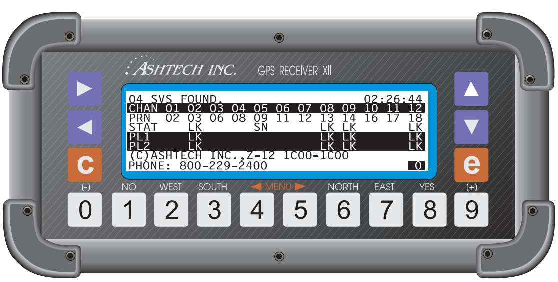
Z-12 GPS Receiver

Operation & Technical Manual



Z0115C

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1

General Information

This manual describes the features of the Z-12 GPS receiver, Figure 1.1, telling you how to set up the receiver, how to collect data, and how the receiver operates. Many field procedures, such as kinematic surveying, are also described.

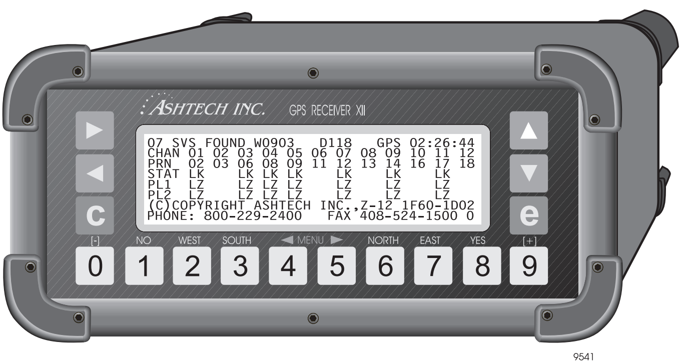

Figure 1.1. Z-12 Receiver

The Z-12 GPS receiver, making full use of the Navstar Global Positioning System, provides state-of-the-art precision surveying and navigation. The Z-12 is the first to offer true all-in-view automatic tracking. With 12 independent channels, it automatically tracks all the satellites in view, eliminating the need for manual, programmed, or pre-programmed selection of common satellites between survey sites.

The system includes a microstrip antenna mounted on a precision machined platform for accurate positioning above the survey mark.

The Z-12 receiver is easy to operate. After you position your tripod, you need only turn the power on. Operating controls are on the front; input and output connections on the back.

Screen Summary

The receiver functions are accessed through various screens, as summarized in Table 1.1. *Information* in the title of a screen means display only. *Control* in the title indicates a screen you interact with, such as Screens 4 and 9. Screens are described in detail in Chapter 3, **Screen Descriptions**.

Table 1.1. Screen Summary

Screen	Display Function
0	Skysearch Information
1	Orbit Information
2	Navigation Information
3	Tracking Information
4	Mode Control
5	Differential Information
6	Waypoint Control
7	Satellite Selection Control
8	System Control
9	Site and Session Control
10	All-in-View Information
11	Visibility Information
12	Bar Code Control

Front Panel

The receiver front panel, Figure 1.2, includes an 8-line x 40-character backlit LCD display, and various keys for controlling the receiver and entering data.

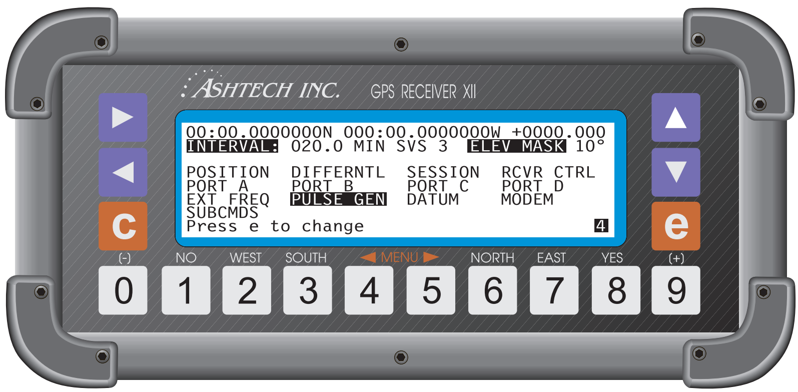

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Figure 1.2. Front Panel

Table 1.2 describes the keys that activate the receiver's functions.

Table 1.2. Keys and Functions

Key or Function	Description
0 - 9	Pressing a number key calls up a specific screen directly. The lower right corner of the screen displays the screen number. Whenever the manual discusses a screen, it identifies the screen by number (e.g., Screen 1, Orbit Information). The number keys are used to enter alphanumeric data such as latitude, antenna height, site name. Depending on the particular screen, number keys may have other functions; for example, the [8] key for 'yes'.
c	**c** Use the **c** key to cancel the current entry.
e	Press the **e** key to enter data-entry mode, to save values you have entered, and to go back to higher level displays. (It functions much like the <ENTER> key on a computer.)
▶ ◀	In display mode, use the right arrow ▶ key or the left arrow ◀ key to change to the next higher or lower numbered screen or subscreen. In data-entry mode, use the left and right arrow keys to move the cursor to highlight a field or to flash in a character position where your next entry will go.
▲ ▼	The up and down arrow ▲▼ keys are used to scroll through the different pages of a screen, or to raise and lower the contrast when only one page is available and the receiver is in display mode.

HIGHLIGHT: To highlight a parameter, use an arrow key to move the cursor until that field displays in inverse video and a character position in that field is flashing.

SELECT: To select a parameter, highlight it and press the **[e]** key.

TOGGLE: To toggle a field, highlight it and press the **+** or **-** key until it displays the setting you want. For example, below Screen 4, on the Port A/B Parameter Selection screen, you can toggle through various baud rates. Use the right arrow key to highlight the BAUD RATE indicator and press the **+** key or **-** key to scan through 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 to the desired baud rate.

BACKLIGHTING: After two minutes of keyboard inactivity, the backlighting automatically turns off to extend the life of the battery. To restore the display, push any key. The **e** key is recommended, since it does not change the display.

Back Panel

Figure 1.3 shows the connectors and power switch on the back panel. The receiver operates with an input voltage between 10 and 32 Vdc from an external power supply.

Two POWER-IN sockets let you use two external batteries. When only one battery is connected and it comes close to discharge, a continuous tone indicates that the voltage has dropped below 10 volts.

You can connect the second battery to the second connector and continue recording data without interruption. Or you can connect two batteries at once for long unattended observations; the receiver operates from the battery with the higher charge. Table 1.3 describes the items on the back panel.

Figure 1.3. Back Panel

Table 1.3. Back Panel

Item	Description
ON/OFF	Power switch turns the receiver on and off.
CAMERA IN	BNC input connector lets you record an accurate event time with a photogrammetry camera-input option and cabling
1PPS	BNC connector outputs a one-pulse-per-second signal synchronized with GPS time.
ANTENNA	Connector for the GPS antenna cable.
PORT 1 and PORT 2	Four RS-232 serial ports are available, embedded within two 16-pin connectors labeled PORT 1 and PORT 2. Port 1 corresponds to software ports A and C. Port 2 corresponds to software ports B and D. All four ports can be used for all functions.
EXT REF	BNC connector for optional external reference frequency input.

Antenna Platform

A geodetic microstrip antenna, Figure 1.4, is seated on a precision machined platform protected by a weatherproof cover. A low-noise preamplifier housed at the base of the antenna provides sufficient gain for a cable up to 30 meters long. Cable specifications are listed in Appendix D.

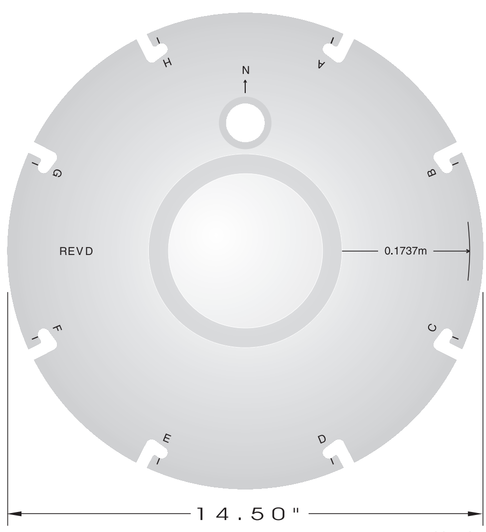

Figure 1.4. Precision Antenna Platform, Top View

Eight dog-legged holes, labeled A to H, in the antenna's ground plane, allow antenna height measurement. Use the special sectioned measuring rod (the HI rod for height of instrument) and measure through one of these openings. When the HI rods are used this way, the distance from the center of the antenna to the outside diameter of the holes is 0.1737 meter. From the center to the outside edge of the ground plane is 0.1842 meter.

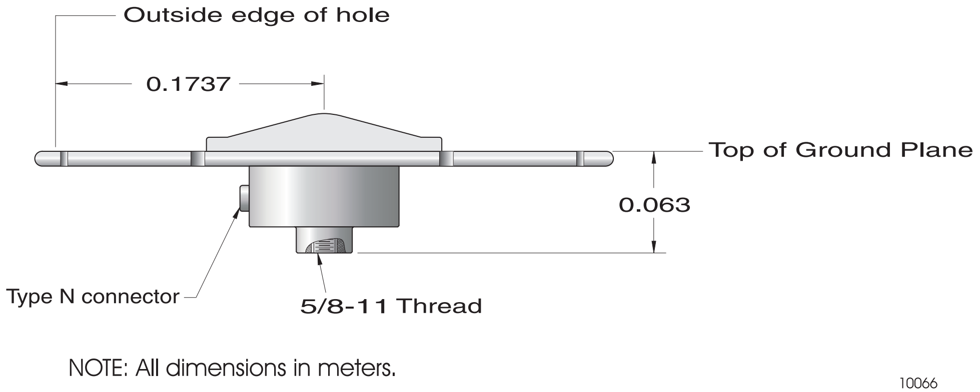

Figure 1.5. Antenna Platform, Side View

The antenna platform can be mounted on a variety of tripods and range poles, using either a 5/8x11 female threaded connector or tribrach connector. The GPS bipod range pole is useful for kinematic survey use.

Upgrading Firmware

The receiver can be upgraded with new firmware without opening the unit. The receiver contains flash EPROMs which can be uploaded with new firmware from your computer. Updates are shipped on a 3 ½-inch disk accompanied by appropriate instructions. Contact Customer Support for more information.

Automatic Power-Down

The receiver automatically turns itself off if input voltage drops below 10 volts. A beep sounds to indicate low battery, at which time you must shut down and connect a fresh battery.

2

Getting Started

Operating the Receiver

Set up the receiver and start operation as described in the following procedure.

1. Connect one end of the power cable to a 10-32 VDC power source (generally a battery pack) and the other end to either of the two POWER connectors on the rear panel of the receiver (Figure 2.1).

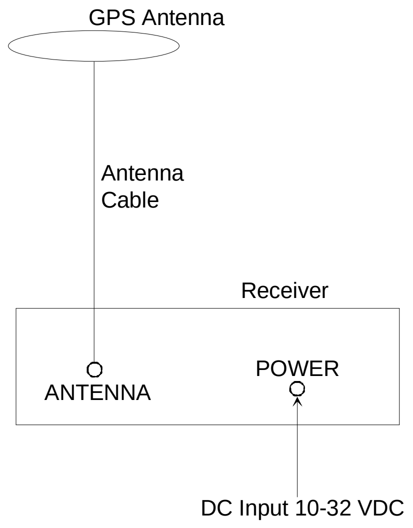

Figure 2.1. Receiver Setup

2. Connect one end of the antenna cable to the GPS antenna and the other end to the ANTENNA connector on the rear panel of the receiver.
3. Measure and record the antenna height (HI, Height of Instrument).
4. Start data collection by setting the ON/OFF switch on the rear panel to ON. This initiates a self-test. If the receiver finds a problem, it stops and displays an error message. If the receiver detects no problems, it briefly flashes the copyright, and then displays Screen 0 (Figure 2.2).

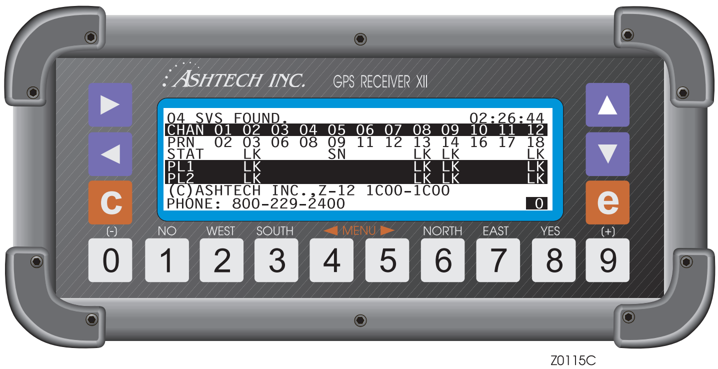

Figure 2.2. Screen 0

In theory, no further interaction with a receiver is required for a static survey. When the receiver is turned on, it automatically:

Searches and locks onto all available satellites

Makes GPS measurements and computes its position

Opens a file and saves all data into this file

When the receiver is turned off after a survey, it automatically saves the collected data and closes the file. At this point, the data stored in the receiver must be transferred (downloaded) to a PC for post-processing.

There are two primary screens for specifying information for a survey. These screens are Screen 4 and Screen 9, described later. To operate the receiver after it has been turned on, continue as follows:

5. On Screen 0, adjust contrast by pressing the up or down key.

You do not have to enter any information for your survey if the default parameters are suitable. For a static survey, accept the defaults and go to step 8.

6. Go to Screen 4, Mode Control (Figure 2.3) where you can change operational parameters. To access Screen 4, press the **[4]** key.

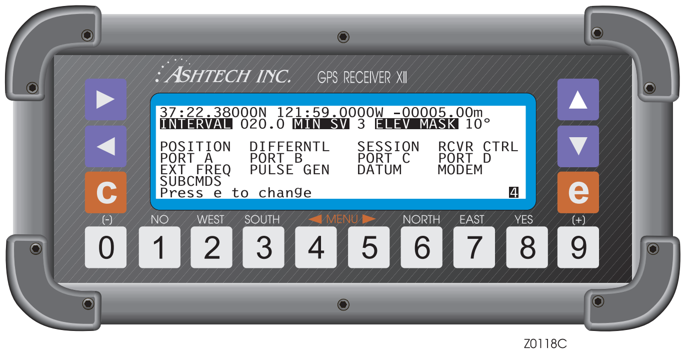

Figure 2.3. Screen 4 - Mode Control

7. The default values work very well for static surveys. However, if you choose to alter a value, press **[e]** to shift to data entry mode. Use an arrow key to move the cursor to the desired parameter, and change its value. Press the **[e]** key to save the changes or the **[c]** key to abandon changes.
8. Call Screen 9, Site and Session Control (Figure 2.4) by pressing the **[9]** key. Like Screen 4, you do not have to alter information to successfully conduct a static survey. However, entering information now assists in automatic processing.

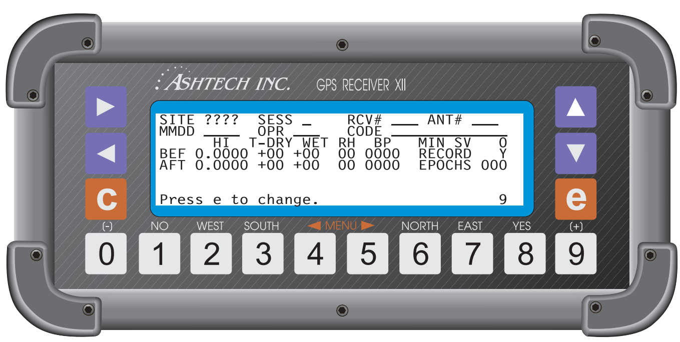

Figure 2.4. Screen 9 - Site and Session Control

Site information can be entered during data collection and do not affect or interrupt the data collection process. The site data is output as an ASCII file when the data is downloaded from the receiver.

9. When it is time to conclude data collection, turn off the receiver by setting the ON/OFF switch on the rear panel to OFF. The receiver automatically saves the collected data, and closes the data file.

Receiver Configuration

To check the factory installed receiver configuration, go to Screen 8 (Figure 2.5).

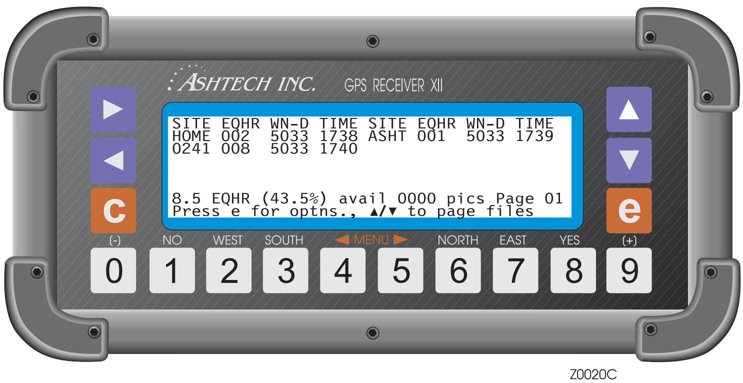

Figure 2.5. Screen 8

Issue command 888 by pressing the **[e]** key, the **[8]** key three times, then the **[e]** key again. The configuration of your receiver appears on the display (Figure 2.6). You need this information when contacting Customer Support.

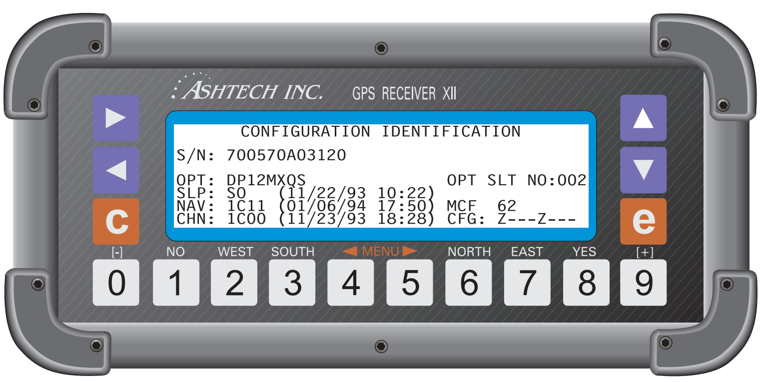

Figure 2.6. Receiver Configuration

S/N is the serial number of the receiver.

OPT is a list of option codes, as listed in Table 2.1. The order is important. A dash (-) means your receiver does not have the corresponding option.

Table 2.1. Option Codes

Code	Installed Option
D or U	D = differential U = remote only
P	Photogrammetry
1	P1
2	P2
M	Remote monitoring
X	External frequency
-	Reserved
-	Reserved
L	Sleep mode
-	Reserved

OPT SLOT NO indicates how many times options have been reloaded into the receiver

SLP indicates the version of the sleep mode firmware, and its release date

NAV indicates the version of navigation firmware and its compilation date.

CHAN indicates the version of channel firmware and its compilation date.

Saving and Resetting User Parameters

When the values of most parameters are modified, they are not saved automatically in the internal memory overriding the defaults, and resets after a power cycle of the receiver.

Modified parameters can be saved by using the command 555. To use this command, from Screen 8, press the **[e]** key, enter 555 and press **[e]** again. The message "**user parameters saved**" displays.

To set parameters back to their original default values, use command 550. To use this command, in Screen 8, press the **[e]** key, enter 550, and press **[e]** again. The message "**default parameters being restored**" displays.

This command updates some parameters to their default values and does not clear the complete internal RAM.

See Appendix C for a list of parameters saved by command 555 and reset by command 550.

Resetting Memory

A reset of the internal memory clears the receiver to the factory defaults, including almanac and ephemeris data. To reset memory:

1. Turn the receiver off.
2. While pressing the up arrow key, turn the receiver on.
3. Keep pressing the up arrow until the message **"Test of internal RAM. Will clear all data. Press YES within 10 seconds to continue"** displays.
4. Press **[8]** (YES), and the message **"Push any key to continue"** should appear shortly. Press any key to continue with receiver normal operation.

A reset of the external memory of the receiver erases all data files displayed on Screen 8 and stored in the memory. To complete this reset:

1. Turn the receiver off.
2. While pressing the right arrow key, turn the receiver on.
3. Keep pressing the up arrow until the message **"Test of external RAM. Will clear all data. Press YES within 10 seconds to continue"** displays.
4. Press **[8]** (YES), and the message **"Push any key to continue"** should appear after several seconds. Press any key. The receiver is now ready for use.

Creating a File

Each time the receiver is turned on, a new file is created. The name is the site name that was entered last. This name is preserved when the power is turned off. The receiver can store up to 100 files.

Upon tracking a minimum of three satellites, data records in the last file shown on Screen 8.

If more than 10 files are in memory, files are stored on a different "page" of the screen. To scroll through the pages of files, press the up and down arrows. When the memory is full, the receiver stops recording. Previously recorded data are not overwritten or lost.

Closing a File

Files automatically close when the receiver is powered off. During data recording, you can close a file and open a new one without turning off the power:

1. From Screen 8, press **[e]** to shift to data-entry mode. Use the number keys, and enter **[1] [2] [3]**.
2. Pressing **[e]** again closes the file and opens a new one; if no data has been logged to the current file, you cannot open a new file.

Downloading a File

After collecting data, you must download the data from the receiver to a PC for post-processing.   The post-processing software includes a download or data transfer utility. Detailed procedures for downloading data are presented in the software manual. The receiver-PC connections are as follows:

1. Connect an RS-232 cable to a serial port (port 1 is preferred) on the receiver and to COM1 (preferred) on the PC.
2. Turn the receiver on.
3. Download the data with the software on your PC.

Deleting a File

You can delete a file at any time. However, before deleting a file, check that it is not needed or the information downloaded.

To delete a file,

1. Go to Screen 8 which displays all files in memory.
2. If there are more than 10 files in the receiver, use the up and down arrow keys to scroll to the page with the desired file.
3. Press **[e]** to shift to data-entry mode. Highlight the file you want to delete.
4. Use the number keys and enter **[4] [5] [6]**. Press **[e]** again and wait until the end of the current cycle for the file to be deleted and erased from the display.

Each time the receiver is turned on, a new empty file is opened. If this file is deleted before closing it, any data collected append to the last file in the list.

System-Level Commands

Several system-level commands are available to the user. These commands can be entered via Screen 4, SUBCMDS menu, or from Screen 8. Table 2.2 lists the commands.

To use these commands, start by pressing the **[e]** key for data-entry mode. Then use the number keys to enter the desired command. Press the **[e]** key again for the command to be accepted. Pressing **[c]** instead of the final **[e]**, cancels the command and the unit returns to display mode.

Table 2.2. Systel-Level Commands

Command	Function
100	Turn off backlighting after 2 minutes since last key press. (Default)
101	Keep backlighting on; if backlighting is left on, the receiver draws significantly more power.
123	Close a file.
191	Initialize the modem.
550	Reset receiver to original default values.
555	Save user parameters
737	Initialize (reset) RTCM
888	Display configuration identification (information such as serial number, list of installed options, firmware version.
990	Trigger photogrammetry on falling edge of pulse.
991	Trigger photogrammetry on rising edge of pulse.
999	Delete all photogrammetry pictures.

3

Screen Descriptions

This chapter presents detailed descriptions of the various screens that allow you to control the receiver and observe results. Table 3.1 summarizes the screen functions.

Table 3.1. Screen Summary

Screen	Display Function	Page
0	Skysearch Information	16
1	Orbit Information	18
2	Navigation Information	20
3	Tracking Information	23
4	Mode Control	24
5	Differential Information	44
6	Waypoint Control	48
7	Satellite Selection Control	62
8	System Control	63
9	Site and Session Control	66
10	All-in-View Information	68
11	Visibility Information	71
12	Bar Code Control	73

Screen 0 - Skysearch Information

Screen 0 (Figure 3.1) displays the status of the satellites that the receiver finds as it performs a sky search. The number in the lower right corner identifies the screen. Table 3.2 describes the screen parameters.

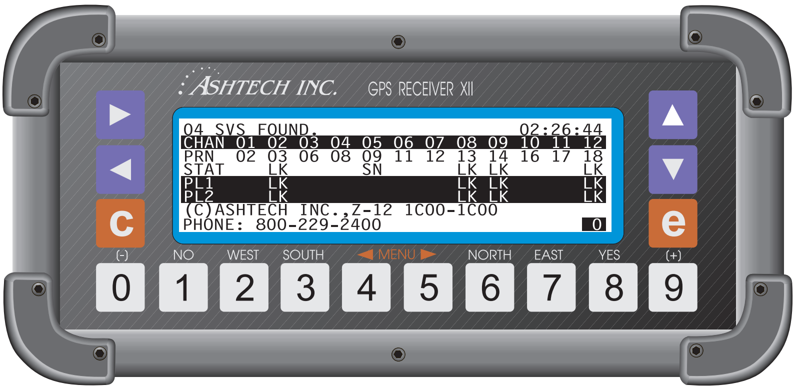

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Figure 3.1. Screen 0 - Skysearch Information

Table 3.2. Screen 0 - Skysearch Parameters

Parameter	Description
SVS FOUND	Reports the number of satellites located
02:26:44	Hours, minutes, and seconds are reported in the upper right in 3 stages. Before it locks on a satellite, the receiver displays time elapsed since you first turned it on. After it locates the first satellite, it reads the satellite time, sets its internal clock, and reports GPS time. After it finds several satellites and collects GPS-to-UTC parameters, it changes to GMT.
CHAN	Contains the channel numbers for the associated satellites.
PRN	PRN number of each satellite being searched for. If lock is not acquired on a satellite after 2 minutes, a new satellite cycles into its channel. If the SV PRN numbers are displayed in reverse video (blue numbers in a white box), then the receiver is in Z-mode.
STAT	Current status of each C/A code channel. When the receiver finds a trace of a satellite signal, it reports SN. It has detected some kind of signal; if not a satellite signal, the receiver continues the search. When a signal proves to be a satellite signal, the receiver reports LK (locked on), and then reads the satellite's ephemeris and almanac files. Status generally changes to LK within 2 minutes of operation.

Table 3.2. Screen 0 - Skysearch Parameters (continued)

Parameter	Description
PL1	Indicates the lock status of the P1 code channels. Like the C/A code channel, reports SN or LK.
PL2	Indicates the lock status of the P2 code channel.
Z-12 1I00-1D02	Reports the type of receiver and the software version number. When calling a service representative with any problem, have this number at hand.

Screen 0 is display only, you cannot enter data on it. To change to other screens in order, press the left or right arrow. To jump to another screen, press a number corresponding to the screen number; for example, to jump to Screen 5, press 5.

Screen 1 - Orbit Information

The receiver collects and displays the orbit parameters from each satellite it has found. It computes and displays information, such as elevation and azimuth, on Screen 1 (Figure 3.2). Screen 1 is display-only, you can not use it to enter information. Table 3.3 describes the screen parameters.

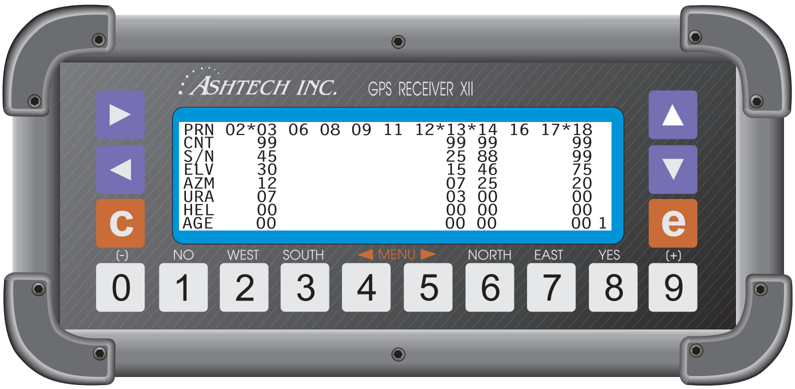


Figure 3.2. Screen 1 - Orbit Information

Table 3.3. Screen 1- Orbit Parameters

Parameter	Description
PRN	The PRN number of each satellite being tracked by the receiver. An asterisk (*****) preceding it says it is currently locked. If the SV numbers are displayed in reverse video (blue numbers in a white box), then that satellite is in Z mode.
CNT	The number of epochs of continuous data collected from this satellite. It is updated every second. It ranges from 0 to 99 and remains at 99 until a cycle slip. If there is a cycle slip or loss of lock, the receiver resets CNT to 0. If CNT often drops to 0, it indicates there are frequent cycle slips with this satellite. However, if the satellite is high in the sky (elevation angle 20° and above), cycle slips are rare unless obstructions exist in the line of sight to the satellite.
S/N	The signal-to-noise ratio, a measure of a satellite's signal strength. When less than 20, the signal is weak; when over 50, the signal is strong. A satellite at low elevation displays a weaker S/N.
ELV	The satellite's angle above horizon, ranging from 0° to 90°.
AZM	Geodetic azimuth of the satellite clockwise from 0° geodetic north in units of 10° (geodetic north according to WGS-84 coordinates). When it displays 12, read it as 120°.

Table 3.3. Screen 1- Orbit Parameters (continued)

Parameter	Description
URA	Indicates the range accuracy of each satellite. When 0, the accuracy is high; when over 8, the accuracy is low.
HEL	Displays the satellite's health (general condition) in hexadecimal. Interpreting this code is covered in Appendix D.
AGE	Shows how many minutes have passed since lock was lost on the satellite. For example, when ELV is 35 and AGE is 12, the satellite was at an elevation of 35° twelve minutes ago when loss of lock occurred. When the satellite is reacquired, the age resets to 00.
1	The "1" in the lower right corner of the screen indicates the screen number

The receiver needs to know its position to compute elevation and azimuth. Until it locks on to enough satellites to determine its own position, it can use an estimate of position; this estimate can be entered on Screen 4, Mode Control.

Screen 1 displays the satellite information for the C/A channel. To see information on P1 (P-code on L1), press the down arrow; the S/N display is updated for those parameters and the screen number is displayed as P over 1. Press the down arrow again to see P2 (P-code on L2); a P displays over the 2 as the screen number.

Screen 2 - Navigation Information

Based on information received from the GPS satellites, the receiver computes and displays on Screen 2 various components of position. This is a display-only screen, you cannot enter data. Screen 2 consists of two pages (Figure 3.3 and Figure 3.4). Table 3.4 describes the parameters shown on page 1.

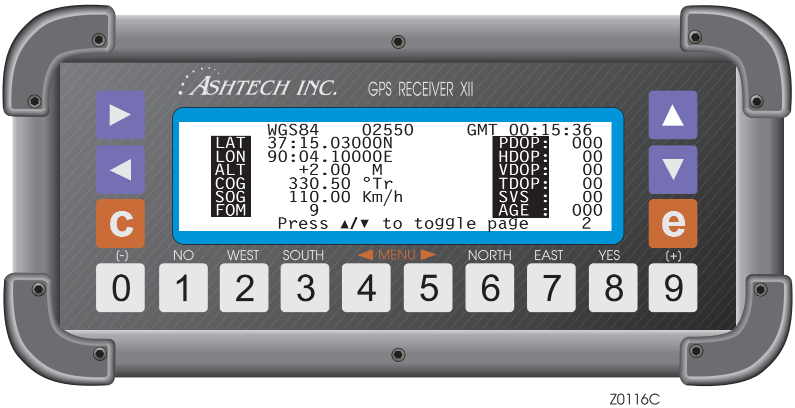


Figure 3.3. Screen 2 - Page 1

Table 3.4. Screen 2 - Page 1 Parameters

Parameter	Description
WGS-84	Indicates the datum of the displayed position. The default is WGS-84. Other datums can be selected in Screen 4, Datum.
02550	Position counter that increments with every half-second update. The display changes to **OLD** when the position data is more than 10 seconds old. When count restarts, the counter begins from last count.
00:15:36	Displays Greenwich Mean Time (GMT) or GPS time (GPS).
LAT	Computed latitude is reported in degrees and minutes to 5 decimal places with N for north and S for south.
LON	Computed longitude is reported in degrees and minutes to 5 decimal places with E for east and W for west.
ALT	Altitude is the ellipsoidal height, in meters.
COG	COG (course over ground) is the heading in degrees. The default unit is in true degrees (Tr). Magnetic mode can be selected in Screen 6.

Table 3.4. Screen 2 - Page 1 Parameters (continued)

Parameter	Description
SOG	SOG (speed over ground) is the receiver's velocity. Can be displayed in miles per hour (labeled MPH), kilometers per hour (KM/H), or knots (KN). The units are set on Screen 6, function 8: Unit Selection option.
FOM	FOM (figure of merit) indicates the accuracy of the stand-alone position based upon satellite range residuals and PDOP. 1 is the best. 9 indicates that a position is not being computed.
PDOP	PDOP (position dilution of precision) is a measure of the strength of the satellite geometry. If the satellites are scattered around the sky, the certainty of a position is better and PDOP is lower than if they are close together. A number above 6 indicates a bad PDOP.
HDOP	HDOP (horizontal dilution of precision) is the two-dimensional horizontal component of PDOP.
VDOP	VDOP (vertical dilution of precision) is the height component of PDOP.
TDOP	TDOP (time dilution of precision) is the time component of PDOP.
SVS	The number of satellites currently being used for the position calculation.
AGE	Reports how many minutes since the position was computed.

Access page 2 of Screen 2 (Figure 3.4) by pressing the up or down arrows. Table 3.5 describes the page 2 parameters.

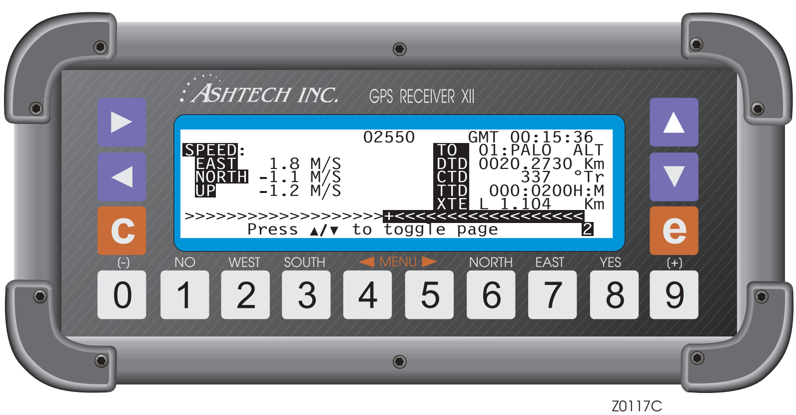


Figure 3.4. Screen 2 - Page 2

Table 3.5. Screen 2 - Page 2 Parameters

Parameter	Description
SPEED	Speed over ground (SOG) parameter displayed in its E (east), N (north), and U (up) (ENU) components.
TO	Displays the TO waypoint, giving its number and name. The waypoint is specified on Screen 6, Waypoint Control.
DTD	Distance-to-destination is the distance from your present position to the waypoint.
CTD	Course-to-destination is the course to follow from your present position to the TO waypoint displayed in either true degrees (°Tr) or magnetic (ºMg).
TD	Time-to-destination is given in hours and minutes (labeled H:M) to the TO waypoint, based on the present SOG.
XTE	Cross-track error indicates deviation from the track between the FROM waypoint and the TO waypoint where R indicates you are right of the track and L indicates you are left of it. The deviation is labeled in kilometers (KM) or miles (MI).
>>>>>+<<<<<	A visual representation of the direction in which to proceed in order to get back on track to the next TO waypoint. This example indicates you take a heading more to the right.

Screen 3 - Tracking Information

Screen 3 (Figure 3.5) displays the data recorded for each tracked satellite. Table 3.6 describes the screen parameters.

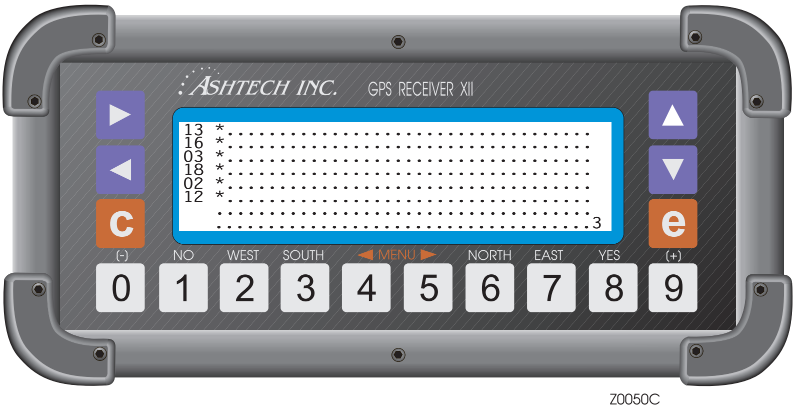


Figure 3.5. Screen 3 - Tracking Information

Table 3.6. Screen 3 Parameters

Parameter	Description
. (dot)	Indicates no data are recorded for that satellite.
* (star)	Indicates data are recorded for that satellite.

The satellite numbers go down the left side in the order in which they are tracked. To the right are columns of dot and star symbols. Each symbol represents 5 minutes. Dark bands mark off 30-minute segments for easy reading, with a maximum display capacity of 180 minutes (3 hours).

Screen 3 is display only, you cannot enter data.

Screen 4 - Mode Control

On Screen 4 (Figure 3.6), you can change several receiver control parameters and access receiver options including:

- Position Fix, Differential Mode
- Session Programming
- Receiver Mode
- Serial Port Setup
- Setting External Frequency
- Pulse Generation
- Datum Selection
- Modem Setup
- Subcommands

Access the applicable subscreen via Screen 4. Table 3.7 describes the Screen 4 parameters.

