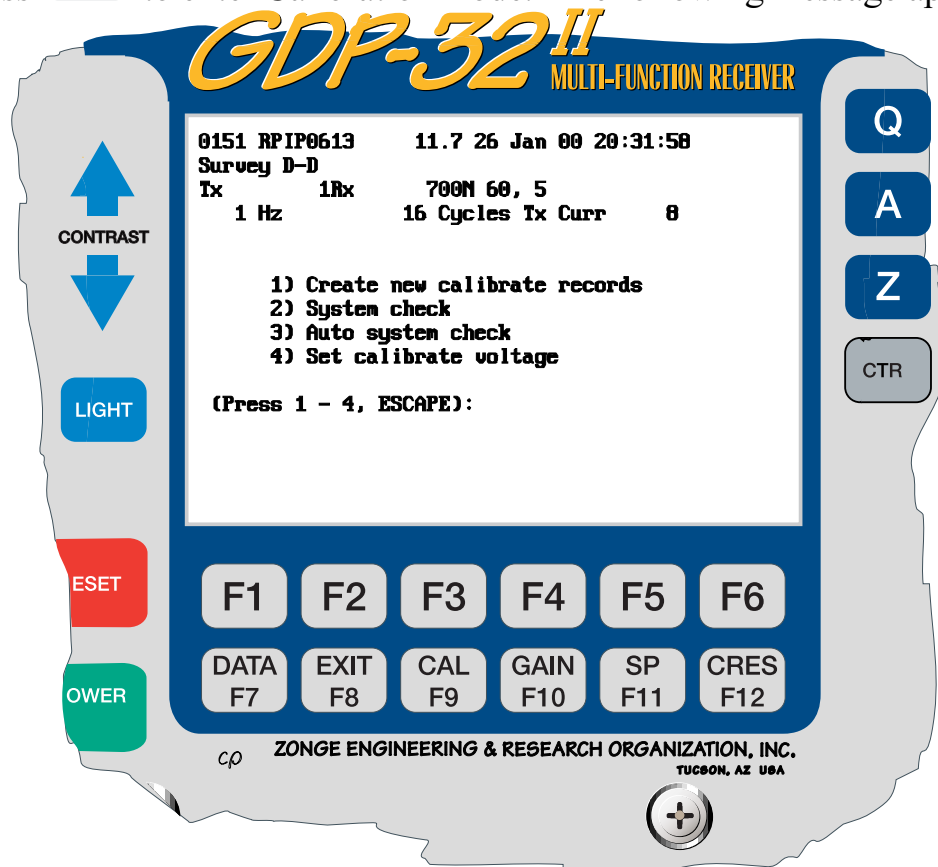
STARTING A CALIBRATION

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, 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-32II using a calibration data set stored previously on a field computer.

Press  to enter Calibration mode. The following message appears:



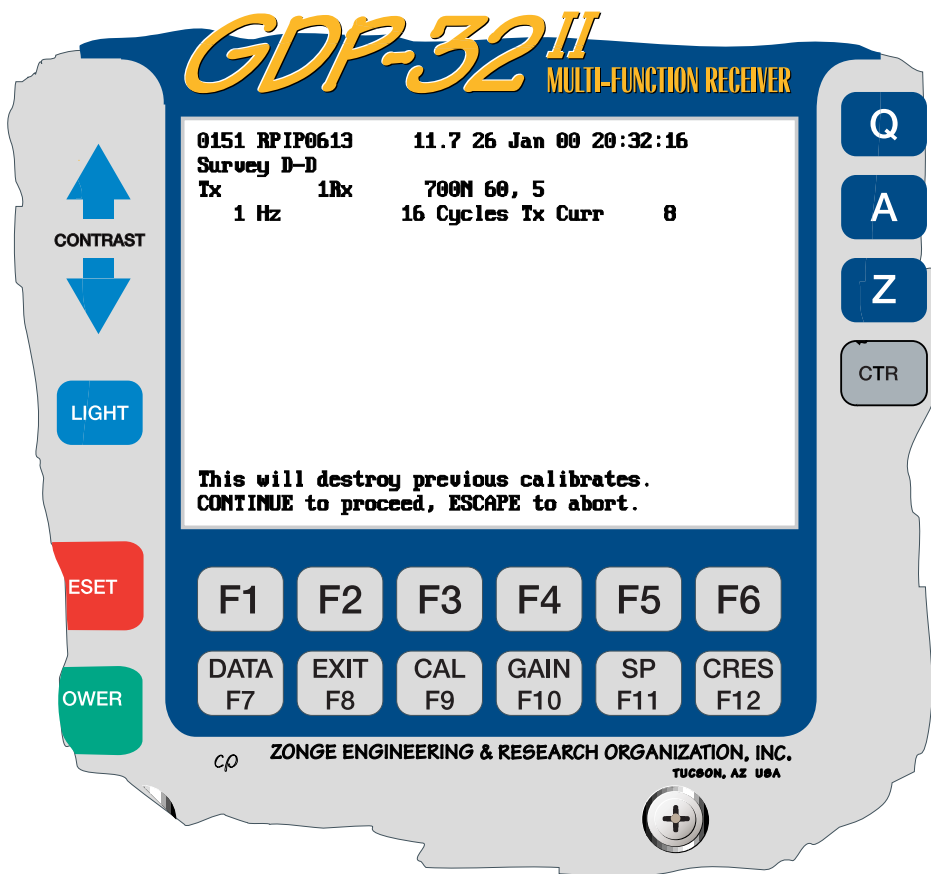
Only the first option performs an automatic calibration and loads the results into the **Calibration** and **Field Data** caches. The second and third options are system checks, useful for checking calibrations and general machine

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 value 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 **1** 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 **STOP AVG** (Escape) to return to the Data Acquisition Screen.

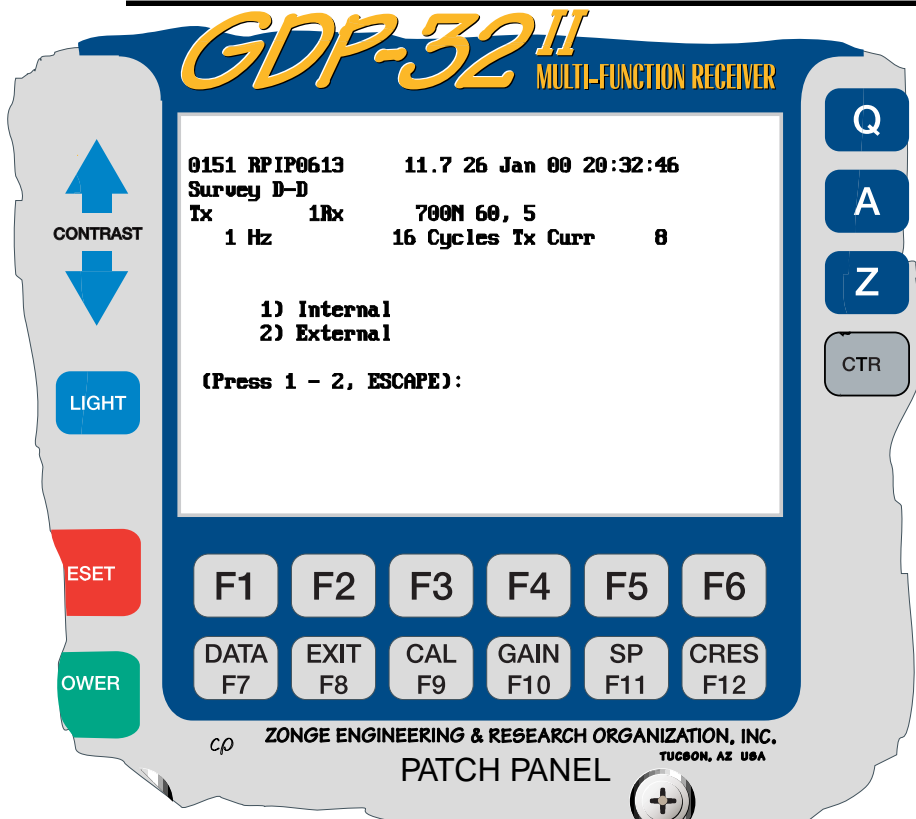
Press **CONTINUE** (Enter) to complete the calibration. The following message

appears (next page):

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

RECEIVER SETUP



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.

