GG Surveyor

GPS+GLONASS™

Reference Manual

Ashtech

Ashtech
1170 Kifer Road
Sunnyvale, CA USA 94086

Phone and Fax Numbers

- Main
  - Voice: 408-524-1400
  - Fax: 408-524-1500
- Sales
  - US: 800-922-2401
  - International: 408-524-1670
  - Fax: 408-524-1500
- Europe
  - Voice: 44-993-883-533
  - Fax: 44-993-883-977
- Support
  - US: 800-229-2400
  - International: 408-524-1680
  - Fax: 408-524-1500
- BBS
  - Direct: 408-524-1527

Internet

- support@ashtech.com
- http://www.ashtech.com

Printed in the United States of America.
Part Number: 630199-01, Revision A
January, 1998

FCC Notice

The equipment described in this manual has been tested pursuant to Part 15 of the FCC Rules and found to comply with the limits for a Class A digital device for use in commercial business, and industrial environments. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. The equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio and television reception. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, you can try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna.
- Relocate the receiver relative to the equipment which it interferes.
- Power the equipment from a different AC receptacle so that this equipment and the interfered equipment are on different branch circuits. If necessary, contact the Ashtech customer service department or an authorized representative for additional advice.

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITY

LICENSOR AND ITS THIRD-PARTY SUPPLIERS MAKE NO WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING THE PROGRAM, MEDIA, DOCUMENTATION, RESULTS OR ACCURACY OF DATA AND HEREBY EXPRESSLY DISCLAIM ANY WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE AND NONFRINGEMENT. LICENSOR AND ITS THIRD-PARTY SUPPLIERS DO NOT WARRANT THE PROGRAM WILL MEET YOUR REQUIREMENTS OR THAT ITS OPERATION WILL BE UNINTERRUPTED OR ERROR-FREE.

LICENSOR, its third-party suppliers, or anyone involved in the creation or deliver of the Program or Documentation to you shall have no liability to you or any third-party for special, incidental, indirect or consequential damages (including, but not limited to, loss of profits or savings, downtime, damage to or replacement of equipment or property, or recover or replacement of programs or data) arising from claims based in warranty, contract, tort (including negligence), strict liability, or otherwise even if LICENSOR or its third-party suppliers have been advised of the possibility of such claim or damages. The liability of LICENSOR and its third-party suppliers for direct damages shall not exceed the actual amount paid for this Program License.

Some states do not allow the exclusion of limitation of implied warranties or liability for incidental or consequential damages, so the above limitations or exclusions may not apply to you.

U.S. GOVERNMENT RESTRICTED RIGHTS

The Program and Documentation are provided with RESTRICTIVE RIGHTS. Use, duplication, or disclosure by the Government is subject to restrictions as set forth in subdivision (c)(1)(ii) of the Rights in Technical Data and Computer Software clause at DFARS 252.227-7013 or subdivision 9(C)(1) and (2) of the Commercial Computer Software - Restricted Rights 48 CFR 52.227.19, as applicable.

Should you have any questions concerning the License Agreement or the Limited Warranties and Limitation of Liability, please contact in writing: Ashtech, 1170 Kifer Road, Sunnyvale, CA 94086

Table of Contents

List of Figures

List of Tables

Introduction

The GG Surveyor™ is the first all-in-view GPS+GLONASS™ receiver. It's revolutionary design allows smooth integration into a wide range of positioning applications on land, sea or in the air.

One of the primary advantages of GPS+GLONASS is increased satellite coverage. With a total of 40 healthy satellites, there are 60% more satellites available for position computation than GPS alone. Thus, GPS+GLONASS is extremely beneficial in obstructed operating environments, such as in cities, mountainous areas, under tree cover, or other areas where much of the sky and many of the satellites can be blocked.

To take advantage of the increased satellite availability, the GG Surveyor has 12 channels for L1 GPS and 12 Channels for L1 GLONASS, providing all-in-view tracking for both constellations. Autonomous GPS+GLONASS positions typically have 16 meter accuracies compared with 100 meters for GPS alone.

Differential corrections and RTK messages are available for both GPS and GLONASS providing real-time, on-the-fly centimeter accuracy when the GG Surveyor is used with a base station and data link.

Functional Description

The GPS constellation contains 26 usable satellites. As of December 1997, the GLONASS constellation has 13 usable satellites of the planned 24 satellites full constellation. The GG Surveyor provides the capability to track up to 24 GPS and GLONASS satellites simultaneously. As the GG Surveyor locks onto the signal generated by each satellite, information (ephemeris data) about the position of each satellite is automatically downloaded and stored in receiver memory. Once the ephemeris data is collected, the GG surveyor can compute its own position.

The GG Surveyor calculates three-dimensional position and velocity when tracking any combination of five satellites (e.g. 3 GPS and 2 GLONASS). By holding the GPS-GLONASS clock offset fixed, the GG Surveyor calculates a 3D position with any combination of 4 satellites (e.g., 2 GPS and 2 GLONASS). By also holding the altitude fixed, the GG Surveyor calculates a 2D position with any combination of 3 satellites.

Up to 5 independent measurements are determined per second, with no interpolation or extrapolation from previous solutions. The position and velocity computations are performed using all the satellites in view simultaneously (up to 16 when in 5 Hz mode). The GG Surveyor uses a Doppler measurement technique for computing on-the-fly velocity (no dependence on the previous position). All computations are accomplished relative to the World Geodetic System WGS-84 reference ellipsoid when the receiver is used in GPS or MIX mode, and in PZ-90 when in GLN only mode.

Upon application of power, the GG Surveyor runs a self-test of internal memories, and thereafter periodically self-tests various functions during normal operation. Test results are stored for commanded output. After self-test, the GG Surveyor initializes the battery-backed RAM. If the battery-backed-up RAM fails self-test (due, for example, to a low battery condition), the GG Surveyor clears and reports the loss of stored data, then initializes the 24 channels and begins searching for all satellites within the field of view of the antenna.

Technical Specifications

Table 1.1 lists the technical specifications of the GG Surveyor.

Table 1.1: Technical Specifications

Characteristic	GG Surveyor Specifications
Tracking	• 12 channels L1 GPS code and carrier • 12 channels L1 GLONASS code and carrier
Size	7.2 cm wide × 5.8 cm height × 22.5 cm depth
Weight	3.4 lbs
Operating temperature	-30° to +55°C
Storage temperature	-40° to +85°C
Environment • Humidity • Vibration • Shock	 • Resistant to wind-driven rain and dust to MIL-STD-810E • N/A • N/A
Power consumption	3 watts
Input Voltage	6 to 15 VDC
Speed (Maximum)	1,000 knots (higher velocities available under validated export license)
Altitude (Maximum)	60,000 ft (higher altitude available under validated export license)
Interface	• Three bi-directional RS-232 ports via DB 25 connector up to 115,200 bps • One antenna port • Event marker and 1PPS via DB25 connector • optional external reference connector • optional radio antenna connector

Performance Specifications

One of the most important functions of the GG Surveyor is providing real-time position solutions with accuracy ranging from centimeter level to 100 meters. Table 1.2 summarizes the positioning modes and expected accuracy.

Table 1.2: Accuracy as Function of Mode

Positioning Mode	GPS + GLONASS	GPS Only	GLONASS Only
Real-Time Position-Autonomous	7 meters (CEP 50%) 16 meters (95%)	25 meters (CEP 50%) 100 meters (95%)	8 meters (CEP 50%) 20 meters (95%)
Real-Time Position-Code Differential	35 centimeter (CEP) 75 centimeters (95%)	40 centimeters (CEP) 90 centimeters (95%)	50 centimeters (CEP) 1 meter (95%)
Real-Time Position-RTK/Carrier Differential-Float mode	<10 centimeters (95%)	<10 centimeters (95%)	N/A
Real-Time Position- RTK/Carrier Differential-Fixed mode	1 centimeter (CEP) 2 centimeters (95%)	N/A	N/A
Velocity Accuracy-Autonomous	0.15 knots (mean) 0.30 knots (95%)	1 knots (mean) 4 knots (95%)	0.03 knots (mean) 0.05 knots (95%)
Velocity Accuracy-Code Differential	0.04 knots (mean) 0.1 knots (95%)	0.05 knots (mean) 0.1 knots (95%)	0.02 knots (mean) 0.05 knots (95%)
Velocity Accuracy-RTK/Carrier Differential-Float mode	0.02 meters/sec (mean) 0.05 meters/sec (95%)	0.02 meters/sec (mean) 0.05 meters/sec (95%)	N/A
Velocity Accuracy-RTK/Carrier Differential-Fixed mode	0.02 meters/sec (mean) 0.05 meters/sec (95%)	N/A	N/A

Position and velocity accuracy are for horizontal errors based on tests except for the 100 meter GPS value, which is the 2dRMS accuracy promised by the US Department of Defense. Tests were conducted in California and Moscow with 10°elevation mask angles, medium to high multipath environment. A GG24 Reference Station board was used to provide differential corrections over a short baseline. Differential data rate 300 bps, HDOP <4. Position accuracy specifications are for horizontal position. Vertical error <2X horizontal error.

Receiver Options

The GG Surveyor has a number of internal receiver options. The commands and features you can use depend upon the options installed in the receiver. For example, if the Photogrammetry option is not installed, you cannot use the $PASHS,TTT command to output event time tags from the serial port.

Table 1.3 lists the available options. Each option is represented by a letter or number presented in a certain order. You can verify the installed options by issuing the **$PASHQ,RID** command to the receiver using an external handheld controller or PC, as described in Chapter 6, **Command/Response Formats**.

The response displays the options as a 14 character alphanumeric string at the end of the response message. For example:

$PASHR,RID,G2,GE00,55OPUBILEGMJCS

If the letter or number is displayed in the response message, the option is available. If the letter/number is not displayed, the option is not available. Table 1.3 lists the available options

Table 1.3: GG Surveyor Receiver Options

Option	Description
5 = 5 Hz 2 = 2 Hz 1 = 1 Hz	Position update rate
5 = 5 Hz 2 = 2 Hz 1 = 1 Hz	Raw measurement update rate
O	Raw data output
P	Carrier phase
U	Differential - remote station
B	Differential - base station
I	RAIM availability
L	Pulse per second (1 PPS)
E	Event/Photogrammetry
G	Geoidal height
M	Magnetic variation
J	Phase differential mode
C	Strobe correlator

Table 1.3: GG Surveyor Receiver Options (continued)

Option	Description (continued)
S	GLONASS

[5,2,1] Position Update Rate

Allows for position fixes to be issued one [1], two [2] or five [5] times per second.

[5,2,1] Raw Measurement Update Rate

Allows for raw measurement messages to be issued one [1], two [2] or five [5] times per second.

[O] Raw Data Output

The [**O**] option enables the output of raw data.

[P] Carrier Phase

The [**P**] option enables output of carrier phase information within the measurement messages.

[U] RTCM Remote

The [**U**] option allows the receiver to be used as a RTCM remote station capable of decoding and using real-time differential corrections.

The GG Surveyor decodes RTCM-104, Version 2.2 format message types 1, 2, 3, 6, 9, 16, 22, 31, 32, and 34. If the **[J]** option is also enabled, the receiver can also decode and use the RTCM RTK messages 18 and 19.