Figure 3.6. Screen 4 - Mode Control

Table 3.7. Screen 4 Parameters

Parameter	Description
First line of display	The entire first line of the display shows the coordinates of the antenna - latitude, longitude, and altitude per the WGS-84 ellipsoid. Press the numbered keys, typing zero where necessary. When a field is full, the cursor automatically jumps to the next one. Position can be entered or displayed in two formats: deg/min or deg/min/sec. The format can be changed under Screen 4, SUBCMDS.
INTERVAL	Recording interval lets you specify how frequently to record data into memory. The default is 20.0 seconds, displayed when the receiver is first turned on. If you want to collect less data, increase this parameter. Conversely if you want more data to examine, decrease the interval, perhaps to 10 seconds. Press **[e]** to go to data entry mode, and press the down arrow until the INTERVAL field is highlighted. Then press the numbered keys such as **0**, **1**, and **0** to enter a 10-second interval. (This is typical for a kinematic survey.) Make sure the recording interval is changed at the beginning of the survey. It should not be changed once data collection has begun. Data can be recorded at any half-second interval (0.5, 5.5, 10.5). Any other subsecond interval is not allowed.
MIN SV	Lets you set the minimum number of satellites with valid ephemerides that need to be locked before data recording can begin. It defaults to 3 when the receiver is first turned on.
ELEV MASK	**L**ets you set the minimum elevation angle below which no satellite data are recorded. Default is 10°. To change the angle, press the right arrow until ELEV MASK is highlighted, then press the numbered keys such as 0 and 0 to enter a 0° angle. For surveying, try to collect everything above 10° and limit the cut-off angle only in post-processing. Note that this mask controls only data recording. For position computation, see Screen 4, Position submenu.
Receiver Options The following entries are Screen 4 options. All options appear on Screen 4 but some can be activated only when they have been installed in your receiver. They are described in the order seen on the screen shown on the first page of this section, left-to-right, top-to-bottom.	
POSITION	Goes to the Position Fix Parameters subscreen where you specify criteria for receiver position computation.
DIFFERNTL	Can be accessed only if the differential option has been loaded into the receiver. When DIFFERNTL is accessed, the receiver goes to the Differential Mode Selection subscreen where you can set up the receiver as a BASE or REMOTE.
SESSION	Calls the Session Programming subscreen which lets you program up to 10 data-recording sessions.
RCVR CTRL	Allows you to set special receiver parameters and control how data and position are stored.

Table 3.7. Screen 4 Parameters (continued)

Parameter	Description
PORT A PORT B PORT C PORT D	Takes you to a subscreen where you can specify serial port output parameters.
EXT FREQ	Can be accessed only if the external frequency (x) option has been loaded into the receiver. When EXT FREQ is selected, the receiver presents a subscreen which lets you set up the external frequency parameters.
PULSE GEN	Goes to the Pulse Generation Parameters subscreen that controls the 1PPS output.
DATUM	Goes to the Datum Selection subscreen where you can select one of 46 possible datums to use for displaying the pseudo-range position shown on Screen 2. Note that this datum is not used for computing the position stored in memory.
MODEM	Lets you set up your modem for Port A, B, C, or D.
SUBCMDS	Lets you enter system-level commands.

Position Fix Parameters

Use the Position Fix Parameters screen (Figure 3.7) to specify position computation criteria (stored and displayed) such as how many satellites to use, when to hold altitude fixed, Dilution of Precision (DOP) masks, elevation mask, and use of unhealthy satellites. You can also enable the ionospheric model to be used for position computation, display computed position in Screen 2 using UTM coordinates, and use point positioning mode.

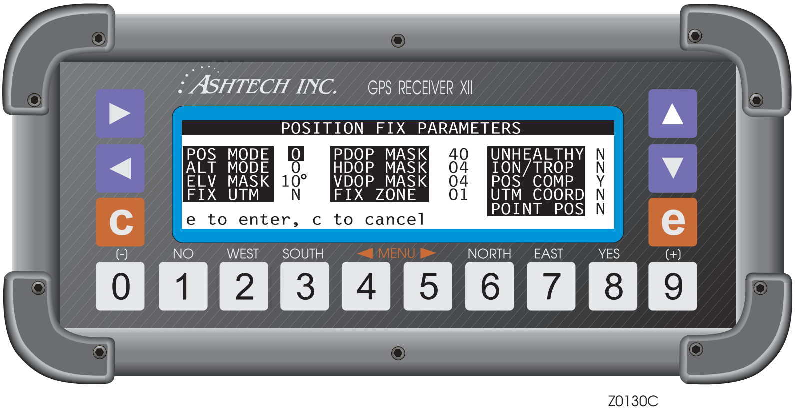


Figure 3.7. Position Fix Parameters

To set a parameter, push the **[e]** key and use the arrow keys to move to the desired parameter. Press the numbered keys, typing zero where necessary. When a field is full, the cursor automatically jumps to the next one. Press **[e]** to save the values and return to Screen 4.

Table 3.8 describes the screen parameters.

Table 3.8. Position Fix Parameters

Parameter	Description
POS MODE	Lets you specify whether to compute altitude or hold it fixed. The field can contain a value ranging from 0 through 3. To be used for position computation, a satellite must be higher than the ELV MASK specified on this subscreen. • 0 specifies that at least 4 satellites be tracked before the receiver computes position. Altitude is never held fixed (default). The following settings for POS MODE require a minimum of three satellites to compute position. • 1 specifies that three satellites are locked, the receiver holds altitude fixed. When more than three are locked, the receiver computes altitude. • 2 specifies when the altitude is always held fixed regardless of the number of satellites tracked. • 3 specifies when 3 satellites are locked, the receiver holds altitude fixed. When more than 3 are locked and HDOP is less than the specified HDOP MASK, it computes altitude. When more than 3 are locked and HDOP is equal to or greater than the specified HDOP MASK, the receiver holds altitude fixed. Remember that when the receiver is first turned on, the altitude is zero. If position mode is set to a value of 1, 2, or 3, enter a value for altitude in the POS field of Screen 4.
ALT MODE	Lets you specify which altitude to use in an altitude fixed position solution. This field can contain 0 or 1 value. • 0 uses last entered altitude or last altitude computed if it was computed with VDOP less than the specified VDOP MASK, depending on which altitude is the most recent. • 1 uses only the altitude entered on Screen 4.
ELV MASK	Allows you to set the minimum elevation angle below which no satellite data are used to compute a position.
FIX UTM	Enables or disables the fixing of the UTM zone. This command is used when you are near a UTM boundary, the receiver is outputting position in UTM coordinates, and you do not want coordinates to shift from one zone to another when the boundary is crossed. Must be used in conjunction with FIX ZONE described below.
PDOP MASK	Lets you define the positional dilution-of-precision parameter. The receiver does not compute position when PDOP exceeds the specified value. The default is 40.

Table 3.8. Position Fix Parameters (continued)

Parameter	Description
HDOP MASK	Lets you define horizontal dilution-of-precision. Effective only when POSITION MODE is set to 3. The default is 4.
VDOP MASK	Lets you define the vertical dilution-of-precision parameter. Effective only when ALT MODE is 0. Default is 4.
FIX ZONE	Lets you set the UTM zone to be held fixed as described above for FIX UTM. Must be used in conjunction with FIX UTM.
UNHEALTHY	Lets you specify whether or not to include unhealthy satellites in the position computation. If Y is specified, a satellite broadcasting an unhealthy message is used to compute a navigation position. Please note that this parameter does not affect data collection for an unhealthy satellite.
ION/TROP	Allows you to enable or disable the ionospheric and tropospheric models to be used in position computation. • M = mathematical ionosphere and mathematical tropospheric models • R = real dual-frequency ionospheric model used, together with the mathematical tropospheric model • N = no model used (default)
POS COMP	Lets you enable or disable the computation of position. USE WITH CAUTION.
UTM COORD	Lets you specify whether to display the compound position in Screen 2 using geodetic coordinates (latitude, longitude) or UTM (east, north) coordinates. If set to Y, UTM coordinates are computed and displayed using the current grid zone.
POINT POS	POINT POS improves the accuracy of a stand-alone absolute position of a stationary receiver from about 50 meters to less than five meters over a period of four hours. Point positioning uses an averaging technique to reduce the effects of SA and other fluctuating errors. The point positioning option must be installed to use this command.

Differential Mode Selection

The differential mode subscreen allows you to set up the receiver as an RTCM differential base or rover (Figure 3.8). This screen also gives access to lower-level screens where you specify parameters such as RTCM format parameters. This is accessed by selecting DIFFERNTL on Screen 4 and pressing the **[e]** key. If you do not have the Differential (D) option installed, this subscreen is unavailable. Table 3.9 describes the screen parameters.

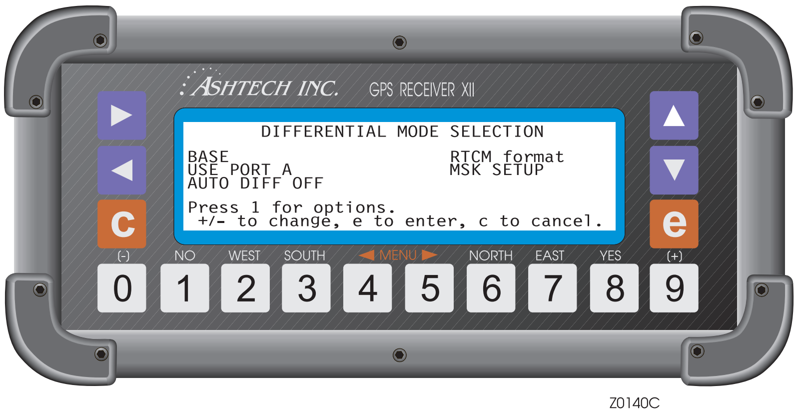


Figure 3.8. Differential Mode Selection Subscreen

Table 3.9. Differential Mode Parameters

Parameter	Description
BASE	Toggle field sets the receiver to **BASE**, **REMOTE**, or **DISABLED** mode. Use an arrow key to highlight the mode indicator and press the **+** or **-** key to toggle it.
RTCM format	The 1 key allows you to access the RTCM option subscreen. This subscreen contains several parameters and is described in Chapter 4, *Advanced Survey Applications*.
USE PORT A	Lets you specify which port to use for differential mode. Press the **[+]** or **[-]** key to toggle through **PORT A, B, C,** or **D** to correspond with the one you are using. Press **[e]** to save.
MSK SETUP	Sets up interface with MSK (Minimum Shift Keying) transmitter. See MSK Setup discussion following this table.
AUTO DIFF OFF	If set to ON, the receiver automatically switches position computation from differential to stand-alone mode when the max age of the differential corrections is exceeded, or differential corrections are not available. Valid only when the receiver is set as a REMOTE.

MSK Setup

Highlighting MSK Setup and press the **[e]** key to access the MSK Setup Menu (Figure 3.9). This menu is applicable only to specialized applications (e.g. US Coast Guard) where the receiver is used in conjunction with an MSK (Minimum Shift Keying) transmitter. Table 3.10 describes the MSK functions.

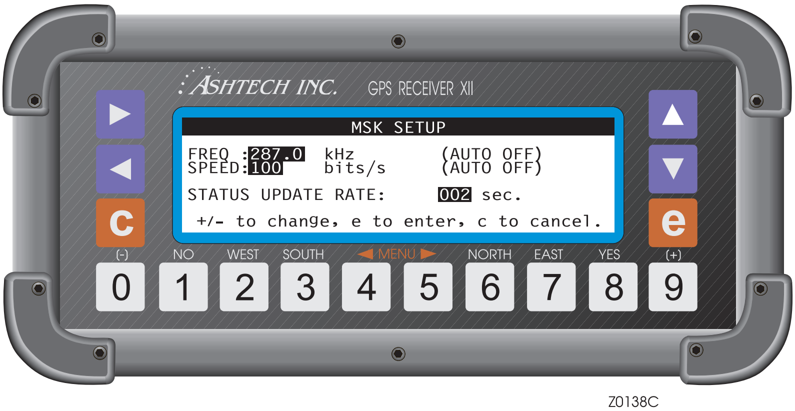


Figure 3.9. MSK Setup Menu

Table 3.10. MSK Setup Parameters

Parameter	Description
FREQ:	Sets channel 1 frequency in kHz.
SPEED:	Sets keying speed in bits per second.
SNR	Signal-to-noise ratio in dB.
SS	Signal strength in dBmicroV.

Session Program Parameters

The Session Program feature allows you to preset up to 10 observation sessions in the receiver. This option can be useful to normal data collection and is particularly useful when used with the Remote Monitor program in your computer. With the Remote Monitor program and a modem, you can operate a receiver that has been left in a remote location, and download its data files from across the world if necessary.

Initial settings can be made on the receiver and it can be left running. Access this screen (Figure 3.10) from SESSION on Screen 4.

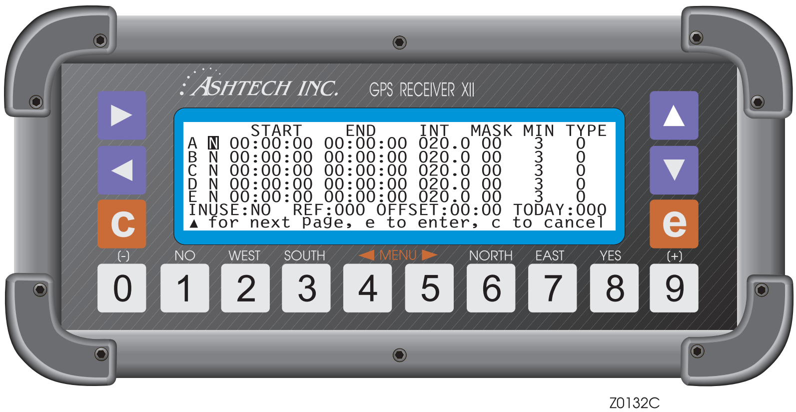


Figure 3.10. SESSION Subscreen

The first column on the left contains the session identifier. Ten sessions, labeled A through J, are possible.

The second column is an individual session toggle. If it is set to Y, the session programmed on this line is activated. If it is set to N, the session is not used. Use the **[8]** and **[1]** keys to toggle the Y and N. Note that sessions are activated only when INUSE is also set to Y or SLP. Individual session parameters are detailed in Table 3.11.

Table 3.11. Session Parameters

Parameter	Description
START	Enter the session start time in hours, minutes, and seconds. If an erroneous value is put here (like 25 hours), it either resets it to 0 or restores the last legal value that it contained.
END	Enter the session end time here. If the end time is earlier than the start time, the session runs into the following day.
INT	Enter data sampling rate in seconds. Values between 000.5 and 999.5 seconds are accepted in ½-second increments.
MASK	Enter the satellite elevation mask in degrees.

Table 3.11. Session Parameters (continued)

Parameter	Description
MIN	The minimum number of satellites that must be visible before the session begins collecting data. The values here for INT, MASK, and MIN override the values set in Screen 4 while this session is running. These values are displayed in Screen 4 when the session goes active and overwrites Screen 4 parameters
TYPE	Refers to the data type collected. Enter 0 for normal geodetic data or 2 for a position-only C-file.
INUSE	A master switch for all sessions. • If INUSE is set to NO, no programmed sessions run, regardless of its individual session setting. If INUSE is set to YES, activates any sessions where the individual session toggle is set to Y. • If the sleep option has been loaded into the receiver, SLP activates the sleep mode. It works essentially like YES, but turns the receiver off between sessions to conserve power. When activated, the sleep mode can be overridden by pressing any key on the front panel of the receiver. Use + and - to toggle. • Whenever INUSE is set to YES, the active file is closed and a new one opened, and the SESSION field flashes, indicating session programming is enabled. When a session goes active, a flashing arrow is displayed by SESSION on Screen 4, indicating data is being recorded.
REF	The reference day (day of the year) for the start and end times. If REF is set to 000, the session does not run. If REF is set to a day of the year later than the present, session programming does not start until REF equals today. If REF is set to a day of the year previous to the present, session programming starts in the present day, applying the offset selected with the REF day as explained in OFFSET.
OFFSET	The displacement of minutes and seconds from the reference day. For a day subsequent to the REF day, the start and end times are decremented by the minutes and seconds specified in OFFSET, multiplied by the day number. (For example, if the offset is 04:00, day 1 is offset 4 minutes, day 2 is offset 8 minutes.) If set to 00:00, the sessions observe during the same time every day. For example, assume a start time for session A of 02:10, an end time is 03:10, REF is day 100, and the OFFSET is 04:00 (4 minutes). If the reference day and offset are not changed on day 101, the start time for session A is 02:06 and the end time is 03:06, or 4 minutes earlier than day 100, thus the receiver can observe the same part of the window every day.

Receiver Control Subscreen

Use the RECEIVER CONTROL subscreen (Figure 3.11) to control the operating mode of the receiver and how data and positions are stored.

Figure 3.11. Receiver Control Subscreen

Z MODE allows you to control when Z tracking is implemented. Z tracking is a method of providing full-wavelength dual-band P-Code data when anti-spoofing (A/S) is present. This parameter can be toggled to A (automatic), Y(es), or N(o):

A - the receiver reverts to Z mode when A/S is detected (default)

Y - the receiver is set to Z mode at all times.

N - the receiver never goes into Z mode.

RANGER MODE controls how data and positions are stored:

0 - indicates geodetic mode. Stores phase data in B-files that can be post-processed differentially using carrier phase or code phase.

1 - stores phase data in B-files that can be post-processed differentially using code phase only. Mode 1 can store more than twice the number of positions as mode 0.

2 - stores smoothed positions in C-files only. These positions can be differentially corrected in real time; they can not be post-processed differentially.

Serial Port Setting

Four RS-232 serial ports are available in the receiver. Two of the ports, A and C, can be accessed through the 16-pin connector labeled PORT 1 on the rear panel. The other two, B and D, can be accessed through PORT 2.

Pin functions for the RS-232 cable that should be used to access the serial ports are described in Appendix C. Two different serial port cables are available: a single RS-232 cable, P/N 700617 for ports A or B, and a dual serial cable, P/N 700619, for ports A and C or B and D.

All ports output real-time messages, NMEA messages, VTS messages, accept serial port commands, hose data, and operate in differential mode.

Following is a description of the screens and settings for all four serial ports.

Port A/Port B/Port C/Port D Parameter Selection

The Port A Parameter Selection subscreen (Figure 3.12) allows you to specify modes and rate of transmission for serial port A. Access this screen by selecting PORT A on Screen 4. Similarly for Port B, C, or D. Table 3.12 describes the screen parameters.

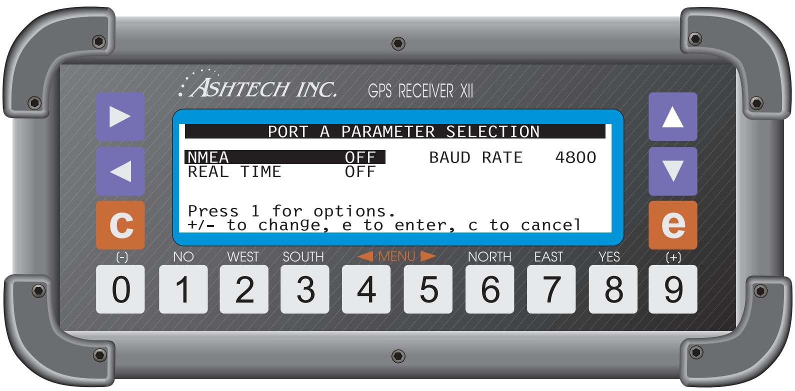


Figure 3.12. Port A Parameter Selection

Table 3.12. Port Parameter Selection Screen Parameters

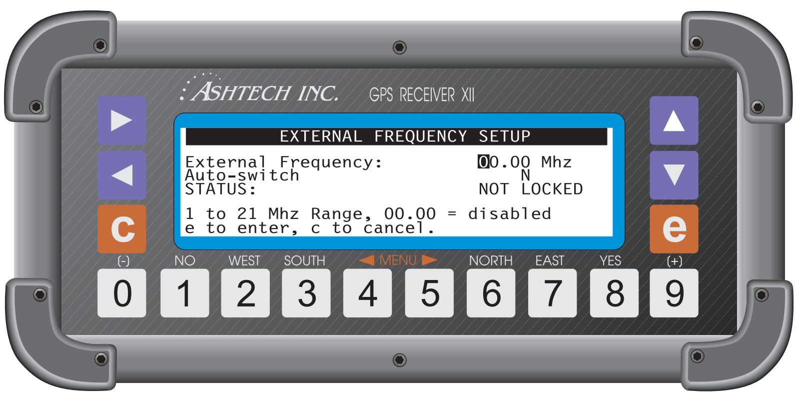
Parameter	Description
NMEA	Toggles the outputs of NMEA messages through Port A. Highlight NMEA and press the **[+]** or **[-]** key to toggle it ON. Press **[1]** to access the NMEA message subscreen. For an explanation of how to set the receiver to output NMEA messages, and for a list of NMEA formats, see Appendix B.

Table 3.12. Port Parameter Selection Screen Parameters (continued)

Parameter	Description
BAUD RATE	If the default baud rate of 9600 bits per second is not satisfactory, highlight the BAUD RATE indicator and press the [+] key or [-] key to toggle it to the desired baud rate.
REAL TIME	Toggles the serial output of real-time or raw data messages. Highlight REAL TIME and press the [+] or [-] key to toggle it on. Press [1] to access the REAL TIME message subscreen. Appendix B defines commands and data formats, as well as how to set the receiver to output real-time data.

External Frequency Setup

This option lets you input an external frequency to override the receiver’s internal oscillator. To configure an external frequency, go to Screen 4 and select EXT FREQ (Figure 3.13). Table 3.13 describes the screen parameters.



Z0124C

Figure 3.13. External Frequency Setup Screen

Table 3.13. External Frequency Parameters

Parameter	Description
External Frequency	Sets the receiver to the input frequency of the external reference source. Range is 1.00 to 21.00 MHz.
Auto-switch	Toggles Y(es) or N(o). **Y** saves the external frequency parameters after a power cycle. **N** resets the receiver to its internal oscillator after a power cycle.

Press **[e]** to save the parameters. A status display indicates when the external reference is locked.   When locked, pressing **[e]** exits that display. If you do not have the external frequency option, you can not access this subscreen.

Pulse Generation Parameters

A one-pulse-per-second (PPS) output option is available. The PPS signal is a TTL signal into a 75-ohm impedance. The signal is normally low and goes high 1 to 2 ms before the falling edge. The rising edge is synchronized with GPS time, as shown in Figure 3.14. The signal is synchronized with GPS time. Access the Pulse Generation screen (Figure 3.15) by selecting PULSE GEN on Screen 4. Table 3.14 describes the pulse generation parameters.

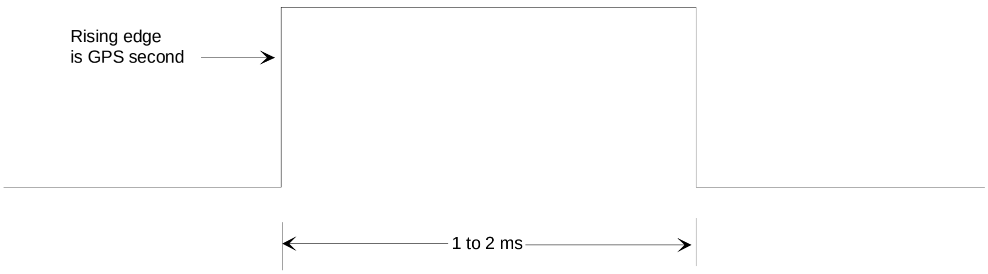


Figure 3.14. One PPS Signal Characteristics

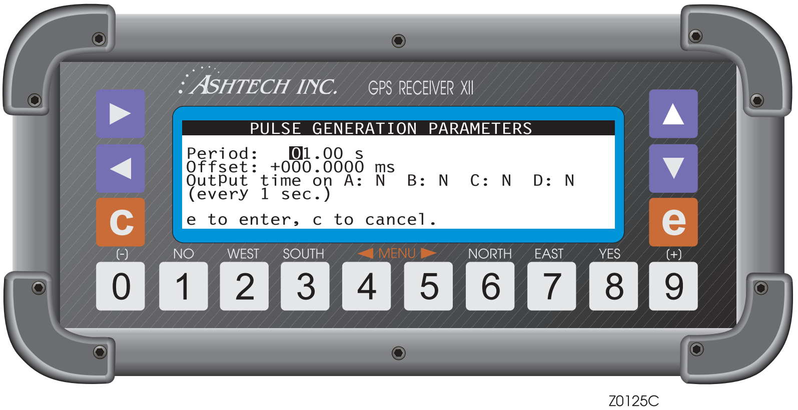


Figure 3.15. Pulse Generation Parameters Screen

Table 3.14. Pulse Generation Parameters

Parameter	Description
PERIOD	The period of the PPS option may be changed from a half second up to a maximum of 60 seconds. Default is 1 second.
OFFSET	PPS may be advanced or delayed up to 500 ms in 100-nanosecond steps. After you specify the period and offset, press **[e]** to save.
OUTPUT TIME ON A:N B:N C:N D:N	Output time message once every second, synchronized with GPS time (rising edge of pulse is also synchronized with GPS time) through serial port A, B, C, or D. Message format is: $PASHR,PPS,dddddd where **dddddd** is the time in seconds of the week

After issuing the 990 command, the falling edge of the pulse is synchronized with GPS time. After issuing the 991 command, the rising edge is synchronized with GPS time.

Datum Select Subscreen

This option lets you specify the datum of the receiver calculated pseudo-range option, or input the parameters for a user-defined datum. (The default is WGS-84.) The datum selected in this screen is only used to compute the position displayed in screen 2. The position stored in memory is always computed using datum WGS-84.

The first datum subscreen is reached by selecting DATUM on Screen 4 (Figure 3.16).

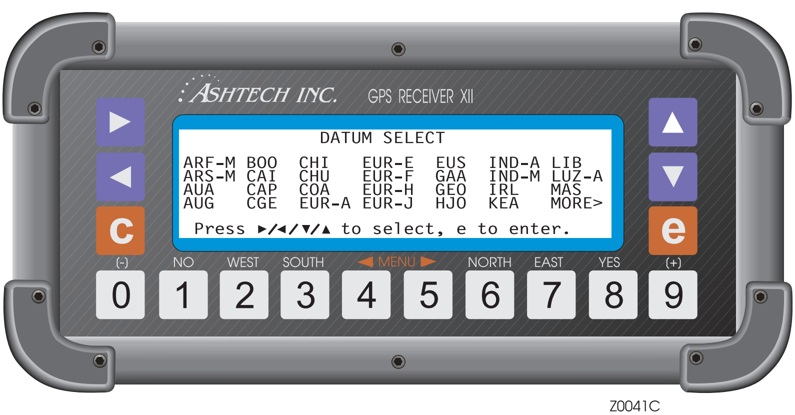


Figure 3.16. Datum Select Subscreen

To select a datum, use the arrow keys to highlight the desired datum and press the **[e]** key; this captures your selection and exits to Screen 4. You can check your selection by returning to Screen 2; the selected datum appears in the upper left.

If the datum you want does not appear on this subscreen, highlight **MORE** and press the **[e]** key. When ARF-M is highlighted, press the left arrow to jump the cursor to **MORE**. This displays the next datums that are available (Figure 3.17). Select MORE again to view the remaining datums.

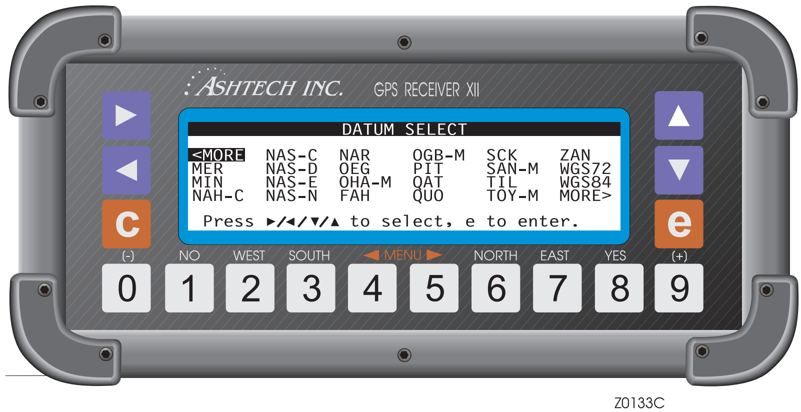


Figure 3.17. More Datums

Fifty datum selections are available under this option. For a complete list, alphabetic by datum, of the transformation parameters that each datum applies to the pseudo-range positions, see Appendix E.

USER lets you input your own datum parameters (Figure 3.18). Table 3.15 describes the screen parameters.

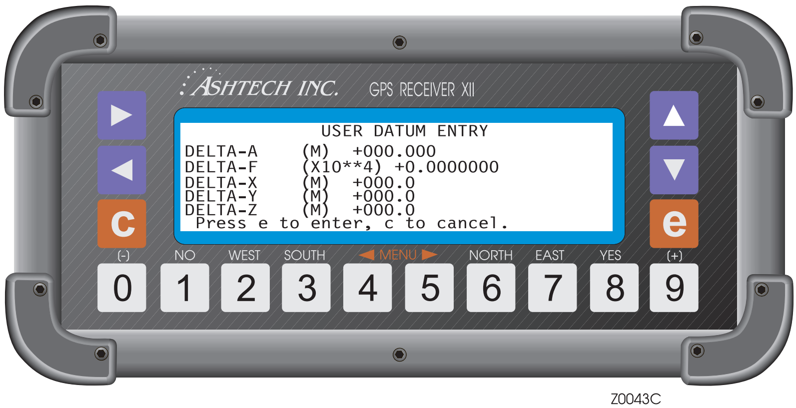


Figure 3.18. User Datum Subscreen

Table 3.15. User Datum Parameters

Parameter	Description
DELTA-A	The difference in the length of the semi-major axis between the WGS-84 reference ellipsoid and the user-defined reference ellipsoid.
DELTA-F	The difference in flattening parameters ($1/f \times 10^4$) between the WGS-84 reference ellipsoid and the user-defined ellipsoid.
DELTA-X DELTA-Y DELTA-Z	The difference in the X, Y, and Z translation parameters between the WGS-84 reference ellipsoid and the user-defined ellipsoid.

Use the number keys to enter values in each field. Define:

delta semi-major axis (a) or delta flattening (1/f) ellipsoid parameters

delta x, y, z translation parameters

To log the values and return to Screen 4, press **[e]**.

You can check your selection by returning to Screen 2; the label USER is visible in the title line. Positions output in this configuration align to the user-defined datum.

Modem Setup Subscreen

This option lets you select the modem type and the port through which data transmit in remote mode. These functions are accessed by selecting MODEM on Screen 4 and pressing the **[e]** key (Figure 3.19) and detailed in Table 3.16.

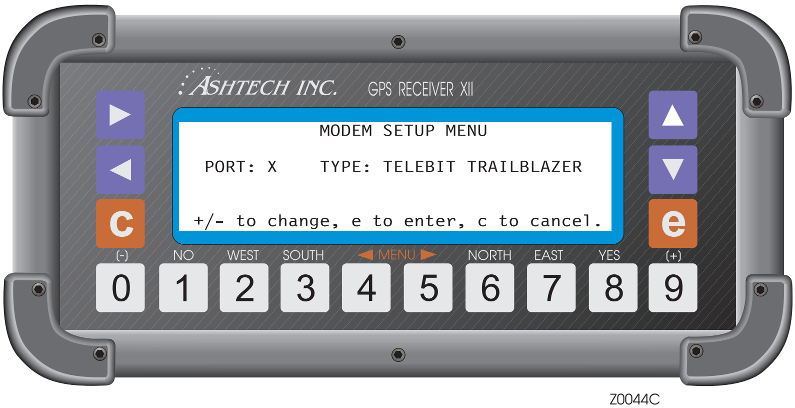


Figure 3.19. Modem Setup Subscreen

Table 3.16. Modem Setup Parameters

Parameter	Description
PORT	Outputs through the specified port. Press the **[+]** or **[-]** key to toggle it to A, B, C, or D.
TYPE	Lets you select the type of modem. The types of modem currently supported are Telebit® Worldblazer, Trailblazer, Cellblazer, and a user-defined modem. To save the selection, press **[e]**. The receiver transmits from the specified port and returns you to Screen 4.

If you are using a modem not listed under TYPE, select USER DEFINED, then press the down arrow key to enter the initialization string (Figure 3.20).

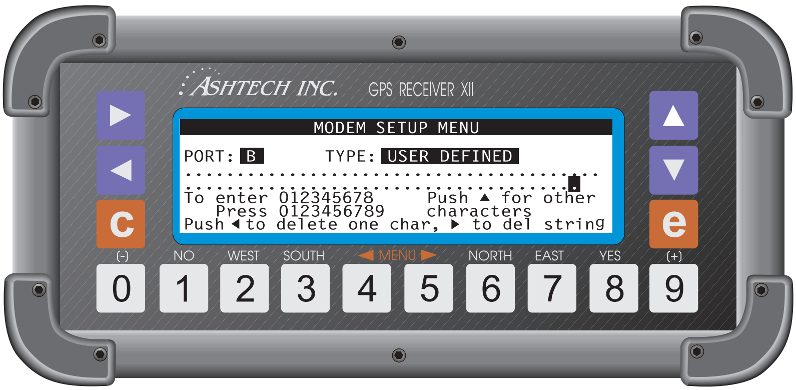


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Figure 3.20. Modem Initialization String

Below the PORT/TYPE line are two lines where you can enter the initialization string for your modem. You must get this initialization string from the modem documentation or from the modem manufacturer. The modem initialization string can be quite long; a typical string is shown below.

> CFG,ATS111=255S45=255S51=252S58=2S0=1&D2&C1X12E0Q0&W\r\n,MOD,AT&F1\r\n,NAM,US_ROBOTICS,D2c+++AT,C2D,ATO\r\n<CARRIAGERTN> <LINE FEED>

If your initialization string requires characters other than the numbers 0 through 8, press the up button to display more characters, i.e., the alphabet, special characters such as #,*,&,+, etc. After you have entered the string, press the up button until you see CARRIAGE RTN. Enter CARRIAGE RTN, then press the up button again to display LINE FEED. Enter LINE FEED. Now press the **[e]** key to save the string.

Subcommands Subscreen

The SUBCMDS option lets you enter system-level commands; this can also be done through Screen 8. To enter a command, go to Screen 4 and select the SUBCMDS option (Figure 3.21).

Figure 3.21. Subcommands Subscreen

To enter a system-level command, press **[e]** for data-entry mode, then use the numbered keys to enter a 3-digit command. For example, to save user parameters, enter the numeric command **[5]**, **[5]**, **[5]** into the data-entry field and press **[e]** again. The receiver executes the command and returns you to Screen 4.

Table 3.17 lists the available commands.

Table 3.17. Available Commands

Command	Function
100	Turn off backlighting after 2 minutes since last key press. (Default)
101	Keep backlighting on. Warning: if backlighting is on, the receiver draws significantly more power.
123	Close a file.
191	Initialize the modem.
300	Enter/display position in Screen 4 in deg/min format (default)
301	Enter/display position in Screen 4 in deg/min/sec format.
550	Reset receiver to original default values.
555	Save user parameters
737	Initialize (reset) RTCM

Table 3.17. Available Commands (continued)

Command	Function
888	Display configuration identification (information such as serial number, list of installed options, nav board, channel board).
990	Trigger photogrammetry on falling edge.
991	Trigger photogrammetry on rising edge
999	Delete all photogrammetry pictures.

For a detailed explanation of each of the commands, see Screen 8.

Screen 5 - Differential Information/Residuals Error/MSK Status

Three different displays are available in this screen:

- Page 1 displays differential information
- Page 2 displays range residuals and position error information
- Page 3 displays MSK status. To toggle between the pages, press the up or down arrows.

RTCM Information

The RTCM information displayed on Screen 5 depends on whether the unit is set as a base or remote station. In base mode, it displays information about transmitted messages; in remote mode, data from received messages (Figure 3.22). Table 3.18 describes the screen parameters.

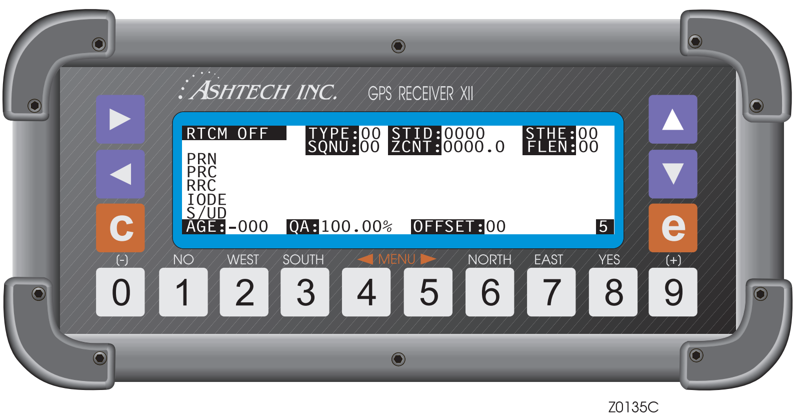

Figure 3.22. Message Data - Screen 5

Table 3.18. Message Parameters

Parameter	Description
RTCM	Displays the receiver's current RTCM mode (OFF, BASE, or REMOTE).
TYPE	Indicates the type of message that is being generated (BASE) or that is being received (ROVER).
STID	The reference station identification, set on the RTCM Options screen (base mode) or received from the base station.