ANALOG I/O PANEL

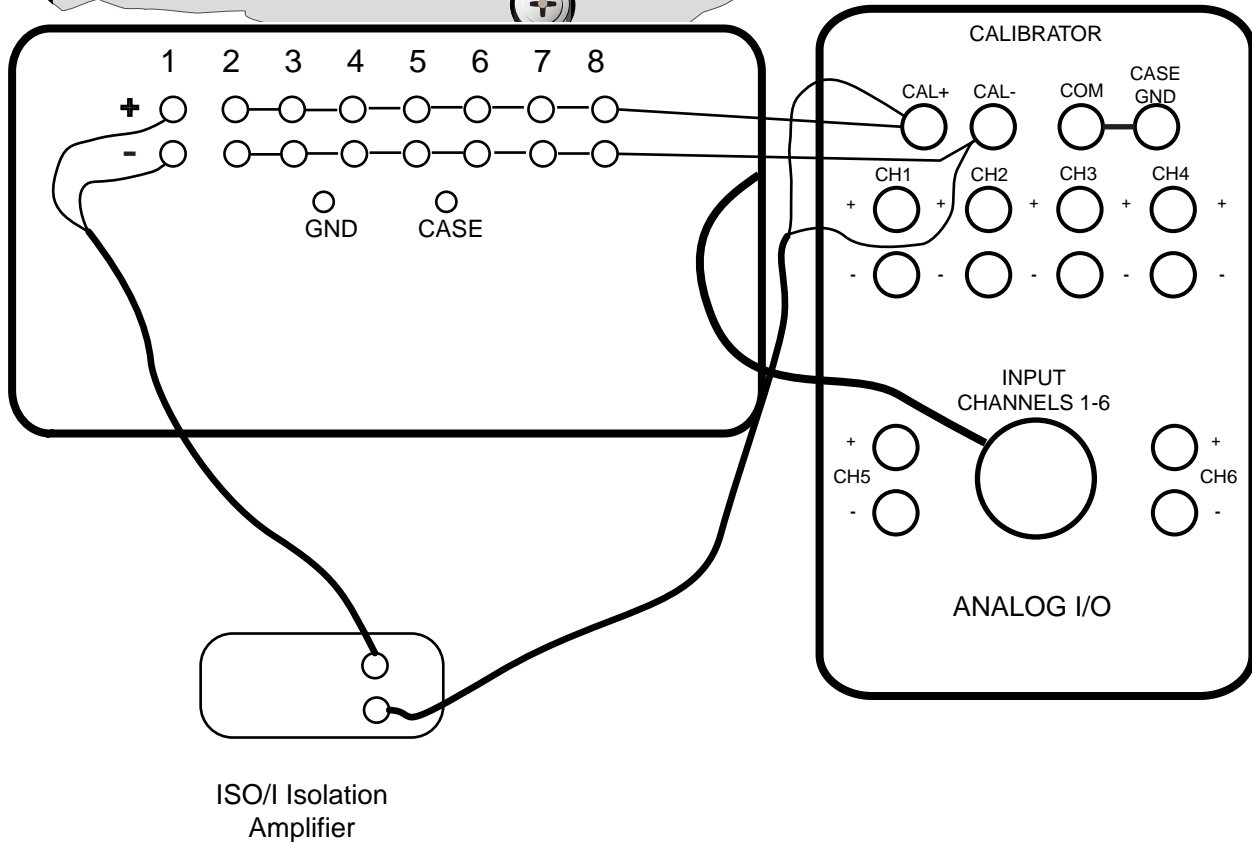


Figure 6.1 - Wiring for an external calibration – large case with Patch Panel using an isolation amplifier on the reference channel.

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-32II 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 advises 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 **1** to exit. Press **2** to change parameters. Upon pressing **2** 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 on 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

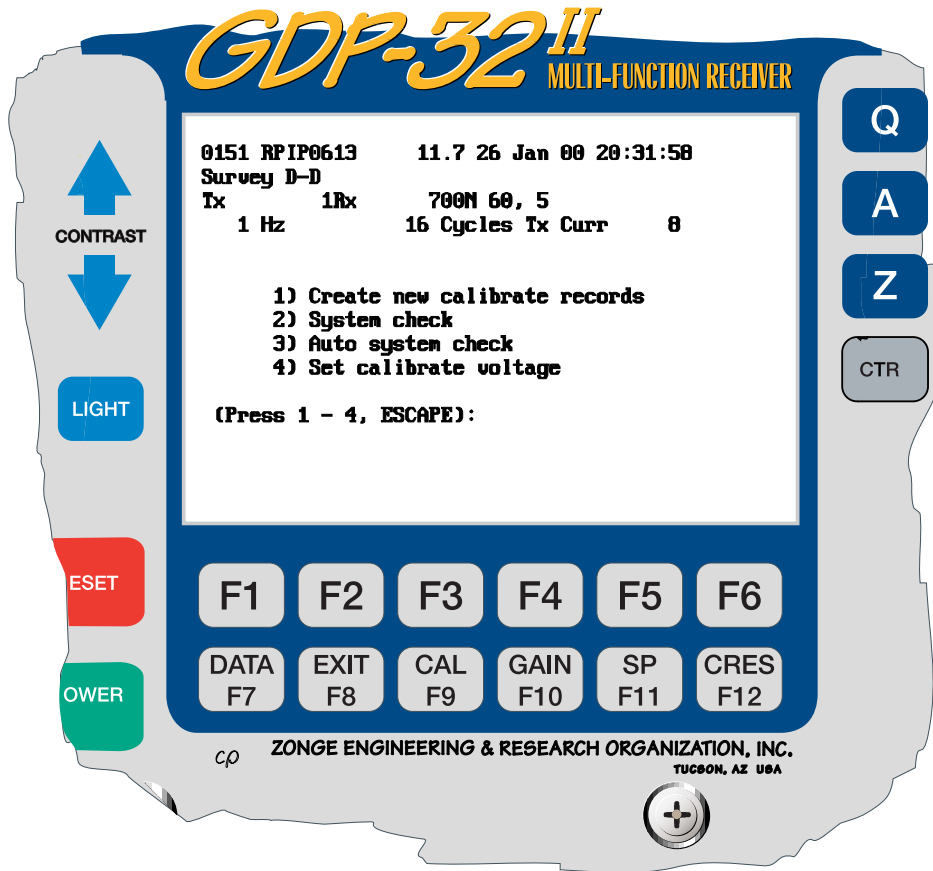
NOTE: A summary of the System Check procedure is located in the Quick Start Section.

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 it is discovered 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. As 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 **2**, "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 3, "Auto System Check".

4. Press **1** for "Internal" voltage source.

5. Press  to set the default calibration voltage (ISys=1 V).

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-32II 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 **2** or  to stay in the System Check mode, or press **1** to exit.

QUALITIES OF A GOOD CALIBRATION

Since all data will be normalized to the system calibration, it is important to ensure the calibration is reasonable immediately after it is taken. (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, calibration incorporates the electronic characteristics of each individual receiver, so the numbers may vary depending on 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 troubleshooting. 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.