[B] RTCM Base

The [**B**] option allows the GG Surveyor to be used as a RTCM differential base station capable of outputting real-time differential corrections.

The GG Surveyor outputs RTCM-104, Version 2.2 format message types 1, 2, 3, 6, 9, 16, 22, 31, 32, and 34. If the **[J]** option is also enabled, the receiver can also generate the RTCM RTK messages 18 and 19.

[I] RAIM Availability

The [**I**] option allows the receiver to utilize autonomous integrity monitoring.

[L] Pulse Per Second (1PPS)

The [**L**] option allows the GG Surveyor to generate a 1 PPS signal.

[E] Event Marker

The [**E**] option allows the output of a time trigger message (TTT) corresponding to the time event created by a trigger signal. The event marker is activated at the rising edge of the trigger signal by default, but can be set to respond to the falling edge on command.

[G] Geoid Height

The [**G**] option uses a geoid model to compute orthometric elevation information.

[M] Magnetic Variation

The [**M**] option uses magnetic variation table.

[J] Phase Differential Mode

The [**J**] option allows the receiver to use the carrier phase differential (RTCM message 18 and 19) data for RTK. Both the **[B]** and **[J]** options must be enabled to generate type 18 and 19 messages from a base station. Both the **[V]** and **[J]** options must be enabled to use type 18 and 18 messages at a remote station.

[C] Strobe Correlator

The [**C**] option enables the use of the strobe correlator in position computation. If this option is installed, then the receiver uses the strobe correlator by default over the edge correlator.

[S] GLONASS

The [**S**] option enables the tracking and use of GLONASS satellites.

Equipment

This chapter includes a functional and hardware description of the GG Surveyor, defines the RF interface connector and the power/input/output connector signal parameters, and lists power requirements and environmental specifications.

Hardware Description

The GG Surveyor (Figure 2.1) has four RS-232 input/output (I/O) ports A-D (D is not available to the user), and an L1-band radio-frequency (RF) antenna port. All RS-232 serial ports are capable of two-way communication with external equipment.

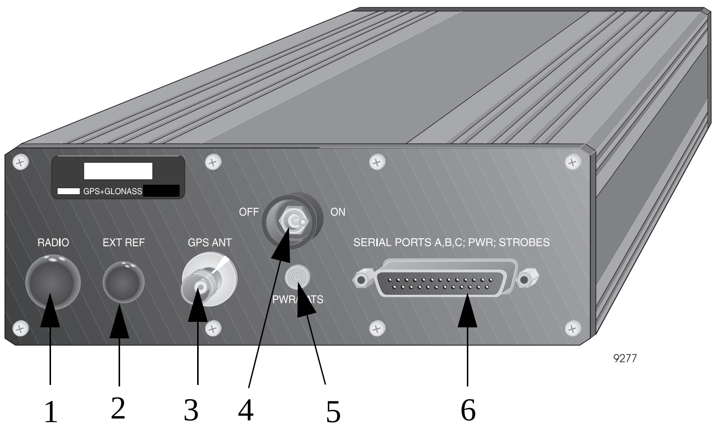

Figure 2.1: GG Surveyor

Table 2.1 describes the front panel components of the GG Surveyor.

Table 2.1: GG Surveyor Front Panel Description

Number	Component	Function
1	External Radio Connector	Allows connection to an external radio
2	External Frequency Reference Connector	Allows input of external reference clocks Input frequencies 5 MHz, sinusoidal

Table 2.1: GG Surveyor Front Panel Description (continued)

Number	Component	Function
3	Antenna Connector	The RF connector is a standard TNC-type female receptacle wired for connection via 50 Ω coaxial cabling to a GPS+GLONASS antenna with an integral LNA.
4	On/Off Switch	Turns the receiver on and off.
5	Power Indicator/SV Indicator	Flashing red light indicates power is applied to the receiver. Number of green flashes indicates number of satellites the receiver is locked onto. A yellow flash separates the count between the number of GPS and GLONASS satellites the receiver is locked onto.
6	Serial Power/I/O Port	The multi-function 25 pin connector serves as the 3 RS-232 Serial input/output ports (ports A, B, and C). The power input and event marker input, and the 1PPS output.

Power/Input/Output Connections

A DB25 power/input/output connector provides the input power connection, an external LED connection, one-pulse-per-second TTL output, photogrammetry input, and RS-232 I/O (Figure 2.2).

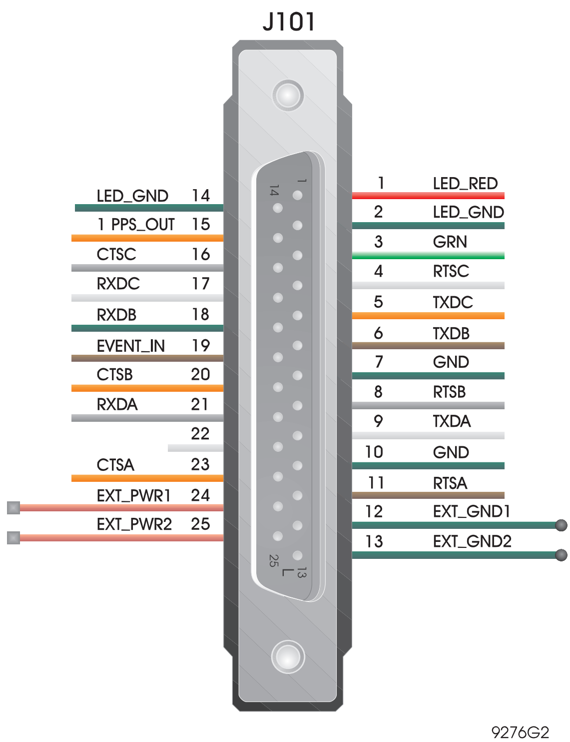

Figure 2.2: DB25 Connector J101

Table 2.2 lists the pin assignments for DB25 connector J101.

CAUTION
No power should be applied while connecting or disconnecting cables.

Table 2.2: J101 Connector Pinout

Pin	Code	Pin	Code
1	LED RED - Can be used to drive external LED	14	LED GND
2	LED GRN - Can be used to drive external LED	15	1PPS OUT
3	GND	16	CTSC
4	RTSC	17	RXDC -
5	TXDC	18	RXDB
6	TXDB	19	EVENT IN
7	GND	20	CTSB
8	RTSB	21	RXDA
9	TXDA	22	No connection
10	GND	23	CTSA
11	RTSA	24	EXT PWR 1
12	EXT GND 1	25	EXT PWR 2
13	EXT GND 2		

Power Requirements

DC voltage: 6 to 15 volts DC, regulated $\pm$ 5%

Wattage: 2.8 watts (LNA not included)

An on-board battery-backed RAM maintains user setup and data.

RF Interface Connector

The RF connector is a standard TNC female receptacle wired for connection via 50-ohm coaxial cabling to a GPS antenna with internal LNA. The TNC connector shell is connected to the ground. The TNC center pin provides +4.8 VDC (to power the LNA) and accepts RF input from the antenna; the RF and DC voltage share the same path.

The RF circuitry receives satellite data from a GPS+GLONASS antenna and LNA via a coaxial cable, and can supply power to the antenna/LNA by means of that cable. No separate antenna power cable is required. The LNA power consumption is usually below 150 milliwatts (depends upon model and manufacturer).

CAUTION
The unit may be damaged if the TNC center pin is not isolated from DC ground.

Equipment

Serial/Power Cable

The serial/power cable (Figure 2.3) connect the GG Surveyor to the power source, the PC or handheld unit and any peripherals.

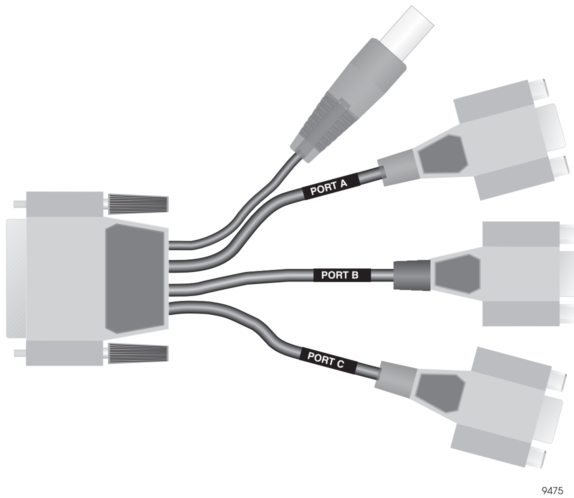

Figure 2.3: Serial/Power Cable

Antenna

The GG Surveyor is designed to work with an antenna-preamplifier that requires five volts and is isolated from DC ground. The gain of the antenna/preamplifier minus the loss of the cable should be between 20 and 30 dB. Connect the antenna cable directly to the antenna connector on the GG Surveyor. Antenna cables exceeding 30 meters require a line amplifier. A Line Amp is available for longer cable length or cable with higher loss.   The Line Amp has N-type connectors to connect to the antenna cable.

Radio Interference

Some radio transmitters and receivers, such as FM radios, can interfere with the operation of GPS receivers. Ashtech recommends that you verify that nearby handheld or mobile communications devices do not interfere with the receivers before setting up your project.

Standard Operation

This chapter discusses system setup, power-up, command format, serial port configuration, parameter settings and status, and how to perform a static survey.

Connection Procedures

Components

The following components comprise a generic surveying configuration:

- GG Surveyor receiver
- GPS+GLONASS antenna and antenna extensions
- Antenna mounting hardware
  - Extension rod
  - Tripod plate
- Precision HI rod
- Tripod
- Antenna cable
- Serial interface/power cable
- Battery and battery charger
- Backpack

Antenna

Connect the antenna cable from the antenna to the antenna TNC connector on the receiver. If the small diameter of the antenna does not allow clearance for connecting the antenna cable, you must use the vertical extension rod to elevate the antenna.

Serial/Power Cable

Connect the 25-pin serial cable to the 25-pin connector on the receiver. Connect a fully charged battery to the power cable.

Power

Before applying power, connect any controller devices or data logging equipment to the input/output ports of the receiver by way of the DB25 connector. Once the receiver has been properly cabled, turn on the receiver by turning the ON/OFF switch to the ON position. **Power feeds through pin 4 of Ports B and C with the receiver off; radios and modems will continue to draw power.**

CAUTION
To avoid damage to the receiver, always turn off the receiver before connecting or disconnecting the DB25 connector.

Once power is on and the antenna is connected, the receiver acquires satellites within the field of view of the antenna. As a channel in the receiver locks on to an Satellite, the two-color LED flashes green between the red power flashes for every channel in use (i.e., satellites locked).

Communication

After you have the GG Surveyor powered and running, you must send it commands in order to receive data and change parameters. Specially designed software which runs on the Husky FS/2 handheld computer can be obtained from Ashtech to perform a variety specific applications. A personal computer can also be used to communicate with the receiver. The following procedure describes how to send commands to and receive information from the GG Surveyor using a personal computer. Many communications software packages, such as the Ashtech EVALUATE software, allow you to interface with the GG Surveyor. EVALUATE includes a communications package that automatically establishes communication with the GG Surveyor receiver.

1. Connect port A of the serial cable to either COM 1 or COM 2 of your computer.
2. Run the communication software of your choice. Set the communication parameters in the software to match the computer and receiver.