Table 3.18. Message Parameters (continued)

Parameter	Description
STHE	The reference station health, set on the RTCM Options screen (base mode) or received from the base station.
SYNC	Indicates that the receiver is synchronous with a message. It has decoded a message, captured its sequence number (SQNU), and found that its parity was good. The receiver displays a question mark (?) when a given message does not carry the next sequential number expected by the receiver. The question mark may be displayed for the first message since there is no previous message with which to be in sequence.
SQNU	The RTC, message sequence number, generated by the base or received by the remote receiver.
ZCNT	is the RTCM message Z-count.
FLEN	Contains the RTCM message frame length.
PRN	The satellite PRN number.
PRC	The pseudo-range correction in meters. Negative numbers are shown in inverse video.
RRC	The range-rate correction in centimeters per second. Negative numbers are shown in inverse video.
IODE	The issue of the data.
S/UD	The scale factor and user-differential range error.
AGE	For remote mode, shows the age of received messages in seconds. In base mode, gives the time elapsed in seconds since the beginning of the transmission of a type 1 message until a new type 1 message is generated.
QA	The communication-quality factor, defined as: (number of good messages / total number of messages) x 100
OFFSET	The number of bits from the beginning of the RTCM byte in case of bit slippage.

Range Residuals

Page 2 of Screen 5 (Figure 3.23) displays the range residuals and position errors determined during position computation. Table 3.19 describes the screen parameters.

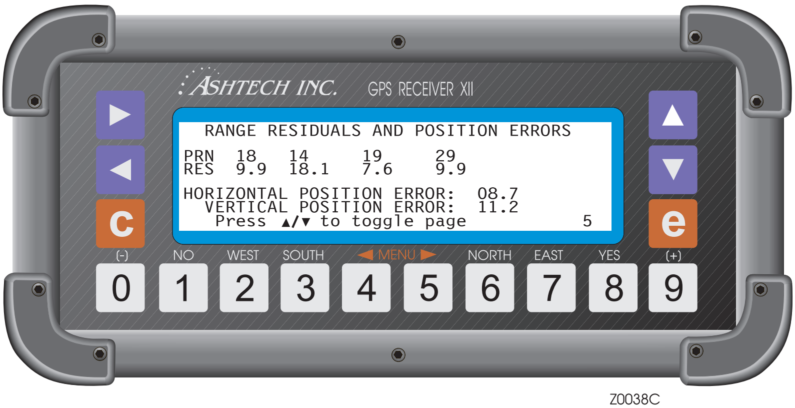

Figure 3.23. Screen 5, Page 2

Table 3.19. Range Residual Parameters

Parameter	Description
PRN	PRN number of satellites being tracked.
RES	Range residual associated with each satellite.
HORIZONTAL/VERTICAL POSITION ERROR:	Horizontal/vertical RMS position error in meters.

MSK Status Menu

Page 3 of Screen 5 (Figure 3.24) displays the status of MSK (Minimum Shift Key) transmission. The screen is applicable only when the receiver is used in conjunction with an MSK transmitter.

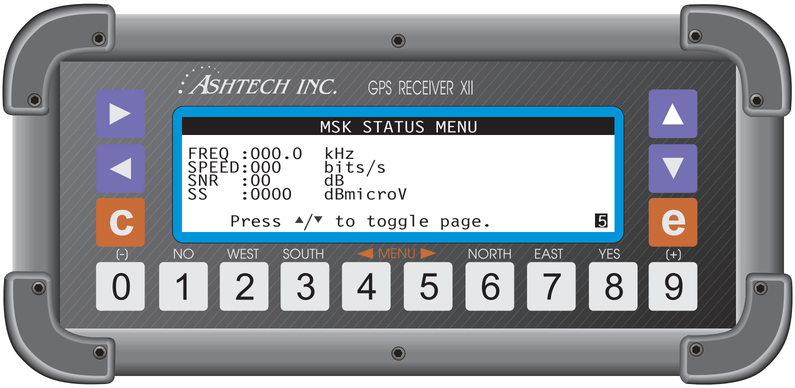

Figure 3.24. Screen5, Page 3 - MSK Status

Table 3.20. MSK Transmission Parameters

Parameter	Description
Freq	Frequency of the MSK transmission in KHz.
Speed	Speed of the MSK transmission in bits per second.
SNR	Signal-to-noise ratio
SS	Signal strength

Screen 6 - Waypoint Control

The Navigation Option allows you to define a navigation route and enter the latitude and longitude of each waypoint included in the route. Knowing the route information and the coordinates of each point, the receiver can compute the distance between the present position and the next destination point (DTD), the course to follow to reach the next destination point (CTD), the time required to reach this point (TTD) based on the present speed over ground, and the cross track error (XTE) which is the deviation from the track between the present position and the next destination waypoint. All this navigation information is displayed in Screen 2.

After accessing Screen 6 (Figure 3.25) the top line indicates the route information, in terms of waypoint numbers, where the current leg is highlighted. The remaining screen displays a list of records showing the current and next waypoints in the route. Each waypoint record consists of a 2-digit waypoint number, a 7 character name, a latitude, and a longitude. Coordinates are entered in degrees, minutes, decimal minutes. Up to 99 waypoints can be stored and a route can be composed of up to 20 waypoints.

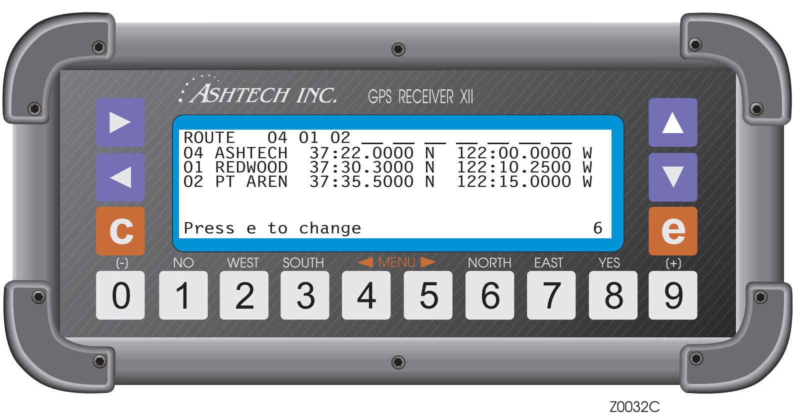

Figure 3.25. Screen 6 - Waypoint Control

If no information has yet been defined, Screen 6 shows the route with only waypoint 01, and the list of records show waypoint 01 with no name and coordinates.

Within Screen 6 the menu allows you to enter the information required for this option to be active. To access these functions, go to Screen 6 and press **[e]** (Figure 3.26).

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Figure 3.26. Screen 6 - Menu Functions

To activate all functions, press the corresponding number and the screen changes for that function. Alternatively, highlight the function and press **[e]**.

To see the options associated with functions 2,5 and 6, highlight the function and press [1].

The two main functions within this menu are: **4: EDIT ROUTE** and **3: EDIT WAYPOINT**. EDIT ROUTE allows you to create or edit a route, and add or delete points from the route. EDIT WAYPOINT allows you to define a list of waypoint records (associated or not with the route) where the name and coordinates of each waypoint have to be included.

1: Log Present Pos

This function allows you to save your present location as a waypoint. When you select 1: LOG PRESENT POS, the receiver records its current latitude and longitude in the next available waypoint in the list and names it HERE_XX, where XX is the next sequential number beginning from 01. Up to 99 positions (HERE_01 to HERE_99) can be logged this way. The logged position is momentarily displayed in Screen 6, in the first waypoint line, acknowledging it was stored. Next time Screen 6 is accessed, the first waypoint line shows the first waypoint of the route (Figure 3.27).

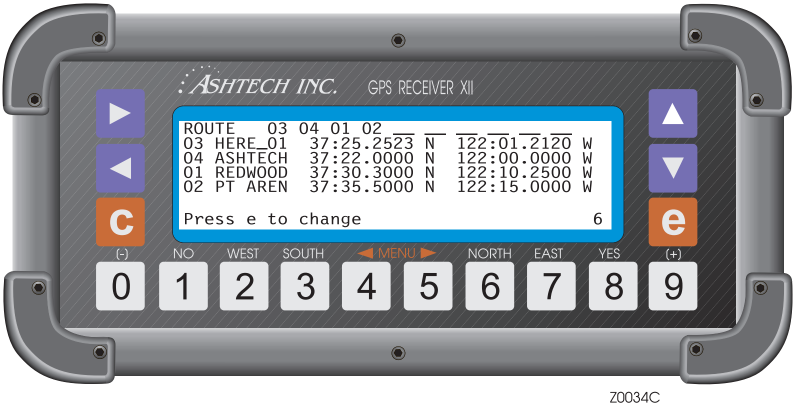


Figure 3.27. Screen 6 - Waypoints

2: Set Display

This function specifies whether the list of records displayed in Screen 6 is the list of waypoints that make the route, or a specific set of selected waypoints.

To access this function highlight "SET DISPLAY" and press **[1]** (Figure 3.28).

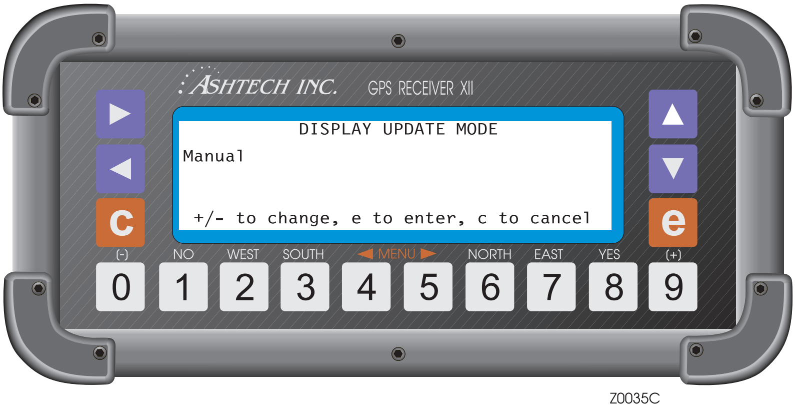


Figure 3.28. Set Display

Press **[+]** or **[-]** to toggle between MANUAL and AUTOMATIC. When the AUTOMATIC option is selected, the receiver automatically displays the list of records of the current and next waypoints in the route. By default the receiver is set to AUTOMATIC. If instead, MANUAL is selected, the receiver displays a specific set of selected waypoints. To save this selection and return to the main menu, press **[e]**.

To define the set of waypoints displayed in MANUAL mode, proceed as follows:

1. Highlight the function "SET DISPLAY" and press **[e]**. A simulation of Screen 6, without the route, displays (Figure 3.29).

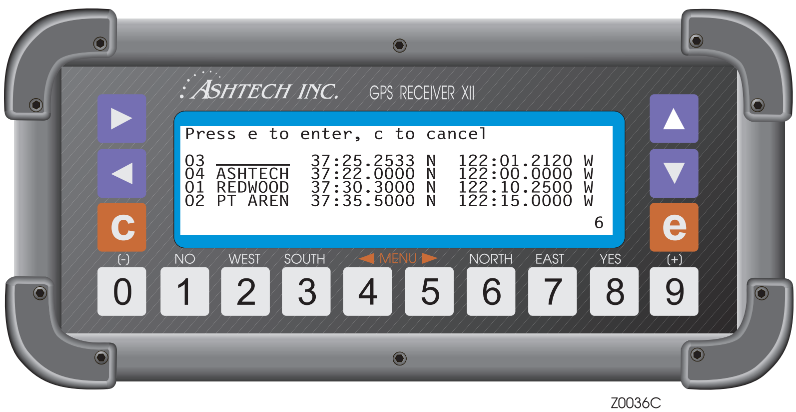


Figure 3.29. Screen 6 - Without Route

2. The first record entry number is highlighted. Using the up and down arrows, scroll through the list until the desired waypoint is found. Or, using the numbered keys, enter the waypoint number, and the name and coordinates of that waypoint displays.
3. Using the right arrow, select the next waypoint.
4. Continue selecting until satisfied.
5. Press **[e]** and the set of selected waypoints display in Screen 6.

   To return Screen 6 to the waypoints list, select AUTOMATIC.

3: Edit Waypoint

This function lets you create, edit and/or clear a waypoint, and to copy the information of one waypoint to another.

To access this function highlight EDIT WAYPOINT, and press **[e]** (Figure 3.30).

Figure 3.30. Edit Waypoint

To edit a waypoint proceed as follows:

1. With the waypoint number highlighted, cycle through the list of waypoints, using the up and down arrows, until the desired waypoint is displayed. Alternatively, using the numbered keys, enter the waypoint number.
2. Press the right arrow to move the cursor to the name field and to bring up the alphanumeric conversion table at the bottom of the screen. Enter the waypoint name See *"Entering a Site Name" on page 80* for more information.
3. Using the down arrow, move to the next field and overwrite the latitude (including N or S) and the longitude (including E or W). From the data field, press **[e]** to save the waypoint information. Note that the up and down arrows allow you to move from one field to the other, while the left and right arrows allow you to move from one character to the other.

The EDIT WAYPOINT option has three additional functions available: CLEAR, HERE, and COPY FROM.

The CLEAR function allows you to clear the information of a waypoint. To use this function, do the following:

1. Select a waypoint with the waypoint number highlighted and using the up and down arrows, or the numbered keys.
2. Using the cursor, highlight the CLEAR field and press the **[e]** key. The name of the waypoint clears and the latitude and longitude reset to zero.
3. From the data field, press the **[e]** key to save the changes. If desired, you can edit a new waypoint.

4. Press **[e]** to return to the main screen.

The HERE function allows logging the current position into a selected waypoint (similar to the LOG POSITION option).

1. Select a waypoint with the waypoint number highlighted and using the up and down arrows, or the numbered keys.
2. Using the cursor, highlight the HERE field and press the **[e]** key. The current position logs to that waypoint position and the information displayed on the screen. The waypoint renames to HERE_XX, where XX is the next sequential number assigned to a logged position beginning from 01.
3. From the data field, press the **[e]** key to save the changes. If desired, you can edit a new waypoint.
4. Press **[e]** to return to the main screen.

The COPY FROM function allows you to copy the information of one waypoint to another.

1. Using the up and down arrows, or the numbered keys, select the waypoint you want to copy TO.
2. Using the cursor keys, highlight COPY FROM. A waypoint displays by the COPY FROM field and its coordinates display at the bottom of the screen. Using the up and down arrows, or the numbered keys, select the waypoint you want to copy FROM, as shown in Figure 3.31.

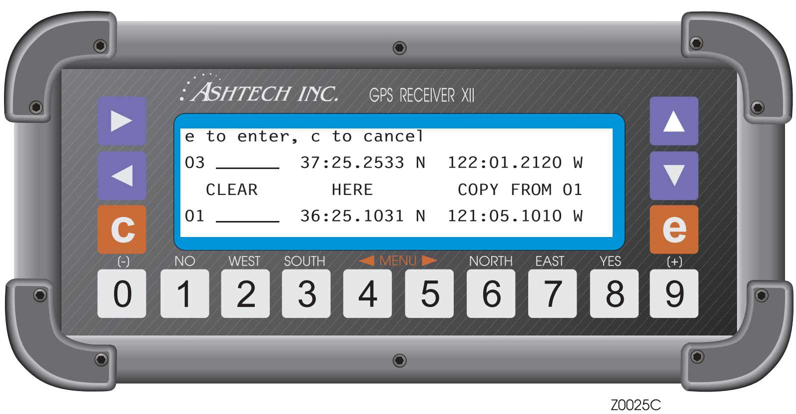


Figure 3.31. Copy Waypoint From

3. Press **[e]** and the FROM waypoint information is copied to the TO waypoint. Edit the copied information if necessary.
4. From the data field, press **[e]** to save the waypoint.

   If desired, you can now edit a new point. If not, press **[e]** to return to Screen 6.

4: Edit Route

This option allows you to create or modify a route. You can edit, add, or remove waypoints from the route, and also reverse the order of the waypoints in the route.To select this option, highlight EDIT ROUTE and press **[e]** (Figure 3.32).

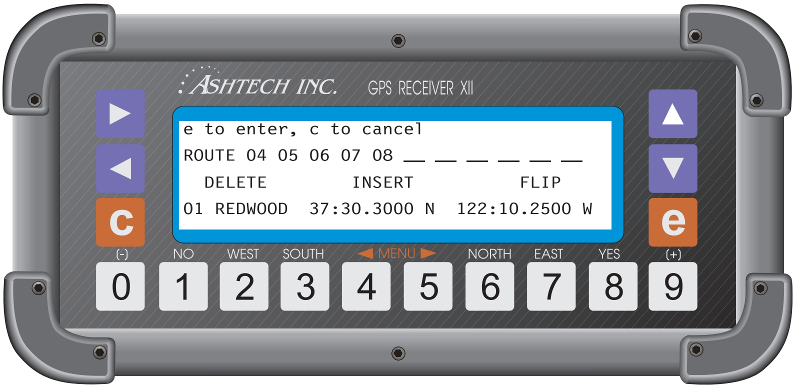


Figure 3.32. Edit Route

The screen shows the current route and, at the bottom of the screen, the information associated with the highlighted waypoint. To edit the route, highlight the point you want to edit and modify it as necessary. Use the left and right arrow keys to move the cursor from one waypoint to the other. The up arrow key allows you to scroll through the waypoint list and modify a waypoint number. Alternatively, you can use the numbered keys to modify the waypoint number.

The EDIT ROUTE option has three additional functions available: DELETE, INSERT, and FLIP.

The DELETE function allows you to delete a waypoint from the route.

1. Use the left and right arrows to highlight the waypoint you want to delete.
2. Using the down arrow and the left and right arrows, highlight DELETE. The selected waypoint blinks.
3. Press **[e]** and the waypoint is deleted.
4. Move the cursor up to the route field and press **[e]** to save the changes.
5. Press **[e]** or **[c]** to return to Screen 6.

The INSERT function allows you to add waypoints:

1. Using the left and right arrows, highlight the position in the route where you want to add the new waypoint.

2. Using the down arrow, and the left and right arrows, highlight INSERT. The selected waypoint blinks.
3. Press **[e]** and waypoint 01 is added. The waypoint previously in that position moves one location to the right and the added way point blinks.
4. Move the cursor up to the route field to edit the newly entered waypoint and press **[e]** to save.
5. Press **[e]** or **[c]** to return to Screen 6.

The FLIP function allows you to reverse the order of the waypoints in the route.

1. Using the down arrow and the left or right arrows, highlight FLIP.
2. Press **[e]** and the order of the waypoints in the route reverses. The last point is the first destination point of the previous route.
3. Move cursor to route field and press **[e]** to save change.
4. Press **[e]** or **[c]** to return to Screen 6.

5: Restart Route

The restart function allows you to instruct the receiver to modify the route according to two options available: restart the route from the beginning or restart the route from the nearest waypoint to your present position.

To select this function do the following:

1. Select RESTART ROUTE and press **[0]** (Figure 3.33).

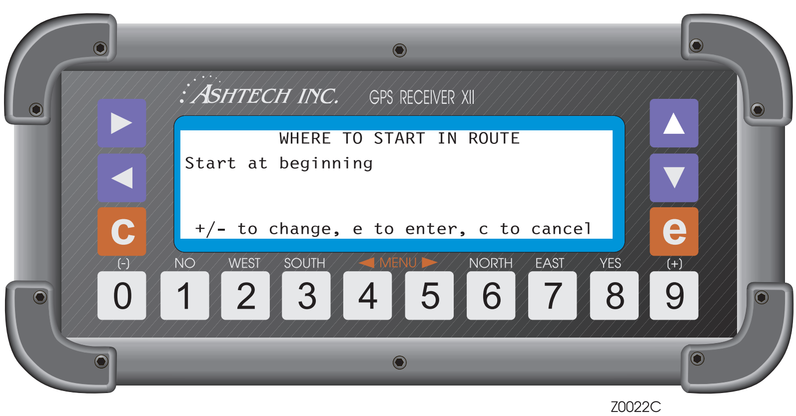


Figure 3.33. Restart Route

2. Using the + or - keys, toggle between "start at beginning" and "start at nearest". Select one.

3. Press **[e]** and the receiver restarts the route. If "start at beginning" were selected, the receiver points TO the first waypoint and uses the current position at that time to navigate FROM. The first waypoint is highlighted. If "start at nearest" were selected, the receiver computes the closest leg and uses this leg as the navigation reference. This leg in the route is highlighted.

6: Waypoint Switch

This function allows you to advance manually or automatically to the next leg of the route.

To access the options of this function highlight "WAYPT. SWITCH" and press 0 (Figure 3.34).

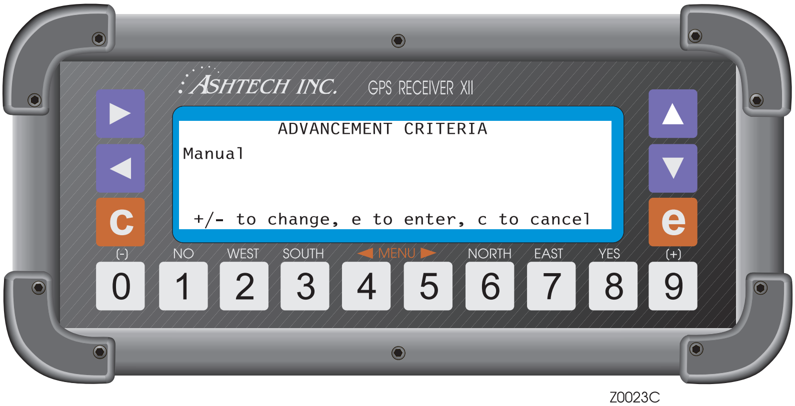


Figure 3.34. Waypoint Switch

Press + or - to toggle between MANUAL and AUTOMATIC, and press **[e]** to save the selection.

When the AUTOMATIC option is selected, the receiver automatically advances to the next leg of the route every time an imaginary angular bisector line (line dividing the angle between the present and next leg of the route in two) under the TO waypoint, or a perpendicular line over the TO waypoint, is crossed.

When the MANUAL option is selected, whenever the WAYPT.SWITCH function is activated (highlight WAYPT. SWITCH and press the **[e]** key), the receiver advances to the next leg of the route (Figure 3.35).

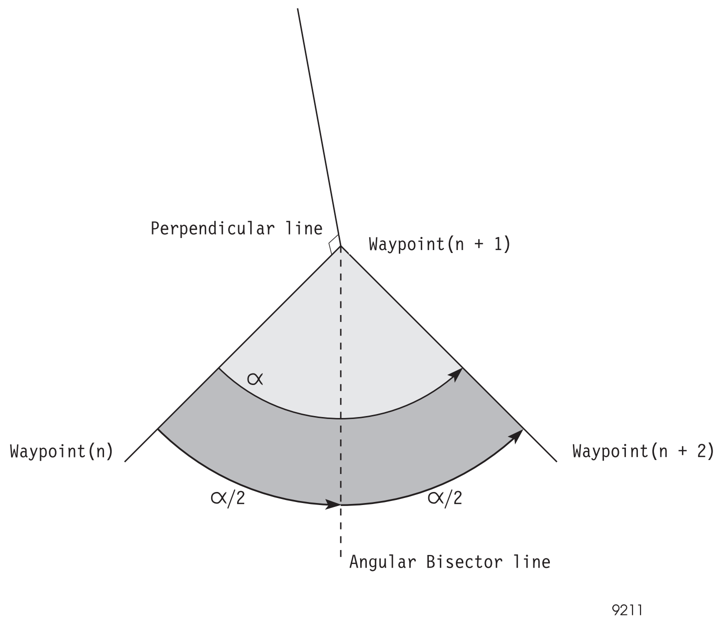


Figure 3.35. Next Leg

7: Range Bearing

This function calculates the range and bearing between any two consecutive waypoints in the route.

To use this function, highlight RANGE/BEARING and press **[e]** (Figure 3.36).

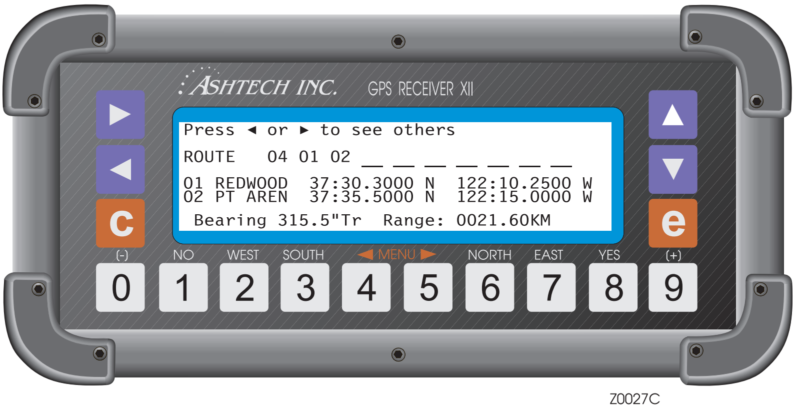


Figure 3.36. Route Display

The display shows the route being followed. One of the legs is highlighted and the coordinates of the waypoints associated with this leg are being displayed in the next two lines. The last line shows the bearing and range values for that leg. To display the range and bearing for a different leg, use the left and right arrows to move the cursor, and the information automatically displays at the bottom of the screen. Press **[e]** or **[c]** to return to the main screen.

8: Unit Selection

This function allows you to specify the units (miles, knots, kilometers) used to display the ALT (altitude), SOG (speed over ground), DTD (distance to destination), and XTE (cross track error) values in Screen 2.

To select this function, highlight UNIT SELECTION and press **[e]** (Figure 3.37).

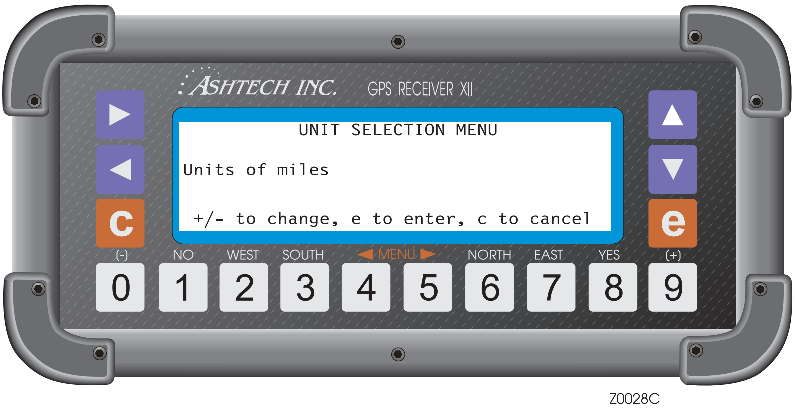


Figure 3.37. Unit Selection

Press + or - to toggle to MILES, KM, or KNOTS. Then press **[e]** to save the change and return to the main menu.

When MILES or KNOTS are specified, the altitude (ALT on Screen 2) is displayed in feet.

9: Magvar Mode

This function allows you to define the magnetic variation mode used when displaying the COG and CTD values in Screen 2 and VTG NMEA message, and the bearing value displayed in 7: RANGE/BEARING (Screen 6), and the APA and BWC NMEA messages.

To select this function, highlight **9:MAGVAR MODE** and press **[e]**. The magnetic variation mode screen (Figure 3.38) displays.

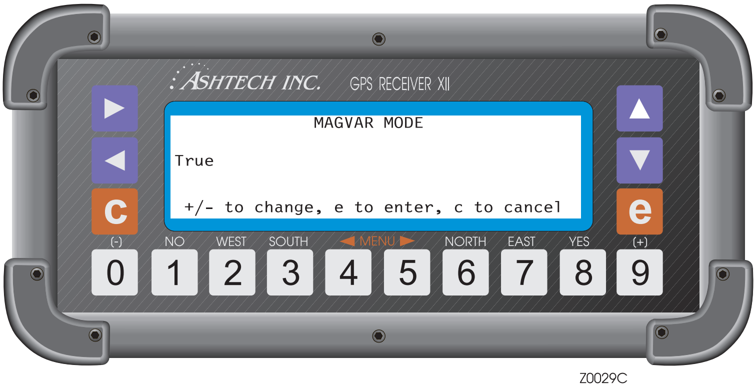


Figure 3.38. Magvar Mode

With the magnetic variation field highlighted, press + or - to toggle between the three modes available: TRUE, AUTOMATIC, or MANUAL.

When the TRUE mode is selected, the COG, CTD, and bearing values are displayed using true degrees (°T).

When the AUTOMATIC mode is selected, the magnetic variation used to display the COG, CTD, and bearing values are shown in the AUTO field. This value is determined, based on the current latitude and longitude, from the magnetic variation table. The COG, CTD, and bearing values are displayed in magnetic degrees (°Mg).

When the MANUAL mode is selected, the magnetic variation used to compute the COG, CTD, and bearing values is the one entered in the MANUAL field. These values display in magnetic degrees (°Mg) (Figure 3.39).

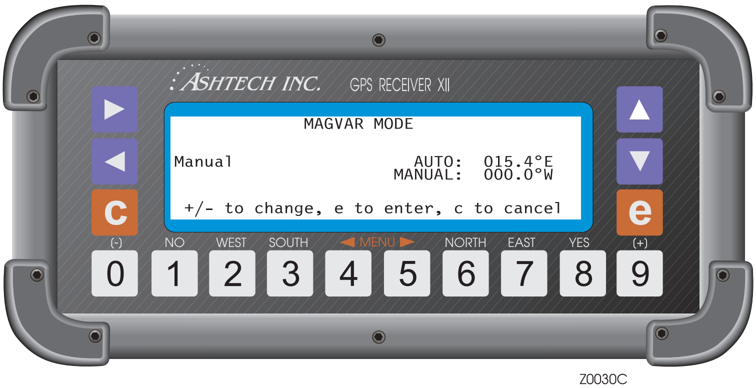


Figure 3.39. Magvar Manual Mode

Highlight the field by MANUAL and enter the magnetic variation to be used. The value displayed in the AUTO field is the value used when the AUTOMATIC mode is selected and is displayed just for reference.

To save the selection, press the **[e]** key. To exit without saving, press the **[c]** key.

Screen 7 - Satellite Selection Control

Use Screen 7 (Figure 3.40) to specify whether to include or omit specific satellites for tracking. Y indicates that the associated satellite are used; N means that are not used.

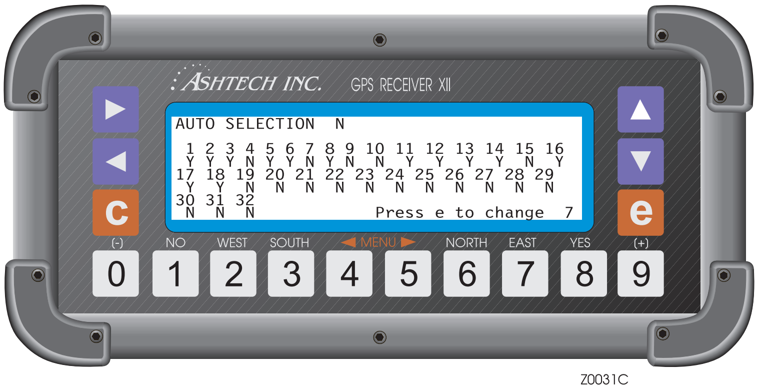


Figure 3.40. Screen 7 - Satellite Selection Control

Also on this screen, you can put the receiver in AUTOMATIC selection or in MANUAL mode by entering either a Y or an N in the AUTO SELECTION field. In automatic mode, all satellites flagged Y are considered for tracking. Of these, satellites that the receiver cannot lock on are replaced with others. Specifying Y for a satellite instructs the receiver to try to lock on, and, if it cannot, to replace it with another Y satellite. The receiver skips over those satellites designated N.

In manual mode (AUTO SELECTION is set to N), the letter Y in a satellite instructs the receiver to select that satellite even when it is not visible. The receiver does not replace it with any other satellite. In this mode, if you specify more than 12 satellites, the receiver uses only the 12 that were displayed on the 12 channels on Screen 0 at the time you went to manual mode. If you specify fewer than 12, the receiver tracks only the specified satellites.

To select the satellites you wish to use:

1. Press **[e]** to shift to data-entry mode. (A blinking cursor indicates that the screen is in data-entry mode.)
2. Press the left and right arrows to highlight the field you want to change.
3. Press **[8]** to include the satellite or **[1]** to omit it.
4. When the flag is acceptable, press **[e]** to save it in memory.

   Pressing **[c]** cancels all entries made since the first **[e]** was pressed.

Screen 8 - File Display and System Control

Screen 8 (Figure 3.41) lists the files stored in the receiver's memory, and accepts system-level commands. Each file is an entry in the two-column display. Table 3.21 describes the screen parameters.

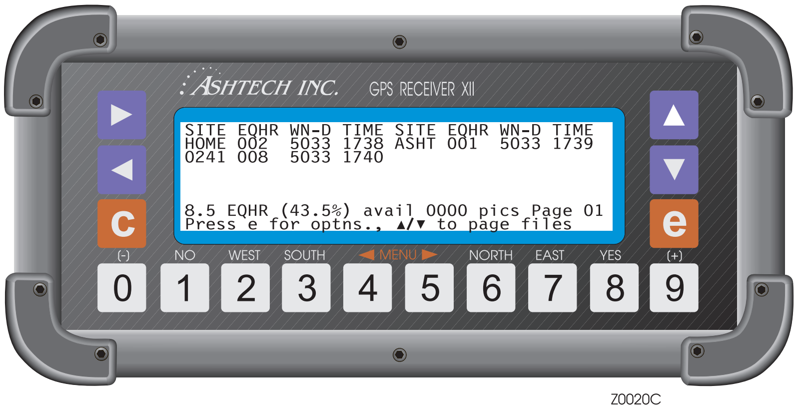


Figure 3.41. Screen 8 - File Display

Table 3.21. File Control Parameters

Parameter	Description
SITE	Four-character site name, the site name in use when the last epoch of data was recorded. (can be changed from Screen 9, Site and Session Control.)
EQHR	Equivalent hours, used instead of bytes or kilobytes to indicate file size. 1 EQHR is equivalent to one hour of data recorded at a 20-second record interval for 5 satellites.
WN	The GPS week number.
D	**T**he day (1=Sunday; 2=Monday; 3=Tuesday; 4=Wednes-day; 5=Thursday; 6=Friday; 7=Saturday).
TIME	Time when the last epoch of data was recorded. It is in the form hhmm (e.g., 1850 indicates 18:50 GMT.)
EQHR (00%) AVAIL	Indicates the available memory in equivalent hours and percent. For example, a Z-12 receiver with the standard one megabyte of memory displays 19.5 EQHR when empty; this is equivalent to 19.5 hours of record capability at 20 seconds record interval for 5 satellites.

Table 3.21. File Control Parameters (continued)

Parameter	Description
PICS	In photogrammetry applications, displays the count of camera signals recorded. Updated each time a picture is taken or event recorded. For more information refer to Application 3, *Photogrammetry Option.*
Page	Page of the screen where the files being displayed are stored.

System-Level Commands

Several system-level commands are available to the user. To use these commands, start by pressing the **[e]** key for data-entry mode. Then use the number keys to enter the desired command. Press the **[e]** key again for the command to be accepted. Pressing **[c]** instead of the final **[e]** cancels the command and returns the receiver to display mode. Table 3.22 summarizes the available commands.

Table 3.22. System-Level Commands

Command	Function
100	Turn off backlighting after 2 minutes since last key press (default).
101	Keep backlighting on. Caution: If backlighting is left on, the receiver draws significantly more power.
123	Close a file.
191	Initialize the modem.
456	Delete the highlighted file.
550	Reset receiver to original default values.
555	Save user parameters.
737	Initialize (reset) RTCM.
888	Display configuration identification (information such as serial number, list of installed options, nav board, channel board).
990	Trigger photogrammetry on falling edge.
991	Trigger photogrammetry on rising edge.
999	Delete all photogrammetry pictures.

Closing a File

The current file close automatically when the receiver turns off. During data recording, you can close a file and open a new one without turning off power.

1. Press **[e]** to shift to data-entry mode. Use the number keys and enter **[1][2][3]**.
2. Press **[e]** again to close the file and open a new one; if no data has been logged to the current file, a new file can not be opened.

Deleting a File

You can delete a file at any time. However, before deleting a file, verify that it is not needed or the information has already been transferred to the post-processing computer.

Note that each time the receiver is turned on, a new empty file is opened. If this file is deleted before closing it, any data collected appends to the last file in the list.

To delete a file:

1. If there are more than 10 files in the receiver, use the up and down arrow keys to scroll to the page with the desired file.
2. Press **[e]** to shift to date-entry mode. Highlight the site (file) you want to delete.
3. Use the number keys and enter **[4][5][6]**. Press **[e]** again and wait until the end of the current cycle for the file to be deleted and erased from the display.

Screen 9 - Site and Session Control

Use Screen 9 (Figure 3.42) to enter information about a specific site. Site information can be entered during data collection and does not affect or interrupt the collection process. Table 3.23 describes the screen parameters.

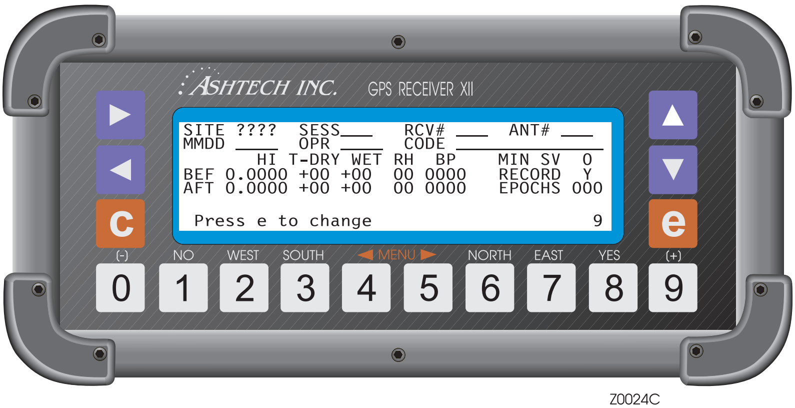


Figure 3.42. Screen 9 - Site and Session Control

Table 3.23. Site and Session Control Parameters

Parameter	Description
SITE	The name of a site, 4 alphanumeric characters, tagged with the raw data in order to record which site you were occupying during that time period. This same site identifier is used to name your data files when you are transferring them to your computer. (See section entitled *Entering a Site Name*.) If you forget to enter a site name, you can fix it during downloading.
SESS	The identifier (letter or number) of the session. The download software puts in this parameter while you are downloading to the PC after data collection. However, if you wish to override the default sessions, you may enter a letter or number here.
RCV#	The receiver identifier, three alphanumeric characters.
ANT#	The antenna identifier, three alphanumeric characters. Entering the last three digits of the antenna and receiver serial number is good practice in case there are problems with the equipment.
MMDD	Indicates the month and day of the session.
OPR	Identifies the operator, 3 alphanumeric characters.