NOTCH FILTER SELECTION								
<u>Frequency</u>	<u>None</u>		<u>60/180 Hz</u>		<u>50/150 Hz</u>		<u>50/60 Hz</u>	
(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

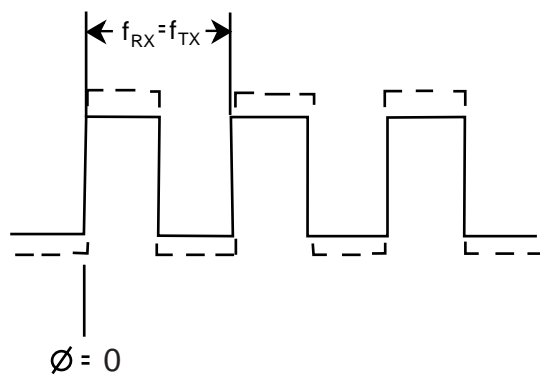
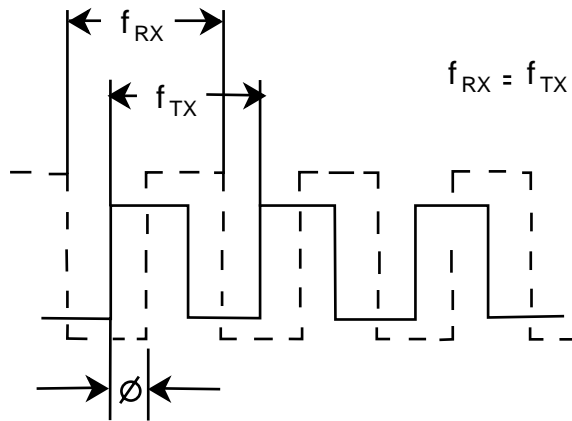
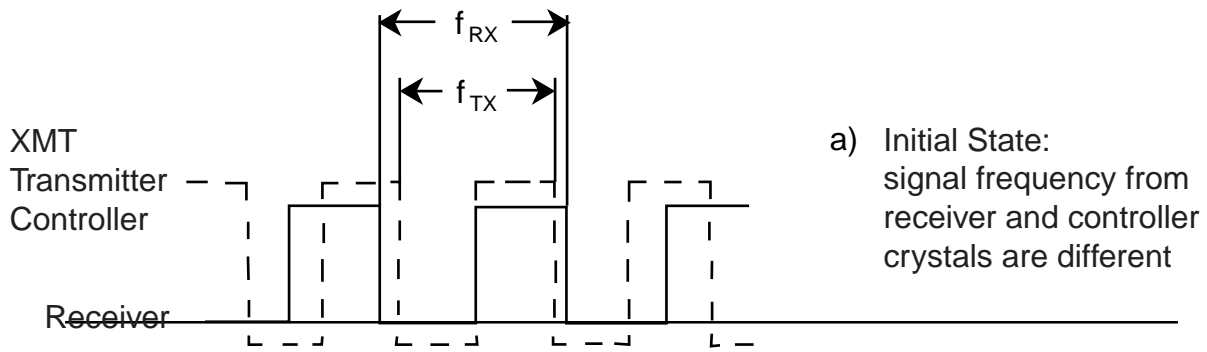


Figure 6.2 - Pictorial description of the Frequency Adjustment and Synchronizing operations.

6.2 SYNCHRONIZING TIMING CIRCUITS

FREQUENCY ADJUST AND SYNCHRONIZING OPERATIONS

The timing circuits of the XMT-32 and the GDP-32II 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 assure 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-32II must be reset so that the switching edges of both occur simultaneously (i.e. the waveforms are synchronized.)

The GDP-32II 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-32II.

The synchronization cable connects the GDP-32II'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:

$$\begin{aligned}\text{Period} &= 1/\text{Frequency} \\ \text{Period/mr} &= \text{Period}/(6.283 \times 1000)\end{aligned}$$

<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	1.3msec/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-32II and XMT-32.

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

RECEIVER SETUP

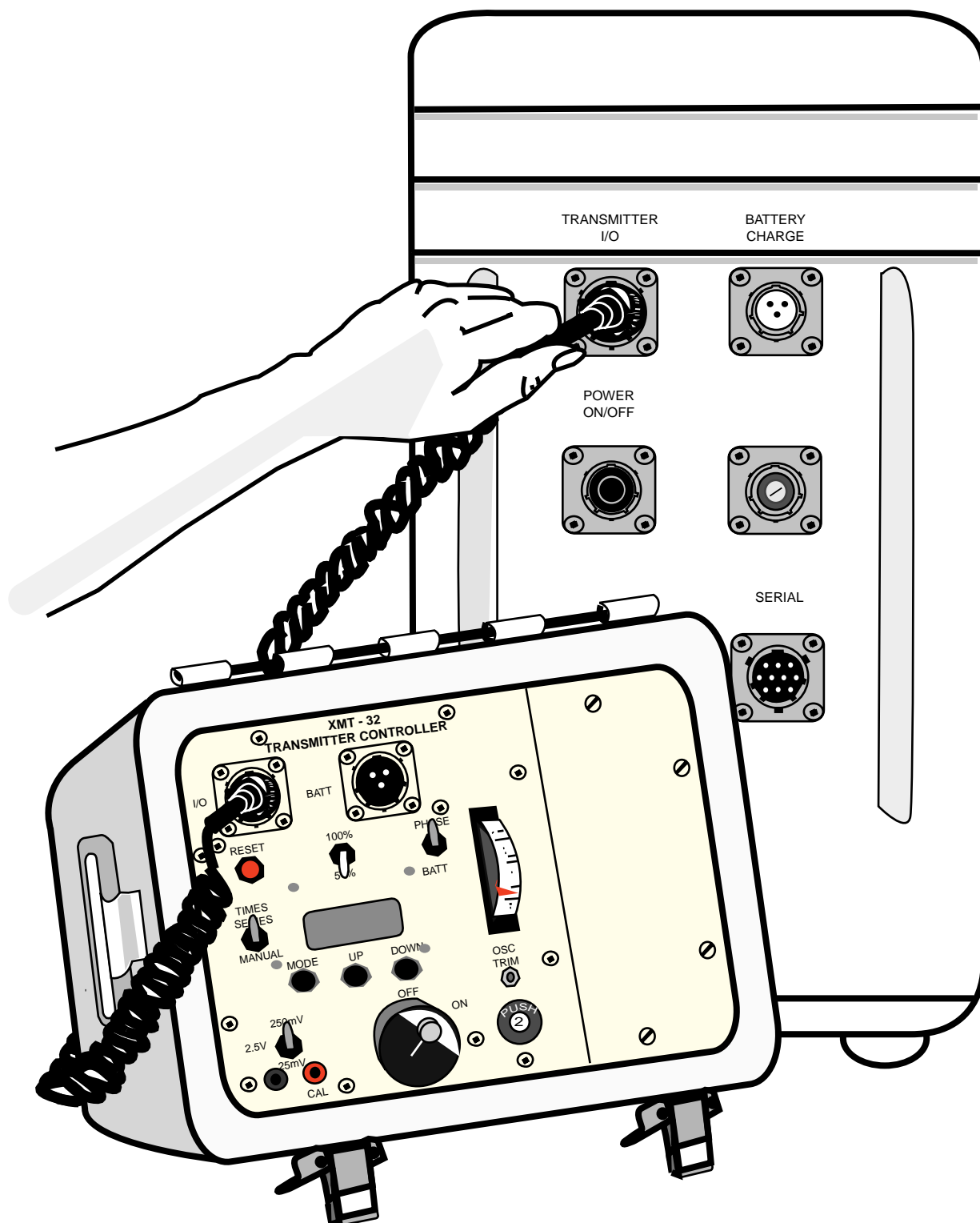


Figure 6.3 – Connecting the GDP-32 Receiver and XMT Transmitter Controller for synchronization.

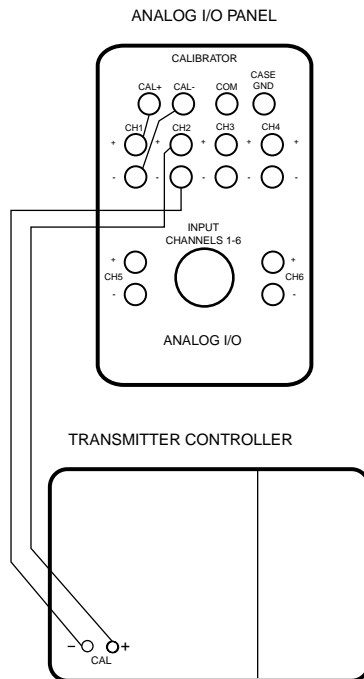


Figure 6.4(a) - Wiring for verifying synchronization to a small case GDP-32^{II}.