   The default communication parameters of the GG Surveyor are:

   9600 baud, 8 data bits, no parity, one stop bit

   When you first establish communication with the GG Surveyor, your communication interface must use this protocol.
3. Once the correct parameters have been set, type: $PASHQ,PRT and press <Enter> to query the communication setup of the port and verify that communication with the receiver is established.

   If the software and receiver are set up properly, the receiver responds with the message:

   ```
   $PASHR,PRT,A,5
   ```

If a response message is not generated, recheck your cable connections and communications parameters, and verify that the receiver is powered on.

Initialization

It is good practice to reset the receiver prior to operating it for the first time or if a system malfunction occurs. A reset of the internal memory clears the memory and restores the receiver to factory defaults.

To reset the receiver, send the receiver command: $PASHS,INI,5,5,5,5,3 <Enter>

Monitoring

Once the receiver has been powered on, connected to an antenna, and communications established, commands may be issued to check the status of the receiver and monitor receiver accuracy. The following examples serve as an introduction to controlling the receiver. For a complete list of commands, see Chapter 6, **Command/Response Formats**.

Satellite Tracking

If you wish to monitor the satellites the receiver is tracking,

1. Type: $PASHQ,STA and press <Enter> to query which satellites are locked and their signal strength at the time the command is sent.

   The response message typically might display:

   ```
   TIME: 18:38:31 UTC
   LOCKED: 03 23 16 39 54
   COUNT:  54 26 17 31 35
   ```

   This message indicates that the current UTC time is 18:38:31, the PRN # of locked GPS satellites are 01 to 24 and the PRN # of GLONASS satellites are 33 to 56.

Position

If you wish to view the current position,

1. Type: $PASHQ,POS and press <Enter> to query the position message.

   The response message displays an ASCII string beginning with the header:

   ```
   $PASHR,POS,
   ```

   The message contains time, position, velocity, and DOP values. For further description of the POS message, see “POS: Position Message” on page 162.

Standard Operation

File Directory

If you wish to view the number of files in the receiver memory:

1. Type: $PASHQ, FLS,0 and press <Enter>.

   The response message displays an ASCII string that begins with the header:

   `$PASHR,FLS`

   The message contains the total number of data files and the amount of free memory remaining. For further description of the FLS message, see “$PASHQ,FLS,d” on page 83.

Saving Parameter Settings

Ordinarily, receiver parameters that have been changed return to their factory default status after a power cycle. To save the receiver settings,

1. Type: $PASHS,SAV,Y and press <Enter>.

For details on these commands and responses, as well as the rest of the GG Surveyor command and response repertoire, refer to Chapter 6, **Command/Response Formats**.

Static Surveying

The static method of GPS surveying utilizes stationary site occupations to solve carrier phase ambiguities. During an extended survey period, the satellites being observed move across the sky, changing the satellite geometry. The changing of the geometry enables the post-processing software to determine carrier phase ambiguities and then determine the position of the unknown point. The required occupation time is dependent upon the length of the base line between the two points being observed (the longer the baseline, the longer the occupation time) and the condition of the atmosphere (the ionosphere) during the data collection period. Average occupation times range from ten minutes to three hours. Users recognize the static method of surveying as the most accurate method because of the large amount of data collected. Since the GG24 is a single-frequency receiver, baselines greater than 20 km may have increased error due to the effects of the ionosphere.

Performing a Static Survey

A static survey uses at least two stationary GG24 receivers that simultaneously observe the range and carrier phase of several common satellites over a specific time period. One receiver is centered over a known point, while the others occupy unknown positions.

By occupying more than one station, a number of common errors cancel, so that the accuracy can be greatly improved. In order to compute accurate baselines and establish accurate positions on the unknown points, the data collected in the field is post-processed later using a personal computer (PC). The following paragraphs describe receiver operations for collecting data necessary for the post-processed solution.

System Setup

When performing a static survey, the antenna remains in position above the survey point for an extended period of time.

If the small diameter of the antenna does not allow clearance for connecting the antenna cable, you must use a special vertical extension bar to elevate the antenna.

If a leveling device (tribrach) is not used, the antenna location is less precise because a centering error occurs if the antenna is not level. The amount of error depends upon the amount of tilt in the antenna. This error should not exceed a few millimeters if the antenna is placed with care.

1. Locate the desired survey mark.

   The survey point must provide line-of-sight reception of the satellite signals, therefore the point should be relatively unobstructed for elevations higher than 10-15 degrees above the horizon.

2. Set up the tripod on the survey mark.
3. Level the tripod using the tribrach.

   Mount the antenna on the tribrach. Use the extension rod if necessary to clear the tribrach.

4. Connect the antenna to the receiver using the supplied antenna cable.
5. Connect the serial/power cable to the serial/power connector on the receiver. The serial interface/power cable has four branches, but only one (the power branch) is used for this setup. Connect the battery lead of the serial/power cable to the camcorder battery using the supplied adapter cable.

For best accuracy, you should select a favorable satellite window. Refer to the Mission Planning manual.

6. Use the HI rod provided, to measure the antenna height.

   Measure from the center of the mark to the top of the groove on the side of the antenna (Figure 3.1). Record the antenna height.

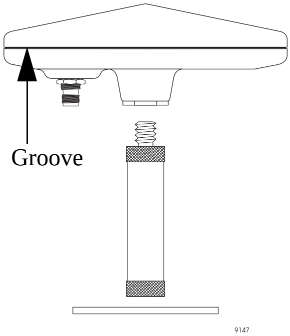

Figure 3.1: Antenna Groove

7. Set the receiver power switch to ON.

   During static surveys, you do not have to interact with the receivers. When powered on, each receiver:

   - Performs a self-test
   - Searches and locks on all satellites “in view”
   - Makes GPS measurements and computes its position
   - Opens a file and collects all data into this file

   The receiver uses default parameters for data collection, s no interaction with the receiver is necessary to collect data. See “Default Parameters” on page 25 to check the default settings.

8. Set up a receiver over each mark for which you need to determine the coordinates. Repeat these steps for all GG Surveyor receivers participating in the survey.

9. During the survey, monitor the LED to ensure that the satellites are tracking. After the survey, turn off the receiver. The receiver automatically closes the file and saves the collected data.

Changing Parameters

If the default parameters are unacceptable, they may be changed by using either a PC with communication software or a handheld computer with one of the Ashtech interface programs. The GG Surveyor receiver works with most Ashtech interface programs, such as Survey Control, GPS TOPO, and Mine Surveyor. Please see the handheld software manual for more information.

Changing parameters using a PC and communication software is done by sending the command that controls the parameter that you wish to change. Chapter 6, **Command/ Response Formats** lists the complete list of available commands. The most common commands used in static surveying include:

- changing the recording interval - $PASHS,RCI
- changing the site id - $PASHS,SIT
- changing the elevation mask - $PASHS,ELM

Downloading Data

The WinPRISM software package, offered as an option, includes many functions necessary to complete a GPS survey including mission planning, data transfer and processing, vector adjustments, and a mapping module.

WinPRISM includes a module named TRANSFER/DOWNLOAD. This module transfers data from the receiver to a post-processing computer; this download is necessary before the data can be processed. To download, perform the following steps:

1. Connect a null modem serial cable from the serial interface/power cable to the COM1 connector on the computer. If COM1 is not available, COM2 may be used; however, remember to enter COM2 information via the setup option in the TRANSFER module, as described in the TRANSFER instructions.
2. Turn on the receiver and computer.
3. Select the DOWNLOAD module of the WinPRISM software.

Detailed instructions for installing and operating the software, as well as completing the survey, can be found in the WINPRISM manual set.

Advanced Operation

Receiver Communications

The built-in command/response firmware allocates the RS-232 ports (A,B, and C) to receive command messages from an external control device, to send response messages to a single external control device (such as a PC), to output data to a separate data logging device, and to send or receive differential corrections from a reference or remote station, respectively. Messages are summarized in this chapter and covered in detail in Chapter 6, **Command/Response Formats**.

Input Messages to the GG Surveyor

The input messages comprise set command messages or query command messages that either change receiver parameters or request receiver information.

Generally speaking, all set and query commands fall into one of five categories:

- general receiver commands
- NMEA message commands
- raw data commands
- RTCM commands
- CPD (carrier phase differential commands)

All command messages (set or query) can be in upper or lower case followed by <Enter>. A valid set command, if this command is successfully executed, causes the GG Surveyor to return the $PASHR,ACK*3D, "acknowledged" response message. Valid query commands are acknowledged by return of the requested information. A set command containing a valid $PASHS set command header, followed by character combinations or parameters unrecognized by the GG Surveyor, returns the $PASHR,NAK*30 "not-acknowledged" response message. All other invalid commands are ignored.

Output Messages From the GG Surveyor

Output messages are messages the GG Surveyor sends to the data logging device in response to a set or query command. Output messages comprise general status messages, command acknowledged/not acknowledged messages, and GPS data messages. The general status messages are in free-form Ashtech proprietary formats. The command acknowledged/not acknowledged messages and GPS data messages are in ASCII format while the raw data messages output in binary format.

Serial Port Configuration

The GG Surveyor provides RS-232 serial ports with two-way full-duplex communication. The default transmit/receive protocol is 9600 baud, eight data bits, no parity, and one stop bit (8N1). The baud rate of the GG Surveyor ports is adjustable using the $PASHS,SPD speed set command; the data bit, stop bit, and parity protocol is always 8N1.

On initial power-up or after use of the $PASHS,INI (memory reset) command, or the $PASHS,RST (reset to defaults) command, the GG Surveyor defaults to 9600 baud for all RS-232 serial ports.

The baud rates between the GG Surveyor and the interfacing equipment must be the same for the port and the device connected to the port.

To resume communication with the GG Surveyor after changing the baud rate using the $PASHS,SPD set command, change the baud rate of the command device.

Parameter Settings and Status

Receiver parameters are changed by using one of the set commands found in Chapter 6, **Command/Response Formats**. Most parameters are not saved through a power cycle unless saved using the SAVE command ($PASHS,SAV,Y). If the parameters have been saved, the default parameters can be retrieved using either the $PASHS,SAV,N command and a power cycle, the $PASHS,RST command, or the $PASHS,INI command. See Chapter 6, **Command/Response Formats** for more information.

The current settings of receiver parameters can be viewed using the query commands. Many individual parameters have a unique query that can be used to check their status. However, there are 4 main query command that can be used to check multiple parameters at one time. Each of these query commands relates to a particular area:

- $PASHQ,PAR - queries general receiver parameters
- $PASHQ,RAW - queries raw data parameters
- $PASHQ,RTC - queries RTCM differential parameters
- $PASHQ,CPD - queries carrier phase differential parameters

The response to each of these queries is in free form format.