Table 3.23. Site and Session Control Parameters (continued)

Parameter	Description
CODE	Can contain up to 13 alphanumeric characters of user comment to further identify a site.
HI	The height of the antenna in meters. If you enter it during the survey, it saves you having to enter it during post-processing. The post-processing software automatically reads the antenna height and uses it in computing the correct station position. Make sure the values are in metric or you will have to correct this in post-processing.
T-DRY	Contains a record of the dry temperature, in degrees Celsius.
T-WET	Contains a record of the wet temperature, in degrees Celsius.
RH	Records the percent of relative humidity
BP	Barometric pressure in millibars.
Fields to the right are used to modify receiver tracking and recording procedures.	
MIN SV	Sets an alarm that sounds a continuous beep when the number of satellites being tracked above the elevation mask falls below this specified minimum. Used during kinematic surveying. To silence the alarm, press the **[e]** key.
RECORD	Lets you control whether or not to record data. Y (yes) is the normal mode; N (no) means do not record data. Use with caution.
EPOCHS	Specifies the number of measurement epochs to be logged with the site name in a kinematic survey. It counts down after each epoch until it reaches 0, at which time the site name changes to**????**, indicating the receiver is moving to the next site.

To enter or change a value on Screen 9:

1. Press **[e]** to shift to data-entry mode. (A blinking cursor indicates that the screen in data-entry mode.)
2. Use the left and right arrows to highlight the field you want to change.
3. Use the down arrow to move the cursor down a line. Note that its function here differs from the other data entry screens.
4. Use the up arrow to display the alphanumeric conversion table. Its use is detailed in the section *Entering a Site Name.*
5. Press **[8]** for "yes" or **[1]** for "no" responses.
6. Examine your entries; they can be changed again by moving the cursor to the desired field and re-entering the information. When the values are acceptable, press **[e]** again to save them in memory.

   Pressing **[c]** cancels all entries. Pressing **[e]** or **[c]** after data entry returns the screen to display mode.

Screen 10 - All-in-View Information

Screen 10 (Figure 3.43) shows a polar plot of the currently available satellites and their orbital paths. The display is reliable once the receiver has a complete almanac and a valid position in Screen 2. From cleared internal memory, the receiver takes about 12 minutes after lock to acquire a full almanac and display correct information. With an almanac present (power cycle) the receiver takes approximately 12 seconds to present a full up-to-date screen.

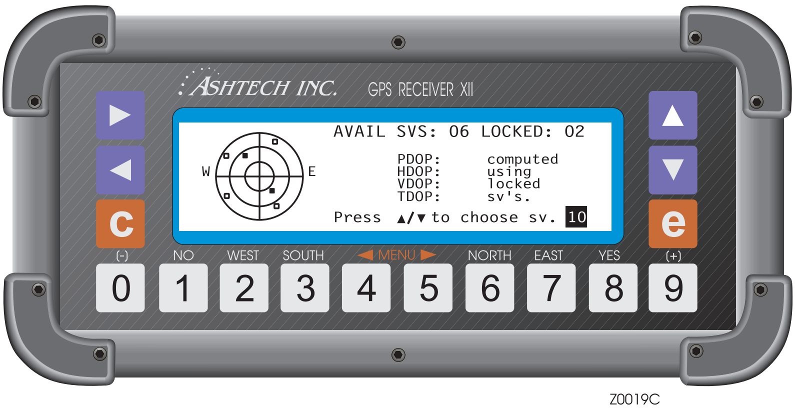


Figure 3.43. Screen 10 - All-in-View Information

Access Screen 10 by one of two ways:

- Press **[9]** then press the right arrow, or
- Press **[0]** first and press the left arrow three times.

The ALL-IN-VIEW screen shows satellite overhead position graphically on an azimuth where 0° (north) is located at the top center of the plot and 180° (south) is at the plot's bottom center. East and west are labeled on the plot. A □ indicates a satellite that is visible but not locked. A **н** indicates a satellite that is locked.

The circles represent varying satellite elevations: the outer circle is 0° elevation, the middle is 30°, and the innermost is 60°. The center of the axis is 90° (directly overhead).

Table 3.24 describes the screen parameters.

Table 3.24. All-In-View Parameters

Parameter	Description
AVAIL SVS	reports how many satellites are visible.
LOCKED	reports how many satellites are locked.
DOPS	displays DOP values computed using satellites with elevation equal to or greater than position elevation mask. Current DOPs of locked satellites are updated every second. The graphic display updates every 12 minutes. To isolate the orbital track of a single available satellite (locked or not), press the down or up arrow. The up arrow displays the orbital track of the next available satellite, in ascending order, starting with the lowest PRN number. The down arrow displays the orbital track of the next available satellite, in descending order, starting with the highest PRN number.

Single Track

The orbital track of a satellite is displayed on the same polar plot (Figure 3.44). This is reached by pressing the up or down arrow on the All-in-View screen. The track starts at the satellite's rising elevation and azimuth and ends at the satellite's current position. This display is updated every 10 minutes.

Table 3.25 describes the screen parameters.

Figure 3.44. Orbital Track

Table 3.25. Orbital Track Parameters

Parameter	Description
PRN: 12 LOCKED	displays the current satellite number, as well as its current elevation (EL) and its azimuth (AZ). It reports status as LOCKED or AVAILABLE. (PRN 12 is an example.) When you press the up arrow, the receiver displays the orbital track of the next higher number available/locked satellite. Pressing it when the highest numbered PRN is displayed returns to ALL-IN-VIEW.

The down arrow scroll down the list, showing the path of the next lower number satellite.

Screen 11 - Visibility Information

Screen 11 (Figure 3.45) lets you see the time when each satellite is visible. The display is fully reliable once the receiver has a complete almanac and a valid position which can be entered on Scree 4 by the user or be computed. From cleared memory without an almanac present, it takes about 12 minutes after lock to get full almanac and display complete information. With an almanac present, it takes approximately 12 seconds. As with Screen 10, if the receiver has not been used for some time, the screen displays old almanac information.

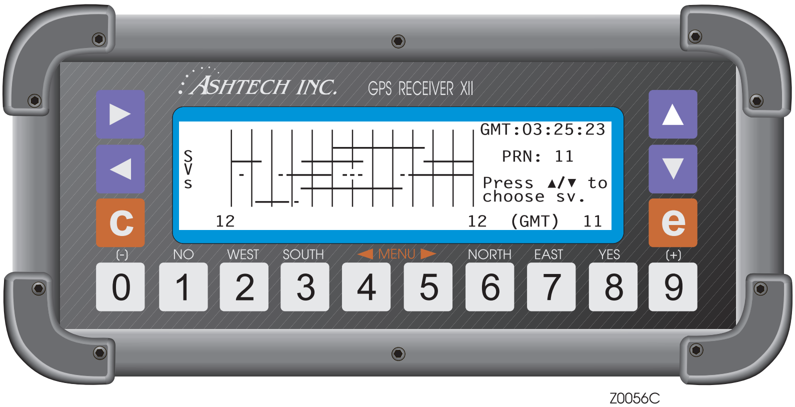


Figure 3.45. Screen 11 - Visibility Information

Access this screen by one of two methods:

Press **[9]** and the right arrow twice, or

Press **[0]** and the left arrow until Screen 11 displays.

This bar graph displays the availability periods of satellites over 24 hours, showing you 2 to 4 hours before and 20 to 22 hours after the current time. Table 3.26 describes the screen parameters.

Table 3.26. Visibility Parameters

Parameters	Description
HORIZONTAL LINES	Satellite availability windows shown in ascending order with PRN 01 at the bottom and PRN 32 at the top. The start/end times are accurate to 10 minutes
GMT:03:25:23	GMT time

Table 3.26. Visibility Parameters (continued)

Parameters	Description
PRN 11	In the upper right corner, contains the number of the PRN whose window is currently marked by the dotted reader-line. Pressing the up or down arrow raises or lowers the reader-line.
VERTICAL LINES	2-hour time marks. The current time is stated as GMT and is rounded to the nearest hour. Each time the screen is entered, the time marks are recalculated to show the previous, nearest 2 hours of availability; 12 and 12 GMT are the times for the first and last vertical lines.

Screen 12 - Bar Code Control

Use Screen 12 (Figure 3.46) to input bar code or keyboard data to mark a survey site or GIS data point. This method lets you enter more descriptive names for post-processing with the software. In addition, Screen 9, Site and Session Information, can also be entered using the bar code reader. **You must specify 9600 baud to be able to scan bar codes**. Only ports A and B are available for bar code scanning.

Figure 3.46. Screen 12 - Bar Code Control

Access Screen 12 by one of three methods:

- Go to Screen 9 and press the right arrow 3 times, or
- Go to Screen 0 and press the left arrow, or
- Read a bar code. (If the bar code screen is accessed by reading a bar code, the top level of the previous screen displays upon exit.)

You can enter a maximum of 80 characters, combining a bar code reader and keyboard. A successful scan is signalled by a short beep from both the bar code reader and receiver. If you try to enter more, the receiver rejects the last scan, displays an error message, and issues a long beep. Error messages are cleared when an entry is made within the 80-character limit.

Each entry is displayed in reverse video. If you make an entry error, you can delete it by scanning the backspace (BKSP) bar code or pressing the down arrow. To clear an entire entry sequence, scan the CLEAR ALL bar code or press the **[c]** key.

The keyboard can also be used to enter characters into a field. Once data has been entered using the bar code reader, keyboard entry can begin immediately. If the bar code reader has not been used, the **[e]** key must be pressed first. Enter data as described in *Entering a Site Name*.

Table 3.27 defines the format used for storing each data entry sequence.

Table 3.27. Data Entry Format

Field	Bytes
ID = 6	2
Length of entered data	2
Time tag	8
Entered data	80 (max.)
Checksum	2

To store the entered data and a time tag in an internal file, read the ENTER bar code or press the **[e]** key. This records the data sequence, emits two short beeps, and exits to Screen 12.

To clear the entered data, do one of the following:

- Read the CLEAR ALL bar code or press the **[c]** key. This clears the entire data sequence and exits to Screen 12.
- Read the backspace (BKSP) bar code, or press **[?]** when only one data entry remains, to exit to Screen 12.

Once the entered data has been stored or cleared, pressing a numbered key accesses the corresponding screen.

BARCODER is an application which creates bar codes that can be printed and carried to the field so that field personnel can readily enter data into the receiver. Using the bar code reader to enter Screen 9 data is described in the BARCODER program reference document.

When entering individual characters for Screen 9 data fields, the bar code screen appears and shows these characters as they are read. The appropriate data entry code must then be read to place the entry into the Screen 9 field.

When using the epoch counter in kinematic surveying, first enter the site name and then the number of epochs to be counted down. When the name is acceptable, press **[e]** to save it in memory and return to display mode.

4

Basic Surveying

There are three methods of surveying using two or more GPS receivers simultaneously collected described as relative or differential positioning:

- static
- pseudo-kinematic
- kinematic

The **static** survey differences phase measurements from two GPS receivers which are simultaneously locked on several common satellites. One receiver gathers data from a known position, the other from an unknown position. Differencing the phase measurements of satellite signals minimizes errors associated with satellite information and receiver biases.

Static surveying is the most reliable and the most accurate method, producing coordinate differences for the points to the millimeter level. The disadvantage of this method is that the receiver must remain at a site for a relatively long time to get these redundant observations.

The **pseudo-kinematic** survey requires receivers occupying points for at least two short periods (gathering 5 to 10 minutes of common data), separated by a longer period (1 hour). Since you do not need continuous lock as you move the rover to the next point, with this technique you can work in areas with overhead obstructions.

The advantage of pseudo-kinematic over static is the shorter point occupation time; its advantage over kinematic is that you do not have to maintain lock while moving a receiver. A disadvantage is that it can be less accurate than static or kinematic because of short data samples which are more susceptible to ionospheric changes between repeat observations.

The **kinematic** method enables very rapid surveys of a number of baselines in areas where there is good satellite visibility. Kinematic surveys require at least one receiver at a known stationary base point, and one or more rover receivers (rovers) which move from point to point. Kinematic surveys are started by occupying a known baseline to initialize the survey to solve for satellite phase ambiguities (the starting number of cycles between the satellite and the receiver).

If an initializing baseline is not known, it must be established. This can be done easily with an antenna swap. This involves placing the base receiver at a known point and the rover at a nearby unknown point. The antennas are then swapped so that each antenna has occupied both the known and the unknown points. The antenna swap and other field procedures are covered in “Kinematic Surveys” on page 83. After you have the starting ambiguities, move a rover through a series of points for brief observations (1 minute) or through a trajectory like the continuous track of a vehicle. Finally return the rover to the start or swap site to serve as a check.

Kinematic surveys are not as easy to do since you must maintain lock on at least four satellites. However it is as accurate as hour-long static observations. Kinematic surveying (based on the carrier phase of GPS) offers first-order control to a series of surveying points without the long observation times required by static surveys.

All three methods may be combined in a large GPS survey network project. Taking the overview of a project and deciding what points to observe statically, pseudo-kinematically, and kinematically is one of the most important tasks in planning each project. It is no longer simply a matter of site reconnaissance and travel time. You must also factor in satellite visibility along the route. Route reconnaissance can be as important as site reconnaissance in today's GPS projects.

Procedures for kinematic and pseudo-kinematic methods are covered in Chapter 5, **Advanced Surveying**. This chapter covers static surveying

Completing a Static Survey

The following procedure steps through a static survey to give you an idea of how to use the receiver in the field. The operations are:

1. Set up the receivers and the antennas.
2. Measure antenna height.
3. Operate the receiver to collect data.
4. Enter site names.
5. Terminate the survey.
6. Connect the receiver to your computer to download the data.

A static survey uses at least two stationary GPS antennas that simultaneously observe the range and carrier phase of several common satellites over a specific time period. One antenna is centered over a known point while the other antennas are occupying unknown stations.

By occupying more than one station, a number of common errors cancel so accuracy greatly improves. In order to compute accurate baselines and establish accurate positions on the unknown points, the data collected in the field is post-processed later in the office. The following sections describe the receiver operations for collecting data necessary for the post-processed solution.

System Set Up

This section describes how to set up the receiver in the field. A minimum of two receivers are required to complete a static GPS survey.

1. Set up and level an antenna over a survey mark. The survey point must provide line-of-sight reception of the GPS signals. You should already know the WGS-84 or NAD-83 coordinates of one position in the session.

   To set up over the point, a tripod and centering device such as a tribrach with an optical plummet is required. When the tribrach is level, attach the antenna.
2. Connect the antenna through the pre-amplifier to the receiver with an antenna cable.
3. Measure antenna height. Use the precision rod or any other accurate method.
4. Connect external battery or power source to one of the POWER sockets on the receiver’s back panel. Align the red dot of the connector with the red dot of the socket and push the connector until it seats.
5. Turn the receiver POWER switch (reap panel of receiver) to ON.
6. Repeat steps 1 through 6 for each receiver for each survey point. Be sure to measure the antenna height and site name for each survey point.

Measuring Antenna Height

In any GPS observation, the measurements are made at the phase center of the top of the antenna receiving the signal. To reduce them to the ground level to serve as a survey control point, you must accurately measure the distance from the antenna to the survey mark. This distance is referred to as the antenna height or **height of the instrument** (**HI**).

1. Using the precision HI rod, direct the rod through one of the dog-legged holes around the edge of the antenna platform. The holes (marked A to H) are situated so that the rod is not blocked by a tripod leg.
2. Put the rod’s point at the center of the mark and read the engraved markings.
3. Measure three different holes to confirm the HI and check that the tribrach is in adjustment and indeed over the point. All three measurements should be within 1 mm of each other.
4. If a non-graduated measuring rod is used, lift it up about ½ inch and place a strip of masking tape on it. Reposition the rod and mark the tape. Measure

from two other holes for redundancy. Then measure the marked rod to obtain the HI.

5. To assure that the HI is correct, measure it several times and preferably in two systems: feet and meters. It is necessary only to measure the distance from the mark to the top **outside** edge of the dog-legged hole on the antenna platform. (post-processing software corrects the diagonal measurement to vertical.) Measure the HI before and after the observation to check that no settling is experienced during the survey.

Operating the Receiver

Connect one end of the power cable to a power source (generally a battery pack) and the other end to either of the POWER connectors on the back of the receiver.

Connect one end of the antenna cable to the antenna and the other end to the ANTENNA connector on the back of the receiver.

Check that the antenna height (HI) has been measured.

To start data collection, set the POWER switch (on the back of the receiver) to ON.

Turning on the power initiates a self-test. If the receiver finds a problem, it displays an error message and stops. The self-test messages are listed in Appendix D. When there are no problems, the receiver briefly displays the copyright before displaying Screen 0.

In theory, no interaction with a receiver is required for static surveys. When the receiver is turned on, it automatically:

- searches and locks on all satellites available.
- makes GPS measurements and computes its position.
- opens a file and saves all data into this file.

When the receiver is turned off after a survey, it automatically closes the file.

There are two primary screens for specifying information for a survey. These are Screens 4 and 9, described in detail in Chapter 3, **Screen Descriptions**. To operate the receiver after it has been turned on, do the following:

1. On Screen 0, adjust contrast by pressing the up or down arrow.

2. Go to Screen 4, Mode Control, Figure 4.1, by pressing the **4** key to change operational parameters.

Figure 4.1. Screen 4 - Mode Control

The default values work very well for static surveys. However if you choose to alter a value, press **[e]** to shift to data-entry mode. Use an arrow key to move the cursor to the desired parameter and change its value. Press the **e** key to save the changes or **c** to abandon changes.

3. Go to Screen 9, Site and Session Control (Figure 4.2) by pressing **9**. Like Screen 4, you do not have to alter information to successfully conduct a static survey; however, site ID and antenna height information should be entered to assist in automatic processing.

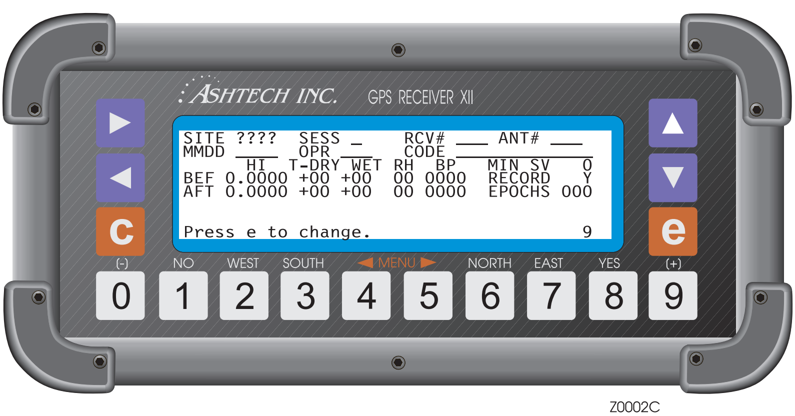


Figure 4.2. Screen 9 - Site and Session Control

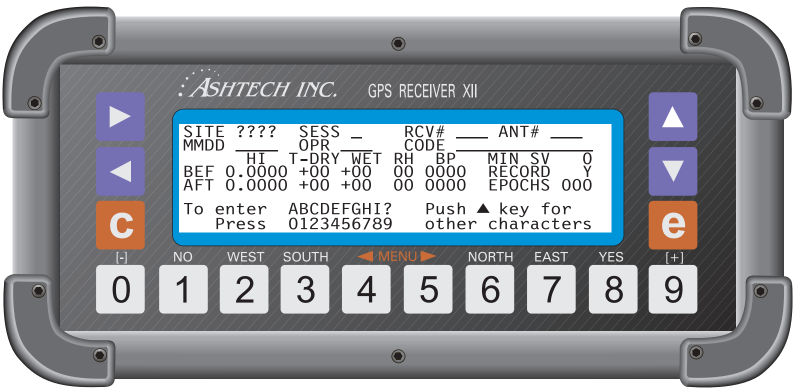
Site information can be entered during data collection and does not affect or interrupt the collection process. Site information is output as an ASCII file when the data is downloaded from the receiver.

When it is time to conclude data collection, turn off the receiver. The receiver automatically closes the data file.

Entering a Site Name

To type in text (done from several screens such as Screen 9):

1. Press **[e]** to switch to data-entry mode. You'll see the alphanumeric conversion table shown in Figure 4.3.



Z0143C

Figure 4.3. Data Entry, Alphanumeric Conversion

2. To see another bank of alphanumeric characters, press the up arrow to cycle through the five displays.
3. Type in the site name, one number at a time, where each number corresponds to the letter you want.
4. If the cursor is in the wrong character position, use the left and right arrows to line it up again.

   After the fourth character of the name, the cursor jumps to the field where you can enter a session identifier.

   When the entries are acceptable, press **[e]** again to save the changes in memory and return to display mode. To cancel the changes before saving them, press **[c]**.

Downloading Data

Post-processing software is provided as part of the GPS Survey System. The software includes functions that post-process GPS survey data as well as perform a variety of survey-related functions.

Use the post-processing software download data from the receiver. You must download your receiver files to the computer before you can process your field data through the software. To do this, you must have an RS-232 cable.

1. Connect one end of the power cord to a power source (generally a battery pack) and the other end to the POWER connection on the back of the receiver (Figure 4.4). Use either POWER connector.

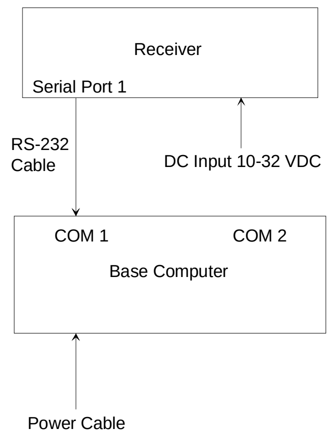


Figure 4.4. Cabling for Downloading

2. Turn the receiver on.
3. Connect the RS-232 cable to serial port 1 on the back panel of the receiver and COM1 on the computer.

   If serial port 1 on the receiver is not available, serial port 2 may be used. If COM1 on the computer is not available, COM2 may be used; if COM2 is used, remember to enter that information via the communication parameters option in the downloading software.
4. Follow the instructions for downloading data found in the software user manual.

5

Advanced Surveying

This chapter covers how to perform kinematic and pseudo-kinematic surveys, as well as how to set up receivers to operate in RTCM differential mode (also known as real-time differential).

Kinematic Surveys

This discussion describes how to use a GPS receiver for a kinematic survey. These topics are covered:

- Methodology and planning;
- Field procedures;
- Initializing the kinematic survey;
- Establishing a known baseline;
- Ending a survey with data closure.

Setting up the equipment, measuring antenna height, entering site names, and connecting the receiver and computer for downloading are covered in *Doing a Static Survey*.

Methodology and Planning

The kinematic survey requires at least two GPS receivers and two antennas. They measure the carrier phase of GPS signals. Typically you begin by establishing a known baseline and then initialize the kinematic survey on the known baseline to solve for starting ambiguities (the unknown number of whole cycles of the signal associated with the first measurement of phase).

After the starting ambiguities are resolved, they are carried forward throughout the survey. In a kinematic survey, a base receiver remains stationary during the session while other receivers, the rovers, are moved through a series of points. At these points, they make brief observations, typically one minute at a 10-second epoch interval. (Alternatively, a rover may be moved through a trajectory like the continuous motion of a vehicle.) All baselines are measured relative to the position of the base receiver. Eventually, the rovers should be returned to the initialization site to serve as a check.

The kinematic technique requires that all receivers maintain lock on at least four GPS satellites at any given time. It is highly recommended that you track 5 or more to reduce the effect of poor satellite geometry or momentary signal loss.

This method provides a level of accuracy comparable to the static survey. However you must maintain a minimum level of lock and each short observation is strongly influenced by the momentary satellite geometry.

Before you start kinematic surveying, you need to determine unobstructed routes to the points in your network. The routes must allow you to maintain necessary lock as you drive between points. In an area where you cannot maintain lock on the minimum configuration, you can install control marks. Survey them by the static method prior to a kinematic survey, then use them as checks and re-initialization points during the kinematic survey.

Kinematic Field Procedures

To begin a kinematic survey, the survey must be initialized by occupying a known baseline with both receivers. This is required to determine the carrier phase ambiguities that are carried through the survey.

The fastest way to initialize a kinematic survey is with a known baseline from a GPS observation done prior to the kinematic survey and accurate to the centimeter level. If a baseline is already known, proceed to step 1 of *Performing a Kinematic Survey*.

Establishing a Known Baseline

If a baseline is not already known, use one of the two methods of establishing a known baseline described below - the antenna swap or a one-hour static session.

Performing an Antenna Swap

An accurate and reliable method of establishing a known baseline is the antenna swap, which quickly determines the coordinates for an unknown point. Once the coordinates of both ends of a baseline are known, they can be used to initialize a kinematic survey.

In an antenna swap, a baseline between a known and an unknown point is occupied. After common data is collected at both sites, the antennas are swapped (maintaining lock on at least 4 satellites) and more data is collected so that each antenna has occupied each point.

The unknown point is a temporary, arbitrary point, set by the observer just for the purpose of the antenna swap. It should be within several meters of the known point and should be retrievable for the duration of the survey.

While used mainly for establishing a known baseline, antenna swaps can also be used to determine a precise geodetic azimuth between two points. As long as lock is maintained on 4 or more satellites, azimuth marks several hundred meters from a base station can be positioned with extraordinary precision.

For this procedure, the known survey control point is called **home**. The unknown point is called **away**. These names are only to make the examples clear; always enter in your 4-character site name for station identification.

To perform an antenna swap:

1. Connect the antenna cables to the antennas and receivers, hook up the batteries, center the antennas over their respective points, measure the antenna heights, and turn on both receivers.
2. On each receiver, on Screen 4 (Figure 5.1), press **[e]** set recording interval (INTVL) to 010 so that data is recorded at 10-second intervals.

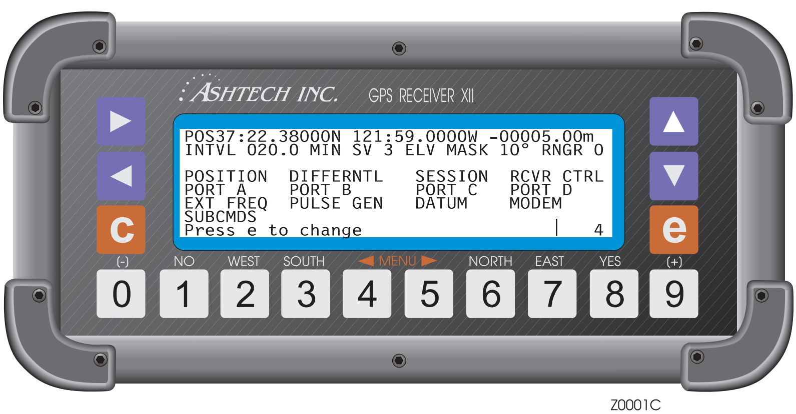


Figure 5.1. Screen 4

3. On each receiver, go to Screen 9, Figure 5.2, and press the **[e]** key to change to data entry. For the site name, type HOME in the base receiver and AWAY in the rover receiver. Press **[e]** again to save the site names.

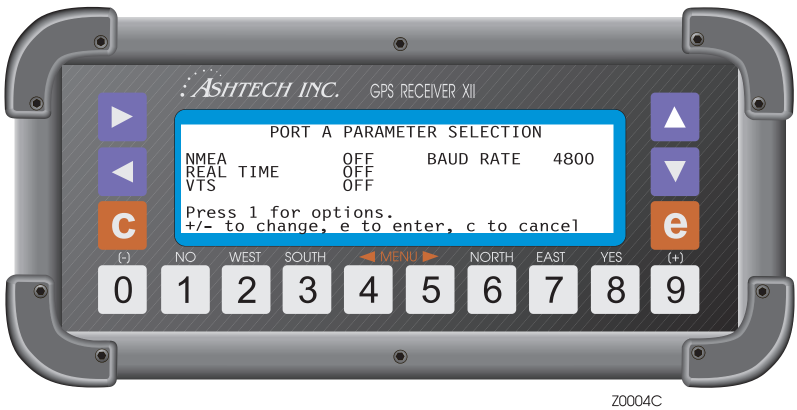


Figure 5.2. Screen 9

4. Collect one minute of common data.
5. On each receiver, go to Screen 9 and press **e**. For the site name, enter ???? to indicate that you are moving the equipment. Press **[e]** again.
6. Without disturbing the tripods, swap the antennas, care-fully keeping the proper orientation. Move one from the home point to the away station and vice versa. Set them up at the switched sites.
7. On the base receiver (which is now at the away point), on Screen 9, press **e,** enter AWAY for site name, and press **[e]** again.
8. On the rover (which is now at the home point), go to Screen 9, press **e**, and enter HOME for the site name. Press **[e]** again.
9. Observe one minute of common data.
10. Again, on each receiver, go to Screen 9, press **[e]** , enter **????** for site name and press **[e]** again. Swap the antennas as before, carefully returning each to their original point.
11. Proceed to step 4 of the kinematic field procedures, *Performing a Kinematic Survey*.

Performing a Static Session

A second method of establishing a known baseline is with a conventional static technique. (This is the same technique discussed on page 16.) The static technique involves collecting data on two stations for enough time to resolve the ambiguities. One site must be known.

The unknown point can be a temporary, arbitrary point set by the observer just for the purpose of initializing the kinematic survey, or a permanent station not yet surveyed. The distance between the two stations should not be more than 5 kilometers to ensure a good bias fixed static baseline solution. Any station separation between 2 meters and 5 Km is acceptable.

Once the kinematic survey has been completed, process the static observations, solve for the unknown baseline, and obtain coordinates for the unknown point. These coordinates and the coordinates of the known station are then held fixed when processing the kinematic survey from a known baseline.

To perform a static survey:

1. Connect the antenna cables to the antennas and receivers, hook up the batteries, center the antennas over their respective points, measure the antenna heights, and turn on both receivers.
2. At the start of the static session, enter the respective site names on Screen 9 of each receiver. For this example, we use HOME and AWAY. Collect data for enough time to resolve the ambiguities, generally about 1 hour.
3. At the end of the session, close the files by entering **123** on Screen 8. This closes the static session file and opens the kinematic session file.

   If the files are not closed prior to the kinematic survey, the kinematic data is included in the static data file. In that case, you have to split them manually before kinematic processing.
4. Proceed to step 4 of the kinematic field procedures, *Performing a Kinematic Survey*.

Performing a Kinematic Survey

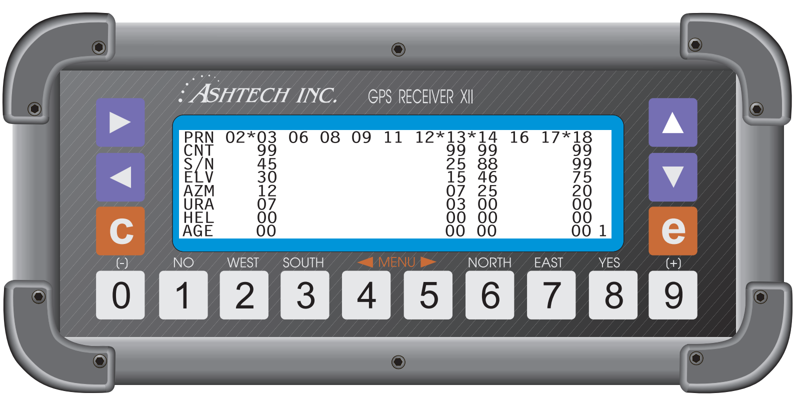
Set up the equipment on the two points of the known baseline. One of these points is designated as the reference or base point and data is collected at the station throughout the survey.

1. Connect the antenna cables to the antennas and receivers, hook up the batteries, center the antennas over their respective points, measure the antenna heights, and turn on both receivers.
2. On Screen 4 of both receivers, press **[e]** and set the recording interval (INTVL) to 010.0 or 10 seconds. Press **[e]** again.

3. On Screen 9 of both receivers, press **[e]** and type in the site name of each point. For this example, the base receiver is called HOME and the rover receiver called AWAY.
4. On Screen 9 of the **rover** receiver, set the MIN SV (minimum number of satellites to track) to 4 and EPOCHS to 6. Press **[e]** to enter the site name, the MIN SV and the EPOCHS into the receiver.

   With the MIN SV set to 4, the alarm goes off if the number of satellites tracked falls below 4, warning you that you must go back and re-initialize the survey.

   When the EPOCHS are set to 6, the receiver counts down from 6 until it reaches 0, at which time it automatically changes the site name to ????, thereby readying the receiver to be moved to the next site. Six epochs at a 10-second record interval results in 1 minute of data collection at each station. One minute is a recommended occupation time.
5. Initialize the kinematic survey by occupying the known baseline for 1 minute. (With EPOCHS set to 6 and the INTVL to 010.0, the site name automatically goes to ???? after 1 minute, indicating that the rover can be moved to the next point.) If the EPOCHS are not set on the rover, enter ???? as the site before moving to the next point.
6. Move the rover to the next unknown point. Maintain lock on 4 satellites at all times. Periodically review Screen 1, Figure 5.3, to see if cycle slips (loss of lock) occur. If a cycle slip occurs, the receiver resets CNT (number of epochs collected) to 0.



Z0053C

Figure 5.3. Screen 1

If at any time the rover tracks fewer than 4 satellites, the kinematic survey must be re-initialized. Return to the previous point, remain there for 1 minute and find an alternate route to your next point - one that avoids losing lock.

7. When you get to the next unknown point, type in that point's site name and press **[e]** to enter it. Data tagging for the new site does not start until a site name is entered. Let the rover collect data for 1 minute.
8. Repeat steps 6 and 7 for each point to be located.
9. Finally, for data closure at the end of the survey, revisit the starting or initializing point, enter the original initializing site name again and take a final one-minute reading.

Ending a Kinematic Survey with Data Closure

It is important that data closure be made at the end of the survey. Data closure lets you process the survey data backwards if necessary, initializing from the closure point. Data closure is useful if there is a break in the data collection part way through collection. An additional benefit is that processing from both ends minimizes what might otherwise be a cumulative error.

The lines which are actually measured are radials that go from the base point to the unknown location. If you complete a loop to the starting point with the rover, the loop checks the continuity of the integer biases. This constitutes data closure.

Data closure does not, however, provide survey closure. There are a number of cases where points are not as precise as possible, such as 4 satellites with poor geometry, radio frequency interference (RFI) at a point, bad satellite ephemeris, etc. These things do not occur often, but if they do, a single kinematic visit to a station provides absolutely no checks.

The recommended method of checking kinematic points is to revisit them the next day using a different base station. This provides checks on the satellites and the base control as well as providing checks on the kinematic sites themselves. Even though you may wish to revisit only some of them, revisit all stations for optimal results.

Completing a Pseudo-Kinematic Survey

This discussion describes how to use the receiver for a pseudo-kinematic survey. Topics covered are:

- Review of field methods.
- Operating procedures for pseudo-kinematic data.

Procedures such as setting up the equipment, measuring antenna height, entering site names, and connecting the receiver and computer for downloading are covered in “Completing a Static Survey” on page 76.

Methodology and Planning

The pseudo-kinematic survey requires at least two GPS receivers and two antennas. In pseudo-kinematic surveying, you typically leave one receiver at a known survey mark while you move another to successive sites, gathering data at each site for 5 to 10 minutes, as shown in Figure 5.4. After about an hour, you revisit each site again with the rover and gather data for 5 to 10 minutes. In this way, you create about an hour's observation for each position with the middle data missing.

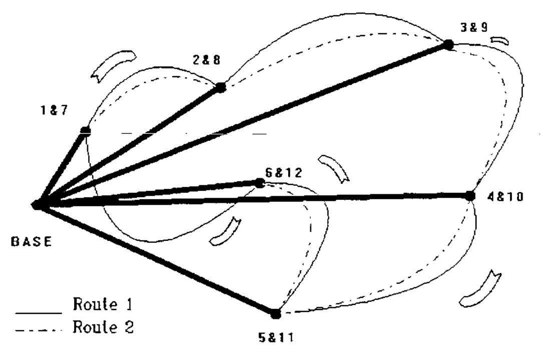


Figure 5.4. Pseudo-Kinematic, One Base, One Rover

The same receiver must visit each of its points twice. That is, one receiver cannot visit a survey point for the first observation while, an hour later, a different receiver gathers data at that survey point for the second observation. Both visits must be made by the same receiver.

The roving receiver starts at point 1/7 with a 5-to-10-minute observation. The rover then moves to point 2/8 for a 5-to-10-minute observation, and so on through point 6/12 until about an hour has passed and the cycle is repeated. The same points are then revisited for 5-10 minutes each, in the same order, by the same receiver. When the second observation at point 6/12 is finished, the survey session is complete.

This technique resembles kinematic in the way you obtain field observations. In contrast to kinematic, there is no initialization, each measurement is 5-10 minutes long, and each point is measured a second time at least 1 hour after the first observation. The hour span lets the satellite geometry change sufficiently to resolve the phase ambiguities. The two 5-10 minute observations separated by an hour are functionally equivalent to a static survey's hour-long baseline observation.