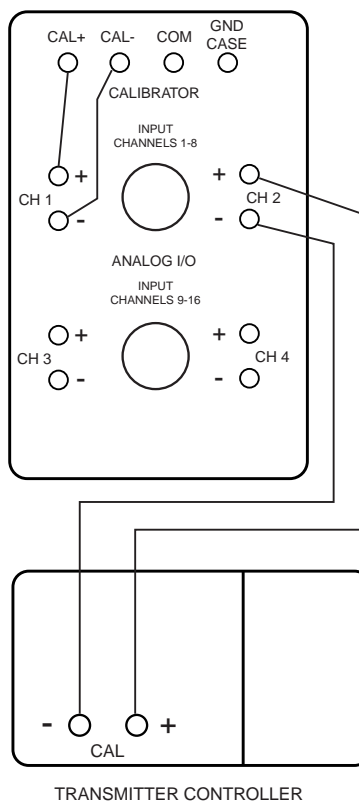


Figure 6.4(b) - Wiring for verifying synchronization to a large case GDP-32^{II}.

SYNCHRONIZING THE TRANSMITTER AND RECEIVER

The GDP-32II 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 complex resistivity (CR), roll-along IP, and NanoTEM surveys 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-32II 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-32II 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, ensure a good calibration for the RPIP (FDCALS in the CALIBRATION cache) exists as that program is used in the synchronization routine.

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

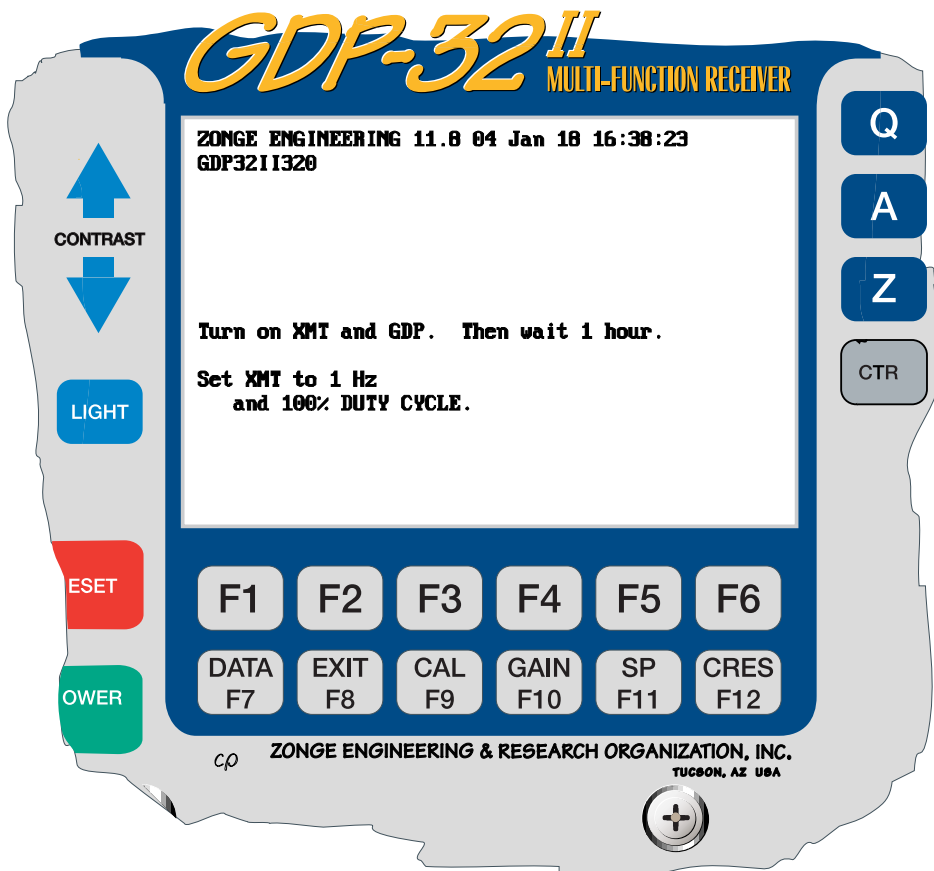
1. Disconnect the Battery Charger.
2. Connect the synchronization cable between the I/O port on the transmitter controller XMT-32 and the TRANSMITTER I/O port on the Control I/O panel of the GDP32-II receiver (Figure 6.3.)
3. Switch the PHASE/BATT switch to the BATT position to check the transmitter 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 between the GDP-32II and the XMT-32 oscillators exists.

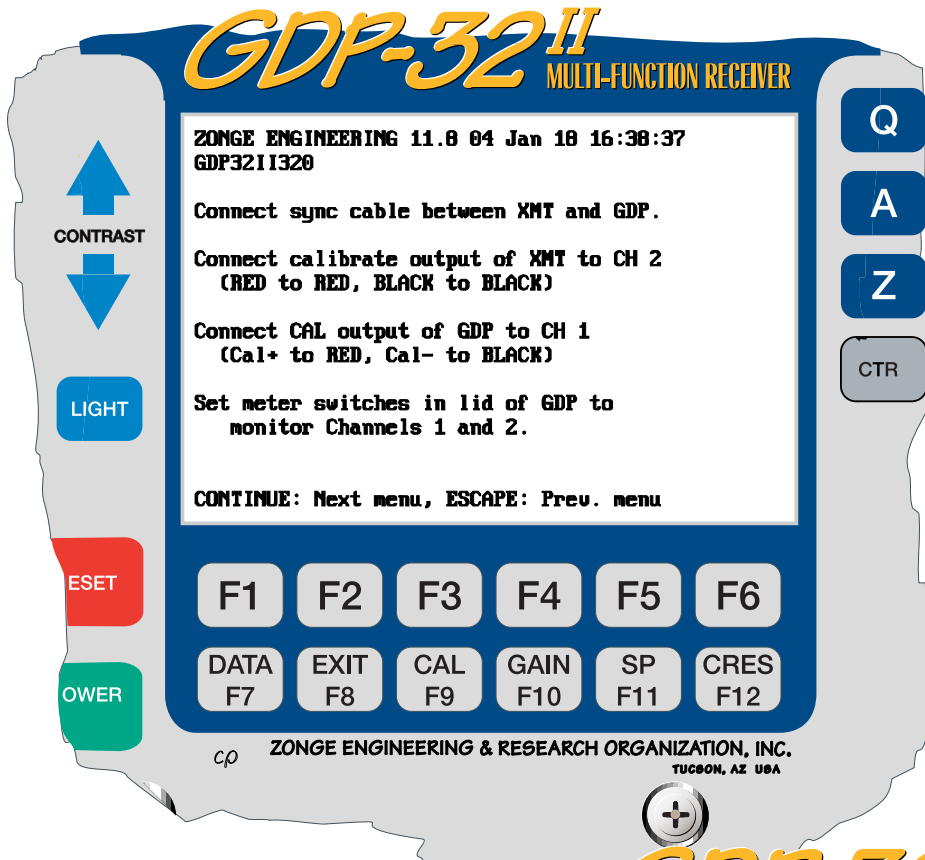
The faster the needle is swinging, the greater the frequency difference. If there is absolutely no swinging over a period of a minute, the oscillators are either adjusted to the exact same frequency (in which case skip to step 10), or the oscillators are very different in frequency and the resultant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