Figure 4.1 shows a typical response message for the general receiver parameters default values of the query command $PASHQ,PAR. See “PAR: Query Receiver Parameters” on page 94 for more information.

```
SPDA:5 SPDB:5 SPDC:5 SPDD:5
GPS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
GLO:YYYYYYYYYYYYYYYYYYYYYYYY
SYS:MIX DTM:W84 GTM:0 GTF:0 DTG:+000000.0000 TDP:04 GTP:Y
PMD:1 FIX:0 ALT:+00000.00 PDP:40 HDP:04 VDP:04
PEM:05 UNH:N ION:N SAV:N
RTC:OFF PRT:A
NMEA: LTN AIM POS GLL GXP GGA VTG GSN MSG GSA SAT GRS RRE TTT ZDA TCM RMC GST
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTD: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PER:001.00
```

Figure 4.1: $PASHR,PAR Default Response Message

The $PASHQ,RAW query is available only if the Binary Data Outputs option [**O**] is installed in the receiver. Figure 4.2 shows a typical response message for the raw data parameters default values of $PASHQ,RAW. See “$PASHQ,RAW,x” on page 120 for more information.

```
RCI:020.00 MSV:3 ELM:05 REC:Y
ANH:0.0000 SIT:???? EPG:000 RNG:0
RAW:  MBN PBN SNV SAL MCA MSB GGB SNG SAG
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTD: OFF OFF OFF OFF OFF OFF OFF OFF OFF
```

Figure 4.2: $PASHR,RAW Default Response Message

The $PASHQ,RTC query is available only if one of the RTCM differential options [**B** or **U**] are installed in the receiver. Figure 4.3 shows a typical response message for the

RTCM differential parameters and status default values of $PASHQ,RTC. See “$PASHQ,RTC,c” on page 179 for more information.

```
STATUS:
       SYNC:    TYPE:00   STID:0000  STHE:0
       AGE:+999   QA:100.0%  OFFSET:00
SETUP:
       MODE:OFF  PORT:A   AUT:N
       SPD:0300  STI:0000 STH:0
       MAX:0060  QAF:100   SEQ:N
       TYP:1  2  3  6  9  16  31  32  6G  34  36
       FRQ:99 00 00 OFF 00 00  99  00  OFF 00  00
BASE:  LAT:0000.0000,N  LON:00000.00000,W  ALT:+00000.00 WGS
MSG:     first 45 characters of RTCM type 16 message
         next 45 characters of RTCM type 16 message
MSG (GLO):first 45 characters of RTCM GLONASS type 36 message
          next 45 characters of RTCM GLONASS type 36 message
```

Figure 4.3: $PASHR,RTC Default Response Message

The $PASHQ,CPD query is available only if the carrier phase option [**P**] is installed in the receiver. Figure 4.4 shows a typical response message for the carrier phase differential parameters and status default values of $PASHQ,CPD. See “$PASHQ,CPD,c” on page 186 for more information.

```
STATUS:
 RST_TIME:000000 FIX_TIME:000000
 LATENCY:0046 AMB:FIXED LENGTH:00000.0011 VELOCITY:000.0037
 ROV_SV: 04 14 16 18 19 22 25 29 42 - 44 52
 BAS_SV: 04 14 16 18 19 22 25 29 42 43 44 52
 BASE POSITION:RECEIVED 3759.729431 N  12159.549345 W  -4.790
ID:0000
 BASE_DELTA:RECEIVED
SETUP:
 MODE:ROV PORT:B SYS:MIX PEM:10
 FST:ON FST_RATE:02 AFP:99.0 MAXAGE:30
```

Figure 4.4: $PASHR,CPD Default Response Message

The query commands $PASHQ,PAR, $PASHQ,RAW, $PASHQ,RTC, and $PASHQ,CPD are intended for use with an interface such as a computer screen. The response messages are formatted to display correctly on a screen; they are not intended as machine-readable messages. Ashtech recommends using the one-line response messages for automated applications.

Default Parameters

During the normal course of receiver operation, a typical user often changes one or more receiver parameters such as recording interval, port baud rate, or elevation mask. To save new settings, the user must save the current setting to memory or else all parameters reset to the default values during a power cycle. Saving parameters to memory can be done by issuing the $PASHS,SAV,Y command. When parameters are saved to the memory, then they are maintained until a memory reset or a receiver initialization is performed which resets all parameters back to their factory default.

Table 4.1 lists the default values of all user parameters.

Table 4.1: Default Receiver Parameter

Parameter	Description	Default
SVS	SV Tracking Selection	Y for all
PMD	Position Mode Selection	1
FIX	Altitude Hold Fix Mode Selection	0
PEM	Position Elevation Mask	5
PDP	Position Dilution of Precision Mask	40
HPD	Horizontal Dilution of Precision Mask	04
VDP	Vertical Dilution of Precision Mask	04
ION	Enable Ionosphere Model	N
PPO	Enable point Positioning Mode	N
SAV	Save parameters in Battery Backup Memory	N
LAT	Antenna Latitude	00N
LON	Antenna Longitude	00W
ALT	Antenna Altitude	+00000.000
DTM	Datum Selection	W84
UDD	Datum Users Defined Parameters	Semi Mayor Axis = 6378137 Inverse Flattening = 298.3 Remaining parameters = 0
PHE	Photogrammetry Edge Selection	R
PPS	Pulse per Second Default Parameters	Period= 0 Offset = 000.0000 Edge = R

Table 4.1: Default Receiver Parameter (continued)

Parameter	Description	Default
POW parameters	Power Capacity of External Battery	ALL 0'S
NMEA messages	NMEA Message Output Status	OFF in all ports
PER	NMEA Messages Output Rate	001.0
RCI	Raw Data Output Rate	020.0
MSV	Minimum Number of SV's for Data Recording	03
ELM	Elevation Mask for Data Recording	5
SIT	Site ID Name	????
EPG	Kinematic Epoch Counter	000
RAW data	Raw Data Output Status	OFF in all ports
Raw data format	Raw Data Output Format	Binary
Serial Port Baud Rate	Serial Ports Baud Rate Selection	9600 in all ports
RTCM MODE	RTCM Differential Mode Selection	OFF
RTCM PORT	RTCM Differential Mode Port Selection	B
AUT	Automatic Differential/Autonomous Switching when RTCM Differential Mode Enabled	N
RTCM SPD	RTCM Differential BPS Speed Setting	0300
STI	RTCM Base or Remote Station ID Setting	0000
STH	RTCM Base Station Health Setting	0
MAX	Maximum Age for old RTCM Corrections to be Used	0030
QAF	RTCM Communication Quality Setting	100
SEQ	Use Sequence Number of RTCM Correction in Remote Station	N
TYPE	RTCM differential Messages Enabled and Output Frequency of the Enabled Messages	1 = 99, 31 = 99, 6 = OFF, 6G = OFF, remaining messages 00
RTCM EOT	End of Character Selection for RTCM Corrections	CRLF
CPD MODE	CPD Mode Selection	OFF
AFP	Setting of Ambiguity Fixing Confidence Level	099.0

Table 4.1: Default Receiver Parameter (continued)

Parameter	Description	Default
CPD POS	Reference Position of the other Receiver	RECEIVED
FST	Fast CPD Mode Selection	ON

Data Recording

All data recording in the receiver is done on an internal PCMCIA data card also known as a PC card. The PC card is a compact and convenient way to store a lot of data. The amount of data that can be stored depends upon the size of the card. PC cards are available in sizes ranging from 2 to 20 Mb. The PC card in the GG Surveyor is not removable, and is formatted to work only in the GG Surveyor. Do not take apart your GG Surveyor to remove or replace the PC card.

File Types

The receiver is capable of creating a number of different files that cover a wide variety of information. Primarily, the receiver will generate raw data files, ephemeris, and site information files, but can also create position only files, event marker files, and site attribute files. Each file is named for the first letter of the file. For example, the raw data files begin with the letter "B", so they are referred to as B-Files. A list of the files is shown in Table 4.2.

Table 4.2: File Types

File Type	Description	Format
B-file	Raw data-generally code and carrier phase data, position data, and SITE ID	Binary
E-file	Satellite ephemeris data	Binary
S-file	Site information data	ASCII
C-file	Position Data	ASCII
M-file	Event Marker files	ASCII
D-file	Site attribute files	ASCII
ALMyy.ddd	Almanac file	Binary

File Naming Convention

The files are automatically named according to a convention that includes the site name, session, and day of the year. Figure 4.5 outlines the file naming convention. The one exception are almanac files that are named ALM*yy.ddd* where yy are the last two digits of the year and ddd is the day of the year.

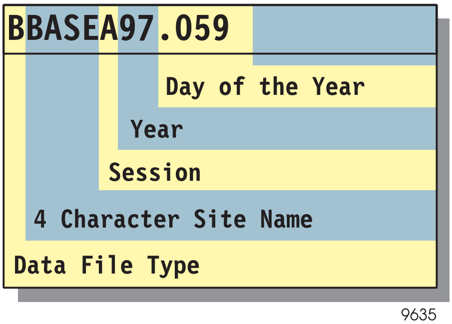

Figure 4.5: GG Surveyor File Naming Convention

- The first letter of each file name is the file type B, S, C, E, M, or D.
- The next 4 characters of each file name is the site ID. If the user has not entered a site ID during the course of the recording session then these 4 characters are replaced by underscores ("____"). In kinematic surveying it is common to change the site ID many times during the recording session. The site ID used for naming the session files is the LAST site ID entered during the session.
- The next character indicates the session identifier. This field automatically increments from A to Z when a new recording session is started. This fields begins at A for the files associated with the first recording session within a particular work day directory, and increments to Z as more sessions are created in the same directory. After 26 files are created the session identifier resets back to A, and the first character of the year will change to A.
- The next two characters are the last two digits of the year (e.g. 97).
- The file extension is the day of the year (e.g. Jan. 1 is day 001; Dec. 31 is day 365).

Data Modes

There are two different modes that the receiver can record in. These modes are referred as data modes or data types. Each mode records different types of data and can only be changed using the serial port command $PASHS,RNG. Table 4.3 describes these modes. The default is 0.

Table 4.3: GG Surveyor Recording Modes

Recording Mode	Typical Application	File Types Created
0	Raw data, full code and carrier phase	B (GPS Raw Data) E (GPS Ephemeris Data) S (Session Info)
2	Position data only	C (GPS Position Data) S (Session Info)

DATALOGR

An alternative way to collect data is to record data directly onto your PC using the DATALOGR.exe program. This method is useful if your data card does not have enough space or if you wish to bypass the download process. For more information on using DATALOGR, see the DATALOGR User's Guide.

Position Mode/ALT Fix Mode

Because the GG Surveyor mixes two different constellation systems (GPS and GLONASS) to determine position, and the clocks between these two systems are not synchronized. The GG Surveyor initially needs to track a minimum of 5 satellites (any combination of GPS and GLONASS satellites) to compute a 3D position, or four satellites to compute a 2D position.

The GG Surveyor has three commands that control the position mode and fix the altitude or time shift between system clocks. These commands enable the GG Surveyor to compute a 3D position using only four satellites, or a 2D position using only 3 satellites. The commands are PMD, GTM, and GTP.

The GG Surveyor performs a position computation in four different modes: 0, 1, 2, or 3. These modes determine the number of satellites required to compute a 3D or 2D position, and depend upon the priority in which the altitude or time shift are held fixed. The position modes are set with command $PASHS,PMD and depend upon the setting of GTM (whether to compute time shift or hold it fixed), and GTP (set priority to hold fixed time shift over altitude, or vice versa) when the number of used satellites is fewer than 5. See "$PASHS,PMD,d" on page 97 for more information.

In **mode 0** with GTM set to 0 (time shift not held fixed), at least 5 satellites with elevation equal to or above the position elevation mask are required to compute a 3D position. With GTM set to 1 (time shift held fixed if number of satellites fewer than

5), or 2 (time shift held fixed), four satellites are required to compute a 3D position; 2D position is not computed in this mode.