Before you start a pseudo-kinematic survey, you need to determine when at least three, preferably four, satellites are common to both 5-10 minute observations at each site. The method needs to have some common satellites. It is a good idea to have an overall selection of 5 or more satellites available. In addition, note the driving time between points, and limit this type of survey to relatively small areas.

There is no requirement for maintaining lock as you move between sites. Although it is not recommended, the receiver may actually be turned off while moving. Turning it off, however, increases your housekeeping chores since you need to combine files prior to processing.

Incidentally, if several roving receivers are collecting data simultaneously and their operators are in radio contact, the baselines between the rovers may also be computed and there is no requirement that one site be a base. All receivers may move. Processing these baselines may be done automatically using the post-processing software.

Pseudo-Kinematic Field Procedures

Start the pseudo-kinematic survey by setting each receiver's antenna over a survey point and observing for 5 to 10 minutes. If there is a base receiver, enter its site code on Screen 9 and leave it throughout the survey session.

Use 10-second epoch intervals for pseudo-kinematic surveys.

1. For each moving receiver, connect an antenna cable to the antenna and receiver, hook up the battery, center the antenna over its survey mark, measure the antenna HI, and turn on the receiver.

2. Press **9** to go to Screen 9, Figure 5.5, press **e**, and enter a site name, for example, 0001. Also take this opportunity to alter other parameters.

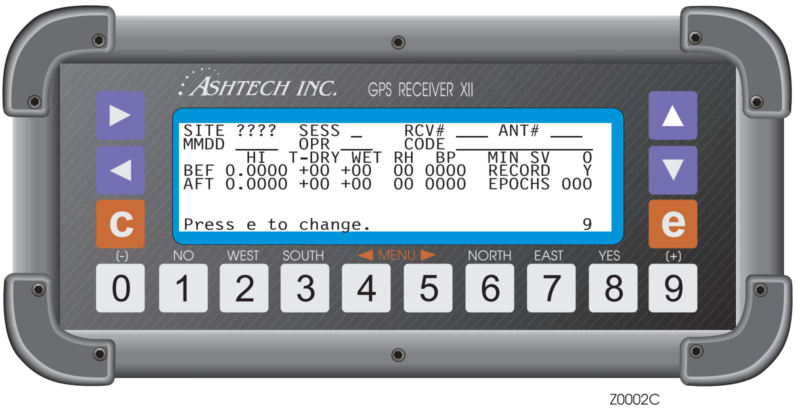


Figure 5.5. Screen 9

3. Observe for 5 to 10 common minutes.
4. Before moving the receivers and antennas, enter **????** as site names on Screen 9. Four question marks tell the post-processing software that the equipment was moving.

   While moving, check that antenna retains site visibility. While it is not necessary to maintain lock, it enables smoother operation and eliminates re-acquisition time.
5. At each unknown point, in the site field (Screen 9), enter a meaningful site name and let the rover collect data for 5 to 10 minutes, a recommended 30 to 60 10-second epochs.
6. Before moving to the next point, reset the site name (Screen 9) on the rover to **????**.

   In contrast with a kinematic survey, you may set the receiver to not record data during the move. Set RECORD to N, but do this after at least one epoch of ????'s has been recorded. If you choose to turn off data recording during your move, remember to turn it back on before enter your next station name. Turning it off is not recommended.

   Repeat steps 4 to 6 for each point to be located.

7. You may periodically review Screen 1 and Screen 11, Visibility Information, Figure 5.6, to check that your chosen satellites are still available.

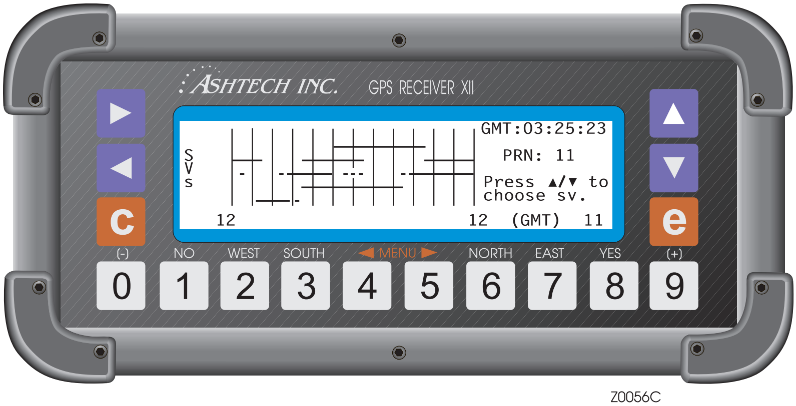


Figure 5.6. Visibility Information

Finally, revisit each point, entering each original site name again and take final 5-10 minute

Real-Time Differential

This discussion describes the Real-Time Differential Option that can be installed on the Z-12 receivers. It gives a general description of the real-time differential philosophy including major sources of errors, followed by a description of the RTCM-104 format (the differential format available) which includes a detailed explanation of RTCM differential setup, options, and operation.

General

Real-time differential GPS requires a **base** receiver computing the satellite range corrections and transmitting them to the **remote** receivers. The base receiver transmits these corrections in real time to the remote receivers via a telemetry link. Remote receivers apply the corrections to their measured ranges using corrected ranges to compute their position.

The base receiver determines range correction by subtracting the **measured** range from the **true range**, computed by using the accurate position entered in screen 4 of the receiver. (This accurate position must have been previously surveyed using GPS or some other technique.) The remote receivers subtract the received corrections from their measured ranges and use the corrected ranges for position computation.

A stand-alone GPS receiver can compute a position of around 25 meters with SA off, and about 100 meters with SA on. Differential GPS, using C/A code, can achieve 1-2 meter accuracy at the remote receivers even with SA on. Differential GPS, using PL1 code, can obtain sub-meter accuracy.

The receiver can be designated as the base or remote station. In base mode, the receiver computes the range errors in every cycle. The cycle is nominally each ? second. The receiver, set to base mode, can transmit the range corrections via either serial port with a wide selection of baud rates.

A communication link must exist between the base and remote receivers. In actual use, the communication link can be a radio link, telephone line, cellular phone, satellite communication link or any other medium that can transfer digital data. For testing, connect both receivers via a full handshake null modem RS-232 cable via any of the serial ports.

Sources of Error

The major sources of error affecting the accuracy of GPS range measurements are satellite orbit estimation, satellite clock estimation, ionosphere, troposphere, and receiver noise in measuring range. The first four are almost totally removed using differential GPS, with residual error in the order of 1 mm for every kilometer between base and remote receivers.

Receiver noise is not correlated between the base and the remote receiver and is not canceled by differential GPS. However, integrated Doppler is used to smooth the range measurements and reduce the receiver noise.

At the instant a satellite is locked, there is also rms noise affecting the range measurement. This rms noise is reduced with the square root of n where n is the number of measurements. For example, after 100 seconds of locking to a satellite, the rms noise in range measurement is reduced by a factor of 10 (1 meter of noise is reduced to 0.1 meter). The noise is further reduced over time.

If the lock to a satellite is lost, the noise goes back to 1 meter and smoothing starts from the 1-meter level. The loss of lock to a satellite is rare. It typically happens only when the direct path to the satellite is blocked by an object.

Total position error (or error-in-position), is a function of the range errors (or errors-in-range) multiplied by the PDOP (three-coordinate position dilution of precision). The PDOP is a function of the geometry of the satellites.

RTCM 104 Format, Version 2.0

This section describes the RTCM 104 format, a real-time differential format for the Z-12 receivers. In base mode, the receiver supplies to rover receivers data for differential corrections. In remote mode, it operates as user equipment and obtains range corrections from the reference station which are used to correct its position.

When a port is dedicated to RTCM in base mode, all other output options on that port are disabled and the message:

"Port N will output differential data at a rate of xxxx baud"

displays. N is the serial port being used for RTCM and xxxx is the selected baud rate for that port.

The RTCM option complies with RTCM 104 Version 2.0 standard of the Radio Technical Commission for Maritime Service.

As a Base Station

When a receiver is used as a base station and the RTCM format is selected, the receiver computes differential corrections for up to 12 satellites, converts those corrections to RTCM format and transmits the converted messages via its serial ports. The option can generate message types 1, 2, 3, 6, and 16, and the remote can decode message types 1, 2, 3, 6, 9, and 16, as described in Table 1.

Table 5.1. RTCM Message Types

Message Type	Content
1	Differential GPS corrections
2	Delta differential corrections
3	Reference station parameters
6	Null frame
9	High-rate differential GPS corrections
16	Special message

The RTCM format uses the 6-of-8 format (data bits A1 through A6 of an 8-bit byte) for communication between the reference station and user equipment.

As a Remote System

When the receiver is used as a remote unit and the RTCM format is selected, the receiver can accept any type of RTCM message. However it decodes only types

1, 2, 3, 6, 9, and 16 and uses only types 1, 2, and 9 for differential corrections. For radio communication, the receiver in remote mode can recover bit slippage.

RTCM Differential Set Up

To use the RTCM differential option, do the following:

1. On Screen 4, press **[e]** to shift to data-entry mode.
2. If the receiver is the base station, a previously surveyed antenna position must be entered in the POS line. Also, you should lower the elevation mask to about 5°.
3. Highlight DIFFERNTL and press **[e]** to access the Differential Mode Selection screen (Figure 5.7).

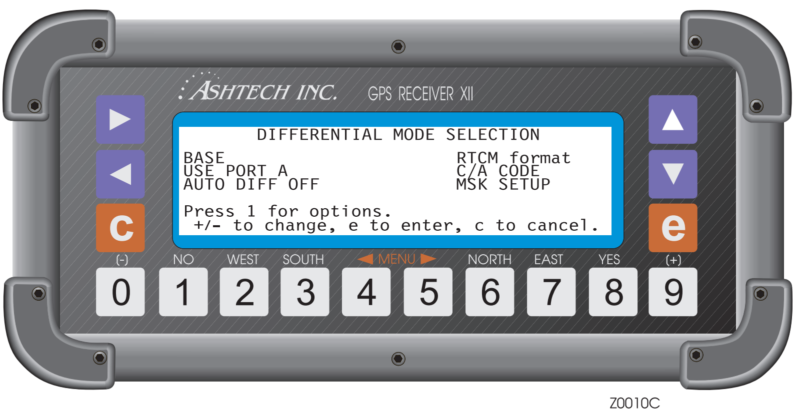


Figure 5.7. Differential Mode Selection Screen

4. Highlight the mode indicator and press **[+]** or **[-]** to toggle it (through base, remote, and disabled) and select the right mode. Select it here or on the RTCM OPTIONS screen.
5. Highlight the output port indicator and toggle it through **USE PORT A** or **B** or **C** or **D** so that it corresponds with the serial port you are using for the differential corrections.
6. If you want the auto differential option enabled, highlight the AUTO DIFF field and press **[+] or [-]** to set it to ON.
7. Press **[e]** to record your new setup. The display shows the specified port and baud rate.
8. Press **[e]** again to return to the main display, Screen 4.

RTCM Options

With RTCM format highlighted on the Differential Mode Selection screen (Figure 5.8), press **[1]** to access the RTCM OPTIONS Menu, Figure 5.8. The defaults set at the factory output type 1 continuously at 50 bits per second.

Figure 5.8. RTCM Options

MODE sets the receiver to operate RTCM differential in BASE, REMOTE, or OFF. For a base station, set it to BASE. For user equipment, set it to REMOTE. You can set it here or on the Differential Mode Selection screen.

SPEED sets the number of bits per second issuing from the serial port. The available speeds are 25, 50, 100, 110, 150, 200, 250, 300, and 1500. Default is 50 bits per second. (Note that an RTCM byte has 6 significant bits.) Not used in remote mode.

STID is the reference station identification supplied by the user. Can be set to any number from 0 to 1023.

STHE is the reference station health. Not used in remote mode. It can be set to a value from 0 to 7. Station staleness refers to a time interval prior to the message at which station measurements were taken, as described in Table 2.

Table 5.2. Health Codes

Code	Health Indication
7	The reference station is not working.
6	Reference station is sending type-16 messages.
5	Station staleness ≥ 96 seconds.
4	Station staleness < 96 seconds.

Table 5.2. Health Codes (continued)

Code	Health Indication
3	Station staleness < 48 seconds.
2	Station staleness < 24 seconds.
1	Station staleness < 18 seconds.
0	Station staleness < 12 seconds.

TYPE indicates the type of message generated. The receiver can generate message types 1, 2, 3, 6, and 16. Default is 1 (pseudo-range corrections).

TYPE 6 enables or disables the output of type 6 messages (user-entered messages).

SEQ check or not for the sequence number in a message to be sequential to accept the RTCM message (used in remote mode only).

FREQ specifies the period/frequency for message types 1, 2, 3, and 16. Each can be set to a value that ranges from 0 to 99. 0 means no message is generated. 99 generates a message continuously and is the usual setting for message type 1. A value from 1 to 98 specifies a number of seconds between transmissions for type 1 and the number of minutes for type 2, 3, and 16, e.g., a setting of 5 transmits a message every 5 minutes.

MAXAGE in remote mode, specifies a maximum age, in seconds, for messages. The remote receiver uses differential messages which are not older than MAXAGE. It may be set to a value from 0 to 1199 seconds. The default is 120. It is not used in base mode.

QAFREQ in remote mode, allows evaluation of the communication quality between the base station and the user equipment. This number is a percent of the parity passed messages. When the total number of received messages reaches QAFREQ, the quality number is reset to 100. QAFREQ may be set to any number from 0 to 999. Defaults to 100. Not used in base mode.

MESSAGE contains an RTCM message (up to 32 characters long) to send from the base station to user equipment. To do that, enter the FREQ value directly under message type 16, and type in the message. In remote mode, contains any special messages (type 16) received from the base station. Messages are scrolled automatically; the old messages are pushed down.

Reference Station or Base Mode

On the differential mode selection screen, Figure 5.9check that you have specified the output port correctly.

To set the receiver into base mode to be a reference station:

1. Highlight RTCM format on the Differential Mode Selection screen (Figure 5.9), and press **[1]** to access the RTCM Options.

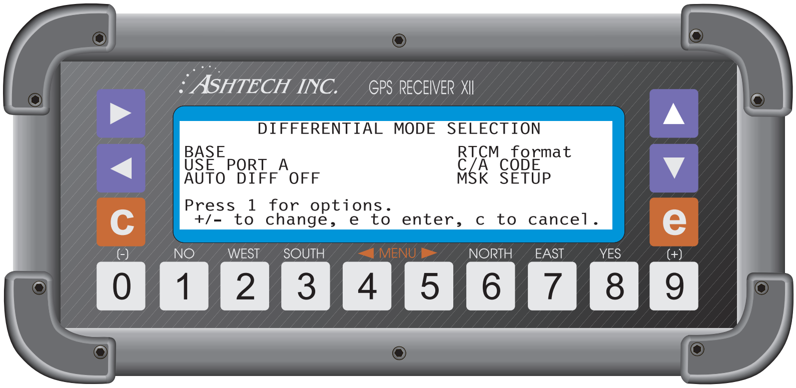


Figure 5.9. Differential Mode Selection Screen

2. Check that the RTCM OPTIONS Menu reads BASE. If not, highlight the MODE indicator and press **[+] or [-]** to toggle it to BASE.
3. Check SPD. The default setting is 50 bits per second. To use another of the available speeds, highlight it and toggle it to the speed you want.
4. Optionally, set STID to a number from 0 to 1023.
5. Optionally, set STHE to a number from 0 to 7.
6. Under FREQ, set the time interval for the messages to be transmitted. Set type 1 frequency to 99 for continuous transmission of differential corrections.
7. If you need to send a message, under MESSAGE, type in the message (up to 32 characters).
8. Press **[e]** twice to return to the main display, Screen 4.

User Equipment or Remote Mode

To set the receiver in user mode to be the remote station:

1. With RTCM format highlighted on the Differential Mode Selection screen, press **[1]** to access the RTCM Options display (Figure 5.10).

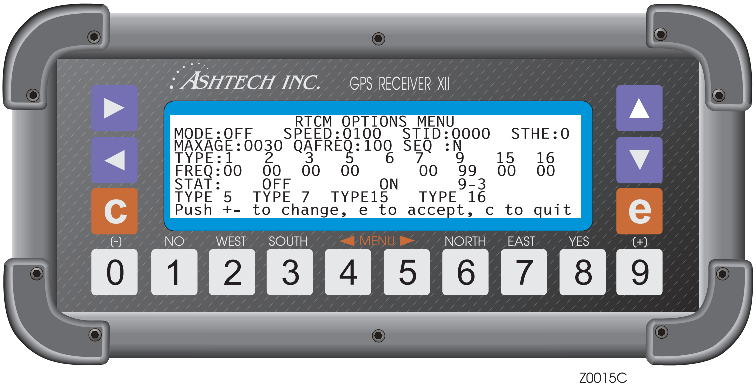


Figure 5.10. RTCM Options

2. On the RTCM Options display, highlight the mode indicator and toggle it to REMOTE.
3. For corrections to be applied by the remote, the remote ID (STID) should be the same as the base, or 0000. To change this field, highlight STID and enter the desired number.
4. To alter MAXAGE, highlight it, set it to a number from 0 to 1199 seconds and press the **[e]** key to enter that value.
5. To change QAFREQ (comm quality), set it to a number from 0 to 999; press the **[e]** key.

A

Serial Port Output

This appendix describes two standard data output features on Z-12 receivers: Real-time data output and NMEA output. Setup for serial output is set in Screen 4.

Real-Time Data Output

This section coves real-time data output. It tells how to access the appropriate screens and enable the various real-time messages, and also details the format of each message.

Real-time data, or raw data, can be output through any of the Z-12's four serial ports (A, B, C, D). It is typically sent to a computer or other data terminal equipment. Specify the type and format of the outgoing data, as listed in Table A.1. The following types and formats are available:

Table A.1. Real-Time Data Formats

Message Type	ASCII Format	Binary Format
MBEN (measurement data)	Yes	Yes
PBEN (position data)	Yes	Yes
SNAV (ephemeris data)	Not available	Yes
SALM (proprietary almanac)	Not available	Yes
DBEN (pseudo-range and CPD measurements)	Not available	Yes
EPB (raw ephemeris)	Not available	Yes

- MBEN messages contain measurement data for each satellite tracked during the session.

- PBEN messages contain position and velocity data.
- SNAV message contains satellite ephemeris data. SNAV is output every 15 minutes, but can be queried for immediate output any time. See [appendix B, Serial Commands] for information on how to query the Z-12.
- SALM messages contain satellite almanac data in an proprietary format. Like SNAV messages, SALM messages are output at 15-minute intervals, but can also be queried anytime for immediate output.
- DBEN is a compacted message which contains one epoch of GPS pseudo-range and carrier phase measurements. DBEN is a differential correction message and should be used only when the receiver is set as a base station.
- EPB messages contain raw ephemeris data as specified in the ICD-GPS-200.

Both the ASCII and binary formats have an ASCII header added to the beginning of the data string: "$PASHR,PBN" for the PBEN message; "$PASHR,MPC" for the MBEN message; etc. Messages that are not available in ASCII format, such as SALM and SNAV, are output in binary regardless of which format is selected.

Real-time messages can be output in any combination from the receiver's RS-232 data ports. The default output interval is 20 seconds. To change this value, go to Screen 4, press **[e]**, use the arrow keys to highlight **INTERVAL**, and use the numeral keys to enter the desired interval. Press **[e]** once again to save the new setting.

SERIAL OUTPUT PROTOCOL
8 Data Bits, 1 Stop Bit, No Parity

Setup for Real-time Data Output

The steps below outline the setup for real-time data output, including message selection, format, and baud rate. This procedure describes setup for Port A:

1. Connect a download cable between Port A on the receiver and a COM port on your computer. If COM1 is not available, use COM2.

2. On Screen 4, Figure A.1, press **[e]** to activate the data-entry mode. Use the arrow keys to highlight **Port A**.

Figure A.1. Z-12 Screen 4

3. Press **[e]** to call the **Port A Parameter Selection** screen, Figure A.2.

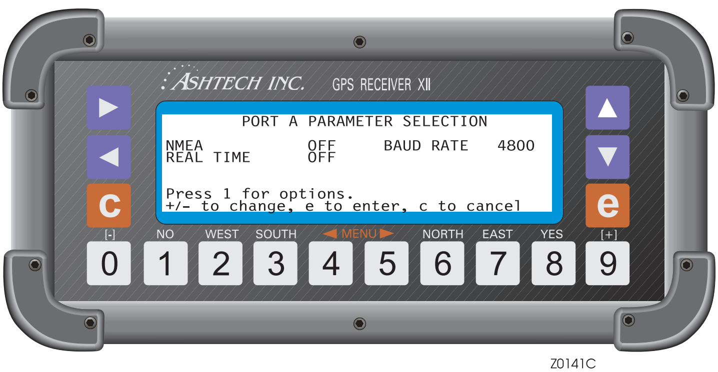


Figure A.2. Port A Parameter Selection

4. Use the arrow keys to highlight **Real Time** and press **1** to call the **Measurements Output on Port A** screen.

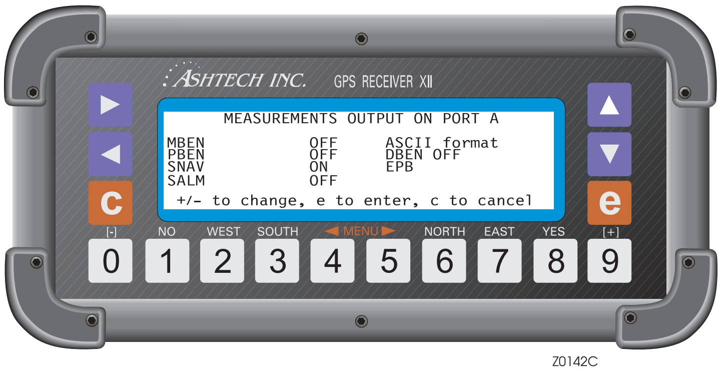


Figure A.3. Measurements Output on Port A Screen

5. To select a message for output, use the arrow keys to highlight the desired message and press **[+]** or **[-]** to toggle it on. Repeat this step for each message you want to output. To disable a message, highlight the desired message and press **[+]** or **[-]** to toggle it off.
6. Highlight the format field to and press **[+]** or **[-]** to select ASCII or binary format. The default is ASCII. Press **[e]** to save the new settings and return to the **Port A Parameter Selection** screen.
7. Check the Baud Rate field. If the baud rate does not match the baud rate of the device to which the Z-12 is connected, use the arrow keys to highlight the baud rate field and toggle **[+]** or **[-]** to chose the correct rate.
8. Highlight **Real Time** and press **[+]** or **[-]** to turn on real-time output.
9. Press **[e]** to save the new settings and return to screen 4.

   Repeat these steps for any of the other ports you want to use for data output. You can send different messages from each port. For example, you can set the Z-12 to send PBEN messages through Port A and SNAV messages through Port B.

Contents of Real-time Messages

Real-time messages are output in binary format, although MBEN and PBEN can also be output in ASCII. Messages output in binary format have the following structure:

"HEADER,MESSAGE ID,DATA + CHECKSUM[CRLF]"

The header field always contains "$PASHR". The message identifier field contains a three character string and is followed by a field containing the binary data string. The header, identifier, and data fields are comma delimited. Depending on the message selected, the checksum is contained in the last one or two bytes of the binary data string. All real-time messages are terminated with a Carriage Return/ Line Feed [CRLF] delimiter. The MBEN message comes out as shown below when binary format is selected:

"$PASHR,MPC,<Binary Data String>[CRLF]"

The structure for messages output in ASCII format is similar, but the data string is divided into comma delimited fields. Most of the fields contain numeric data comprised of either integers, real numbers, or values in which integers and real numbers are combined. The MBEN message has a three-digit checksum in the last data field before the carriage return/line feed. The PBEN message does not have a checksum when output in ASCII format:

"HEADER,MESSAGE ID,DATA+CHECKSUM[CRLF]"

The MBEN message comes out as shown below when ASCII format is selected:

"$PASHR,MPC,<ASCII Data String>*Checksum[CRLF]"

Table A.2 contains symbols and the types of data represented by them used to illustrate real-time message structures in the ASCII format:

Table A.2. ASCII Message Parameter Symbols

Symbol	Parameter Type	Example
d	Numeric integer	3
f	Numeric real	2.45
m	Combined numeric (integer and real) for lat/lon	037:21.0682
s	Character string	PALO
h	Hexadecimal number	A5

MBEN Message

MBEN messages contain satellite measurement data, including satellite PRN, elevation, azimuth, SNR, channel index, and more. MBEN can be output in either ASCII or binary format. A separate message is generated for each tracked satellite above the elevation mask. Table A.3 and Table A.4 outline the contents of the MBEN message for the binary and ASCII formats.

The structure of the MBEN message in binary format is shown below:

$PASHR,MPC,<Satellite Measurment Data + Checksum>

Table A.3. MBEN Message Structure [Binary Format]

Binary Type	Size	Contents
unsigned short	2	sequence tag (unit: 50 ms) modulo 30 minutes
unsigned character	1	number of remaining struct to be sent for current epoch.
unsigned character	1	satellite PRN number.
unsigned character	1	satellite elevation angle (degree).
unsigned character	1	satellite azimuth angle (two degree increments).
unsigned character	1	channel ID (1 - 12).
C/A code data block 29 bytes		
unsigned character	1	Warning flag
unsigned character	1	Indicates quality of the position measurement. (good/bad)
character	1	(set to 5 for backward compatibility)
unsigned char	1	Signal to noise of satellite observation (db.Hz)
unsigned character	1	Spare
double	8	Full carrier phase measurements in cycles.
double	8	Raw range to satellite (in seconds); i.e., receive time - raw range = transmit time
long	4	Doppler (10^{-4} Hz).
long	4	Bits 0 - 23: Smooth correction (bit 0 - 22 = magnitude of correction in cms, bit 23 = sign) Bits 24 - 31: Smooth count, unsigned (0 = unsmoothed; 1=least smoothed; 200 = most smoothed)
	(29)	P code on L1 block (same format as C/A code data block)
	(29)	P code on L2 block (same format as C/A code data block)
unsigned character	1	Checksum, a bytewise exclusive OR (XOR)
total bytes	97	

For details on warning flag and good/bad flag, see *MBN message structure in ASCII.*

The structure of the MBN message in ASCII format is shown below:

$PASHR,MPC,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,f12,f13,f14,f15,
d16,d17,d18,d19,d20,d21,f22,f23,f24,f25,d26,d27,d28,d29,d30,d31,
f32,f33,f34,f35,d36,hh

Table A.4. MBN Message Structure [ASCII format]

Parameter	Description	Units	Range
d1	Sequence tag. This is the time tag used to associate all structures with one epoch. It is in units of 50 ms and modulo 30 minutes.	50 ms	0 - 36000
d2	Number of remaining structures		0 - 11
d3	Satellite PRN number		1 - 32
d4	Satellite elevation	degrees	0 - 90
d5	Satellite azimuth	degrees	0 - 360
d6	Channel index		1-12
C/A Code Data Block			
d7	Warning flag (see Table A.5)		0 - 255
d8	Good/bad flag (see Table A.6)		22 - 24
d9	Space		5
d10	signal to noise indicator	dB Hz	30 - 60
d11	spare		0
f12	Full carrier phase	cycles	±999999999.9
f13	Code transmit time	ms	0 - 999999999.9
f14	Doppler measurement	10^{-4} Hz	±99999.99999
f15	Range smoothing correction. Raw range minus smoothed range.	meters	0 - 99.99
d16	Range smoothing quality		0 - 200
PL1 Code Data Block			
d17	Warning flag (see Table A.5)		0 - 255
d18	Good/bad flag (see Table A.6)		22 - 24

Table A.4. MBN Message Structure [ASCII format] (continued)

Parameter	Description	Units	Range
d19	5 for backward compatibility		5
d20	Signal to noise indicator	dB Hz	30 - 60
d21	spare		
f22	Full carrier phase	cycles	0 - 999999999.999
f23	Code transmit time	ms	0 - 99.9999999
f24	Doppler measurement	10^{-4} Hz	±99999.99999
f25	Range smoothing correction. Raw range minus smoothed range	meters	0 - 99.99
d26	Range smoothing quality		0 - 200
PL2 Code Data Block			
d27	Warning flag (seeTable A.5)		0 - 255
d28	Good/bad flag (see Table A.6)		22 - 24
d29	5 for backward compatibility		5
d30	Signal to noise indicator	dB Hz	30 - 60
d31	spare		
f32	Full carrier phase	cycles	0 - 999999999.999
f33	Code transmit time	ms	0 - 99.9999999
f34	Doppler measurement	10^{-4} Hz	±99999.99999
f35	Range smoothing correction. Raw range minus smoothed range	meters	0 - 99.99
d36	Range smoothing quality		0 - 200
ccc	Checksum Displayed in decimal. A bytwise exclusive OR (XOR) on all bytes from the sequence tag to the checksum (starts after MPC, and includes the last comma before the checksum).		

Table A.5. Warning Flag Settings

Bits Index		Description of parameter d_7
1	2	Combination of bit 1 and bit 2
0 0 1	0 1 0	same as 22 in good/bad flag same as 24 in good/bad flag same as 23 in good/bad flag
3		carrier phase questionable
4		code phase (range) questionable
5		range not precise (code phase loop not settled)
6		Z tracking mode
7		possible cycle slip
8		loss of lock since last epoch

Table A.6. Measurement Quality [Good/Bad Flag]

Value of d_8	Description
0	Measurement not available and no additional data is sent
22	Code and/or carrier phase measured
23	Code and/or carrier phase measure, and navigation message was obtained but measurement was not used to compute position
24	Code and/or carrier phase measured, navigation message was obtained, and measurement was used to compute position

PBEN Message

PBEN messages contain position data, including velocity data, DOP values, and time. PBEN can be output in ASCII or binary format. Table A.7 and Table A.8 below outline the contents of the PBEN message in binary and ASCII format.

The structure of the PBEN message in binary format is shown below:

$PASHR,PBN,<Position Data + Checksum>.

Table A.7. PBN Message Structure (binary format)

Binary Type	Bytes	Description	Units
long (pbentime)	4	GPS time when data was received.	10^{-3} seconds of week
char (sitename)	4	Site name	4 character
double (navx)	8	Station position: ECEF-X	meters
double (navy)	8	Station position: ECEF-Y	meters
double (navz)	8	Station position: ECEF-Z	meters
float (navt)	4	clock offset	meters
float (navxdot)	4	Velocity in ECEF-X	m/sec
float (navydot)	4	Velocity in ECEF-Y	m/sec
float navzdot	4	Velocity in ECEF-Z	m/sec
float navtdot	4	Clock drift	m/sec
unsigned short pdop	2	PDOP	
unsigned short chk-sum	2	checksum	
Total bytes	56		

The structure of the PBEN message in ASCII format is shown in below:

$PASHR,PBN,f1,f2,f3,f4,m5,m6,f7,f8,f9,f10,d11,s12,d13,d14,d15,d1

Note that a checksum is absent from the PBEN message when ASCII format is selected.

Table A.8. $PASHR,PBN Message Structure (ASCII)

Parameter	Description	Range
f1	Receiver time with seconds of the week when code is received	0 - 604800.00
f2	Station position: ECEF-X (meters)	±9999999.9
f3	Station position: ECEF-Y (meters)	±9999999.9
f4	Station position: ECEF-Z (meters)	±9999999.9
m5	Latitude in degrees and decimal minutes (ddmm.mmmmmm) Positive north.	±90

Table A.8. $PASHR,PBN Message Structure (ASCII) (continued)

Parameter	Description	Range
m6	Longitude in degrees and decimal minutes (dddmm.mmmmmm) Positive east.	±180
f7	Altitude (meters)	±99999.999
f8	Velocity in ECEF-X (m/sec).	±999.99
f9	Velocity in ECEF-Y (m/sec).	±999.99
f10	Velocity in ECEF-Z (m/sec).	±999.99
d11	Number of satellites used for position computation.	3 -12
s12	Site name	4 character string
d13	PDOP	0 - 99
d14	HDOP	0 - 99
d15	VDOP	0 - 99
d16	TDOP	0 - 99

SNAV Message

The SNAV message contains satellite ephemeris data, including values for orbital parameters, satellite health status, clock corrections, etc. SNAV is output in binary format only. One message is output for each satellite being tracked. Table A.9 below outlines the contents of the SNAV message.

The structure of the SNAV message is shown below:

$PASHR,SNV,<Ephemeris Data + Checksum>

Table A.9. $PASHR,SNV Message Structure

Binary Type	Size	Contents
short	2	Wn. GPS week number
long	4	Seconds of GPS week
float	4	Tgd. Group delay (sec)
long	4	IODC. Clock data issue
long	4	toc. second
float	4	af2. sec/sec2 (clock correction)
float	4	af1. sec/sec (clock correction)

Table A.9. $PASHR,SNV Message Structure (continued)

Binary Type	Size	Contents
float	4	af0. sec (clock correction)
long	4	IODE Orbit data issue
float	4	Δn.Mean anomaly correction (semi-circle/sec)
double	8	M0. Mean anomaly at reference time (semi-circle).
double	8	e. Eccentricity
double	8	(A)1/2. Square root of semi-major axis (meters 1/2).
long	4	toe.Reference time for orbit (sec).
float	4	Cic. Harmonic correction term (radians).
float	4	Crc. Harmonic correction term (meters).
float	4	Cis. Harmonic correction term (radians).
float	4	Crs. Harmonic correction term (meters).
float	4	Cuc. Harmonic correction term (radians).
float	4	Cus. Harmonic correction term (radians).
double	8	(OMEGA)0. Lon of Asc. node (semi-circles).
double	8	ω. Argument of Perigee (semi-circles)
double	8	I0. Inclination angle at reference time (semi-circles).
float	4	OMEGADOT. Rate of right Asc. (semi-circles per sec).
float	4	IDOT. Rate of inclination (semi-circles per sec).
short	2	Accuracy
short	2	Health
short	2	Curve fit interval (coded).
char	1	Satellite PRN number -1
char	1	Reserved byte.
unsigned short	2	Word checksum
Total =	132 bytes	

SALM Message

The SALM message contains much of the same data available in the SNV message, but also includes an almanac week reference. Like SNAV, the SALM message is output in binary format only. One SALM message is output for each satellite for which the receiver has collected almanac data. Table A.10 below outlines the contents of the SALM message.

The structure of the SALM message is shown below:

$PASHR,ALM,<Almanac Data + Checksum>

Table A.10. ALM Message Structure

Type	Size	Contents
short	2	Satellite PRN -1
short	2	Health. see ICD - 200 for description
float	4	e. Eccentricity
long	4	toe. Reference time for orbit (sec)
float	4	I0. Inclination angle at reference time (semi-circles).
float	4	OMEGADOT. Rate of right Asc. (semi-circles per sec).
double	8	(A)1/2. Square root of semi-major axis (meters 1/2).
double	8	(OMEGA)0. Lon of Asc. node (semi-circles).
double	8	ω. Argument of Perigee (semi-circles)
double	8	M0. Mean anomaly at reference time (semi-circle).
float	4	af0. sec
float	4	af1. sec/sec.
short	2	almanac week number
short	2	GPS week number
long	4	Seconds of GPS week
unsigned short	2	Word checksum
Total bytes70		

DBEN Message

DBEN messages contain differential correction data used for the carrier phase differential (CPD). Each DBEN message represents one epoch of GPS pseudo-range and carrier phase measurements. DBEN is a "packed", or compressed, message. The size of a DBEN message depends on the number of satellites being tracked. DBEN data includes time, satellites PRN, and pseudo-range and carrier phase measurements for each satellite being tracked. Tables A.11 through A.13 below outline the contents of DBEN messages.

The structure of the DBEN message is shown below:

$PASHR,RPC, <Data Length> <Packed Data> <Checksum>

Table A.11. $PASHR,RPC

Parameter	Type	# of bytes	Description
data length	unsigned short	2	number of bytes in <packed data> part
packed data	unsigned char[]	data length	see below
ChkSum	unsigned short	2	Accumulative unsigned short summation of the <packed data>, after <data length> before <ChkSum>

<packed data> Parameter:

Table A.12. $PASHR,RPC Packed Parameter Descriptions

Data Type	Symbol	Range	Resolution	Compressed # Bits	Description
double	rcvtime	0 - 604800000	1 msec	30	Receiver time in GPS milliseconds of week
char[4]	site ID			32	Receiver's four character's site ID
long	PRN			32	PRN for the satellites which have data in this message. It is a bitwise indication. Starting from least significant bit, bit 1 corresponds to Satellite PRN #1, bit 2 corresponds to Satellite PRN #2, and so on. Bit value of 1 means that Satellite PRN has data in this message, 0 otherwise.
The following data repeats for each satellite whose corresponding bit in PRN is "1":					
double	PL1		1.0E-10 seconds	31	Pseudorange in units of 1.0e-10 seconds (or 0.1 nanoseconds). Multiply this value by 1.0e-10 to get pseudo-range in seconds. A zero value indicates bad pseudo-range
char	WN			1	Warning bit 1- bad carrier phase and has possible cycle-slips 0 - good carrier phase
	Sign		1	1	Carrier phase sign bit 1 - negative carrier phase value 0 - positive carrier phase value

Table A.12. $PASHR,RPC Packed Parameter Descriptions (continued)

Data Type	Symbol	Range	Resolution	Compressed # Bits	Description
long	PH_I		1	28	Integer part of the carrier phase measurement in cycles
double	PH_F		15.0E-4	11	Fractional part of the carrier phase measurement in units of 5E-4 cycles. Multiply this number by 5E-4 to get fractional carrier phase in cycles. Whole carrier phase measurement = PH_I + PH_F*5.0E-4

Zeros are padded so that all of <Packed Data> part is a module of 16 bits.