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

5. Follow the directions given on the screen:



6. Press .

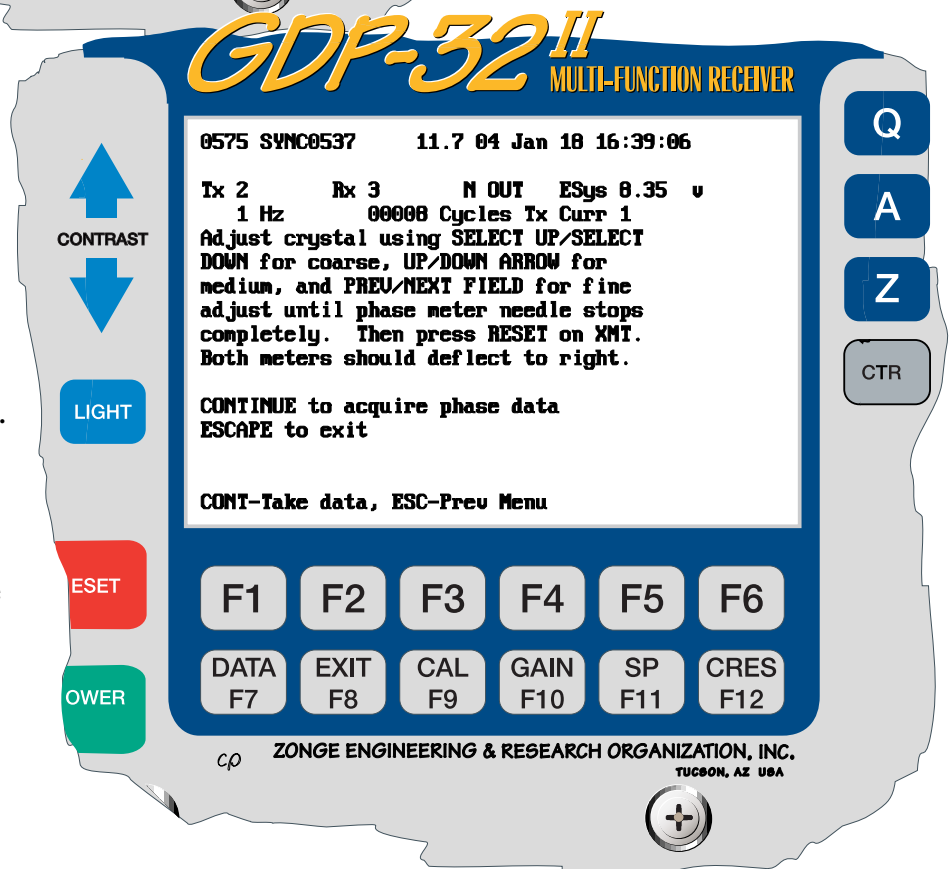



7. Continue to follow screen instructions for external connections (see Figure 6.4).

8. Press **CONTINUE** when the connections have been completed.

9. To electronically adjust the crystal frequency of the GDP-32II 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.



10. 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 toward 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.
11. Press . 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.
12. Repeat step 11 several times to check the synchronization. The measured phase difference should remain close to 0.0 mr.
13. Ensure that synchronization can be maintained without the synchronization cable. First, disconnect the cable from the XMT-32, then from the GDP-32^{II} and repeat the phase measurement.





MANUALLY TRIM THE XMT-32

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 an operator 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-32II 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-32II, trim the frequency until 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 GDP32-II to mid-range and manually trimming the XMT-32 oscillator, it is necessary to adjust the crystals in either the GDP-32II or XMT-32. Consult Zonge Engineering before attempting this procedure.

LOSING SYNCHRONIZATION

Synchronization can be lost in the following circumstances:

- Turning off crystal 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-32II 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 the  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.. Usually, loss of synchronization must be corrected immediately.

RECEIVER SETUP

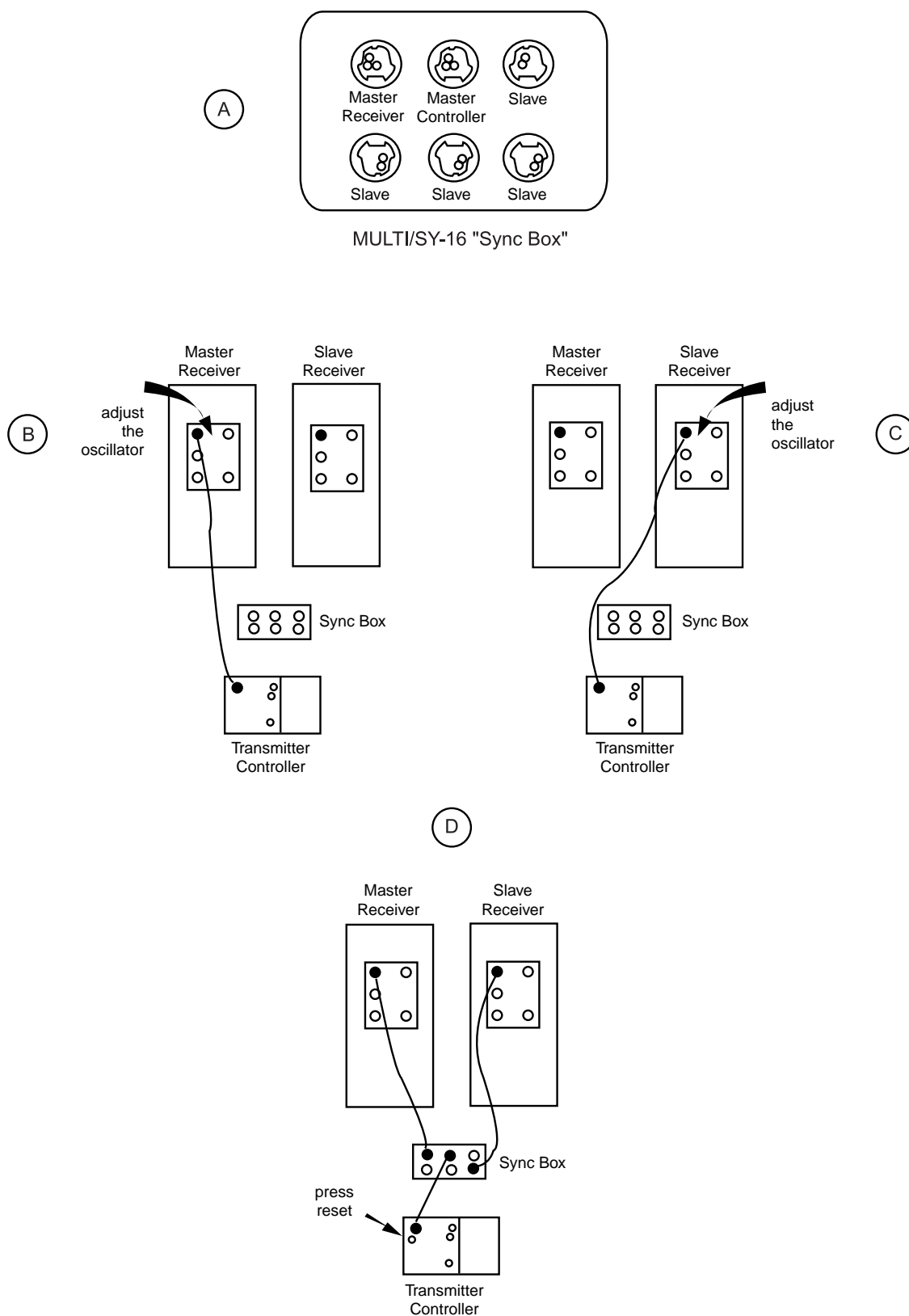


Figure 6.5 - Synchronizing a system of multiple receivers with the older MULTI/SY-16 Synchronization Box.

SYNCHRONIZING MULTIPLE RECEIVERS

With the MULTI/SY-16 Sync. Box:

Up to five receivers can be synchronized to one XMT when using a MULTI/SY-16 Sync Box. Additional Sync Boxes can be linked for synchronizing an unlimited number of receivers. Two or more receivers can be synchronized to a single 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. Arbitrarily 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-32II 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 (see page 23) 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' 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.
9. Disconnect the synchronization cables. Remove the cable from the XMT-32 first, and then from the GDP-32II.
10. 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

RECEIVER SETUP

Transmitter and Receiver.)