In **mode 1** depending upon the setting of GTM and GTP, five or four satellites are required to compute a 3D position, and four or three satellites to compute a 2D position.

In **mode 2** depending upon the setting of GTM, three or four satellites are required to compute a position. In this mode, altitude is always held fixed and only 2D position is computed.

In **mode 3** depending upon the setting of GTM and GTP, three or four satellites are required to compute a 2D position. To compute a 3D position, four or five satellites are required, and the computed HDOP must be less than the HDOP mask. If HDOP is higher that the mask, a 2D position is computed.

Altitude Definition

Two modes define the altitude selected when the GG Surveyor is in altitude hold mode. Use the $PASHS,FIX set command can be used to select between these modes. See “$PASHS,FIX,x” on page 83 for more information.

In **mode 0** the most recent altitude is used. This is either the one entered by using the $PASHS,ALT set command or the one computed when four or more satellites are used in the solution, whichever is most recent. If the last altitude is the one computed with four or more satellites, it is used only if VDOP is less than the VDOP mask.

In **mode 1** only the last altitude entered is used in the position fix solution.

On initial power-up or after use of the $PASHS,INI memory reset command, or $PASHS,RST default parameter reset command, the most recent antenna altitude is set to 0.

Time Shift Hold Definition

Two modes determine what time shift is selected when the GG Surveyor is in time shift hold mode. The $PASHS,GTF command selects the mode, 0 or 1. See “$PASHS,GTF,d” on page 85 for more information.

In **mode 0**, the GG Surveyor uses most recent computed time shift is used: the time shift entered with the $PASHS,DTG command, or the time shift computed in the position solution. If the most recent time shift is from the position solution, it is used only if TDOP is less than the TDOP mask.

In **mode 1**, the GG Surveyor uses only the last time shift entered using $PASHS,DTG in the position solution. The GG Surveyor does not compute a position when the time shift entered using the $PASHS,DTG, if this command is not close to the real time shift (varies slightly, current value -1.3 µsec).

Daisy Chain Mode

The Daisy Chain mode establishes a communication link through the GPS receiver, between a PC/handheld and a peripheral device. When the GPS receiver is in Daisy Chain mode, all commands entering one serial port are passed back out through another serial port. The commands are not interpreted by the GPS receiver. The command $PASHS,DSY enables the Daisy Chain mode and allows the user to assign which serial ports to be used. A typical example of the use of Daisy Chain mode is communicating with a radio through a handheld. The radio and handheld are not directly connected but are both connected to the GPS receiver via separate serial ports. By enabling the Daisy Chain mode between the two serial ports used by the handheld and radio, the handheld can communicate with the radio through the GPS receiver. Refer to “$PASHS,DSY,x,y” on page 78.

Pulse Generation (1PPS) and Strobe

When the 1PPS [**L**] option is installed, the GG Surveyor provides the capability of a 1 pulse-per-second (1PPS) signal synchronized with receiver time. If the GG Surveyor is set to use the GPS constellation, the 1PPS pulse synchronizes with GPS system time. If it is set to use the GLONASS constellation only, the 1PPS pulse synchronizes with GLONASS system time. If it is set to use a mixed constellation, it synchronizes with the time selected by the TSC command (default is GPS system time).

The PPS signal is TTL-level into a 75-ohm impedance. 1PPS is generated by default once every second with its rising or falling edge (selectable) synchronized to GPS or GLONASS system time. Using the $PASHS,PPS command, the period of the PPS may be changed from 0.2 second up to 999 seconds, depending upon the receiver update rate; the PPS may be offset from the reference time with a resolution of 100 nanoseconds, and the synchronization edge can be set to rising or falling.

In order to provide notification to peripheral equipment and software with respect to time tagging the instant of the 1PPS pulse, it is necessary to request the output of the PBN raw data structure. The GPS system time contained in the PBN message plus one second is the time of the next 1PPS pulse that occurs (Figure 4.6). This PBN time is already internally rounded to GPS system time so it is the actual time to which the navigation 1PPS pulse generation which preceded it (unless that pulse has been intentionally advanced or retarded). The data latency of this PBN message is normally about 40 milliseconds after the 1PPS pulse.

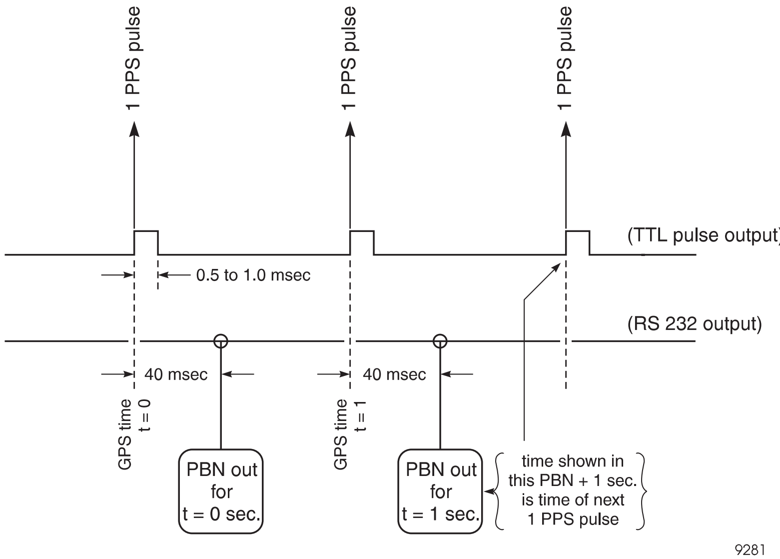

Figure 4.6: Relationship of GPS Time in PBN Record to 1 PPS Pulse

Figure 4.7 shows the PPS characteristics. The PPS occurs when the signal goes high. The PPS is generated exactly on the GPS second, and the pulse remains high for 1-2 milliseconds. The precision of the PPS signal is 70 nsec (nanoseconds) in stand-alone mode, and 45 nsec in differential mode. A position must be computed for this accuracy to be valid.

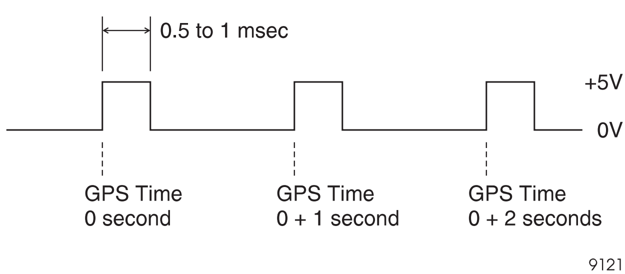

Figure 4.7: 1PPS Characteristics

The 1PPS option [**L**] also controls the output of the Measurement Strobe output. The Measurement Strobe output is TTL-level into a 75-ohm impedance. Its output is controlled by the $PASHS,STB command, and is synchronized with GPS or GLONASS system time, depending upon the constellation selected. The period depends upon the xxxx value and the setting of the RCI parameter. The ±yyy.yyyy field allows you to set an offset value from reference time with a resolution of 100 nanoseconds, and also allows you to synchronize the rising or falling edge of the output with reference time. The accuracy of the measurement strobe output is the same as the accuracy of the 1PPS pulse (Table 4.4).

Table 4.4: PPS and Photogrammetry Accuracy

Condition	Accuracy
Setting PPS resolution	100 ns
PPS accuracy GPS+GLONASS stand-alone	~70 ns
PPS accuracy GLONASS stand-alone	~70 ns
PPS accuracy GPS stand-alone	~340 ns
PPS accuracy differential mode	~45 ns
Setting photogrammetry TTT output resolution	100 ns
Photogrammetry accuracy GPS+GLONASS stand-alone	~160 ns
Photogrammetry accuracy GLONASS stand-alone	~160 ns
Photogrammetry accuracy GPS with SA ON stand-alone	~430 ns

Photogrammetry Event Marking

When the photogrammetry [**E**] option is installed, the GG Surveyor can measure and record event times with high accuracy. The input signal is TTL level into a 5 KΩ impedance. The photogrammetry feature allows the event time to be output by using the $PASHS,NME,TTT command.

At the rising or falling edge (selectable) of the trigger signal, the time is measured and output of TTT NMEA message is enabled. The trigger signal can be set to the rising or falling edge using the $PASHS,PHE (photogrammetry edge) command.

The measured time is accurate to 120 nanoseconds. If the constellation system is set to GPS, this time is GPS system time; if the constellation system is set to GLONASS, this time is GLONASS system time, which is equal to UTC + 3 hours; if the constellation system is set to mixed, this time depends upon the TSC setting (default is GPS). The time is output as day number, hours, minutes, seconds, and fractional seconds up to 6 digits.

The photogrammetry time measures the event time relative to the receiver's time. It measures only the first event during the period between 2 epochs. See Figure 4.8

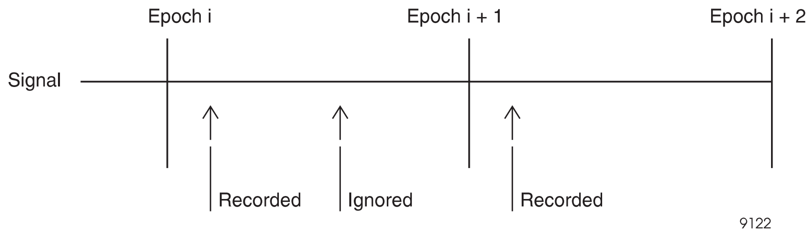

Figure 4.8: Photogrammetry Timing

CAUTION
The GG Surveyor measures only one event time per data collection period. If more than one event time is measured within a data collection period, the receiver measures only the first one. The event time record rate is then dependent upon the setting of the RCI parameter.

Because the 1 PPS signal is being used to measure the photogrammetry events, the period of the 1 PPS signal needs to be set to a value equal to or less than the period of the photogrammetry pulse.

The trigger pulse may be TTL-compatible or open collector. Minimum pulse duration is 100 nanoseconds. The impedance is approximately 2K ohms.

Usage of a coaxial connection cable is recommended.

Time Tagging the Shutter Signal

In this technique, the signal generated by the camera shutter is fed to a GPS receiver for accurate time-tagging which can then be post-processed with the GPS observations. Since the time of the picture is not synchronized with the time that the GPS measurement is taken, the two position computations before and after the shutter time are interpolated to compute the position of the camera at the time the picture was taken.

For instance, if GPS measurements are recorded at the rate of one per second, the distance the aircraft moves in ½ second is about 100 meters. Therefore, the distance between the position of the camera at the time the picture was taken and the GPS position fixes can be as much as 50 meters. The motion of the aircraft during this time may be in the meter range. To minimize the errors discussed above, the closed loop technique is recommended.

Closed-Loop Technique (Advanced Trigger)

The closed-loop technique combines PPS synchronization and shutter timing as shown in Figure 4.9.