Total number of bits in <Packed Data>: ceil ((94 + 72*2*Nsvs)/16) * 16

<Data Length> = ceil ((94 + 72*2*Nsvs)/16) * 2, in which ceil (a) means truncates to +Inf, e.g., ceil (3.1) = 4, ceil (3.5) = 4, ceil (3.95) = 4. Nsvs is number of satellites.

Table A.13 shows DBEN message sizes in relation to the number of satellites being tracked:

Table A.13. DBEN Message Sizes

# of Satellites	bits	bytes
4	808	101
5	952	119
6	1096	137
7	1240	155
8	1384	173
9	1528	191
10	1672	209
11	1816	227
12	1960	240

EPB Message

The EPB message contains actual broadcast ("raw") ephemeris data. See the ICD-GPS-200 for a definition of the parameters. Each subframe word is right-justified in a 32-bit long integer.

The structure of the EPB message is shown below:

$PASHR,EPB,d,<Ephemeris Data + Checksum>

Table A.14 outlines the response format.

Table A.14. $PASHR,EPB Response Format

Type	Size	Contents
d	2	PRN number
struct		
long	4	Subframe 1, word 1
long	4	Subframe 1, word 2
long	4	Subframe 1, word 3
long	4	Subframe 1, word 4
long	4	Subframe 1, word 5
long	4	Subframe 1, word 6
long	4	Subframe 1, word 7
long	4	Subframe 1, word 8
long	4	Subframe 1, word 9
long	4	Subframe 1, word 10
long	4	Subframe 2, word 1
long	4	Subframe 2, word 2
long	4	Subframe 2, word 3
long	4	Subframe 2, word 4
long	4	Subframe 2, word 5
long	4	Subframe 2, word 6
long	4	Subframe 2, word 7
long	4	Subframe 2, word 8
long	4	Subframe 2, word 9
long	4	Subframe 2, word 10
long	4	Subframe 3, word 1
long	4	Subframe 3, word 2
long	4	Subframe 3, word 3
long	4	Subframe 3, word 4
long	4	Subframe 3, word 5

Table A.14. $PASHR,EPB Response Format (continued)

Type	Size	Contents
long	4	Subframe 3, word 6
long	4	Subframe 3, word 7
long	4	Subframe 3, word 8
long	4	Subframe 3, word 9
long	4	Subframe 3, word 10
short	2	Word checksum begin with header ‘P’.
total =	122	struct size

NMEA Output

This section covers NMEA message output and output of Ashtech’s NMEA-style messages. Standard NMEA messages are output as a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards (version 2.1). Ashtech’s NMEA-style messages are also output in a comma-delimited string of ASCII characters, but may deviate slightly from NMEA standards. For example, the maximum length of a standard NMEA message is eighty characters, but the length of some messages go beyond eighty characters. Both NMEA messages and Ashtech NMEA style messages begin with a dollar sign ($) and end with a Carriage Return/Line Feed [CRLF] delimiter. Any combination of these messages can be output through different ports at the same time. The output rate can be set to any value between 0.5 and 999 seconds. The default output interval is five seconds.

NMEA output parameters are set in Screen 4. The receiver supports seventeen standard NMEA messages and six Ashtech messages in the NMEA style. Table A.15 describes the three letter identifier and a brief description for each message:

Table A.15. NMEA Data Message Commands

Message ID	Type	Description	Page
ALM	NMEA	GPS almanac message (hex numeric format)	121
APA	NMEA	Autopilot control message	123
AS1	Ashtech	GPS position message in UTM grid coordinates referenced to the RT90 datum (Sweden)	125

Table A.15. NMEA Data Message Commands (continued)

Message ID	Type	Description	Page
BWC	NMEA	Bearing and distance to waypoint (great circle)	126
DAL	Ashtech	GPS almanac data (decimal format)	128
GGA	NMEA	GPS position data (lat / long / alt)	129
GLL	NMEA	GPS position data (lat / long)	131
GRS	NMEA	GPS range residuals	132
GSA	NMEA	Active (tracked) satellites and DOPs	134
GSN	NMEA	Active (tracked) satellites and signal strengths	135
GSV	NMEA	Satellites in view	136
GXP	NMEA	GPS position data (lat / long)	138
MSG	NMEA	RTCM base station message	139
POS	Ashtech	DGPS status; GPS position data (lat / lon / alt), velocity, DOPs.	141
RRE	NMEA	Range residual measurements for each tracked satellite	143
SAT	Ashtech	Locked satellites, elevation, azimuth, SNRs	144
TTT	Ashtech	Event marker	146
UTM	Ashtech	Position in UTM coordinates	147
VT3	NMEA	Vehicle tracking data (standard)	148
VT4	NMEA	Vehicle tracking data (precision)	150
VTG	NMEA	Velocity and course over the ground	151
XTE	NMEA	Cross-track error	152
ZDA	NMEA	Time and date	153

Setup for NMEA Output

The steps below outline the setup for NMEA output, including message selection, output interval, and baud rate. This procedure describes setup for Port A:

1. Connect a download cable between Port A on the receiver and a COM port on your computer. If COM1 is not available, use COM2.

2. On Screen 4 (Figure A.4) press **[e]** to activate the data-entry mode. Use the arrow keys to highlight **Port A**.

Figure A.4. Screen 4

3. Press **[e]** to call the **Port A Parameter Selection** screen,

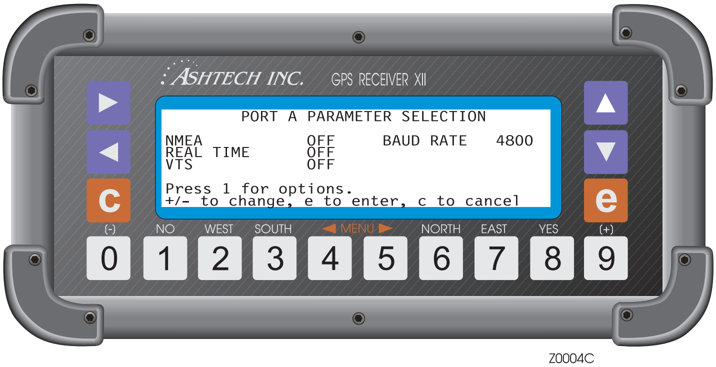


Figure A.5. Port A Parameter Selection Screen

4. Use the arrow keys to highlight NMEA and press **1** to call the **NMEA Options Menu Port A** screen, Figure A.6.

Figure A.6. NMEA Options Screen

5. To select a message for output, use the arrow keys to highlight the desired message and press **[+]** or **[-]** to toggle it on. Repeat this step for each message you want to output. To disable a message, highlight the desired message and press **[+]** or **[-]** to toggle it off.
6. To change the output interval, highlight **Send Interval** and press the numeral keys to enter the desired interval (seconds). Press **[e]** to save the new settings and return to the **Port A Parameter Selection** screen.
7. Check the Baud Rate field. If the baud rate does not match the baud rate of the device to which the receiver is connected, use the arrow keys to highlight Baud Rate and toggle **[+]** or **[-]** to chose the correct baud rate.
8. Highlight **NMEA** and press **[+]** or **[-]** to turn on NMEA output.
9. Press **[e]** to save the new settings and return to Screen 4.

Repeat these steps for other receiver ports you want to use for NMEA output. You can send different messages from each port; that is, you can send GGA and VTG messages out of Port A and ALM and SAT messages from Port B. The output interval is the same for all ports. If the output interval is set to 10 seconds in the **NMEA Options Menu Port B** screen, the same interval is set automatically in the **NMEA Options Port A** screen.

Contents of NMEA Messages

Standard NMEA messages have the following structure:

"HEADER,DATA*CHECKSUM[CRLF]"

The comma after the header is followed by the ASCII data string and the message checksum. The checksum is separated from the data string by an asterisk. Both standard and Ashtech NMEA-style standard NMEA messages use a dollar sign ($) to indicate the beginning of a message, and both types are terminated with a [CRLF] delimiter. GGA, which is a standard NMEA message, comes out as shown below:

"$GPGGA,DATA*CHECKSUM[CRLF]"

The structure of Ashtech NMEA-style messages is shown below:

"HEADER,MESSAGE ID,DATA*CHECKSUM[CRLF]"

Standard NMEA messages include the message identifier in the header. Ashtech NMEA-style messages, which have a proprietary format, have the message identifier in a separate field. SAT, an Ashtech NMEA-style message, comes out as shown below:

"$PASHR,SAT,DATA*CHECKSUM[CRLF]"

The data types that appear in NMEA messages can be integers, real numbers (decimal), hexadecimal numbers, alphabetic characters, and alphanumeric character strings. Table A.16 lists the symbols used to indicate the type for each field.

Table A.16. ASCII Message Parameter Symbols

Parameter	Parameter Type	Example
d	Numeric integer	3
f	Numeric real	2.45
c	1 character ASCII	N
s	character string	1K00
m	mixed parameter (integer and real) for lat/lon or time	3729.12345
h	hexadecimal digit	FD2C
*hh	hexadecimal checksum which is always preceded by a*	*A5

ALM: GPS Almanac Message

The ALM message contains satellite almanac data, including values for orbital parameters, satellite health status, clock corrections, etc. One response message is outputfor each satellite in the GPS constellation.

The ALM message is output in the format shown below:

$GPALM,d1,d2,d3,d4,h5,h6,h7,h8,h9,h10,h11,h12,h13,h14,h15*hh

Table A.17. ALM Response Message

Parameter	Description	Range
d1	Total number of messages	01 -32
d2	Number of this message	01 -32
d3	Satellite PRN number	01 - 32
d4	GPS week	4 digits
h5	Satellite health (ASCII hex format)	2 bytes
h6	Eccentricity (ASCII hex format)	4 bytes
h7	Almanac reference time measured in seconds. (ASCII hex format)	2 bytes
h8	Inclination angle measured in semicircles. (ASCII hex format)	4 bytes
h9	OMEGADOT. Rate of ascension (semicircles/sec. In ASCII Hex)	4 bytes
h10	A½. Square Root of semi-major axis (Meters & ½ In ASCII Hex)	6 bytes
h11	W. Argument of perigee (semicircle. In ASCII Hex)	6 bytes
h12	ω0. Longitude of ascension mode (semicircle. In ASCII Hex)	6 bytes
h13	Mo. Mean anomaly (semicircle. In ASCII Hex)	6 bytes
h14	afo. Clock parameter (seconds. In ASCII Hex)	3 bytes
h15	af1. Clock parameter (sec/sec. In ASCII Hex)	3 bytes
*hh	Checksum	

Typical ALM message:

$GPALM,26,01,01,0899,00,1E8C,24,080B,FD49,A10D58,EB4562,BFEF85
,227A5B,011,000*0B

where each item is described in Table A.18.

Table A.18. Typical ALM Message

Parameter	Description
$GPALM	Header
26	Total number of messages
01	Number of this message

Table A.18. Typical ALM Message (continued)

Parameter	Description
01	Satellite PRN Number
0899	GPS week number
00	Satellite Health
1E8C	Eccentricity
24	Almanac Reference Time
080B	Inclination angle
FD49	Rate of ascension
A10D58	Root of semi-major axis
EB4562	Argument of perigree
BFEF85	Longitude of ascension mode
227A5B	Mean anomaly
011	Clock parameter
000	Clock parameter
*0B	checksum

APA: Autopilot Message

The APA message contains navigation data used to drive marine autopilot systems. This message is not output unless a position is computed and a route is activated. See "Screen 6: Waypoint and Route Functions", for more information.

The APA message is output in the form shown below and described in Table A.19.

$GPAPA,c1,c2,f3,c4,c5,c6,c7,d8,c9,s10*hh

Table A.19. APA Message Structure

Parameter	Description	Range
c1	SNR Warning Flag (always "A", since the message is not output unless positions are being computed)	A = Valid V = Invalid
c2	Cycle Lock Warning Flag (always "A", since this message is not output unless positions are being computed)	A = Valid V = Invalid
f3	Magnitude of Cross-track Error (measured perpendicularly from the current position to the intended track)	0.0 - 999.999
c4	Direction to Steer (toward the destination)	L(eft) or R(ight)
c5	Cross-track Error Units (nautical miles)	N

Table A.19. APA Message Structure (continued)

Parameter	Description	Range
c6	Arrival Circle Status for Waypoint Switching (always "V"; arrival circle criterion for waypoint switching not supported in Z-12)	A = Valid V = Invalid
c7	Perpendicular Arrival Status for Waypoint Switching (always "A")	A = Valid V = Invalid
d8	Bearing to destination from starting point	0—359
c9	Bearing reference	T = True M = Magnetic
s10	Waypoint identifier	3 character string
*hh	Checksum	

A typical APA message is shown below and described in Table A.20.

$GPAPA,A,A,1.421,L,N,V,A,089,T,001*2D

Table A.20. Typical APA Message

Parameter	Description
$GPAPA	Header
A	Valid SNRs
A	Valid cycle lock
1.42	Cross-track error measurement
L	Indicates that the vessel must be steered to the left to get back on course.
N	Cross-track error measured in nautical miles.
V	Indicates that arrival circle for waypoint switching is invalid.
A	Indicates that arrival perpendicular for waypoint switching is valid
089	Indicates that the bearing from the starting point to the destination is 89 degrees
T	Indicates that the bearing is referenced to true north
001	Waypoint identifier
2D	Checksum

AS1: Grid Coordinate Output for RT90 Datum

The AS1 message contains data for time, position (northing / easting / altitude), and differential GPS status. Positions are referenced to the RT90 datum (Sweden) and rendered in UTM coordinates. This message is not output unless positions are being computed:

The AS1 message is output in the format shown below:

$PASHR,RT90,m1,f2,f3,d4,d5,f6,f7,c8,f9,c10,d11,s12*hh

Table A.21. AS1 Message Structure

Parameter	Description	Range
m1	UTC of position in hours, minutes, and decimal seconds (hhmmss.ss)	0 - 235959.90
f2	East UTM coordinate (meters)	±9999999.999
f3	North UTM coordinate (meters)	±9999999.999
d4	Position indicator. 1: Raw position 2: RTCM code differential, or CPD float solution 3: Carrier Phase differential (CPD) fixed	1, 2, 3
d5	Number of GPS satellites being used	3 - 12
f6	Horizontal dilution of precision (HDOP)	999.9
f7	Altitude in meters	±99999.999
c8	Altitude units	M(eters)
f9	Geoidal separation [Always null. Geoidal modelling not supported by Z-12]	±999.999
c10	Geoidal separation units	M(eters)
d11	Age of differential corrections (seconds)	0 - 999
s12	Differential reference station ID	4 character string
*hh	checksum	2 character hex

Typical AS1 message:

$PASHR,RT90,223302.00,+588757.62,+4136720.05,2,07,0.12,+475.38,M,
,M,05,733,*3A

Table A.22. Typical AS1 Message

Parameter	Description
223302.00	UTC time
+588757.623	UTM easting coordinate
+4136720.056	UTM northing coordinate
2	RTCM code differential position
07	Number of satellites used to compute position
0.12	HDOP
00012.123	Ellipsoidal altitude
M	Altitude units (M = meters)
null	geoidal separation [not supported by Z-12]
M	geoidal separation units (M = meters)
05	age of corrections
733	Differential Station ID
*3A	checksum

BWC: Bearing and Distance to Destination

The BWC message contains position and bearing for the current destination. This message is output only when positions are being computed and a destination (waypoint) has been selected.

The BWC message is output in the format shown below:

$GPBWC,m1,m2,c3,m4,c5,f6,c7,f8,c9,f10,c11,s12*hh

Table A.23. BWC Message Structure

Parameter	Description	Range
m1	UTC in hours, minutes, seconds, and decimal seconds (hhmmss.ss)	0 - 235959.59
m2	Latitude of destination in degrees, minutes, and decimal minutes (ddmm.mmmm)	0° - 90°

Table A.23. BWC Message Structure (continued)

Parameter	Description	Range
c3	Direction of latitude	N(orth) S(outh)
m4	Longitude of destination in degrees, minutes, and decimal minutes (dddmm.mmmm)	0° - 180°
c5	Direction of longitude	E(east) W(est)
f6	Bearing	0° - 359.99°
c7	Bearing reference (true north)	T
f8	Bearing	0° - 359.99°
c9	Bearing reference (magnetic)	M
f10	Distance to destination	0 - 999.999
c11	Distance units = nautical miles	N
s12	Waypoint identifier	3 character string
*hh	checksum	2 character hex

Typical BWC message:

GPBWC,232317.00,3721.0929,N,12156.1115,W,088.82,T,073.43,M, 008.789,N, 001*0C

Table A.24. Typical BWC Message

Parameter	Description
$GPBWC	Header
232317.00	UTC
3721.0929	Latitude of the destination
N	Direction of latitude
12156.1115	Longitude of destination
W	Direction of longitude
088.82	Bearing to destination
T	Bearing reference (true north)
073.43	Bearing to destination
M	Bearing reference (magnetic)

Table A.24. Typical BWC Message (continued)

Parameter	Description
008.789	Distance to destination
N	Distance units (nautical miles)
001	Waypoint identifier
*0C	Checksum

DAL: GPS Almanac Message (Decimal Format)

The DAL message contains the same information as the ALM message, but the numbers associated with almanac parameters are output in decimal format rather than hex format. One message is output for each satellite in the GPS constellation.

The DAL message is output in the format shown below:

$PASHR,DAL,d1,d2,f3,d4,f5,f6,f7,f8,f9,f10,f11,f12,d13*hh,

Table A.25. DAL Message Structure

Parameter	Description	Symbol	Range
d1	Satellite PRN number		1 - 32
d2	Satellite health		0 - 255
f3	Eccentricity	e	±9.9999999E±99
d4	toe, reference time for orbit (in seconds)	t_a	0 - 999999
f5	i0, inclination angle at reference time (semicircles)	ι_o	0 - 9.9999999E±99
f6	omegadot, the rate of right ascension (semicircles/sec)		±9.9999999E±99
f7	roota, the square root of semi-major axis (meters 1/2)		0 - 9.9999999E±99
f8	omega0, the longitude of the ascension node (semicircle)		±9.9999999E±99
f9	Argument of perigee (semicircle)	w	±9.9999999E±99
f10	Mean anomaly at reference epoch (semicircle)	M_o	±9.9999999E±99
f11	Clock parameter (seconds)	a_o	±9.9999999E±99
f12	Clock parameter (sec/sec)	a_1	0 - 9.9999999E±99

Table A.25. DAL Message Structure

Parameter	Description	Symbol	Range
d13	GPS almanac week number	WEEK	4 digits
*cc	checksum in hex		hex

Typical DAL message:

$PASHR,DAL,01,00,3.7240982E03,061440,3.0392534E-01,-2.5465852E-09,5.1536646E03,1.6172159E-01,-5.0029719E-01,2.7568674E-01,1.6212463E-05,0.0000000E00,0899*51

Table A.26. Typical DAL Message

Parameter	Description
$PASHR,DAL	Header
01	Satellite PRN Number
00	Satellite Health
3.7240982E03	Eccentricity
061440	Reference Time for orbit
3.0392534E-01	Inclination angle
-2.5465852E-09	Rate of right ascension
5.1536646E03	Square root of semi-major axis
-1.6172159E-01	Argument of perigree
-5.0029719E-01	Longitude of ascension mode
2.7568674E-01	Mean anomaly
1.6212463E-05	Clock Parameter
0.0000000E00	Clock Parameter
0899	GPS week number
*51	checksum

GGA: GPS Position Message

The GGA message contains data for time, position (lat / lon / altitude), and differential GPS status. This message is not output unless positions are being computed.

The GGA message is output in the format shown below:

$GPGGA,m1,m2,c3,m4,c5,d6,d7,f8,d9,c10,f11,c12,f13,d14*hh

Table A.27. GGA Message Structure

Parameter	Description	Range
m1	Current UTC time of position fix in hours, minutes, and seconds (hhmmss.ss)	0 - 235959.90
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmm)	0° - 90°
c3	Latitude sector	N(orth) S(outh)
m4	Longitudinal component of position in degrees and decimal minutes (dddmm.mmmmm)	0 - 180
c5	Longitude sector	W(est) E(ast)
d6	Position type 0. Position not available or invalid 1. Autonomous position 2. RTCM differential corrected position or CPD float position	0, 1, 2
d7	Number of GPS satellites being used in the position computation	3 - 12
f8	Horizontal dilution of precision (HDOP)	0 - 99.9
d9	Antenna height (ellipsoidal)	±9999
c10	Altitude units	M(eters)
f11	Geoidal separation in meters (always null; Z-12 does not support geoidal modelling)	
c12	Geoidal separation units	M(eters)
f13	Age of differential corrections (seconds)	0 - 999
d14	Base station ID (RTCM only)	0 - 1023
*hh	checksum	2 character hex

Typical GGA message:
$GPGGA,015454.00,3723.28513,N,12202.23851,W,2,04,03.8,00012,M
,,M,014,0000*75

Table A.28. Typical GGA Message

Parameter	Description
$GPGGA	Header
015454.00	UTC time
3723.28513	Latitude (ddmm.mmmmm)
N	North Latitude
12202.23851	Longitude (dddmm.mmmmm)
W	West longitude
2	RTCM differential position
04	Number of satellites used in position
03.8	HDOP
00012	Ellipsoidal height
M	Units of altitude
null	Geoidal separation
M	Units of geoidal separation
014	Age of correction
0000	Base station ID
*75	checksum

GLL: Latitude / Longitude Message

The GLL message contains data for position (lat / lon) and time. This message is not output unless positions are being computed.

The GLL message is output in the format shown below:

$GPGLL,m1,c2,m3,c4,m5,c6*hh

Table A.29. GLL Message Structure

Parameter	Description	Range
m1	Position latitude in degrees and decimal minutes (ddmm.mmmmm)	0° - 90°

Table A.29. GLL Message Structure

Parameter	Description	Range
c2	Latitude sector	N(orth) S(outh)
m3	Position longitude in degrees and decimal minutes (dddmm.mmmmm)	0° - 180°
c4	Longitude sector	W(est) E(east)
m5	UTC Time of position in hours, minutes, and seconds (hhmmss.ss)	00 - 235959.90
c6	Status of position data (always "A", since the message is not output unless positions are being computed)	A = Valid V = Invalid
*hh	Checksum	2 character hex

Typical GLL message:

$GPGLL,3722.41429,N,12159.85282,W,202556.00,A*12

Table A.30. Typical GLL Message

Parameter	Description
$GPGLL	Header
3722.41429	Latitude
N	North Latitude
12159.85282	Longitude
W	West Longitude
202556.00	UTC time of position
A	Position data is valid
*12	checksum

GRS: Satellite Range Residuals

The GRS message contains data for time, range residual computation mode, and range residuals for each tracked satellite. This message is not output unless positions are being computed and five or more satellites are being tracked.

The GRS message is output in the format shown below

$GPGRS,m1,d2,**n**(f3)*hh

where **n** is the number of satellites used in the position solution.

Table A.31. GRS Message Structure

Parameter	Description	Range
m1	Current UTC time of GGA position in hours, minutes and seconds (hhmmss.ss)	0 - 235959.90
d2	Mode used to compute range residuals: • Residuals were used to calculate the position given in the matching GGA line • Residuals were re-computed after the GGA position was computed (post fit residuals) • Always = 1; by default, the Z-12 recomputes residuals after computing the GGA message	0, 1
f3	Range residuals for each satellite used in position computation. The order of the residuals matches the order of the satellites in the GSV message. An empty field indicates that a particular satellite is being tracked, but is not used in the position solution	±999.999
*hh	checksum	

Typical GRS message:

$GPGRS,203227.50,1,-007.916,051.921,-048.804,-026.612,
-002.717,021.150*63

Table A.32. Typical GRS Message

Parameter	Description
$GPGRS	Header
203227.50	UTC time of GGA position
1	Residuals computed after GGA position calculation
-007.916	Range residuals of the first satellite
051.921	Range residuals of the second satellite
-048.804	Range residuals of the third satellite
-026.612	Range residuals of the fourth satellite
-002.717	Range residuals of the fifth satellite
021.150	Range residuals of the sixth satellite
*63	checksum

GSA: Active Satellite and DOP Message

The GSA message contains data for position mode (2D, 3D, no position), DOP values, and also lists currently tracked satellites.

The GSA message is output in the format shown below:

$GPGSA,c1,d2,,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,d14,f15,
f16,f17*hh

Table A.33. GSA Message Structure

Parameter	Description	Range
c1	Position mode switch for 2D/3D positioning	M(anual) A(utomatic)
d2	Position Mode: • no position fix • 2D position • 3D position	1 - 3
d3 - d14	Satellites used in the position solution (null fields for unused channels)	1 - 32
f15	PDOP	0 - 9.9
f16	HDOP	0 - 9.9
f17	VDOP	0 - 9.9
*hh	Checksum	

Typical GSA message:

$GPGSA,M,3,,02,,04,27,26,07,,,,,09,3.2,1.4,2.9*39

Table A.34. Typical GSA Message

Parameter	Description
$GPGSA	Header
M	Manual 2D/3D switch mode
3	3D mode
empty field	No satellite in channel 1
02	PRN of satellite in channel 2
empty field	No satellite in channel 3
04	PRN of satellite in channel 4
27	PRN of satellite in channel 5

Table A.34. Typical GSA Message (continued)

Parameter	Description
26	PRN of satellite in channel 6
07	PRN of satellite in channel 7
empty field	No satellite in channel 8
empty field	No satellite in channel 9
empty field	No satellite in channel 10
empty field	No satellite in channel 11
09	PRN of satellite in channel 12
3.2	PDOP
1.4	HDOP
2.9	VDOP
*38	checksum

GSN: Satellite Numbers and Signal Strengths

The GSN message lists satellite PRN numbers and the corresponding signal strength measured for each locked satellite.

The GSN message is output in the format shown below:

$GPGSN,d1,**n**(d2,f3),d4*hh

where **n** is equal to the number of locked satellites.

Table A.35. GSN Message Structure

Parameter	Description	Range
d1	Number of satellites locked	0 - 12
d2	PRN number	1 - 32
f3	Signal strength	1.0 - 99.0
d3	Age of RTCM correction. 999 if RTCM age of correction is not available or RTCM mode is off.	0 - 999
*hh		2 character hex

Typical GSN message:

$GPGSN,04,02,46.5,04,48.4,07,50.8,09,51.2,999*7C

Table A.36. Typical GSN Message

Parameter	Description
$GPGSN	Header
04	Number of satellites locked
02	PRN number of the first satellite
46.5	Signal to noise of the first satellite
04	PRN number of the second satellite
48.4	Signal to noise of the second satellite
07	PRN number of the third satellite
50.8	Signal to noise of the third satellite
09	PRN number of the fourth satellite
51.2	Signal to noise of the fourth satellite
999	RTCM age of correction not available or RTCM mode is off
*7C	checksum

GSV: Satellites in View

The GSV message contains a list of the satellites in view along with the corresponding elevation, azimuth, and SNR.

The GSV message is output in the format shown below:

$GPGSV,d1,d2,d3,**n**(d4,d5,d6,f7)*hh

The maximum value of **n** is 4. If more than 4 satellites are tracked, a second message is sent automatically; a 3rd message is sent if more than 8 satellites are tracked. The items are described in Table A.37.

Table A.37. GSV Message Structure

Parameter	Description	Range
d1	Total number of messages being sent	1 - 3
d2	Message number	1 - 3
d3	Total number of satellites in view	1 - 12

Table A.37. GSV Message Structure (continued)

Parameter	Description	Range
d4	Satellite PRN	1 - 32
d5	Elevation in degrees	0° - 90°
d6	Azimuth in degrees	0° - 359°
f7	SNR	1.0 - 99.0
*hh	checksum	2 character hex

Typical GSV message:

$GPGSV,2,1,08,16,23,293,50.3,19,63,050,52.1,28,11,038,51.5,29,14,145,50.9*78

Table A.38. Typical GSV Message

Parameter	Description
2	Total number of messages sent
1	message number 1
8	number of satellites in view
16	PRN of first satellite
23	elevation of first satellite
293	azimuth of first satellite
50.3	signal-to-noise for the first satellite
19	PRN of second satellite
63	elevation of second satellite
050	azimuth of second satellite
52.1	signal-to-noise of second satellite
28	PRN of third satellite
11	elevation of third satellite
038	azimuth of third satellite
51.5	signal-to-noise of third satellite
29	PRN of fourth satellite
14	elevation of fourth satellite
145	azimuth of fourth satellite

Table A.38. Typical GSV Message (continued)

Parameter	Description
50.9	signal-to-noise of fourth satellite
*78	message checksum in hexadecimal

GXP: Horizontal Position Message

The GXP message contains data for position and time. This message is not output unless positions are being computed.

The GXP message is output in the format shown below (Table A.39):

$GPGXP,m1,m2,c3,m4,c5*hh

Table A.39. GXP Message Structure

Parameters	Description	Range
m1	UTC of fix in hours, minutes and seconds (hhmmss.ss)	00 - 235959.90
m2	Latitude in degrees and decimal minutes (ddmm.mmmmm)	0° - 90.00°
c3	Latitude sector	N(orth) S(outh)
m4	Longitude in degrees and decimal minutes (dddmm.mmmmm)	0° - 180.00°
c5	Longitude sector	W(est) E(ast)
hh	checksum	2 character hex

Typical GXP message (Table A.40):

$GPGXP,212958.00,3722.396956,N,12159.849225,W*7A

Table A.40. Typical GXP Message

Parameter	Description
$GPGXP	Header
212958.00	UTC of position fix
3722.396956	Latitude
N	Latitude direction

Table A.40. Typical GXP Message (continued)

Parameter	Description
12159.849225	Longitude
W	Longitude direction
*7A	checksum

MSG: Base Station Status Message

The MSG messages contain data and status for incoming and outgoing RTCM messages. The messages vary depending upon the type of RTCM message being sent or received.

RTCM Messages:

Message type 1 format:

$GPMSG,d1,d2,f3,d4,d5,d6,m7,n(d8,d9,f10,f11,d12)*hh

Message type 2 format:

$GPMSG,d1,d2,f3,d4,d5,d6,m7,n(d8,d9,f10,f11,d12)*hh

Message type 3 format:

$GPMSG,d1,d2,f3,d4,d5,d6,m7,f8,f9,f10*hh

Message type 6 format:

$GPMSG,d1,d2,f3,d4,d5,d6,m7*hh

Message type 16 format:

$GPMSG,d1,d2,f3,d4,d5,d6,m7,s8*hh

Table A.41 shows the common part of the MSG message for RTCM Types 1, 2, 3, 6, and 16.

Table A.41. Common Parameters of Type 1, 2, 3, 6, and 16.

Parameter	Description	Range
d1	RTCM message type	1, 2, 3, 6, 16, 18, 19, 20, 21
d2	Station Identifier	0 - 1023
f3	Z count	0 - 9999.9
d4	Sequence number	0 - 9
d5	Station health	0 - 7

Table A.41. Common Parameters of Type 1, 2, 3, 6, and 16. (continued)

Parameter	Description	Range
d6	Total number of characters after the time item (include the comma and <CR><LF>)	0 - 999
m7	Current GPS time of position fix (hhmmss.ss)	00 - 235959.90

Remainder of message for Type 1:

Table A.42. Remainder of Type 1 Message

Parameter	Description	Range
d8	User differential range error (UDRE)	0 - 9
d9	Satellite PRN number	1 - 32
f10	Pseudo range correction (PRC) in meters	±9999.99
f11	Range rate correction (RRC) in meters/sec	±9.999
d12	Issue of data ephemeris (IODE)	0 - 999
*hh	checksum	2 character hex

Remainder of message for Type 2:

Table A.43. Remainder of Type 2 Message

Parameter	Description	Range
d8	User differential range error (UDRE)	0 - 9
d9	Satellite PRN Number	1 - 32
f10	Delta pseudo range correction (Delta PRC) in meters	±99.99
f11	Delta range rate correction (Delta RRC) in meters/sec	±9.999
d12	Issue of data ephemeris (IODE)	0 - 999
*cc	Checksum	

Remainder of message for Type 3:

Table A.44. Remainder of Type 3 Message

Parameter	Description	Range
f8	Station X component	±9999999.99
f9	Station Y component	±9999999.99
f10	Station Z component	±9999999.99
*cc	Checksum	

Remainder of message for Type 16. The structure of the remainder for Type 6 is the same, but contains no text.

Table A.45. Remainder of Type 16 Message

Parameter	Description	Range
s8	text message send from base receiver	Up to 80 alpha-numeric characters
*cc	checksum	

Examples:

$GPMSG,01,0000,2220.0,1,0,127,003702.00,2,12,-0081.30, 0.026,235,2,13,0022.86,0.006, 106,2,26,-0053.42,-0.070, 155,2,02,0003.56,+0.040,120,2,27,.0047.42,-0.004,145*1D

$GPMSG,03,0000,1200.0,7,0,038,231958.00,-2691561.37,-4301271.02, 3851650.89*6C

$GPMSG,16,0000,1209.6,5,0,036,23200.008,THIS IS A MESSAGE SENT FROM BASE*5C

$GPMSG,06,0000,1209.6,5,0,036,23200.008*2A

POS: Comprehensive Position Message

The POS message contains data for 3D position, time, differential status, the number of satellites being tracked, speed and course over the ground, and DOP values. If positions are not being computed, only the header is output.

The POS message is output in the format shown below:

$PASHR,POS,d1,d2,m3,m4,c5,m6,c7,d8,f9,d10,d11,d12,d13,d14,d15,
d16,s17*hh

Table A.46. POS Message Structure

Parameter	Description	Range
d1	Raw/differential position 0: Raw; position is not differentially corrected 1: Position is differentially corrected with RTCM code	0, 1
d2	Number of satellites used in position fix	3 - 12
m3	Current UTC time of position fix (hhmmss.ss)	00 - 235959.90
m4	Latitude component of position in degrees and decimal minutes (ddmm.mmmmm)	0° - 90°
c5	Latitude sector	N(orth) S(outh)
m6	Longitude component of position in degrees and decimal minutes (dddmm.mmmmm)	0° - 180°
c7	Longitude sector	W(est), E(ast)
d8	Altitude above the ellipsoid (altitude can be held fixed for 2-D position computations)	±30000
f9	Reserved	
d10	Track/course over ground in degrees (true north)	0° - 359°
d11	Speed over ground in knots	0 - 999
d12	Vertical velocity in decimeters per second	±999
d13	PDOP - position dilution of precision,	0 - 99
d14	HDOP - horizontal dilution of precision.	0 - 99
d15	VDOP - vertical dilution of precision.	0 - 99
d16	TDOP - time dilution of precision.	0 - 99
s17	Firmware version ID	4 character string
*hh	Checksum	2 character hex

Typical POS message:

$PASHR,POS,0,06,214619.50,3722.385158,N,12159.833768,W,00043,,
331,000,000,02,01,02,01,UC00*6C

Table A.47. Typical POS Message

Parameter	Description
$PASHR,POS	Header
0	Raw Position
06	Number of satellites used in position fix
214619.50	UTC time of position fix
3722.385158	Latitude
N	North Latitude
121159.833768	Longitude
W	West Longitude
00043	Altitude (meters)
empty field	reserved
331	Course over ground (degrees)
000	Speed over ground (knots)
000	Vertical velocity (dm/sec)
02	PDOP
01.2	HDOP
02	VDOP
01	TDOP
UC00	Firmware version ID
*6C	checksum

RRE: GPS Residual/Position Error Message

The RRE message contains data on the range residual for each satellite being tracked along with the measurements for horizontal and vertical error. This message is not output unless positions are being computed. If fewer than five satellites are being used to compute the position, residuals are not computed and the values for range residual and position error are zero.

The RRE message is output in the format shown below:

$GPRRE,d1,**n**(d2,f3),f4,f5*cc

where **n** = number of satellites used to compute the position

Table A.48. RRE Message Structure

Parameter	Description	Range	Units
d1	Number of satellites used to compute position	3 - 12	n/a
d2	Satellite number (PRN Number)	1 - 32	n/a
f3	Range residual	± 999.9	meter
f4	RMS Horizontal position error	0 - 9999.9	meter
f5	RMS Vertical position error	0 - 9999.9	meter
*cc	Checksum		

Typical RRE message:

$GPRRE,04,23,8.4,28,-9.2,11,-2.2,17,3.2,34.4,49.7*0A

Table A.49. Typical RRE Message

Parameter	Description
04	Number of satellites used for position computation
23	PRN number of the first satellite
8.4	Range residual for the first satellite
28	PRN number of the second satellite
-9.2	Range residual for the second satellite
11	PRN number for the third satellite
-2.2	Range residual for the third satellite
17	PRN number for the fourth satellite
3.2	Range residual for the fourth satellite
34.4	Horizontal position error
49.7	Vertical position error
*0A	checksum

SAT: Satellite Status Message

The SAT message contains the number of satellites being tracked along with elevation, azimuth, and Signal/Noise ratio for each satellite.

The SAT message is output in the format shown below:

$PASHR,SAT,d1,**n**(d2,d3,d4,d5,c)*hh

where **n** = the number of satellites tracked.

Table A.50. SAT Message Structure

Parameter	Description	Range
d1	Number of satellites locked	1 - 12
d2	Satellite PRN number,	1 - 32
d3	Satellite azimuth angle in degrees	0° - 359°
d4	Satellite elevation angle in degrees	0° - 90°
d5	Satellite signal/noise ratio	01 - 99
c	Satellite used/not used in position computation	"U" = Used "-" = Not used
*hh	checksum	2 character hex

The elevation/azimuth prior to the first computed position may be erroneous if there is a large geographic separation between the last position stored in battery-backed memory and the current position.