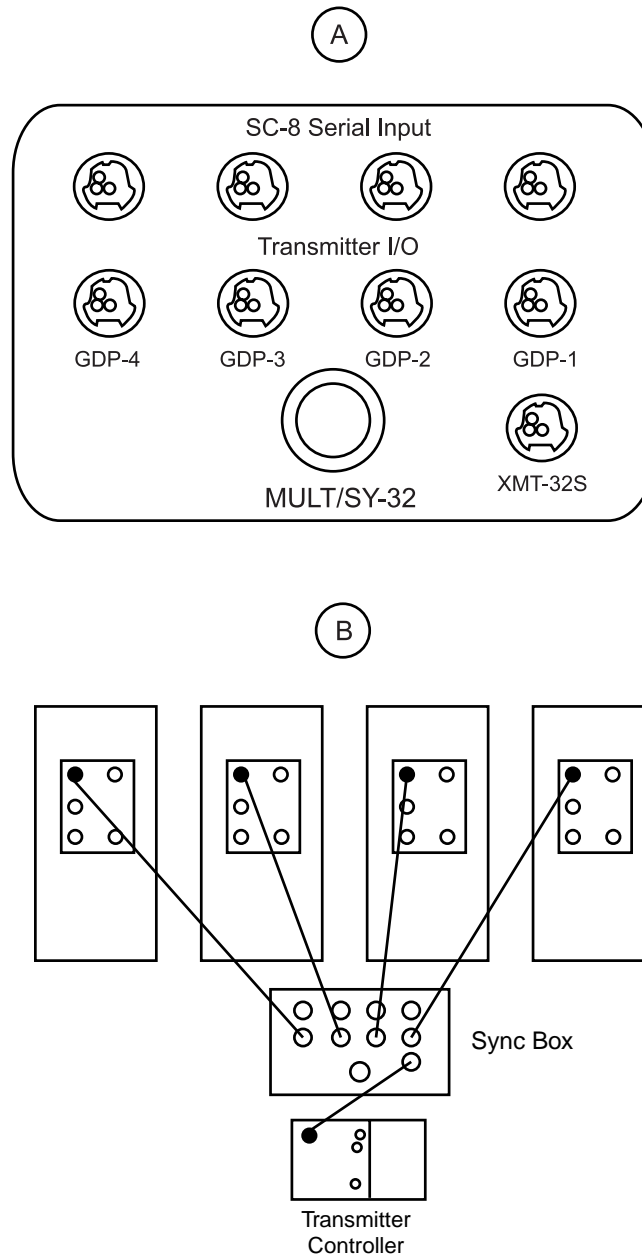


Figure 6.6 (a) MULT/SY-32 Synchronization Box (b) Synchronizing a system of multiple receivers with the MULT/SY-32 Synchronization Box

With the MULT/SY-32 Sync. Box:

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

1. Connect all GDP-32IIs to be synchronized to the Transmitter I/O port on the MULT/SY-32 Sync Box (Figure 6.6(a)), as shown in Figure 6.6(b) using synchronization cables.
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-32IIs:

Red XMT-32 cal output to Red Ch 2 on GDP-32II

Blk XMT-32 cal output to Blk Ch 2 on GDP-32II

(Connect all GDP-32s in tandem to XMT-32)

4. Using the selector switch on the MULT/SY-32 Sync Box, adjust the oscillator on each GDP-32II until the needle on the XMT-32 comes to rest.

CAUTION: DO NOT PRESS RESET ON THE XMT-32 UNTIL ALL GDP-32IIS 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.
7. Disconnect the synchronization cables. Remove the cable from the XMT-32 first, then from the GDP-32II.
8. 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 using the following procedure:.

1. Adjust all receivers 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 depressed while **RESET** is pressed and released on the master transmitter controller. (**RESET** on the slave controller may be released after releasing **RESET** on the master controller.)

Check the synchronization

To check the synchronization of the two transmitter controllers and one GDP32-II receiver:

1. Enable three channels on the GDP32-II.
2. Connect one transmitter controller cal output to receiver's channel 2 and the other transmitter controller cal output to receiver's channel 3 (red to red, blk to blk). Connect receiver's channel 1 to the receiver's cal output as shown in Figure 6.4(a, b).

NOTE: The timing systems of the GDP-16/XMT-16 and the GDP-32/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-16s were originally manufactured with either a 5.0 MHz or 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 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.

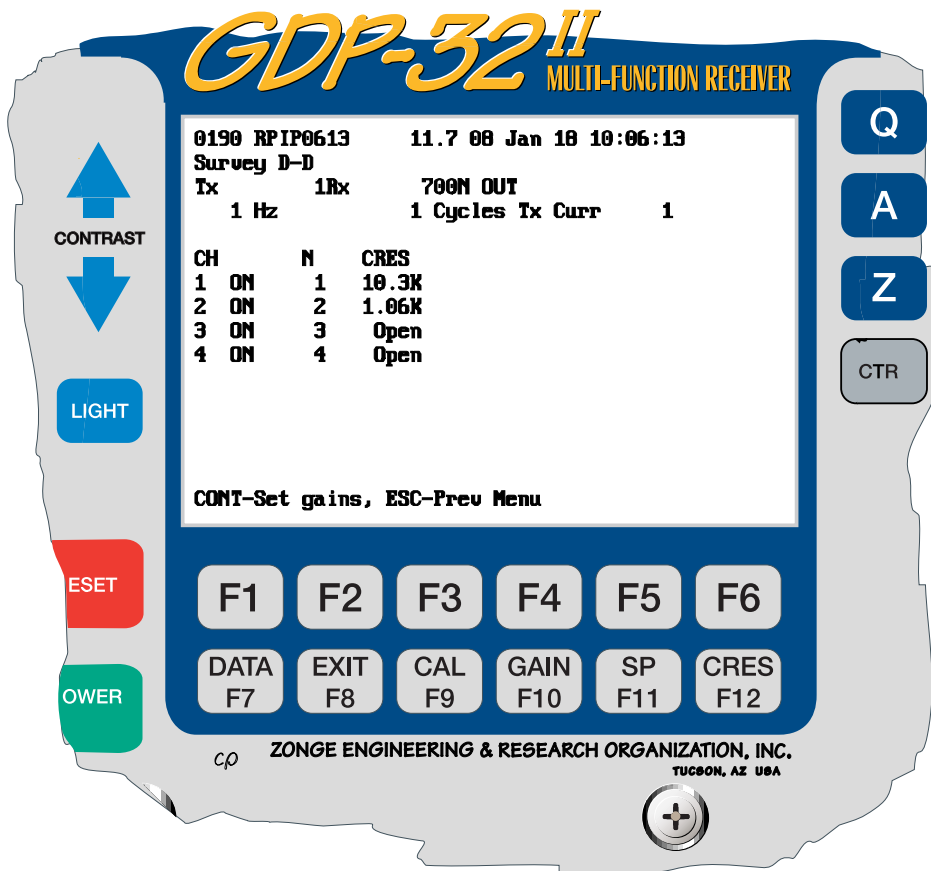
1. With the transmitter off and all fieldwires attached to the receiver, press **CRES**.

NOTE: For methods utilizing low signal levels, such as CSAMT, it is often unnecessary to turn the transmitter off prior 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 resistances for each channel are then displayed on the screen, as shown in the screen below.

In the following screen 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 indicate 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 as 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, ensure 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-32II, enter the RPIP survey program and, in the Data Acquisition Screen, select a high frequency (e.g. 512Hz).
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 exists (i.e., a factor of 2 or more), turn on the appropriate notch filters.

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

NOTE: If a survey is to be run with a 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

Two ways of expressing gains in the GDP-32II exist: as a multiplier, and as a binary gain number. Gain are expressed by the relationship $G = 2^g$ (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” would be 6, since $64 = 2^6$.

The receiver design employs three gain stages, G0, G1 and G2. An input attenuator A is also utilized. 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 $G=16,384$ ($g=16$.) “Bits of Resolution” (Section 6.6) discuss the various definitions of gain.