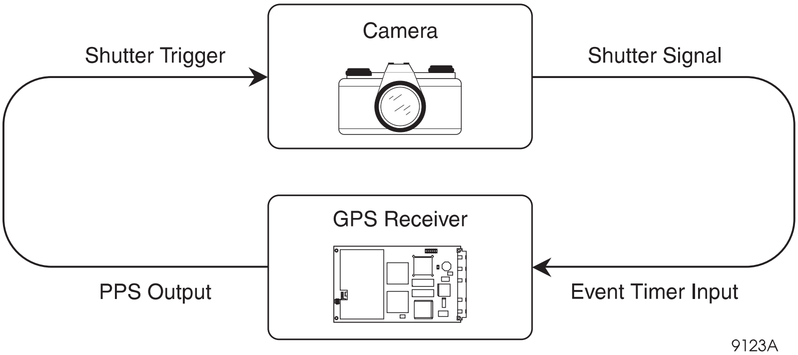

Figure 4.9: Closed Loop Technique

In this technique, the 1PPS output of the GG Surveyor triggers a camera shutter. The camera shutter generates a signal that is fed to the GG Surveyor for accurate time tagging.

The delay between the camera receiving the pulse and triggering the photogrammetry port should be calculated. This may then be applied so as to advance the 1PPS from the GG Surveyor so that the shutter time exactly matches the GPS system time for the epoch. No interpolation between the shutter time and the GPS position time will be needed.

Data Output

Real time data output is only available through the three RS-232 ports. Refer to “NMEA Data Message Commands” on page 129 and “Raw Data Commands” on page 115 for more details. There are three types of messages:

- NMEA

  NMEA is a standard data transfer format developed to permit ready and satisfactory data communication between electronic marine instruments, navigation equipment and communications equipment when interconnected via an appropriate system. This is data in printable ASCII format and may include information such as position, speed, frequency allocation, etc.

Typical messages might be 20 to a maximum of 79 characters in length and generally require transmission no more often than once per second.

- Proprietary

  When specific information was needed, and the NMEA standard did not contain a suitable message, Ashtech created proprietary messages in a NMEA style format. Messages are available in ASCII.

- RAW

  Raw Data outputs in binary format and includes measurement data, ephemeris data, almanac data, and position data.

The receiver has two options which affect the rate at which data output: position update rate and Raw measurement update rate. The highest output rate supported under different conditions is 5 Hz.

5 Hz Output

The GG Surveyor, as an option, provides the capability of 5 Hz internal receiver update rate, allowing raw data and NMEA data to be output every 0.2 seconds. Two options are available to control this feature: the position update rate option for NMEA output rate, and raw measurement update rate for raw data output. See “Receiver Options” on page 4 for more information. Because of CPU power limitation, when this option is set, the receiver will update at 2 Hz until command $PASHS,POP,5 is issued. When updating at 5 Hz, the receiver will use only 16 satellites in the position solution, although it will track all available satellites. During the period while 5 HZ update is not required, you can revert to 2 HZ and use all available satellites in the position solution by issuing the command $PASHS,POP,2.

CAUTION
When collecting data at 5 Hz, because of large amounts of data being output through the serial ports, a 486-66 MHz or Pentium™ computer with a fast serial and parallel port card (i.e., 16550 serial and parallel card) is recommended. The serial port baud rate should be set to a baud rate above 38K.

NMEA Outputs

As an option, the GG Surveyor allows you to output NMEA message format and other miscellaneous messages through the serial ports. The following standard NMEA messages are available: GLL, GXP, GGA, VTG, GSN, MSG, GSA, GRS, GST, RMC and ZDA. Additional non-standard messages are available: LTN, AIM, POS, SAT, RRE, TCM, and TTT. All standard NMEA messages 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 Ashtech proprietary response format. Any combination of these messages can be output through any of the serial ports, and the same 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 0.2 and 999 seconds depending upon the update rate option installed (5, 2, or 1 Hz). See “NMEA Data Message Commands” on page 129 for more information.

Raw Data Outputs

As an option, the GG Surveyor allows you to output raw data through the serial ports. Table 4.5 outlines the different types of messages available.

Table 4.5: Raw Data Messages

Message	Description
MCA	measurement data output with Ashtech type 3 data structure
PBN	position data
SNV	GPS ephemeris data
SNG	GLONASS ephemeris data
SAL	GPS almanac data
SAG	GLONASS almanac data

All outputs are in binary format. Any combination of messages can be output through any of the serial ports, and the same messages can be output through different ports at the same time. The output rate is determined by the $PASHS,RCI setting, and can be set to any rate between 0.2 and 999 seconds depending upon the raw data update rate option installed (5, 2, or 1 Hz). See “Raw Data Outputs” on page 37 for more information.

Signal to Noise Ratio

The GG Surveyor calculates the signal to noise ratio using one of two methods: DBH or AMP. Select which method using the $PASHS,SNR command. The default method is the AMP method.

The DBH method the classic method of dB*Hz units, and the result is independent of the hardware. The result is presented in true SNR, in dB*Hz. The range is approximately 30 to 55. The receiver can track signals with SNR > 26 dB*Hz, and can find signals with SNR >34 dB*Hz. The algorithm is

$$SNR[dB*Hz] = 10*\log10\ (mean(I)^2/[mean(I^2) - (mean(I)^2])/(2*T)$$

where T is the time of averaging of I. Note that mean(I^2) - mean (I) is the dispersion of the mean value of I. If DBH is selected, SNR is presented in dH*Hz units in all messages that report SNR.

The AMP method computes the SNR in actual amplitude, and this value is dependent upon hardware. In the receiver, an internal scale coefficient is chosen such that under usual circumstances, AMP is approximately equal to satellite elevation in degrees. The range is from 1 to 99.   If AMP is selected, SNR is presented in AMP units in all messages that report SNR.

Satellite Search Algorithm

When the GG Surveyor operates for the first time after receipt from Ashtech, no almanac or ephemeris data are loaded. The GG Surveyor always assigns the first 12 elements of a 32-element table of satellite PRN numbers to its first 12 channels and the first 12 elements of a 24-element table of the GLONASS frequency numbers to its last 12 channels. If no ephemeris data is available in the memory, or if the data is older than ten hours, 30 to 60 seconds will be needed to collect data. After locking onto four or five satellites and collecting almanac/ephemeris data, the GG Surveyor computes its first position. The GG Surveyor continuously collects in its on-board battery-backed-up memory (no external battery is required for memory) almanac and ephemeris data as well as the most recent position. The time to the first position computation, if no almanac/ephemeris data are available, is typically two minutes (this is called a cold start).

At the next power up, if the almanac/ephemeris data from battery-backed-up memory are available, the GG Surveyor uses the almanac data, the last computed position, and the time from the on-board real-time clock to search only the visible satellites; under these conditions, the GG Surveyor recomputes a position in 10 to 20 seconds (this is called a warm start).

Ionospheric and Tropospheric Models

The GG Surveyor can be set to use an ionospheric and tropospheric model in its position computation using the $PASHS,ION,Y/N command. The ionospheric and tropospheric models are based on the models defined in ICD-GPS-200, Revision B. Typically this function is used to improve the accuracy of stand-alone position by minimizing the influence of ionosphere and troposphere on the code phase. In differential mode, however, the model should not be applied since differential corrections already contain the errors induced by ionosphere and troposphere. Both models are simultaneously turned on or off with the $PASHS,ION command. See “$PASHS,ION,x” on page 89 for more information.

RAIM

GG Surveyor RAIM (Receiver Autonomous Integrity Monitoring) provides the detection of anomalous satellite pseudorange error with miss detection probability 0.999 and false alarm probability 0.002 per hour (requirements from RTCA/DO-208) under given horizontal alarm limit in range 200 m to 2 nautical miles. In addition GG Surveyor RAIM isolates wrong satellite and correct position and velocity errors.

GG Surveyor RAIM includes three procedures which are called every epoch. The first one is Availability Check which checks current satellites constellation available to determine the possibility of anomalous error detection with given alarm threshold, false alarm and miss detection probabilities. Availability percentage depends on alarm threshold value, satellites number and their position. The less alarm threshold is, the less availability percentage will be. For example, if 7 satellites of the same system or 8 ones of two different systems (GPS/GLONASS) with good PDOP are in view and alarm threshold is the one nautical mile (terminal mode) detection is always available. If only 4 satellites of the same system or 5 satellites of the two different systems are visible, detection is impossible.

If detection is available then Detection procedure is called. Detection algorithm compares the residuals with threshold depending on number of redundant satellites in view. If the threshold is exceeded then anomalous error is detected. RAIM is a snapshot type algorithm, so detection usually takes place at the first epoch after alarm limit being exceeded.

If error is detected and at least 6 satellites of the same system or 7 ones of the two different systems with good PDOP are in view, then Exclusion And Correction algorithm is called. Exclusion And Correction algorithm determines the number of "wrong" satellites by maximal normalized residual, after that the position and velocity are corrected by exclusion of that "wrong” satellite. To avoid possible incorrect isolation, the rest of satellites' set is tested by Availability Check and Detection algorithm. If the rest of satellites' set is available and no error is detected, it means the successful correction of position and velocity. The procedures above can be executed recursively. It provides the possibility of more than one simultaneously wrong satellites exclusion. However, in some cases where not enough satellites are available or too many errors are detected, the probability requirement can not be met because of statistical limitations.

External Frequency

This feature lets you input an external frequency so that you can synchronize the receiver clock to a more stable external reference. To enable the external frequency connect the external clock to the EXT REF connector on the front panel and issue the command $PASHS,EXF. To check the status of this function, issue the command $PASHQ,EXF. Frequency selection can be made between 10 KHz and 21 MHz in 10-KHz increments. To disable the external frequency, issue the command $PASHS,EXF,OFF.

The external frequency parameters are summarized in Table 4.6

Table 4.6: External Frequency Parameters

Parameter	Specifications
Input impedance	50 ohms
Frequency range	10 KHz to 21 MHz in 10KHz increments
Lock range	± 5 ppm

The setting of the external frequency is always saved through the power cycle.

Datums

The receiver normally computes and outputs positions in the WGS-84 coordinate reference frame. However, it is possible to output positions in NMEA messages in a number of different pre-defined datums, as well as in a user defined datum.

To set the receiver to output positions in a different datum, use the $PASHS,DTM command. Once set to a different datum, then all position outputs in NMEA messages such as GGA and GLL and the position dare referenced to the chosen datum. For a list of Datums, refer to Appendix B, **Reference Datums and Ellipsoids**.

If the list of datums does not include a datum of interest to the user, a user defined datum may be created and supplied to the receiver. This is done using the command $PASHS,UDD command along with the $PASHS,DTM command. Prior to using these commands, the user must first define the required parameters including the length of the semi-major axis and amount of flattening in the reference ellipsoid, and the translation, rotation, and scale between the user defined system and WGS-84.

To use this datum for the position computation and measurements, use the $PASHS,DTM,USR command after defining the datum parameters.

After issuing the $PASHS,DTM,USR command, the receiver internally transforms positions *from* the reference datum (WGS-84) *to* the user-defined datum. In standard text books, however, the datum transformations are given *from* local datums *to* WGS-84. To simplify entering the transformation parameters, the translation, rotation, and scale parameters are defined *from* the local datum *to* WGS-84.

The generic formula used to translate and rotate from coordinate system 1 to coordinate system 2 is as follows:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_2 = \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta z \end{bmatrix} + (1 + m \times 10^{-6}) \begin{bmatrix} 1 & \varepsilon_{rz} & -\varepsilon_{ry} \\ -\varepsilon_{rz} & 1 & \varepsilon_{rx} \\ \varepsilon_{ry} & -\varepsilon_{rx} & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_1$$

where $\varepsilon_{rx} = \varepsilon_x$ expressed in radians, similarly for ε_{ry} and ε_{rz}.