Typical SAT message:

$PASHR,SAT,04,03,103,56,50.5,U,23,225,61,52.4,U,16,045,02,51.4,U,
04,160,46,53.6,U*6E

Table A.51. Typical SAT Message

Parameter	Description
$PASHR,SAT	Header
04	Number of satellites locked
03	PRN number of the first satellite
103	Azimuth of the first satellite in degrees
56	Elevation of the first satellite in degrees
50	Signal strength of the first satellite
U	Satellite used in position computation
23	PRN number of the second satellite
225	Azimuth of the second satellite in degrees

Table A.51. Typical SAT Message (continued)

Parameter	Description
61	Elevation of the second satellite in degrees
52	Signal strength of the second satellite
U	Satellite used in position computation
16	PRN number of the third satellite
045	Azimuth of the third satellite in degrees
02	Elevation of the third satellite in degrees
51	Signal Strength of the third satellite
U	Satellite used in position computation
04	PRN number of fourth satellite
160	Azimuth of fourth satellite in degrees
46	Elevation of fourth satellite in degrees
53	Signal strength of fourth satellite
U	Satellite used in position computation
*6E	Message checksum in hexadecimal

TTT: Event Marker

The TTT message is not output unless an event pulse is being input through one of the serial ports.

The TTT message is output in the format shown below:

$PASHR,TTT,d1,m2*hh

Table A.52. $PASHR,TTT Message Structure

Parameter	Description	Range
d1	Day of the week. 1: Sunday, 7: Saturday	1 - 7
m2	GPS time tag in hours, minutes and seconds (hh:mm:ss.sssssss)	0 - 23:59:59.9999999
*cc	checksum	

Typical TTT message:

$PASHR,TTT,3,18:01:33.1200417 *AC

Table A.53. Typical TTT Message

Parameter	Description
$PASHR,TTT	Header
3	Tuesday
18:01:33.1200417	GPS time tag
*hh	checksum

UTM: UTM Coordinates

The UTM message contains data for 3D position, time, and differential status. Positions are output in UTM grid coordinates along with any applicable UTM zone numbers and zone letters.

The UTM message is output in the format shown below:

$PASHR,UTM,m1,m2,f3,f4,d5,d6,f7,d8,M,f9,M,d10,s11*hh

Table A.54. UTM Message Structure

Parameter	Description	Range
m1	UTC of position in hours, minutes, and decimal seconds (hhmmss.ss)	0 - 235959.90
m2	Zone number for coordinates Zone letter for coordinates	1 - 60, 99 N(orth) S(outh)
f3	East UTM coordinate (meters)	±9999999.99
f4	North UTM coordinate (meters)	±9999999.99
d5	Position indicator. • Raw position • RTCM code differential solution	1, 2
d6	Number of GPS satellites being used	3 - 12
f7	Horizontal dilution of precision (HDOP)	999.9
d8	Height above the ellipsoid	±99999
M	Altitude units	M(eters)
f9	Geoidal separation in meters (always null; geoidal modelling not supported in Z-12)	±999.999

Table A.54. UTM Message Structure (continued)

Parameter	Description	Range
M	Geoidal separation units	M(eters)
d10	Age of differential corrections	0 - 999
s11	Differential reference station ID	4 character string
*hh	checksum	2 character hex

Typical UTM message:

$PASHR,UTM,015454.00,10S,588757.623,4136720.056,2,04,03.8,
00012,M,,M,014,1010*3A

Table A.55. Typical UTM Message

Parameter	Description
015454.00	UTC time
10S	UTM zone
588757.623	UTM easting coordinate
4136720.056	UTM northing coordinate
2	RTCM code differential position
04	Number of satellites used to compute position
03.8	HDOP
00012	Altitude
M	Altitude units (M = meters)
null	Geoidal separation
M	Geoidal separation units (M = meters)
014	Age of corrections
1010	Differential Station ID
*3A	Checksum

VT3: Vehicle Tracking Message (Standard)

The VT3 message contains data designed for vehicle tracking applications. It is not output unless positions are being computed.

The VT3 message is output in the format shown below:

$GPVTS,m1,c2,m3,c4,s5*hh

Note that the identifier in the header is "VTS" instead of VT3. The "3" denotes that minutes in the lat/lon measurements in this version of the VTS message are carried three places past the decimal.

Use the following steps to enter characters for the vehicle ID string:

1. Go to Screen 9.
2. Press **[e]** to activate the configuration mode.
3. Use the arrow keys to move the cursor to the **RCV#** field.
4. Use the ▲ and ▼ keys to cycle through the character menu. Press the corresponding numeral key to enter the desired letter, symbol, or number.
5. Press **[e]** to save the entry.

Table A.56. VTS Message Structure (Standard)

Parameter	Description	Range
m1	Latitude (ddmm.mmm)	0° - 359.999°
c2	Latitude sector	N(orth) S(outh)
m3	Longitude (dddmm.mmm)	0° - 180°
c4	Longitude sector	W(est) E(ast)
s5	Vehicle ID (RCV # from Screen 9)	3 character string
*hh	Checksum	2 character hex

Typical VT3 message:

$GPVTS,3721.092,N,12156.130,W,003*13

Table A.57. Typical VTS Message (Standard)

Parameter	Description
3721.092	Latitude
N	Latitude sector
12156.130	Longitude
W	Longitude sector

Table A.57. Typical VTS Message (Standard)

Parameter	Description
003	Vehicle ID
*13	Checksum

VT4: Vehicle Tracking Message (Precision)

The VT4 message contains data designed for vehicle tracking applications. It is not output unless positions are being computed.

The VT4 message is output in the format shown below:

$GPVTS,m1,c2,m3,c4,s5*hh

Note that the identifier in the header is VTS instead of VT4. The "4" denotes that minutes in the lat/lon measurements are carried four places past the decimal.

See the VT3 message above for information on how to enter a vehicle ID.

Table A.58. VTS Message Structure (Precision)

Parameter	Description	Range
m1	Latitude (ddmm.mmmm)	0° - 359.999°
c2	Latitude sector	N(orth) S(outh)
m3	Longitude (dddmm.mmmm)	0° - 180°
c4	Longitude sector	W(est) E(ast)
s5	Vehicle ID (RCV # from Screen 9)	3 character string
*hh	Checksum	2 Character hex

Typical VT4 message:

$GPVTS,3721.0916,N,12156.1301,W,003*17

Table A.59. Typical VTS Precision Message

Parameter	Description
3721.0916	Latitude
N	Latitude sector
12156.1301	Longitude

Table A.59. Typical VTS Precision Message (continued)

Parameter	Description
W	Longitude sector
003	Vehicle ID
*17	Checksum

VTG: Velocity/Course Message

The VTG message contains data for course over the ground (COG) and speed over the ground (SOG).

The VTG message is output in the format shown below:

$GPVTG,f1,c2,f3,c4,f5,c6,f7,c8*hh

Table A.60. VTG Message Structure

Parameter	Description	Range
f1	COG (Course Over Ground) true north	0 - 359.99
c2	COG orientation (T = true north)	T
f3	COG magnetic north	0 - 359.99
c4	COG orientation (M = magnetic north)	M
f5	SOG (Speed Over Ground)	0 - 999.99
c6	SOG units (N = knots)	N
f7	SOG (Speed Over Ground)	0 - 999.99
c8	SOG units (K = Km/hr)	K
*hh	checksum	2 character hex

Typical VTG message:

$GPVTG,004.58,T,349.17,M,000.87,N,001.61,K*46

Table A.61. Typical VTG Message

Parameter	Description
$GPVTG	Header
004.58	Course Over Ground (COG) oriented to true north
T	True North orientation

Table A.61. Typical VTG Message (continued)

Parameter	Description
349.17	Course Over Ground (COG) oriented to magnetic north
M	Magnetic north orientation
000.87	Speed Over Ground (SOG) in knots
N	SOG units (N = nautical miles)
001.61	Speed over ground (SOG) in km/hr
K	SOG units (K=km/hr)
*46	checksum

XTE: Cross-track Error Message

The XTE message contains much of the same data as appear in the APA message: SNR and cycle lock status, magnitude of the cross-track error, direction to steer, etc.

The XTE message is output in the format shown below:

$GPXTE,c1,c2,f3,c4,c5*hh

Table A.62. XTE Message Structure

Parameter	Description	Range
c1	SNR Warning Flag (always "A", since the message is not output unless positions are being computed)	A = Valid V = Invalid
c2	Cycle Lock Warning Flag (always "A", since this message is not output unless positions are being computed)	A = Valid V = Invalid
f1	Magnitude of Cross-track Error (measured perpendicularly from the current position to the intended track)	0.0 - 999.999
c3	Direction to Steer (toward the destination)	R(ight) L(eft)
c4	Cross-track Error Units (nautical miles)	N
hh	Checksum	2 character hex

Typical XTE message:

$GPXTE,A,A,000.001,R,N*41

Table A.63. XTE Message Structure

Parameter	Description
$GPXTE	Header
A	Valid SNRs
A	Valid cycle-lock
000.001	Cross-track error measurement
R	Indicates that the vessel must be steered to the right to get back on course.
N	Nautical miles
hh	checksum

ZDA: Time and Date Message

The response message is in the form:

$GPZDA,m1,d2,d3,d4,d5,d6*cc<CR><LF>

Table A.64. ZDA Message Structure

Parameter	Description
m1	UTC time (hhmmss.ss) (hours, minutes, seconds)
d2	Current day 01 - 31
d3	Current month 01 - 12
d4	Current year 0000-9999
d5	Local zone offset from UTC time where s = sign and hh = hours Range 00 - ±13
d6	Local zone offset from UTC time where mm = minutes with same sign as hh
*cc	Checksum

Typical ZDA message:

$GPZDA,132123.00,10,03,1998,-07,20*22

Table A.65. Typical ZDA Message

Parameter	Description
$GPZDA	Message header
132123.00	UTC time
10	Current day
03	Current month
1998	Current year
-07	Local zone offset (hours)
20	Local zone offset (min)
*22	Checksum in hexadecimal

B

Serial Port Commands

This chapter details the formats and content of the commands by which the receiver can be controlled and monitored from an external computer. These commands set receiver parameters and request data and receiver status information.

Use Receiver Communication Software (RCS) (or REMOTE) or any other standard serial communication software to send and receive messages. The baud rate and protocol of the computer COM port must match the baud rate and protocol of the receiver port for commands and data successfully transmitted and received. The receiver protocol is 8 data bits, 1 stop bit, and parity = none.

All commands sent to the receiver are either **Set** commands or **Query** commands. **Set** commands generally change receiver parameters and initiate data output. **Query** commands request receiver status information. The set commands begin with the string $PASHS, and the query commands begin with $PASHQ. All commands must end with an <Enter> keystroke to transmit the command to the receiver. If desired, an optional checksum may precede the <Enter> character.

The serial commands are grouped into four categories:

- **Receiver commands**—commands that relate to general receiver operations
- **Raw data commands**—commands that control the output of measurement, ephemeris, and almanac information.
- **NMEA message commands**—commands that control NMEA-style messages
- **RTCM commands**—commands that control RTCM differential operation

Within each section, the commands are listed alphabetically and described in detail. Information about the command, including the syntax, a description, the range and default, and an example of how it is used, are presented for each command. The syntax includes the number and type of parameters that are used or required by the command. These parameters may be either characters or numbers, depending upon the particular command.

Table B.1 lists the symbol that is a part of the syntax.

Table B.1. Command Parameter Symbols

Parameter	Description	Example
d	Numeric integer	3
f	Numeric real	2.45
c	1 character ASCII	N
s	Character string	OFF
m	Mixed parameter (integer and real) for lat/lon or time	3729.12345
h	Hexadecimal digit	FD2C
*cc	Hexadecimal checksum which is always preceded by a *	*A5
<Enter>	Combination of <CR><LF> (carriage return, line feed, in that order)	

For example, for the receiver command:

$PASHS,RCI,f <Enter>

the parameter f indicates that the RCI (Recording Interval) command accepts a single parameter that is a real number, such as 0.5 or 10.0. If a character is entered instead, the command is rejected. Generally speaking, the parameter must be in the specified format accepted. However, most parameters that are real numbers (f) also accept an integer. For example, in the case of the RCI command, both 10 and 10.0 are accepted.

Table B.2 summarizes the set commands by function. The commands are then presented alphabetically and described in detail in the pages following the table.

Table B.2. Set Command Summary

Command	Description	Page
Antenna Position Commands		
$PASHS,ALT	Sets the altitude of the antenna.	158
$PASHS,LAT	Sets the latitude of the antenna.	163
$PASHS,LON	Sets the longitude of the antenna.	163
$PASHS,POS	Sets the position of the antenna.	166
Data Recording Commands		

Table B.2. Set Command Summary (continued)

Command	Description	Page
$PASHS,ANH	Set antenna height	158
$PASHS,DSC	Store event or attribute string	159
$PASHS,ELM	Sets the elevation mask for data recording.	160
$PASHS,EPG	Set kinematic epoch counter	160
$PASHS,MSV	Sets the minimum number of satellites to record data.	163
$PASHS,PJT	Specifies the project information.	165
$PASHS,RCI	Sets the recording interval for data collection.	167
$PASHS,REC	Enable/disable date recording	167
$PASHS,RNG	Set data recording type	169
$PASHS,SIT	Sets the four-character site name	169
File Management Commands		
$PASHS,FIL,C	Close the current file.	161
$PASHS,FIL,D	Delete file number dd from receiver memory.	161
$PASHS,FLS	Query data file information	161
Memory Commands		
$PASHS,RST	Resets all receiver operating parameters to their default values.	169
$PASHS,INI	Resets the receiver.	162
Position Computation Commands		
$PASHS,FIX	Set altitude computation mode	161
$PASHS,PDP	Set PDOP mask	164
$PASHS,PEM	Set elevation mask for position computation	164
$PASHS,PMD	Set position computation mode	164
$PASHS,VDP	Set VDOP mask	172
$PASHS,UNH	Omit/include unhealthy satellites	171
Receiver Configuration Commands		
$PASHS,DSY	Specifies daisy chain mode for the ports.	159
$PASHS,EXT	Sets external frequency parameters.	160
$PASHS,LTZ	Set local time zone offset	163
$PASHS,PPS	Sets pulse generation parameters for 1 PPS output pulse	165

Table B.2. Set Command Summary (continued)

Command	Description	Page
$PASHQ,PRT	Displays the baud rate of the connected communication port.	167
$PASHQ,RID	Requests information about the receiver type, firmware, and available options.	168
$PASHS,SPD	Sets serial port baud rate.	170
$PASHS,ZMD	Sets the Z-tracking mode of the receiver.	173
Satellite Commands		
$PASHS,STA	Query status of locked satellites	170
$PASHS,SVS	Select satellites to track	171
$PASHS,USE	Enables or disables a satellite.	172
Waypoint Control Commands		
$PASHS,WPL	Uploads waypoints to the receiver.	172
$PASHS,RTE	Uploads the route information.	169

ALT: Set Ellipsoid Height

$PASHS,ALT,f

Sets the ellipsoidal height of the antenna where f = ±9999.99 meters and must include the sign (+ or -). The receiver uses this data in the position calculation for 2-D position computation, and when in differential base mode.

Example: Set the ellipsoidal height of the antenna to 100.25 meters:

$PASHS,ALT,+100.25<Enter>

Example: Set the ellipsoidal height of the antenna to -30.1 meters:

$PASHS,ALT,-30.1<Enter>

ANH: Set Antenna Height

$PASHS,ANH,f

Sets the antenna height where f is from 0.0 - 64.0000 meters.

Example: Set antenna height to 3.534 meters:

$PASHS,ANH,3.534 <Enter>

DSC: Store Event or Attribute String

$PASHS,DSC,s

Store a string as event datum to current open session in receiver, where s is a character string of up to 80 characters in length. The string is stored in the D-file with a time tag.

Example: Set the string 'LightPole' to the receiver.

$PASHS,DSC,LIGHTPOLE <Enter>

DSY: Daisy Chain

$PASHS,DSY,c1,c2 or $PASHS,DSY,OFF

Redirects all characters from one serial port to another without interpreting them, where c1 is the source port, and c2 is the destination port as listed in Table B.3. Any combination may be chosen. This command is used primarily to initialize the radio from an external monitor (handheld or PC). When a port is in daisy chain mode, it can only interpret the OFF command; all other characters are redirected. The OFF command discontinues the daisy chain mode. Redirection can also be bi-directional (i.e. A to B and B to A at the same time), but a second command is necessary to set the other direction.

Table B.3. DSY Parameter Table

Parameter	Description	Range
c1	Source Port	A, B, C, D
c2	Destination Port	A, B, C, D

Example: Redirect A to B. Can issue from any port.

$PASHS,DSY,A,B <Enter>

Example: Redirect B to A. Can issue from any port, but cannot be issued from port A if $PASH,DSY,A,B <Enter> has been sent.

$PASHS,DSY,B,A <Enter>

Example: Turn off redirection from A. Can issue from any port.

$PASHS,DSY,A,OFF <Enter>

Example: Turn off daisy chain on all ports. Can issue from any port.

$PASHS,DSY,OFF <Enter>

ELM: Set Elevation Mask

$PASHS,ELM,d

Set the value of the satellite elevation mask for data collection, where d is a number between 0 and 90 degrees (default is 10 degrees).

Example: Set elevation mask to 15 degrees:

$PASHS,ELM,15 <Enter>

EPG: Set Kinematic Epoch Counter

$PASHS,EPG,d

Set the initial value of the epoch counter for recording at a site, where d is the number of epochs and ranges from 0 to 999. The command is used during kinematic surveys, when you occupy a site for a set amount of time. When the number of epochs goes to zero, the site name is set to???? automatically indicating that the receiver is in motion.

Example: Set the epoch counter to 20:

$PASHS,EPG,20 <Enter>

EXT: External Frequency

$PASHS,EXT,f1,c2

Set the external frequency parameters that allow the receiver to connect to an external reference frequency and bypass the internal oscillator. Parameter f1 is the frequency in MHz (xx.x) and c2 is the auto-switch parameter, either A(uto) or M(anual). To disable the external frequency, set frequency to 0.0.

Example: Set the external frequency to 15 MHz and auto-switch to manual:

$PASHS,EXT,15.0,M <Enter>

$PASHQ,EXT,c

The associated query command is $PASHQ,EXT,c where c is the optional output port; if port is not specified, the response goes to the current port.

Example: Query external frequency parameters to the current port:

$PASHQ,EXT <Enter>

$PASHR,EXT,f1,c2,c3

The response message to the query is:

$PASHR,EXT,f1,c2,c3

where f1 is the frequency, c2 is the auto-switch setting, and c3 is the lock status (L/U) that indicates if the receiver has locked onto the external frequency.

FIL,C: Close a File

$PASHS,FIL,c

This command closes the current file in the receiver.

Example: Close the current file in the receiver.

$PASHS,FIL,c <Enter>

FIL,D: Delete a File

$PASHS,FIL,d

This command deletes data file(s) from the receiver, where d is the file index number, and ranges from 0 - 99. If d is set to 999, then all files are deleted. If the deleted file is not the last file in the receiver, the receiver reorders all files after the deleted file, changing the file index numbers for the remaining files.

Example: Delete 6th file from receiver.

$PASHS,FIL,D,5 <Enter>

FIX: Set Altitude Computation Mode

$PASHS,FIX,d

Set altitude hold position fix mode for the altitude used (for 2-D position determination), where d is 0 or 1, as detailed in Table B.4. This command must be used with the $PASHS,PMD command. The default is 0.

Table B.4. FIX Parameter Settings

Parameter	Description
d = 0	(default) The most recent antenna altitude is used in altitude hold position fix. The altitude is taken from either the altitude entered by the $PASHS,ALT command, or the last one computed when VDOP is less than VDOP mask.
d = 1	always use the altitude entered by $PASHS,ALT command.

Example: Fix altitude to always use the entered altitude.

$PASHS,FIX,1 <Enter>

FLS: Query Data File Information

$PASHQ,FLS,d

This command requests file information from the memory card, where d is the beginning file index number and can range from 0 - 99. The file index number is a sequence number where the first file has a file index = 0, the second file has a file index = 1, and continuing through to the 100th file which has a file index number of 99.

The output displays files in blocks of up to 10 files. If d is greater than the highest file index number, then the receiver does not acknowledge the command (NAK is returned).

Example: Display file information for files 1-10.

$PASHQ,FLS,0 <Enter>

Display file information for files 6-15.

$PASHQ,FLS,5 <Enter>

INI: Receiver Initialization

$PASHS,INI,d1,d2,d3,d4,d5,c6

The INI command resets the receiver memory, sets the serial port baud rate to the specified rates, and/or sends the modem initialization string through the specified port, where the field parameters are as defined in Table B.5.

Table B.5. INI Parameters

Parameter	Description	Range	Default
d1	Port A baud rate code	0 = 300 baud 1 = 600 baud 2 = 1200 baud 3 = 2400 baud 4 = 4800 baud 5 = 9600 baud 6 = 19200 baud 7 = 38400 baud 8 = 57500 baud 9 = 115200 baud	5
d2	Port B baud rate code	Same as Port A	5
d3	Port C baud rate code	Same as Port A	5
d4	Port D baud rate code	Same as Port A	5
d5	Reset memory code	0 = No memory reset 1 = Reset internal memory 2 = Reset external memory 3 = Reset internal memory and external memory	n/a
c6	Modem initialization	Port A-D 0 = No initialization	n/a

Reset memory codes 0 and 2 behave like a power cycle. Any parameters not saved with the $PASHS,SAV command are lost. Codes 1 and 3 reset all parameters to default as well as the ephemeris and almanac (i.e., creates a cold start).

LAT: Set Latitude

$PASHS,LAT,m1,c2

Sets the latitude of the antenna (displayed on Screen 4), where m1 is the latitude in degrees and decimal minutes (ddmm.mmmmmmm), and c2 is N (north) or S (south).

Example: Set latitude to 37° 22.3819219 north:

$PASHS,LAT,3722.3819219,N<Enter>

LON: Set Longitude

$PASHS,LON,m1,c2

Sets the longitude of the antenna (displayed on Screen 4), where m1 is the longitude in degrees and decimal minutes (dddmm.mmmmmmm), and c2 is E (east) or W (west).

Example: Set longitude to 121° 59.8291219 west:

$PASHS,LON,12159.8291219,W<Enter>

LTZ: Set Local Time Zone Offset

$PASHS,LTZ,d1,d2

Set local time zone value, where d1 is the number of hours that should be added to the local time to match GMT time, and d2 is the number of minutes; minutes have the same sign as d1. The d1 value is negative for east longitude, and the range is 0 to 13. The setting is displayed by NMEA message ZDA.

Example: Set local time zone to East 7 hours, 20 minutes:

$PASHS,LTZ,-7,-20 <Enter>

MSV: Set Minimum Number of Satellites

$PASHS,MSV,c

Sets the minimum number of satellites required in memory, where c is a number between 1 and 9. Default is 3.

Example: Set minimum number of satellites to 4:

$PASHS,MSV,4<Enter>

PDP: Set PDOP Mask

$PASHS,PDP,d

Set the value of the PDOP mask to d, where d is a number between 0 and 99. Position is not computed if the PDOP exceeds the PDOP mask. The default is 40.

Example: Set PDOP mask to 20

$PASHS,PDP,20 <Enter>

PEM: Set Elevation Mask for Position Computation

$PASHS,PEM,d

Set elevation mask for position computation where d is 0 to 90 degrees. Default is 10 degrees. Satellites with elevation less than the elevation mask are not be used for position computation.

Example: Set position elevation mask to 15 degrees

$PASHS,PEM,15 <Enter>

PMD: Set Position Computation Mode

$PASHS,PMD,d

Set position mode for minimum number of satellites required to compute a position fix, where d = 0, 1, 2, or 3. The default is 0.

Table B.6. PMD Parameter Table

Parameter	Description
d = 0	Minimum of 4 satellites needed (e.g., for 3-D)
d = 1	Default, minimum of 3 satellites needed; with 3 satellites, altitude is held (2-D); with 4 or more, altitude is not held (3-D)
d = 2	Minimum of 3 satellites needed; altitude always held (always 2-D)
d = 3	Minimum of 3 satellites needed; with 3 satellites, altitude is always held; with 4 satellites, altitude is held only if HDOP is greater than HDOP mask (2-D), otherwise 3-D

Example: Set minimum satellites required for position computation to 4

$PASHS,PMD,0 <Enter>

PPS: Pulse Per Second

$PASHS,PPS,f1,f2,c3,c4,c5,c6

Sets the pulse generation parameters that control the output of a 1 PPS pulse synchronized to GPS time. The pulse is can be output through the 1 PPS port on the receiver or through serial ports A, B, C, or D. Table B.7 defines the 1PPS parameters.

Table B.7. 1PPS Parameters

Parameter	Description	Range
f1	Period of the pulse (seconds)	0.5 - 59.5
f2	Offset of the pulse (milliseconds). The sign, + or - is required, even if the offset is 0.0.	-999.9999 to +999.9999
c3	Output via port A	Y/N
c4	Output via port B	Y/N
c5	Output via port C	Y/N
c6	Output via port D	Y/N

A pulse can only be output via ports A-D if the offset is 0.0. If an offset other than 0.0 is entered, the output port selections are set automatically to "N", in which case the pulse is output through the 1PPS connector.

Example: Output a 1PPS pulse with 2-second period and 50-msec offset:

$PASHS,PPS,2.0,+50.0,N,N,N,N<Enter>

$PASHQ,PPS,c

The associated query command is $PASHQ,PPS,c <Enter>, where c is the optional output port.

Example: Query the 1 PPS parameters to port B:

$PASHQ,PPS,B <Enter>

$PASHR,PPS,f1,f2,c3,c4,c5

The response message to the query is:

$PASHR,PPS,f1,f2,c3,c4,c5

where the parameters are as defined in Table B.7.

PJT: Specify Project Information

$PASHS,PJT,c1,s1,s2,s3,s4,s5

This command specifies the project information that appears in Screen 9 and in the

S-file. Table B.8 defines the project parameters.

Table B.8. PJT Parameter Table

Parameter	Description	Range
c1	Session	1-character alphanumeric
s2	Receiver ID	3-character alphanumeric
s3	Antenna ID	3-character alphanumeric
s4	Month and Day (mmdd)	mm = 01-12 dd = 01-31
s5	Operator initials	3-character alphanumeric
s6	Comment	9-character alphanumeric

Example: Session 1, receiver 3, antenna 3, March 7, Tom M. Jones, section 5 survey

$PASHS,PRJ,1,003,003,0703,tmj,sect5srvy<Enter>

POS: Set Antenna Position

$PASHS,POS,m1,c2,m3,c4,f5

This command sets the position of the antenna used in differential base mode, where the parameters are as defined in Table B.9.

Table B.9. POS Parameters

Parameter	Description	Range
m1	Latitude in degrees, decimal minutes (ddmm.mmmmmmm)	0 - 90.0
c2	North (N) or South (S)	N, S
m3	Longitude in degrees, decimal minutes (dddmm.mmmmmmm)	0 - 180.0
c4	East (E) or West (W)	E, W
f5	Ellipsoidal height in meters (+ or -) and xxxx.xxx	$\pm$0-9999.999

Example: Set antenna position to 37° 22.2912135,N,121° 59.7998217,W,15.25:

$PASHS,POS,3722.2912135,N,12159.7998217,W,15.25 <Enter>

PRT: Query Port Setting

$PASHQ,PRT,c

Displays the baud rate setting for the connected communication port, where c is the optional output port. The c parameter is not required to direct the response message to the current communication port.

Example: Query the baud rate of the current port:

$PASHQ,PRT <Enter>

$PASHR,PRT,c1,d2,*cc

The response from the receiver is a message in the form:

$PASHR,PRT,c1,d2

where the field parameters are as described in Table B.10.

Table B.10. $PASHS,PRT Message Structure

Parameter	Description	Range
c1	Serial port	A, B, C, D
d2	Baud rate code	CodeBaud Rate 0 300 1 600 2 1200 3 2400 4 4800 5 9600 6 19200 7 38400 8 56800 9 115200

RCI: Set Recording Interval

$PASHS,RCI,f1

Set the value of the interval for data recording and raw data output, where f1 is any full- or half-second increment between 0.5 to 999.5 in seconds. The default is 20.0.

Example: Set recording interval to 5 seconds:

$PASHS,RCI,5<Enter>

REC: Enable/Disable Data Recording

$PASHS,REC,c

Data recording switch that turns data recording to either Yes or No (Table B.11).

Yes and No are used to enable/disable data recording. The default is Yes.

See $PASHQ,RAW command for a list of the various states this parameter can take internally.

Table B.11. REC Message Structure

Setting parameter	Description	Range
c	Y = Record data N = Do not record data	Y or N

Example: Disable recording data:

$PASHS,REC,N <Enter>

REC,N disables recording but does not close the session. Whenever REC,Y is issued, recording resumes in the same session. REC,S closes the session, and a new session is created if REC,R is used or if the card is reinserted.

RID: Query Receiver ID

$PASHQ,RID,c

Requests information about the receiver type and firmware version, where c is the optional output port. If c is not specified, the current port is used.

Example: Query the current port for receiver identification:

$PASHQ,RID <Enter>

$PASHR,RID,s1,d2,s3,s4,s5

The receiver returns a message from in the form:

$PASHR,RID,s1,d2,s3,s4,s5*cc

where the field parameters are as defined in Table B.12.

Table B.12. Receiver ID Parameters

Parameter	Description	Range
s1	Receiver type	ZM
d2	Channel option: Codeless option:	3 (C/A, PL1, P L2) 30
s3	Nav version	4-character string
s4	Reserved	C05
s5	Channel version	4-character string
*cc	Checksum	Hexadecimal checksum

Example: $PASHQ,RID<Enter>

Typical response: $PASHR,RID,ZM,30,1K00,C05,1D04*5E

RNG: Set Data Recording Type

$PASHS,RNG,d

Sets data recording mode where d is the data type as detailed in Table B.13.

Table B.13. RNG Data Modes

Parameter	Description	Range
d	Data recording mode: 0 - creates B-file that includes carrier phase, code phase and position data 2 - creates a C-file with smoothed positions only	0, 2

Example: Set data recording mode to create a C-file with smoothed positions only:

$PASHS,RNG,2 <Enter>

RST: Reset Receiver

$PASHS,RST

Resets all the receiver parameters to their default values, including the baud rate of the modem port.

Example: Reset receiver parameters:

$PASHS,RST<Enter>

RTE: Upload Route

$PASHS,RTE,d1,d2,....

Define a route and upload the route information, where d1,d2.... are waypoint numbers up to a maximum of 20.

Example: Upload route waypoints 4, 7, 11, and 15:

$PASHS,RTE,4,7,11,15<Enter>

SIT: Set Site Name

$PASHS,SIT,s

Lets you enter a four-character site name, where s is a string of four alphanumeric characters. The site name appears on Screen 9 and in the B-File.

Example: Set site name to 1234:

$PASHS,SIT,1234<Enter>

SPD: Set Serial Port Baud Rate

$PASHS,SPD,c,d

Set the baud rate of the serial ports, where c is port A, B, C, or D and d is a number between 0 and 9 specifying the baud rate as listed in Table B.14. Default is 9600 baud.

Table B.14. $PASH,SPD Baud Rate Codes

Code	Baud Rate	Code	Baud Rate
0	300	5	9600
1	600	6	19200
2	1200	7	38400
3	2400	8	56800
4	4800	9	115200

To resume communication with the receiver after changing the baud rate using this command, be sure to change the baud rate of the command device.

Example: Set port A to 19200 baud:

$PASHS,SPD,A,6<Enter>

STA: Query Status of Locked Satellites

$PASHQ,STA,c

Show the status of satellites currently locked, where c is the optional output serial port.

Example: Query satellite status to the current port:

$PASHQ,STA <Enter>

The return message is a free form format. A typical response is:

```
TIME:   03:24:24 UTC
LOCKED: 23 22 17 06 30 10 26
CA S/N 50 46 54 53 43 43 44
P1 S/N 48 00 52 51 36 00 00
P2 S/N 44 00 48 47 38 00 00
```

Table B.15. STA Message Structure

Return Parameter	Description	Range
TIME	Current UTC time in hours, minutes, & seconds (or GPS time if GPS is indicated instead of UTC)	hh:mm:ss
LOCKED	PRN number of all locked satellites	1-32
CA S/N	Signal-to-noise ratio of the C/A observable in dB Hz	30-60
P1 S/N	Signal-to-noise ratio of the L1 P-code observable in dB Hz	30-60
P2 S/N	Signal-to-noise ratio of the L2 P-code observable in dB Hz	30-60

After a cold start the receiver can take up to 12.5 minutes to obtain UTC time; during this period, GPS time is displayed in the TIME field.

SVS: Select Satellite to Track

$PASHS,SVS,c1c2c3.....c32

Select satellites that the receiver attempts to acquire, where:

c = Y, satellite is used (default).

c = N, satellite is not used.

Up to 32 satellites may be selected. They are entered in order of PRN number. If fewer than 32 are specified the rest are set to N. Only the characters Y and N are accepted.

Example: Attempt to acquire satellite 1 to 9; do not acquire 10,11; acquire 12, 13; do not acquire 14-32

$PASHS,SVS,YYYYYYYYYNNYYNNNNNNNNNNNNNNNNNNN <Enter>

UNH: Omit/Include Unhealthy Satellites

$PASHS,UNH,c

Include unhealthy satellites for position computation, where c is Y (yes) or N (no, default)

Example: Include unhealthy satellites in position computation:

$PASHS,UNH,Y <Enter>

USE: Use Satellites

$PASHS,USE,d,c

Selects satellites to track or not track, where d is the PRN number of the satellite (range from 1 to 32) or ALL for all satellites, and c is Y (enable) or N (disable).

Example: Do not track satellite 14:

$PASHS,USE,14,N<Enter>

VDP: Set VDOP Mask

$PASHS,VDP,d

Sets the value of VDOP mask, where d is between 0 and 99. The default is 4.

Example: Set VDOP to 6:

$PASHS,VDP,6 <Enter>

WPL: Upload Waypoints

$PASHS,WPL,m1,c2,m3,c4,d5,s6

This command defines and uploads waypoints to the receiver, where the waypoint parameters are as defined in Table B.16.

Table B.16. Waypoint Parameters

Parameter	Description
m1	Latitude of the point in degrees (dd) and minutes (mm.mmmm)
c2	N (north) or S (south),
m3	Longitude in degrees and decimal minutes (dddmm.mmmm)
c4	E (east) or W (west)
d5	Waypoint number
s6	Waypoint name, up to 7 characters

Example: Upload waypoint Point 1 at N 35° 23.123, W 095° 33.2939:

$PASHS,WPL,3523.123,N,09533.2939,W,01,Point1<Enter>

ZMD: Set Receiver Mode

$PASHS,ZMD,c

Sets the Z tracking mode of the receiver, where c is A for auto switching, Y for Z mode always, and N for P-mode always.

Example: Set receiver for Z-mode always:

$PASHS,ZMD,Y<Enter>

Raw Data Commands

The raw data commands cover all query and set commands related to measurement, ephemeris, and almanac data.

Set Commands

There is only one set command that controls the continuous output of all raw data messages; the $PASHS,OUT command. The $PASHS,OUT command allows you to enable or disable the output of one or more raw data messages simultaneously as well as change the format (ASCII or Binary) of the messages types where the format is an option. The general format of the $PASHS,OUT command is:

$PASHS,OUT,c,str(,str...),s

where c is the output serial port (A-D), str is one or more 3 character strings that denote the different raw data output types, and s is the optional format of the message and is either ASC (ASCII) or BIN (binary). For example, the command

$PASHS,OUT,A,MBN,PBN,BIN <Enter>

outputs MBEN and PBEN messages in binary format to serial port A. If the format field is not included, then the message is sent in ASCII format, which is the default. The ephemeris and almanac messages are available in binary format only. If you attempt to output a raw data message type in ASCII format when only binary is available, the receiver sends data in binary format. Also, be aware that a $PASHS,OUT command overrides anything set in a previous $PASHS,OUT command.

If the $PASHS,OUT command is sent correctly, raw data messages are output to the indicated serial port at the recording interval defined by the $PASHS,RCI command or the INTERVAL field on Screen 4. The default output frequency is every 20 seconds. The structure of the output messages can be found in Appendix A.

Raw data messages are disabled by sending the $PASHS,OUT command with no data strings. For example the command:

$PASHS,OUT,A <Enter>

disables the output of all raw data output from port A. See the $PASHS,OUT command for more details.

In general, the parameters that affect raw data output are the same as those that control data recording including: recording interval, elevation mask, and minimum number of satellites.

Query Commands

The query commands output a single raw data message type one time. The general format of the query commands is:

$PASHQ,s,c

where s is the 3-character string that denotes the raw data message type, and c is the serial port which outputs the message. The serial port field is optional. If the query is sent with the port field left empty, then the response is sent to the current port. If the port field contains a valid port (A-D), then the response is output to that port. For example, the query:

$PASHQ,PBN <Enter>

outputs a single PBEN message to the current port. The command:

$PASHQ,MBN,C <Enter>

outputs a single MBEN message to port C. It is not possible to change the format (ASCII or binary) of the response with a query command. If the format of the port is ASCII, the response is ASCII, unless the ASCII format is not available for that message type. In this case, the receiver sends the raw data message in binary format.

If the query has been enter properly, and the data is available (for example, MBEN is not available unless the receiver is tracking enough satellites above the elevation mask), then the acknowledgment is the data response message.

Table B.17 lists the available raw data available, the associated 3-character string used in the commands, and the format that is available for each data type.