GAIN SETTING STRATEGY

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

1. The GDP-32II 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 $\pm 1.0\text{V}$ or less for NOISY Gain mode or $\pm 2.25\text{V}$ 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 selected, 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.

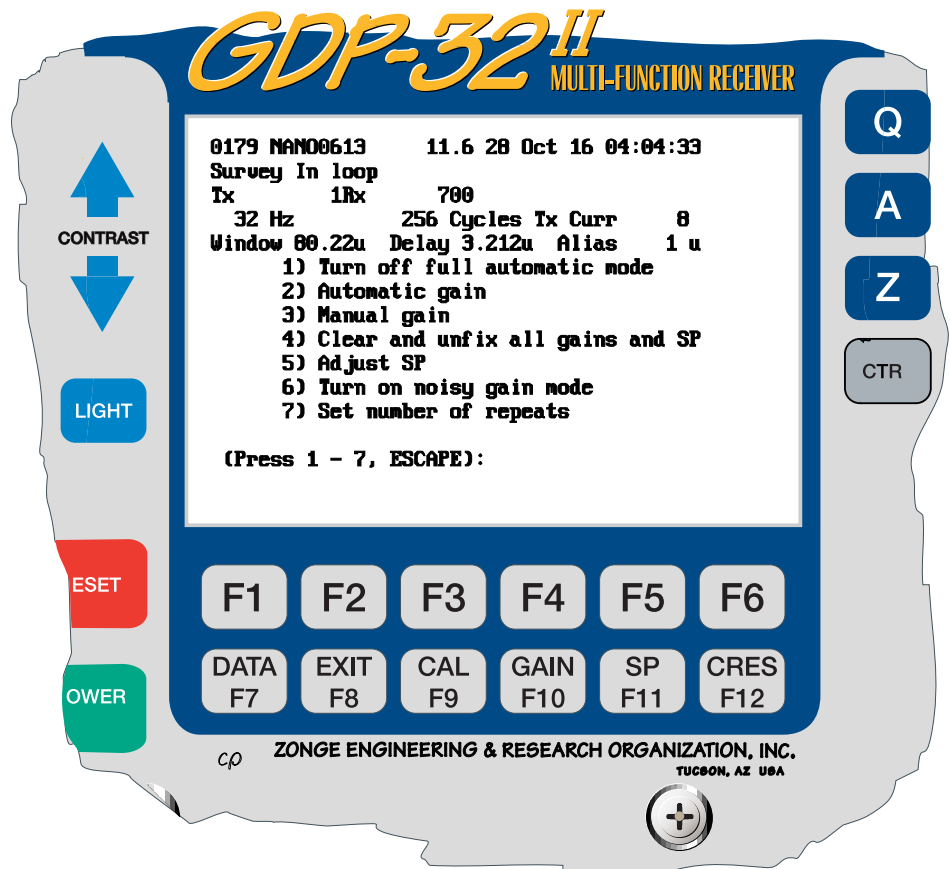
NOTE: If the front end gain state (G0) is enabled, then above in paragraph 3, where gain stage G1 is mentioned should read "G0 and then G1"

SETTING GAINS

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

1. Turn on the transmitter.
2. Enter the Data Acquisition Screen for the survey program on the GDP-32II.
3. Select the Frequency and Current.
4. Press **GAIN F10**. The Gain Setting Menu (in this case for nanoTEM survey) appears:

The Gain Setting Menu has six Gain Setting options, a setting for the number of data stacks to acquire, and one Independent SP control. A brief



description of the options follows. Detailed instructions for using each option begins on page39..

Option 1 - Turn off (or on) full automatic mode

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

Option 2 – Automatic Gain

Automatically determines Gains. Receiver automatically adjusts the gains and returns to the Data Acquisition screen.


Option 3 – Manual Gain

Allows operator to set and fix Gains and Attenuator manually. Enables user to flip Gains between amplifier stages.

Option 4 – Clear and unfix all gains and SP

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

Option 5 – Adjust SP

Adjusts the SP buckout without changing the gain settings. Allows operator to adjust SP in environments where it varies rapidly and user does not want to continue adjusting the gains. Pressing  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 (G2) first and then adjusts the Gain of the first stage (G1), if necessary.

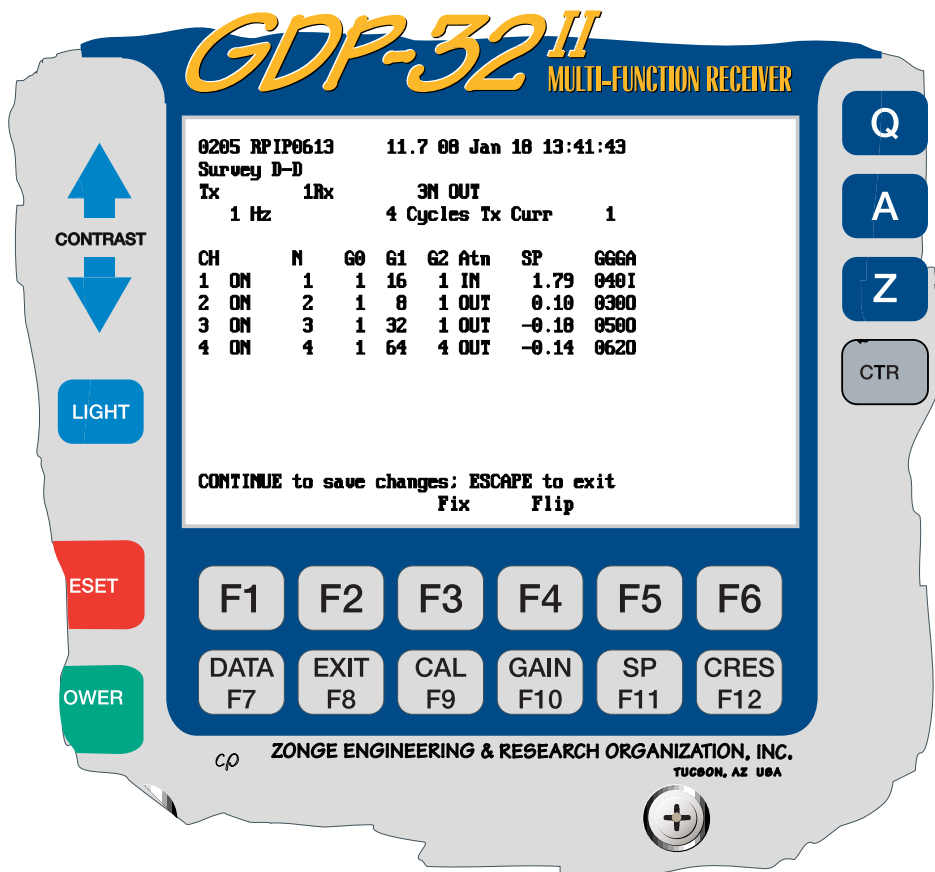
Standard gain mode:

- Works with automatic gain ranging
- Permits signal amplification up to ± 2.25 V

- Adjusts G1 first and G2 second.

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 (above screen)

- **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) and O (out).