Example: Define local datum as the WGS-72 datum

$PASHS,UDD, 0,6378135.0, 298.26,0,0,4.5,0,0,-0.554,0.23

$PASHS,DTM,USR

This implements the transformations listed in Table 4.7 and below.

Table 4.7: Ellipsoid Parameters for WGS-72 and WGS-84

Datum	Reference Ellipsoid	a[m]	1/f
WGS-72	WGS-72	6378135.0	298.26
WGS-84	WGS-84	6378137.0	298.257223563

$\Delta x = \Delta y = 0$ $\Delta z = 4.5$ meters $m = 0.23 \times 10^{-6}$

$\varepsilon_x = \varepsilon_y = 0$ $\varepsilon_z = -2.686 \times 10^{-6}$ radians = –0.″554

in the following equation:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} 0 \\ 0 \\ 4.5 \end{bmatrix} + (1 + 0.23 \times 10^{-6}) \begin{bmatrix} 1 & -2.686 \times 10^{-6} & 0 \\ 2.686 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{1WGS72}$$

Internally, the receiver implements the transformation *from* WGS-84 *to* WGS-72. Figure 4.10 demonstrates the change in the coordinate systems.

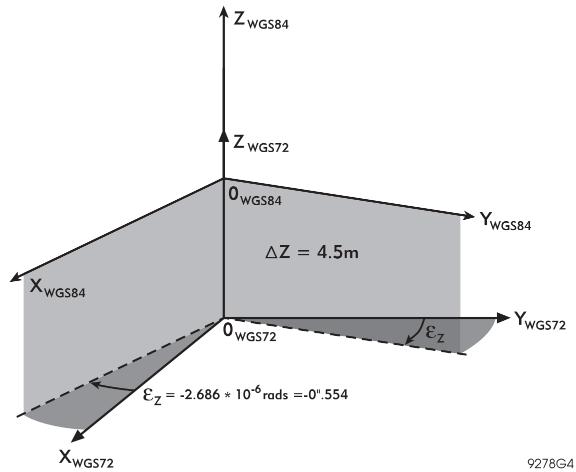

Figure 4.10: Rotation and Translation Between Coordinate Systems

Point Poistioning

The Point Positioning feature improves the accuracy of a stand-alone absolute position of a stationary receiver to about 4 meters horizontal over a period of about 4 hours, and under 3 meters (horizontal) over a period of about 12 hours. (Figure 4.11). Point positioning uses an averaging technique to reduce the effects of Selective Availabiltiy (SA) and other fluctuating errors. Point positioning mode can be set using the $PASHS,PPO command. We recommend that when using the point positioning mode that the system be set to use GPS only ($PASHS,SYS command)

and that the ionospheric model be enabled ($PASHS,ION command). Refer to Chapter 6, **Command/Response Formats** for more details about these commands.

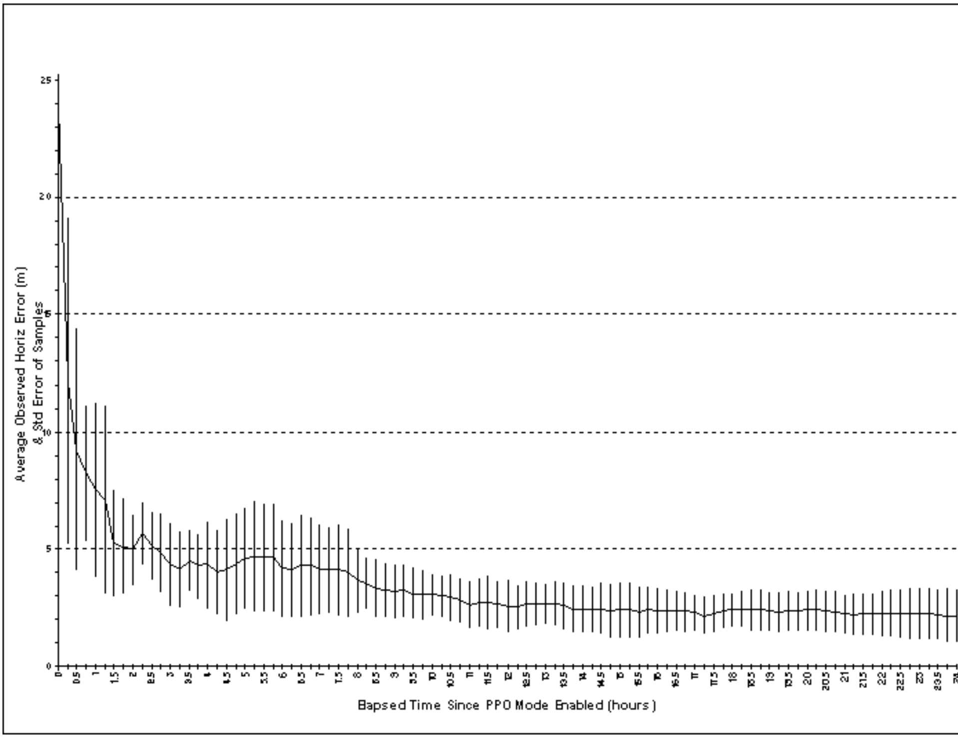

Figure 4.11: Point Positioning Mode Position Error - GPS Only

Differential and RTK Operations

Real-time differential positioning involves a reference (base) station receiver computing the satellite range corrections and transmitting them to the remote stations. The reference station transmits the corrections in real time to the remote receivers via a telemetry link. Remote receivers apply the corrections to their measured ranges, using the corrected ranges to compute their position.

RTK (Real-time kinematic) positioning can be used in lieu of real-time differential positioning. RTK uses the carrier signal in addition to the code signal and is much more accurate. Although messages transmitted and calculations performed vary, RTK is essentially a special form of differential positioning. A base station receiver is required to transmit RTK data to remote receivers. The remote receivers use the RTK data to compute a corrected position.

As stand-alone, the GG Surveyor can compute a position to around 15 meters. Differential GPS achieves sub-meter precision at a remote receiver, and RTK positioning achieves centimeter accuracy at a remote receiver.

A communication link must exist between the base and remote receivers. The communication link can be a radio link, telephone line, cellular phone, communications satellite link, or any other medium that can transfer digital data.

Base Stations

Setting Up a Differential Base Station

You must have the Base option [**B**] installed on the receiver.

Send the commands listed in Table 5.1 to the receiver to generate RTCM differential corrections using message types 1 and 31.

Table 5.1: Differential Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,PEM,4	Set the Base differential mask to four degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna

Table 5.1: Differential Base Station Commands (continued)

Command	Description
$PASHS,RTC,BAS,x	Turn on RTCM corrections on port x When this command is sent, a base station automatically sends RTCM message types 1 and 31 once per second.
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode.
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver.
$PASHS,SAV,Y	Save settings

Do not try to transmit corrections on the same GG Surveyor serial port you are using to set up the receiver from your PC.

The receiver is set as a base station which transmits RTCM message types 1 and 31 every second. Following a power cycle it automatically starts transmitting these corrections again (because you have saved the settings with the $PASHS,SAV,Y command). To change the message rate, use the $PASHS,RTC,TYP command.

Setting Up an RTK Base Station

You must have both the Base option [**B**] and the Phase Differential option **[J**] installed on the receiver.

Send the commands listed in Table 5.2 to the receiver to generate RTCM RTK message types 3,18,19 and 22.

Table 5.2: RTK Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,ELM,4	Set the RTK Base mask to nine degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna
$PASHS,RTC,BAS,B	Turn on RTCM corrections on port x When this command is sent, a base station automatically sends RTCM message types 1 and 31 once per second.
$PASHS,RTC,TYP,1,0	Turn off RTCM messasge type 1.
$PASHS,RTC,TYP,31,0	Turn off RTCM messasge type 31.
$PASHS,RTC,TYP,3,1	Turn on RTCM messasge type 3.

Table 5.2: RTK Base Station Commands (continued)

Command	Description
$PASHS,RTC,TYP,18,1	Turn on RTCM messasge type 18.
$PASHS,RTC,TYP,19,1	Turn on RTCM messasge type 19.
$PASHS,RTC,TYP,22,1	Turn on RTCM messasge type 22.
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode.
$PASHS,CPD,MOD,BAS	Set receiver as RTK base station with default settings: Type 18 and 19 messages generated one per second. Type 3 and 22 messages generate once per minute. RTCM data output on port B in burst mode.
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver
$PASHS,SAV,Y	Save settings

The receiver is set as a base station which transmits RTCM messages types 18 and 19 every second, and types 3 and 22 every minute. Following a power cycle it will automatically start transmitting these messages again (because you have saved the settings with the $PASHS,SAV,Y command). To change the message rate, use the $PASHS,RTC,TYP command.

Setting Up a Combined Differential and RTK Base Station

You must have both the Base option **[B]** and the Phase Differential option **[J]** installed in your receiver.

Send the commands listed in Table 5.3 to the receiver.

Table 5.3: Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,PEM,4	Set the Base differential mask to four degrees
$PASHS,ELM,4	Set the RTK base elevation mask to nine degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna
$PASHS,RTC,BAS,x	Turn on RTCM corrections on port x
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode

Table 5.3: Base Station Commands (continued)

Command	Description
$PASHS,RTC,TYP,3,1 $PASHS,RTC,TYP,22,1	Turn on base station position messages, once per minute
$PASHS,RTC,TYP,18,1 $PASHS,RTC,TYP,19,1	Turn on Code and Carrier phase messages, once per second
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver
$PASHS,SAV,Y	Save settings

Type 1 and 31 messages are ON by Default.

The receiver is set as a base station which transmits RTCM Differential corrections (messages 1 and 31) every second, RTCM messages types 18 and 19 every second, and types 3 and 22 every minute. Following a power cycle it automatically starts transmitting these messages again (because you have saved the settings with the $PASHS,SAV,Y command).

Advanced Base Station Operation

Recommended Advanced Parameter Settings for Base Stations

There a many parameters that control the operation of the receiver. Most should be left at default values, except for the settings identified in Table 5.1, Table 5.2, and Table 5.3.

Antenna

Locate the antenna with a clear view of the sky.

The antenna position, entered with the $PASHS,POS command, is the WGS84 phase center of the antenna. If you do not have a surveyed position on which to locate your antenna you may use the command $PASHS,POS,CUR. This sets the base station position to the autonomous position calculated by the receiver. The relative accuracy of the remote receiver positions is the same, with respect to the base station, as if you had entered the true position of the antenna. The absolute accuracy translates by the difference between the nominal base station position (from $PASHS,POS,CUR) and the true WGS84 position. That is, if the nominal base station position is one meter north of the true position, then all remote positions well be translated north by exactly one meter. You may check which position was set by using the $PASHQ,RTC command.