Table B.17. Raw Data Types and Formats

Raw Data Type	3-Character String	Description	Format Available
MBEN	MBN	Measurement data	ASCII / Binary
PBEN	PBN	Position data	ASCII / Binary
SNAV	SVN	Ephemeris data	Binary only
SALM	SAL	Almanac data	Binary only

Table B.17. Raw Data Types and Formats

Raw Data Type	3-Character String	Description	Format Available
EPB	EPB	Raw ephemeris	Binary only
DBEN	DBN	CPD carrier phase	Binary only

Table B.18 lists all the raw data commands. A complete description of each command can be found in alphabetical order following the table.

Table B.18. Raw Data Commands

Function	Command	Description	Page
Almanac data	$PASHQ,SAL	Almanac query	177
CPD data	$PASHQ,DBN	DBEN query	175
Ephemeris data	$PASHQ,SNV	SNAV query	177
	$PASHQ,EPB	Raw ephemeris data query	176
Measurement data	$PASHQ,MBN	MBEN query	176
Position data	$PASHQ,PBN	PBEN query	177
Raw data output	$PASHS,OUT	Enable/disable raw data output	176
Raw data parameters	$PASHS,SIT	Set site name	169
	$PASHS,ELM	Set elevation mask	160
	$PASHS,RCI	Set recording Interval	167
	$PASHS,MSV	Set minimum # of satellites	163

DBN: DBEN Message

$PASHQ,DBN,c

Query DBEN message for one epoch where c is the optional output port.

Example: $PASHQ,DBN <Enter>

DBEN is a packed message which contains one epoch of GPS pseudo-range and carrier phase measurements. It is an essential message which is used for CPD operation.

EPB: Raw Ephemeris

$PASHQ,EPB,d

Query for raw ephemeris data output, where d is the PRN number. If no PRN number is specified, data for all available satellites is given.

Example: Query for raw ephemeris for all available satellites:

$PASHQ,EPB <Enter>

Query ephemeris data for PRN 25:

$PASHQ,EPB,25<Enter>

OUT: Turn On/Off Raw Data

$PASHS,OUT

This command turns specified types of output on or off. The command has two forms: **global off** and **selective on**. The structure for the **global off** command is:

$PASHS,OUT,c<Enter>

where c is the output port A, B, C, or D.

The structure for the **selective on** command is:

$PASHS,OUT,c1,s2,s3,.....,f4<Enter>

where c1 is the port and s2, s3, and f4 are character strings as defined in Table B.19.

Table B.19. $PASHS,OUT Parameters

Parameter	Description
c1	Serial port A, B, C, or D
s2, s3,...	Raw data type string, may be one or more of the following strings delimited by commas: MBN, PBN, SNV, DBN, EPB, SAL
f4	ASCII (ASC) or binary (BIN) format. ASCII is default.

Example: Turn on MBN and PBN on port A:

$PASHS,OUT,A,MBN,PBN<Enter>

MBN: Measurement Data

$PASHQ,MBN,c

Query MBEN data for one epoch, where c is the optional output port.

Example: Query MBEN message to the current port:

$PASHQ,MBN <Enter>

PBN: Position Data

$PASHQ,PBN,c

Query PBEN data for one epoch, where c is the optional output port, but is not required to direct the response message to the current communication port.

Example: Request PBN message to port B:

$PASHQ,PBN,B <Enter>

The response message is defined in Appendix A.

SAL: Almanac Data

$PASHQ,SAL,c

Request for almanac data in proprietary format, where c is the optional serial port.

Example: Query receiver for almanac data on current port.

$PASHQ,SAL <Enter>

SNV: Ephemeris Data

$PASHQ,SNV,c

This command requests ephemeris data from the receiver, where c is either the optional output port or the specific PRN number. If either the port is specified, or if this field is left blank, the ephemeris structures for all available satellites is output.

Example: Send out SNAV data for all available satellites to the current port:

$PASHQ,SNV <Enter>

Example: Send out SNAV data for PRN 10:

$PASHQ,SNV,10 <Enter>

The response message is defined in Appendix A.

NMEA Message Commands

The NMEA message commands control all query and set commands related to NMEA format messages and miscellaneous messages in a NMEA style format. All standard NMEA message are a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards version 2.1. All non-standard messages are a string of ASCII characters delimited by commas in the proprietary format. Any combination of these messages can be output through different ports at the same time. The output rate is determined by the $PASHS,NME,PER command and can be set to any value between 0.5 and 999 seconds.

For NMEA messages there are two **set** commands to enable messages, and a **query** command for each message type. The set commands are used to continuously output the NMEA response message at the period defined by the $PASHS,NME,PER command. The query command outputs an NMEA response message only once.

Set Commands

There are two set commands: one to enable the output port, and one to specify which strings to output. Both commands must be sent to enable NMEA message output.

The command to enable the output port is:

$PASHS,OUT,x,NME<Enter>

where x is the output port (A through D).

The command to specify the message(s) is:

$PASHS,NME,s1,x2,ON<Enter>

where s1 is the three-character string that specifies the NMEA message type, and x2 is the output port. Available NMEA messages are: APA, ALM, AS1, BWC, DAL, GGA, GLL, GRS, GSA, GSN, GSV, GXP, MSG, POS, RRE, SAT, TTT, UTM, VTG, VT3, VT4, XTE, and ZDA.

For example, to output the GGA message on port A, type the following commands:

$PASHS,OUT,A,NMEA<Enter>

$PASHS,,NME,GGA,ON<Enter>

When the set commands are sent correctly, the receiver outputs the corresponding NMEA data message at the interval defined by the $PASHS,NME,PER command, unless a necessary condition for the output message is not present. Formats for response messages are found in Appendix A. To disable all NMEA messages, use the $PASHS,NME,ALL,x,OFF command, where x is the serial port.

Query Commands

The general structure of the NMEA query commands is:

$PASHQ,str,x<Enter>

where str is one of the 3-character NMEA strings, and x is the serial port to which the response message is sent (A, B, C or D). The serial port field is optional. If a port is not included, the receiver outputs the response to the current port. Unlike the set commands, the query command initiates a single response message.

Formats for all response messages are found in Appendix A.

Example: Query POS message and send the response to port D:

$PASHQ,POS,D <Enter>

Example: Query GSA message and send the response to the current port:

$PASHQ,GSA <Enter>

Table B.20 lists the NMEA data message commands. A detailed description of each NMEA set command, in alphabetical order, follows the table.

Table B.20. NMEA Data Message Commands

Command	Description	Page
Enable/Disable Output		
$PASHS,NME,ALL	Disable all messages	180
$PASHS,NME	Enable/disable selected NMEA message on selected port	183
$PASHS,OUT	Enable/disable serial port for NMEA output	176
Almanac Information		
$PASHQ,ALM	Hex format almanac data	180
$PASHQ,DAL	Decimal format almanac data	181
Differential Information		
$PASHQ,MSG	Differential base station messages	183
Output Rate Parameter		
$PASHS,NME,PER	Set output interval of NMEA response messages	184
Photogrammetry		
$PASHQ,TTT	Query event marker photogrammetry time tag message	185
Position Information		
$PASHQ,GGA	Query GPS position response message	182
$PASHQ,GLL	Query lat/lon message	182
$PASHQ,GXP	Query position computation with time of fix	183
$PASHQ,POS	Query position message	184
$PASHQ,UTM	Query UTM coordinates message	185
Residual Information		
$PASHQ,GRS	Query satellite range residual information	182

Table B.20. NMEA Data Message Commands (continued)

Command	Description	Page
$PASHQ,RRE	Query satellite residual and position error	184
Satellite Information		
$PASHQ,GSA	Query satellites used message	182
$PASHQ,GSN	Query signal strength/satellite number	182
$PASHQ,GSV	Query satellites in view message	183
$PASHQ,SAT	Query satellite status message	185
Track and Speed		
$PASHQ,VT3 $PASHQ,VT4 $PASHQ,VTG	Query velocity/course message, 3 places. Query velocity/course message, 4 places. Query course over ground (COG) and speed over ground (SOG) messages.	185 186 186
$PASHQ,APA	Query marine autopilot systems message	181
$PASHQ,AS1	Query data for time, position (northing/easting/altitude), and differential GPS status. Positions are referenced to the RT90 datum (Sweden).	181
$PASHQ,BWC	Query position and bearing for the current destination.	181
$PASHQ,XTE	Query cross-track error message.	186
Time Sync		
$PASHQ,ZDA	Query time synchronization message	186

ALL: Disable All NMEA Messages

$PASHS,NME,ALL,c,OFF

Turn off all enabled NMEA messages, where c is the specified serial port.

Example: Turn off all NMEA messages currently sent out through port B:

$PASHS,NME,ALL,B,OFF <Enter>

ALM: Almanac Message

$PASHQ,ALM,c

The almanac query command directs the almanac data message to port c, where c is port A, B, C, or D.

Example: Direct almanac data to port C:

$PASHQ,ALM,C <Enter>

APA: Autopilot Message

$PASHQ,APA,c

Queries the APA message, where c is the optional output port. The APA message contains navigation data used to drive marine autopilot systems. This message is not output unless a position is computed and a route is activated. See Screen 6 for more information.

Example: Query APA message to port C:

$PASHQ,APA,C<Enter>

AS1: Grid Coordinate Output for RT90 Datum

$PASHQ,AS1,c

Queries the AS1 message, where c is the optional output port. The AS1 message contains data for time, position (northing/easting/altitude), and differential GPS status. Positions are referenced to the RT90 datum (Sweden) and rendered in UTM coordinates. This message is not output unless positions are being computed.

Example: Query AS1 message to current port:

$PASHQ,AS1<Enter>

BWC: Bearing and Distance to Destination

$PASHQ,BWC,c

Queries the BWC message, where c is the optional output port. The BWC message contains position and bearing for the current destination. This message is output only when positions are being computed and a destination (waypoint) has been selected. The current port is default unless a port is specified.

Example: Query BWC message to port D:

$PASHQ,BWC,D<Enter>

DAL: Decimal Almanac

$PASHQ,DAL,c

Query decimal almanac where c is the optional output serial port A, B, C, or D. If port is not specified, the output goes to the current port.

Example: Query decimal almanac to current port:

$PASHQ,DAL <Enter>

GGA: GPS Position Message

$PASHQ,GGA,c

Query GPS position, where c is the optional receiver port where the message is output. If no position is computed, the message is output but the position-related fields are empty. If port is not specified, the message goes to the current port.

Example: Query GGA message to port B:

$PASHQ,GGA,B <Enter>

GLL: Latitude/Longitude Message

$PASHQ,GLL,c

Query latitude/longitude, where c is the optional receiver port where the message is output. If port is not specified, the message goes to the current port.

Example: GLL message to port A:

$PASHQ,GLL,A <Enter>

GRS: Satellite Range Residuals

$PASHQ,GRS,c

Query satellite range residual where c is the optional receiver output port. The message is not output unless position is being computed.

Example: Query GRS message to port D:

$PASHQ,GRS,D <Enter>

GSA: Active Satellite and DOP Message

$PASHQ,GSA,c

Query GSA active satellite and DOP message, where c is the optional receiver output port.The GSA message contains data for position mode (2D, 3D, no position), DOP values, and also lists currently tracked satellites. If output port is not specified, the output goes to the current port.

Example: Query GSA message to port B:

$PASHQ,GSA,B<Enter>

GSN: Satellite Numbers and Signal Strengths

$PASHQ,GSN,c

Query GSN satellite number and signal strength message, where c is the optional receiver output port. The GSN message contains the GPS PRN number and corresponding signal strength for each locked satellite. If output port is not specified, the output goes to the current port.

Example: Query GSN message to port A:

$PASHQ,GSN,A<Enter>

GSV: Satellites in View

$PASHQ,GSV,c

Query GSV satellites in view message, where c is the optional receiver output port.The GSV message contains a list of the satellites in view along with the corresponding elevation, azimuth, and SNR. If output port is not specified, the output goes to the current port.

Example: Query GSV message to current port:

$PASHQ,GSV<Enter>

GXP: Position Computation with Time of Fix

$PASHQ,GXP,c

Query GXP position computation message, where c is the optional receiver port. If port is not specified, the message goes to the current port.

Example: GXP message to current port:

$PASHQ,GXP <Enter>

MSG: Base Station Messages

$PASHQ,MSG,c

Query MSG base station message types 1,2,3,6 and 16, where c is the optional receiver output port. If output port is not specified, the output goes to the current port.

Example: Query MSG message to port B:

$PASHQ,MSG,B<Enter>

NME: Enable/Disable NMEA Messages

$PASHS,NME,s1,x2,s3

Enables/disables specific NMEA message output where s1 is the 3-character NMEA data string, x2 is the port, and s3 is ON (enable) or OFF (disable). The serial port must be enabled by the $PASHS,OUT command for the NMEA message output.

Example: Enable the GGA message on port A:

$PASHS,NME,GGA,A,ON<Enter>

OUT: Enable/Disable Serial Port for NMEA Output

$PASHS,OUT,x,NMEA

Enables the serial port to output NMEA messages, where x is the serial port enabled. Must be used with the $PASHS,NME command to enable NMEA messages. The serial port can be disabled by sending the command without the NMEA string.

Example: Enable port B for NMEA messages:

$PASHS,OUT,A,NMEA<Enter>

Example: Disable port A for NMEA messages:

$PASHS,OUT,A<Enter>

PER: Set NMEA Output Interval

$PASHS,NME,PER,f

Sets send interval of NMEA messages, where f is the interval from 0.5 to 999.5 seconds.

Example: Output NMEA messages every 5 seconds:

$PASHS,NME,PER,5<Enter>

POS: Position Message

$PASHQ,POS,c

Query position message where c is the optional output serial port. If port is not specified, the message goes to the current port.

Example: Query POS message to current port:

$PASHQ,POS <Enter>

RRE: Range Residual Message

$PASHQ,RRE,c

Query range residual message where c is the optional receiver output port. The message is not output unless position is being computed. If port is not specified, the message goes to the current port.

Example: Query RRE message to Port A:

$PASHQ,RRE,A <Enter>

SAT: Satellite Status

$PASHQ,SAT,c

Query satellite status where c is the optional output port. If output port is not specified, the output goes to the current port.

Example: Query SAT message to port D:

$PASHQ,SAT,D <Enter>

TTT: Event Marker

$PASHQ,TTT,c

Query TTT event marker message, where c is the optional receiver output port.The TTT message is not output unless an event pulse is being input through one of the serial ports. If output port is not specified, the output goes to the current port.

Example: Query TTT message to port D:

$PASHQ,TTT,D<Enter>

UTM: UTM Coordinates

$PASHQ,UTM,c

Query UTM coordinates where c is the optional output serial port. The UTM message contains data for 3D position, time, and differential status. Positions are output in UTM grid coordinates along with any applicable UTM zone numbers and zone letters. The message is not output unless position is being computed. If output port is not specified, the output goes to the current port.

Example: Query UTM message to the current port:

$PASHQ,UTM <Enter>

VT3: Vehicle Tracking Message (Standard)

$PASHQ,VT3,c

Query VT vehicle tracking message, where c is the optional receiver output port.The VT3 message contains data designed for vehicle tracking applications. It is not output unless positions are being computed. If output port is not specified, the output goes to the current port.

Example: Query vehicle tracking message to port C:

$PASHQ,VT3,C<Enter>

VT4: Vehicle Tracking Message (Precision)

$PASHQ,VT4.c

Query vehicle tracking message, where c is the optional output port.The VT4 message contains data designed for vehicle tracking applications. It is not output unless positions are being computed.

Example: Query VT4 message on current port:

$PASHQ,VT4<Enter>

VTG: Velocity/Course Message

$PASHQ,VTG,c

Query VTG message, where c is the output port. The VTG message contains data for course over the ground (COG) and speed over the ground (SOG). If port is not specified, the message goes to the current port.

Example: Query VTG message on port C:

$PASHQ,VTG,C<Enter>

XTE: Cross-track Error Message

$PASHQ,XTE

The XTE message contains much of the same data as appear in the APA message: SNR and cycle lock status, magnitude of the cross-track error, direction to steer, etc.

Example: Query XTE to port C:

$PASHQ,XTE,C<Enter>

ZDA: Time and Date Message

$PASHQ,ZDA,x

Query ZDA time and date message, where c is the optional receiver output port. If output port is not specified, the output goes to the current port.

Example: Query ZDA to current port:

$PASHQ,ZDA<Enter>

RTCM Commands

The RTCM commands allow you to control and monitor RTCM real-time differential operations. The RTCM commands are only available if the differential options are installed in the receiver. If the Base Station option (B) is installed, then only the base parameter and general parameter commands are accessible. If the Remote option (U) is installed, then only the remote parameter and general parameter commands are available. For a more detailed discussion of RTCM differential, refer to the RTCM differential section of the Operations chapter.

Table B.21 summarizes the RTCM commands. All these commands are **set** commands except one ($PASHQ,RTC). Through the set commands you can modify and enable a variety of differential parameters. Certain set commands are applicable only to the base station, and certain commands only apply to the remote station. The commands are discussed in alphabetical order in the pages following the table.

Table B.21. RTC Command Summary

Command	Description	Page
RTCM STATUS		
$PASHQ,RTC	Query RTCM differential status	189
BASE PARAMETERS		
$PASHS,RTC,BAS	Sets receiver to operate as differential base station	188
$PASHS,RTC,MSG	Defines RTCM Type 16 message	188
$PASHS,RTC,SPD	Sets bit rate of base station	190
$PASHS,RTC,STH	Sets health of base station	190
$PASHS,RTC,TYP	Sets message type and message period	189
REMOTE PARAMETERS		
$PASHS,RTC,AUT	Turns auto differential mode on or off.	188
$PASHS,RTC,MAX	Sets maximum age of RTCM differential corrections	188
$PASHS,RTC,QAF	Sets communication quality threshold	189
$PASHS,RTC,REM	Sets receiver to operate as differential remote station	189
GENERAL PARAMETERS		
$PASHS,RTC,INI	Resets RTCM internal operation	188
$PASHS,RTC,OFF	Disables differential mode	189
$PASHS,RTC,STI	Sets the station identification of base or remote	191

AUT: Auto Differential

$PASHS,RTC,AUT,s

This command turns auto differential mode on or off, where s is ON or OFF. When in auto-differential mode, the receiver generates raw positions automatically if differential corrections are older than the maximum age, or are not available. It is used only in REMOTE mode. Default is OFF.

Example: Turn auto differential mode on:

    $PASHS,RTC,AUT,ON <Enter>

BAS: Enable Base Station

$PASHS,RTC,BAS,c

Set the receiver to operate as an RTCM differential base station, where c is the differential port and can be set to port A, B, C or D.

Example: Set to differential base mode using port B:

    $PASHS,RTC,BAS,B <Enter>

INI: Initialize RTCM

$PASHS,RTC,INI

Initialize RTCM internal operation. This should be issued to the RTCM base or remote station (or both) if communication link between base and remote is disrupted.

Example: Initialize RTCM internal operation:

    $PASHS,RTC,INI <Enter>

MAX: Max Age

$PASHS,RTC,MAX,d

Sets the maximum age in seconds of a RTCM differential correction above which the correction is not used, where d is any number between 1 and 1199. Default is 60. This command is used only in REMOTE mode.

Example: Set maximum age to 30 seconds

    $PASHS,RTC,MAX,30 <Enter>

MSG: Define Message

$PASHS,RTC,MSG,s

Defines RTCM type 16 message up to 90 characters long sent from the base to the remote, where s is a character string (text message) up to 90 characters. This command is used only at the base station and only if message type 16 is enabled.

Example: Define RTCM message “This is a test message”

$PASHS,RTC,MSG,This is a test message <Enter>

OFF: Disable RTCM

$PASHS,RTC,OFF

Disables base or remote differential mode.

Example: Turn RTCM off:

$PASHS,RTC,OFF <Enter>

QAF: Quality Factor

$PASHS,RTC,QAF,d

Sets the number of received differential correction frames in RTCM differential mode above which the quality factor is set to 100%. The command structure is:

$PASHS,RTC,QAF,d<Enter>

where d is any number between 0 and 999. This QAF number is used to compute the QA value where:

QA = good messages/QAF

The QA parameter allows you to evaluate the communication quality between the base and remote stations. Default is 100. This command is used only in REMOTE mode.

Example: Set quality factor to 200:

$PASHS,RTC,QAF,200<Enter>

REM: Enable Remote RTCM

$PASHS,RTC,REM,c

Set the receiver to operate as an RTCM differential remote station, where c is differential port A, B, C, or D.

Example: Set receiver as differential remote using port B

$PASHS,RTC,REM,B <Enter>

RTC: Query RTCM Status

$PASHQ,RTC,x

Query RTCM differential status, where x is the optional output port.

Example: Query receiver for RTCM status:

$PASHQ,RTC<Enter>

SPD: Base Bit Rate

$PASHS,RTC,SPD,d

This command sets the number of bits per second that are being generated to the serial port of the base station, where d is the code for the output rate in bits per second. The available speeds and corresponding codes are listed in Table B.22. Default is code 1, 50 bits per second. This command is used only in BASE mode.

Table B.22. Available Bit Rate Codes

Code	0	1	2	3	4	5	6	7	8	9
Rate	25	50	100	110	150	200	250	300	1500	0 (burst mode)

Example: Set bit rate to 110 bits/sec

$PASHS,RTC,SPD,3 <Enter>

STH: Station Health

$PASHS,RTC,STH,d

This command sets the health of the base station, where d is any value between 0 and 7, as listed in Table B.23. This command is used only in base mode. Default is 0.

Table B.23. RTC,STH Health of Base Station

Code	Health Indication
7	Base station not working.
6	Base station transmission not monitored.
5	Specified by service provider/UDRE scale factor = 0.1
4	Specified by service provider/UDRE scale factor = 0.2
3	Specified by service provider/UDRE scale factor = 0.3
2	Specified by service provider/UDRE scale factor = 0.5
1	Specified by service provider/UDRE scale factor = 0.75
0	Specified by service provider/UDRE scale factor = 1

Example: Set health to “Base station not working”:

$PASHS,RTC,STH,7 <Enter>

STI: Station ID

$PASHS,RTC,STI,d

This command sets the user station identification (user STID), where d is any integer value between 0000 and 1023. Use the STID to restrict the use of differential corrections to a base station.

If the STID in the remote station is set to any non-zero number, then corrections are used only from a base station with the same STID number. For example, if a remote station STID is set to 0987, then uses only the differential corrections from a base station with an STID of 0987.

If the remote station STID is set to 0000 (the default) then the station uses any differential corrections received, regardless of the STID of the base station.

Example: Set site identification to 0001:

$PASHS,RTC,STI,0001<Enter>

TYP: Message Type

$PASHS,RTC,TYP,d1,d2

This command enables the type of message sent and period by the base station, where d1 is the type and d2 is the period. This command is used only in base mode. Table B.24 lists the message types available and the period range. The default is type 1 set to 99, and type 6 is ON.

Table B.24. RTC,TYP Message Types

Type	Range
01	0-99 seconds, where 0 is disabled and 99 is generated continuously
02	0-99 minutes, where 0 is disabled and 99 is generated continuously
03	0-99 minutes, where 0 is disabled and 99 is generated continuously
06	1 = ON, 0 = OFF (ON and OFF are also accepted)
16	same as type 03

All messages can be enabled simultaneously with any output period setting, with the exception of period 99; with simultaneous messages, only one can be set at 99.

Example: Enable type 1, sent out every second:

$PASHS,RTC,TYP,1,01<Enter>

This message only exists in binary format. If ASCII format is requested (default), only the header is sent ($PASHR,SNV).

C

Receiver Parameters

Receiver user parameters are stored in the internal memory of the receiver. Initially, they are set to their default values, but can be overridden in two different ways, depending on the parameter. Some are overridden automatically when their values are modified through their corresponding screen, and others are saved in memory when issuing the command 555 (see Screen 8). Once parameters are saved in the internal memory, powering the receiver off does not change their values.

Some of these parameters can be set back to their default values by issuing the command 555. To set all parameters back to their default values, do an internal memory reset of the receiver.

Table C.1 lists all receiver user parameters, showing their default values. The table also lists which parameters are saved automatically when their values are modified through their corresponding screen, which parameters are saved with command 555, and which parameters are set to their defaults with command 550.

Table C.1. Z-12 Default Parameters

Parameter	Default	Saved Automatically	Saved by 555	Reset by 550
SCREEN 4				
POS	0	Yes	No	No
REC INT	20.0	No	Yes	Yes
MIN SV	3	No	Yes	Yes
ELEV MASK	10	No	Yes	Yes
RNGR	0	No	Yes	Yes
POSITION				

Table C.1. Z-12 Default Parameters

Parameter	Default	Saved Automatically	Saved by 555	Reset by 550
POS MODE	0	Yes	No	No
ALT MODE	0	Yes	No	No
ELV MASK	10	No	Yes	Yes
UNHEALTHY	N	No	Yes	Yes
PDOP MASK	40	No	Yes	Yes
HDOP MASK	04	No	Yes	Yes
COMP POS	Y	No	Yes	Yes
ION MODEL	N	No	Yes	Yes
UTM COORD	N	No	Yes	Yes
DATUM	WGS84	No	No	No
SESSION				
START, END	0	Yes	No	No
INT	20.0	Yes	No	No
MASK,MIN,TYPE	10,3,0	Yes	No	No
IN USE	N	Yes	No	No
REF	000	Yes	No	No
OFFSET	00:00	Yes	No	No
DIFFERENTIAL				
MODE	Disabled	No	Yes	Yes
AUTO DIFF	Disabled	No	Yes	Yes
OUTPUT PORT	A	No	Yes	Yes
CODE	C/A	No	Yes	Yes
RTCM				
SPD	0050	Yes	No	Yes
STID	0000	Yes	No	No
STHE	0	Yes	No	No
FREQ (Type 1)	99	Yes	No	Yes
FREQ (Type 2)	00	Yes	No	Yes

Table C.1. Z-12 Default Parameters

Parameter	Default	Saved Automatically	Saved by 555	Reset by 550
FREQ (Type 3)	00	Yes	No	Yes
FREQ (Type16)	00	Yes	No	Yes
TYPE 6	On	Yes	No	Yes
SEQ	N	Yes	No	Yes
MAXAGE	0120	Yes	No	No
MESSAGE	Empty	Yes	No	Yes
PORT A, B, C, or D				
NMEA	Off	No	Yes	Yes
All NMEA Messages	Off1	Yes	No	No
Send Interval	005	Yes	No	Yes
Real Time	Off	No	Yes	Yes
MBEN	Off	No	Yes	Yes
PBEN	Off	No	Yes	Yes
SNAV	Off	No	Yes	Yes
SALM	Off	No	Yes	Yes
FORMAT	ASCII	No	Yes	Yes
VTS	Off	No	Yes	Yes
BAUD RATE	9600	Yes	No	Yes
PULSE GENERATION				
PERIOD	01.001	No	Yes	Yes
OFFSET	+000.000 0	No	Yes	Yes
OUTPUT ON A	N	No	No	No
OUTPUT ON B	N	No	No	No
EXT FREQ				
FREQUENCY	00.00	No	Yes	Yes
SAVE	N	No	Yes	Yes
MODEM				
PORT	A	No	Yes	Yes

Table C.1. Z-12 Default Parameters

Parameter	Default	Saved Automatically	Saved by 555	Reset by 550
TYPE	Telebit World-Blazer	No	Yes	Yes
RCVR CTRL				
Z MODE	A	Yes	No	No
AUTOSELECTION	Y	No	Yes	Yes
ALL SATELLITES	Y	No	Yes	Yes
SCREEN 7				
SITE	????	Yes	No	Yes
SESS	----	Yes	No	Yes
RCV #	----	Yes	No	Yes
ANT #	----	Yes	No	Yes
MMDD	----	Yes	No	Yes
OPR	----	Yes	No	Yes
CODE	------------	Yes	No	Yes
HI	0.0000	No	No	No
T-DRY	+00	No	No	No
WET	+00	No	No	No
RH	00	No	No	No
BP	0000	No	No	No
MIN SV	0	No	No	No
RECORD	Y	No	No	No
EPOCHS	000	No	No	No

D

Equipment Notes

This appendix provides information about various cables that are used with the receiver, and some information about radio interference.

Antenna Cables

An antenna cable used with the receiver may be up to 30 meters long. A line amplifier is available for greater distances. Other technical specifications are given in table 1 below. The available cables are:

- 10-meter Belden 8219 (RG-58/U-type, but with better loss specifications).
- 30-meter Belden 8214 (RG-8/U-type, but with better loss specifications).

The cables use type-N male connectors at both ends which are center captured. If you want to substitute a non-Z-12 cable for one of the Z-12 cables, it must be the same type and have the same connectors as listed above.

Table D.1 lists cable specifications. Not all RG-58/U and RG-8/U cables meet these specifications. Make sure any substitute cables satisfy these electrical requirements or the Z-12 will not perform properly.

Table D.1. Cable Specifications

Insertion loss	17 db max. (at 1.5 GHz)
Characteristic impedance	50 ohm (nominal)
VSWR (Input/output)	1.1:1 max (at 1.5 GHz)
DC resistance	0.5 ohm ground braid and center conductor

Power Cables

Use at least 22-gauge wire for external power cables.

Pin A is the positive 10-32 VDC connection.

Pin B is ground.

Pin C is for the battery charger if internal batteries are installed (model L receiver only).

Figure D.1 shows the power connector located at the back of the receiver.

Figure D.1. Power Connector

RS-232 Cables

The RS-232 cable used with the Z-12 receiver should mate with the female 16-pin circular connector on the receiver (Figure D.2). Table D.2 lists pin assignments.

Figure D.2. RS-232 16-Pin Circular Connector, View from Rear of Receiver

Table D.2. RS-232 Cable Pin Assignments

Pin Number	Description	Abbreviation
1	Ground	GND
2	Transmit data port A/B	TXD0
3	Receive data port A/B	RXD0
4	Request to send port A/B	RTS0
5	Clear to send port A/B	CTS0
6	Data set ready port A/B	DSR0
7	Ground	GND
8	Data carrier detect port A/B	DCD0
9	Data terminal ready port A/B	DTR0
10	+5 VDC	+5V
11	Ground	GND
12	Transmit data port C/D	TXD2
13	Receive data port C/D	RXD2
14	Request to send port C/D	RTS2
15	Clear to send port C/D	CTS2

Port A/B is configured for full handshake, while port C/D is not.

Radio Interference

Verify that the broadcast frequencies of any hand-held or mobile communications devices do not interrupt or obstruct GPS receivers during data collection.

CAUTION

Some radio transmitters and receivers (such as FM radios) can interfere with the operation of GPS receivers if operated in close proximity.

Power Consumption

The power consumption of the Z-12 receiver varies depending on whether the screen backlighting is off or on. When the screen backlight is off, the power consumption is approximately 20W. When on, approximately 22W.

E

Datums

This appendix presents transformation parameters that are used by GPS receivers to convert pseudo-range positions, shown on Screen 2, from WGS-84 into the desired datum. The datums are from Deptartment of Defense document SS-M/V-500, Rev. P, 16 Oct. 1991. Receiver datum codes are selected from a subscreen of Screen 4 on the receiver DATUM SELECT option.

- Geoid heights computed using spherical harmonic expansion and WGS-84 EGM.
- WGS-84 minus local geodetic systems. All values in meters.

Table E.1. Datum Translation Parameters

Reciver Datum Codes	Local Geodetic System	Area	Reference Ellipsoid	Parameter Differences		Transformatio Parameters		
				a (m)	f ×10^4	X(M)	Y(M)	Z(M)
ARF-M	ARC 1950	Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbawe	Clarke 1880	-112.145	-0.54750714	-143	-90	-294
ARS-M	ARC 1960	Kenya, Tanzania	Clarke 1880	-112.145	-0.54750714	-160	-8	-300
AUA	Austr. Geod. 1966	Australia, Tasmania Island	Aust. Nat'l.	-23	-0.00081204	-133	-48	148
AUG	Austr. Geod. 1984	Australia, Tasmania Island	Aust. Nat'l.	-23	-0.00081204	-134	-48	149

Table E.1. Datum Translation Parameters (continued)

Reciver Datum Codes	Local Geodetic System	Area	Reference Ellipsoid	Parameter Differences a (m)	f ×10^4	Transformatio Parameters X(M)	Y(M)	Z(M)
BOO	Bogota Observatory	Columbia	Int'l.	-251	-0.14192702	307	304	-318
CAI	Campo Inchauspe	Argentina	Int'l.	-251	-0.14192702	-148	136	90
CAP	Cape	S. Africa	Clarke 1880	-112.145	-0.54750714	-136	-108	-292
CGE	Carthage	Tunisia	Clarke 1880	-112.145	-0.54750714	-263	6	431
CHI	Chatham 1971	Chatham Island, New Zealand	Int'l.	-251	-0.14192702	175	-38	113
CHU	Chua Astro	Paraguay	Int'l.	-251	-0.14192702	-134	229	-29
COA	Corrego Alegre	Brazil	Int'l.	-251	-0.14192702	-206	172	-6
EUR-A	European 1950	Western Europe: Austria, Denmark, France, F.R.Germany, Netherlands, Switzerland	Int'l.	-251	-0.14192702	-87	-96	-120
EUR-E	Eur. 1950	Cyprus	Int'l.	-251	-0.14192702	-104	-101	-140
EUR--F	Eur. 1950	Egypt	Int'l.	-251	-0.14192702	-130	-117	-151
EUR-H	Eur. 1950	Iran	Int'l.	-251	-0.14192702	-117	-132	-164
EUR-J	Eur. 1950	Sicily	Int'l.	-251	-0.14192702	-97	-88	-135
EUS	European 1979	Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland	Int'l.	-251	-0.14192702	-86	-98	-119
GAA	Gandajika Base	Rep. of Maldives	Int'l.	-251	-0.14192702	-133	-321	50
GEO	Geodetic Datum 1949	New Zealand	Int'l.	-251	-0.14192702	84	-22	209
HJO	Hjorsey 1955	Iceland	Int'l.	-251	-0.14192702	-73	46	-86

Table E.1. Datum Translation Parameters (continued)

Reciver Datum Codes	Local Geodetic System	Area	Reference Ellipsoid	Parameter Differences a (m)	f ×10^4	Transformatio Parameters X(M)	Y(M)	Z(M)
IND-A	Indian	Thailand, Vietnam	Everest	860.655	0.28361368	214	836	303
IND-M	Indian	Bangladesh, India, Nepal	Everest	860.655	0.28361368	289	734	257
IRL	Ireland 1965	Ireland	Modified Airy	796.811	0.11960023	506	-122	611
KEA	Kertau 1948	W. Malaysia Singapore	Modified Everest	832.937	0.28361368	-11	851	5
LIB	Liberia 1964	Liberia	Clarke 1880	-112.145	-0.54750714	-90	40	88
LUZ-A	Luzon	Philippines, excl Mindanao Island	Clarke 1866	-69.4	-0.37264639	-133	-77	-51
MAS	Massawa	Eritrea, Ethiopia	Bessel 1841	739.845	-0.10037483	639	405	60
MER	Merchich	Morocco	Clarke 1880	-112.145	-0.54750714	31	146	47
MIN	Minna	Nigeria	Clarke 1880	-112.145	-0.54750714	-92	-93	122
NAH-C	Nahrwan	Saudi Arabia	Clarke 1880	-112.145	-0.54750714	-231	-196	482
NAS-C	North American 1927 (CONUS)	North America	Clarke 1866	-69.4	-0.37264639	-8	160	176
NAS-D	Alaska	Alaska	Clarke 1866	-69.4	-0.37264639	-5	135	172
NAS-E	Canada	Canada incl. Newfoundland Island	Clarke 1866	-69.4	-0.37264639	-10	158	187
NAS-N	Central America	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Mexico	Clarke 1866	-69.4	-0.37264639	-6	127	192
NAR	North American 1983	Alaska, Canada, Central America, CONUS, Mexico	GRS 80	0	-0.00000016	0	0	0
OEG	Old Egyptian	Egypt	Helmert 1906	-63	0.00480795	-130	110	-13

Table E.1. Datum Translation Parameters (continued)

Reciver Datum Codes	Local Geodetic System	Area	Reference Ellipsoid	Parameter Differences a (m)	f ×10^4	Transformatio Parameters X(M)	Y(M)	Z(M)
OHA-M	Old Hawaiian	Hawaii	Clarke 1866	-69.4	-0.37264639	61	-285	-181
FAH	Oman	Oman	Clarke 1880	-112.145	-054750714	-346	-1	224
OGB-M	Ordnance Survey of Great Britain 1936	England, Isle of Man, Scotland, Shetland Islands, Wales	Airy	573.604	0.11960023	375	-111	431
PIT	Pitcairn Astro 1967	Pitcairn Island	Int'l.	-251	-0.14192702	185	165	42
QAT	Qatar National	Qatar	Int'l.	-251	-0.14192702	-128	-283	22
QUO	Qornoq	South Greenland	Int'l.	-251	-0.14192702	164	138	-189
SCK	Schwarzeck	Nambia	Bessel 1841	653.135	0.10037483	616	97	-251
SAN-M	South American 1969	Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paaguay, Peru, Venzuela, Trinidad, Tobago	South America 1969	-23	-0.00081204	-57	1	-41
TIL	Timbalai 1948	Brunei, East Malaysia, Sarawak, Sabah	Everest	860.655	0.28361368	-689	691	-46
TOY-M	Tokyo	Japan, Korea, Okinawa	Bessel 1841	739.845	0.10037483	-128	481	664
WGS 72	WGS 1972		WGS 72	-2.0	-0.3121057	0	0	-4.5
WGS 84	WGS 1984		WGS 84	0	0	0	0	0.0
ZAN	Zanderij	Surinam	Int'l.	-251	-0.14192702	-265	120	-358

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