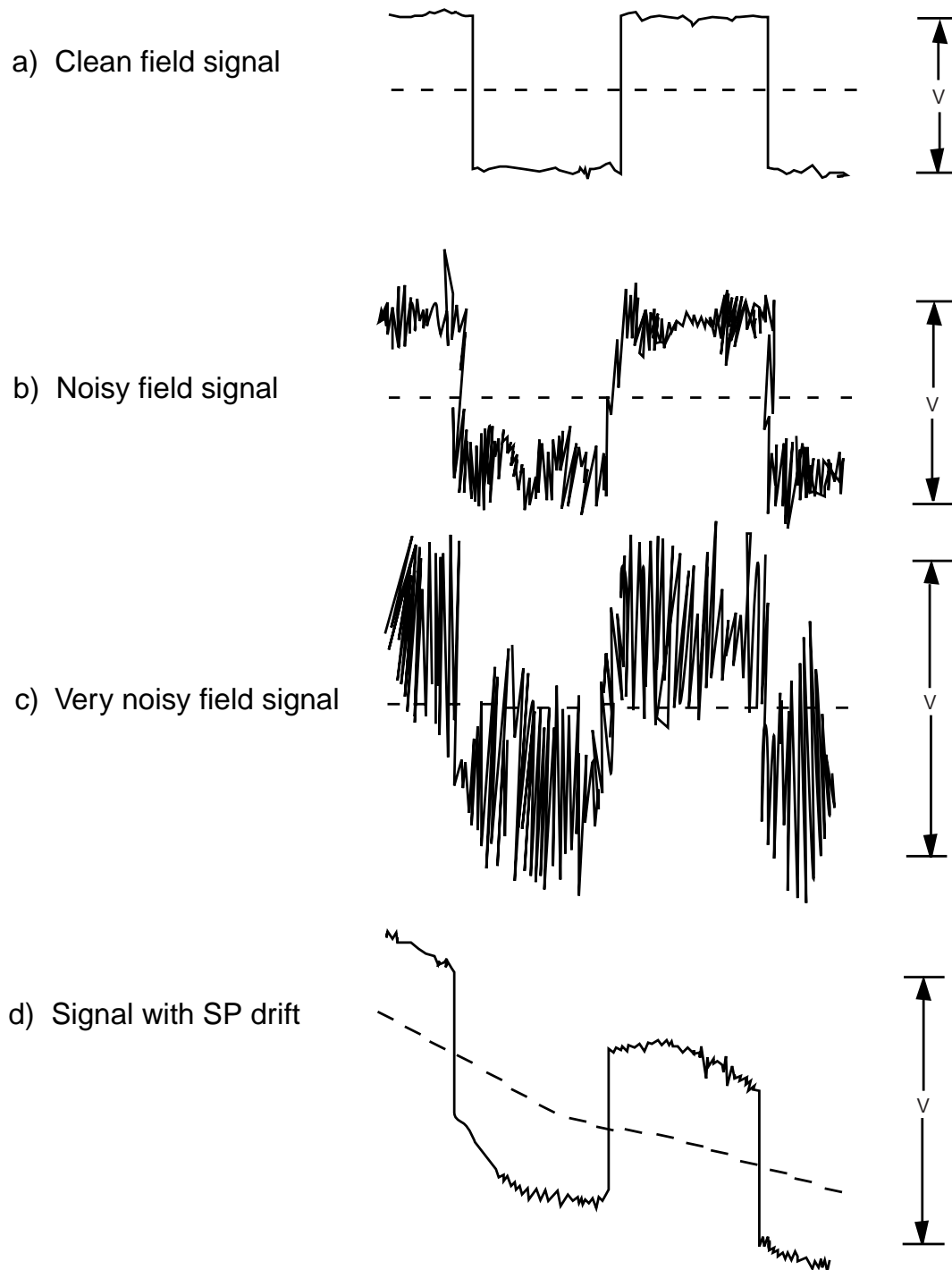
Definition of Signal Voltage V 

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) is 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. Receiver adjusts Gain stage 0 first (if enabled) and then Gain stages 1 and 2 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 fully automatic mode is enabled by pressing GAIN . 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 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 effecting

the signal level changes (e.g. frequency, transmitter current, notch filter, etc.)


Things to Consider

1. Avoid setting gains during anomalous bursts of noise.
2. See Section 6.4 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 manually disabled.

To DISABLE the automatic gain mode:

1. Press  to view gain setting menu.
2. Since the receiver is in fully automatic mode, Option 1 reads:
1) Turn off full automatic mode
3. Select 1. Receiver automatically returns to the Data Acquisition Screen.


NOTE: 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 **2**, “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 spent adjusting SP and gains. Using the manual mode often causes input saturation, thus, manual gain setting is seldom used except in troubleshooting or research.

Features


This option permits manual gain adjustment 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 **1** 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 ).
7. Manually gain GDP-32II. It is best not to manually adjust G1 without an oscilloscope. Confine adjustments to G2. Increment gain stage G2 until signal level is just below ± 2 volts (Needle ± 20 on meter), or until the

maximum gain (64) is reached.




9. Observe analog meters to ensure needles swing around zero (if not, repeat step 8).

10. Exit gain-setting mode by pressing .

NOTE: Selectable gains range from 1 to 64 for gain stages 1 and 2. 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, limiting the Gain to the first input amplifier or setting the Attenuator permanently IN or OUT is advisable. The fix gain option enables the operator to fix only specific gain fields (e.g. G2) while allowing the receiver to automatically gain the other fields (e.g. G0, G1, A).

1. Connect field wires and turn on the transmitter.
2. Set the frequency on both the controller and receiver.
3. Press  and then **3** for the manual gain option. “Fix” and “Flip” keys appear on the screen above  and .
2. Select the G0, G1, G2 or Atn fields, and manually set the gain or attenuator values. Fix by pressing **F3**. This operation places an asterisk “*”, or Fix Flag, beside the gain value or attenuator state.
3. To remove the Fix Flag, Press **F3**.


Gains can be “flipped” only once after each automatic gain setting. This operation, initiated by pressing **F4**, 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 **F4** 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 gain setting menu.
2. Press **4**, “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 or the attenuator.


The receiver displays these values on the screen and 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.

Since SP corrects for a DC effect, Powerline notch filters can be 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.


1. From the Data Acquisition Screen, press  to view gain setting menu.
2. Press **5**. 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 **SP** 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:

1. Press  to view gain setting menu.
2. If NOISY gain mode is enabled,, Option 6 reads:
6) Turn off noisy gain mode
3. Press 6 to enable STANDARD gain mode. Receiver automatically returns to the Data Acquisition Screen.
4. If STANDARD gain mode is enabled,, Option 6 reads:
6) Turn on noisy gain mode
3. Press 6 to enable NOISY gain mode. Receiver automatically 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.) Receiver adjusts gain 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, it rearranges gains by filling gain stage 2 first with any additional gain over 64 put into gain stage 1. 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 firstscreen after choosing 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 ± 5 volts, providing plenty of head-room 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 LCD displays the values in gain stages G0, G1 and 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.

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

$$\begin{aligned}G_0 &= 2^{g_0} & g_0 &= 0, 2, 4 \\G_1 &= 2^{g_1} & g_1 &= 0, 1, 2, 3, 4, 5, 6 \\G_2 &= 2^{g_2} & g_2 &= 0, 1, 2, 3, 4, 5, 6 \\A &= 2^a & a &= 0 \text{ (OUT) or } -3 \text{ (IN)}\end{aligned}$$

The total system gain is $G_0 \times G_1 \times G_2 \times A$, or, in binary terms, $g_0 + g_1 + g_2 + a$. The total bits of resolution, B' , is the sum of the binary gain and the zero-gain bits B from Table 6.2:

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

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 G_0 set to 1.
- From Table 2.2, the unity-gain bits value is “-1”.
- $G_0=1=2^0$, $G_1=64=2^6$ and $G_2=16=2^4$, or equivalently, $g_0=0$, $g_1=6$ and $g_2=4$.
- 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, which limits the maximum gains, thus reducing the Bits of Resolution of the signal itself. Increasing the signal strength (e.g. improving the transmitter electrodes, using a larger transmitter and generator) increases signal to noise resolution.

Table 6.2 - Bits of Resolution of the GDP-32 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

Unity-Gain Bits Signal Level

<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		1.10mv
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		1.13v
15		2.25

How many bits are enough?

Try for as many as possible without saturating the A/Ds.

Typically, 4 or more Bits of Resolution will allow sufficient data quality, depending on the signal-to-noise ratio. Low signals yielding 1 to 2 bits may cause problems, although acceptable data with zero bits in some areas has been acquired, due to the dithering effect of random noise on the least significant bits in the A/D.

6.7 AUTOMATIC START-UP MODE

Not yet compleated.