Message Rate

To improve Differential and RTK performance, minimize base station data latency by using the highest possible data rates that your data link supports. There are three different settings that affect data rates:

- RTCM message bit rate. $PASHS,RTC,SPD. This is the internal bit rate used to generate the RTCM messages. This should be as high as possible without exceeding the baud rate of the serial port. Recommended bit rate setting is burst mode (9), which automatically adjusts the bit rate to the fastest possible rate based on the serial port baud rate:

  $PASHS,RTC,SPD,9

- Serial port baud rate. This should be as high as possible.
- RTCM message rate. This is the rate at which messages are generated.
  - RTK messages (18 and 19) are the most important. They should be generated as fast as possible, ideally once per second. If they are generated slower then the effect on the remote receiver depends on the mode. The slowest allowable setting for type 18 and 19 is once per 5 seconds.
    - Fast RTK mode: accuracy will degrade by approximately 1cm for each second of latency (example: type 18 and 19 generated every 5 seconds, fast RTK accuracy of 5cm, horizontal 1σ. Fast RTK update rate is unaffected.
    - Synchronized RTK mode: accuracy is unaffected. Update rate is limited to the update rate of messages 18 and 19.
  - Differential messages (1 and 31) are next most important, ideally once per second. If the data rate does not support this, these messages may be generated slower, with a corresponding decrease in differential accuracy (Figure 5.2) to see the accuracy sensitivity to lower update interval.
  - RTK base station position (3 and 22) are least important. They affect the RTK initialization time following power on of the remote receiver, (the remote receiver cannot provide an RTK position until it has received messages 3 and 22 once or until receiving the $PASHS,CPD,POS command), but the rate at which these messages are generated does not affect RTK accuracy.

Required Differential Update Rates

For RTK operation there is a minimum radio baud rate that is acceptable. The required radio rate depends on which messages are being generated at the base station, and the message period. The slowest rate at which one should send RTK data is once every 5 seconds. The remote receivers can fix integers with base station data arriving once every 5 seconds or faster.

Message size

Table 5.4 lists the message size for RTCM messages 18 and 19.

Table 5.4: Message Size for RTCM Messages 18 and 19

Number of Satellites	Number of RTCM Words in Message Type 18. (30 bits/word)	Number of RTCM Words in Message Type 19. (30 bits/word)
7 GPS + 7 GLONASS	(2+1+2*7)*2 = 34	(2+1+2*7)*2 = 34
9 GPS + 9 GLONASS	(2+1+2*9)*2 = 42	(2+1+2*9)*2 = 42
12 GPS + 12 GLONASS	(2+1+2*12)*2 = 54	(2+1+2*12)*2 = 54

Required Radio Rate

For RS232 communications, 1 start bit and 1 stop bit is required for each byte. The required number of bits is 10/8 times the number of message bits.

For RTCM, the data is packed in 6/8 format. The required number of bits is 8/6 times the number of bits in the message.

For RTCM data on an RS232 link, the required number of bits is 8/6*10/8 times the number of bits in the message.

Table 5.5 lists the minimum baud rates, for a GG-RTK receiver sending RTCM 18 and 19 messages only.

Table 5.5: Minimum Baud Rates for RTCM Messages 18 and 19

Number of Satellites	Minimum baud rate (message period = T)	Minimum standard baud rate (T = 5 sec)	Minimum standard baud rate (T = 1 sec)
12 total GPS+GLO	30*30*2*8/6*10/8*1/T	600 bps	4800 bps
14 total GPS+GLO	34*30*2*8/6*10/8*1/T	1200 bps	4800 bps
18 total GPS+GLO	42*30*2*8/6*10/8*1/T	1200 bps	4800 bps
24 total GPS+GLO	54*30*2*8/6*10/8*1/T	1200 bps	9600 bps

Table 5.5 lists the minimum baud rates, assuming no other data is sent on the data link. If other RTCM messages are transmitted, then the minimum standard baud rate may increase.

The recommended optimal setting is to transmit type 18 and 19 messages once every second on a high-speed link.

If a high speed data link is not available, you have *indirect* control over the number of satellites used, by setting elevation mask angles. The elevation angle for any particular satellite changes by 1° for every 100 km of baseline length. For baselines of less than 100 km, you should set the base station elevation mask at 1° less than the remote receiver elevations masks to guarantee that the base station sends data for all satellites the remote might use, while not sending data for low elevation satellites that the remote does not use.

Recommended mask angle settings for RTK:

Remote: 5° (Default)

Base: 4°

Use Ashtech's Mission Planner to determine the maximum number of satellites visible above a given mask angle. Table 5.6 shows the maximum number of satellites above a 4° mask angle, with the constellations available August 11, 1997, (25 GPS satellites, 14 GLONASS satellites) using a 24 hour simulation at 0° longitude. GPS or GLONASS geometry is primarily a function of latitude, and varies only slightly with longitude for a constant latitude.

Table 5.6: Maximum Number of Satellites Above a 4° Mask Angle

Latitude	Maximum Number of GPS SVs	Maximum Number of GPS+GLONASS SVs
0°	11	16
10°	12	16
20°	11	15
30°	11	16
40°	11	15
50°	10	15
60°	11	16
70°	12	17
80°	11	17
90°	12	17

Mask Angle

The Base station mask angle for RTK messages 18 and 19 is controlled by $PASHS,ELM. The Base station mask angle for all Differential corrections (1,9,31,34) is controlled by $PASHS,PEM. If your data link bandwidth is large enough, then you can set both mask angles to zero degrees for base stations. This ensures that the base station will send data for all satellites that it can "see" above the horizon.

If your bandwidth limits the number of satellites for which you can transmit base station data, then you may raise the mask angle. On baselines less than 100 km, the remote station sees satellites at approximately the same elevation angles as the base station sees them, the base station mask angle should be set one degree lower than the remote mask angle. On long baselines the elevation angle changes by approximately 1° for every 100 km. So for baselines of x*100 km the base station should not have a mask angle higher than the remote station mask minus x*1°.

The two different controls allow you, for a combined RTK/Differential base station, to set the mask angles higher for RTK (which typically operates on short baselines) than Differential (which often operates on longer baselines).

Base Station Position

The RTCM messages 3 and 22 broadcast the base station position. The base station position may also be entered directly into the remote unit, using the $PASHS,CPD,POS and $PASHS,UBP commands. This reduces bandwidth requirements by obviating the need for messages 3 and 22.

Base Station Antenna Offset

If you set up the base station antenna over a known, surveyed point, you may enter the position of the surveyed point and the offset from this point to the antenna phase center. Or you may enter the phase center directly.

If you are using 3 & 22:

- At the base station, enter the phase center of the antenna directly using $PASHS,POS or
- At the base station, enter the surveyed reference point using $PASHS,POS and enter the antenna offset using $PASHS,ANT.

If you are entering the base station position directly at the remote:

- At the remote, enter the phase center of the base station antenna directly using $PASHS,CPD,POS or
- At the remote, enter the surveyed base station reference point using $PASHS,CPD,POS and enter the base station antenna offset using $PASHS,CPD,ANT.

Using Reference Station ID

You may monitor which reference or base station the remote receiver uses by setting a reference station ID at the base station. Set the reference station ID using the command $PASHS,RTC,STI.

You may also control which reference station the remote receiver uses by setting the desired station ID at the remote receiver, or all the remote receiver to use corrections from any base station.

Reference Station Health

You may set the reference station to "unhealthy", which causes all remote receivers to ignore the messages they receive from that base station.

Other RTCM Messages

Partial Differential corrections: Message 9 and 34

These are alternatives to messages 1 and 31. They should only be used if you have a low bandwidth data link (~100bps). Use of high-bandwidth datalinks, and messages 1 and 31 are recommended.

Message type 1 cannot generate at the same time as type 9. Message type 31 cannot be generated at the same time as 34. It is possible, though unusual, to generate message types 1 and 34, or 9 and 31.

Message 2 and 32

These are automatically generated when the base station is transmitting differential corrections and a new ephemeris is downloaded from the satellites.

Filler: Message 6 and 34 Null Frame

This message is provided for datalinks that require continuous transmission of data, even if there are no corrections to send.

Special Message: Message 16 and 36

These message allow you to transmit an ASCII message from the base station.

Using a PC Interface

If you are using Evaluate software to interface to your receiver you may use initialization files (`*.gps`) to send the base station setting commands for you.

To monitor the corrections from a PC, turn on the MSG message

$PASHS,NME,MSG,y,ON

This generates an ASCII echo of the RTCM messages being transmitted by the base station. Use different receiver serial ports for MSG and the actual transmitted RTCM messages.

Using a Handheld Interface

If you are using Ashtech software running on the Husky FS/2 handheld computer, differential set-up is controlled via a series of menus designed to free users from knowing or entering commands. Handheld software allows users to monitor and control most receiver functionality.

Remote Stations

Setting Up a Differential Remote Station

You must have the Differential remote option **[U]** installed on your receiver.

You must have a source of differential corrections, usually a radio receiving a transmission from a base station. Connect this radio to one of the GG Surveyor serial ports.

Send the following commands to the receiver. The receiver will accept RTCM differential corrections in message types 1 or 9 (for GPS) and 31 or 34 (for GLONASS). You do not have to tell the receiver which message types to expect, it will automatically use whatever it receives on serial port x.

Table 5.7: Differential Remote Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,RTC,REM,x	Set the receiver as a remote station, receiving corrections on serial port x
$PASHS,SPD,x,n	Set the baud rate of serial port x to the same as the radio providing the corrections.
$PASHS,SAV,Y	Save settings

You have now set up the remote station. Turn on the GGA, GLL, POS or PBN message to obtain position.

Setting Up an RTK Remote Station

Operating an RTK remote is almost identical to operating a Differential remote receiver. The main differences are:

1. The data from the base station is RTCM Types 18,19,3 and 22, instead of 1 and 31 or 9 and 34.
2. The accuracy is approximately 100 times better.

You must have both the Differential remote option, [**U**], and the Phase differential option, [**J**], installed in your receiver.

You must have a source of RTK data, usually a radio receiving a transmission from an RTK base station. Connect this radio to one of the GG Surveyor serial ports.

Send the following commands to the receiver. The receiver accepts RTCM RTK data in message types 18 (Carrier phase data) and 19 (Code phase data) and 3 and 22 (Base station position).

Table 5.8: RTK Remote Station Command

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,RTC,REM,x	Set the receiver as a remote station, receiving corrections on serial port x
$PASHS,SPD,x,n	Set the baud rate of serial port x to the same as the radio providing the corrections.
$PASHS,CPD,MOD,ROV	Set the receiver as an RTK remote
$PASHS,SAV,Y	Save settings

The receiver is set up as a RTK remote station. Turn on the GGA, GLL, POS or PBN message to obtain position.

RTK (Real Time Kinematic) and CPD (Carrier Phase Differential) are synonyms.

Advanced Remote Station Operation

Recommended Advanced Parameter Settings for Differential Remote Stations

There are many parameters that control the operation of the receiver. Most should be left at default values. The following settings are recommended for Differential Remote Stations.

$PASHS,CRR,S

$PASHS,LPS,10,3,1 (for high dynamic or high vibration applications)

$PASHS,AIM,0.015

Other parameter settings at factory default.

Recommended Advanced Parameter Settings for RTK Remote Stations

There are many parameters that control the operation of the receiver. Most should be left at default values. The following settings are recommended for RTK Remote Stations.

$PASHS,CRR,E

$PASHS,LPS,10,3,1 (for high dynamic or high vibration applications)

Other parameter settings at factory default.

Base Station RTCM Data

Both Differential remote stations and RTK remote stations automatically extract the messages needed from the data coming in to the designated serial port. So you can set up a combined Differential/RTK base station (see See "Setting Up a Combined Differential and RTK Base Station" on page 47.), and operate DGPS remote receivers, DGG remote receivers and RTK remote receivers.

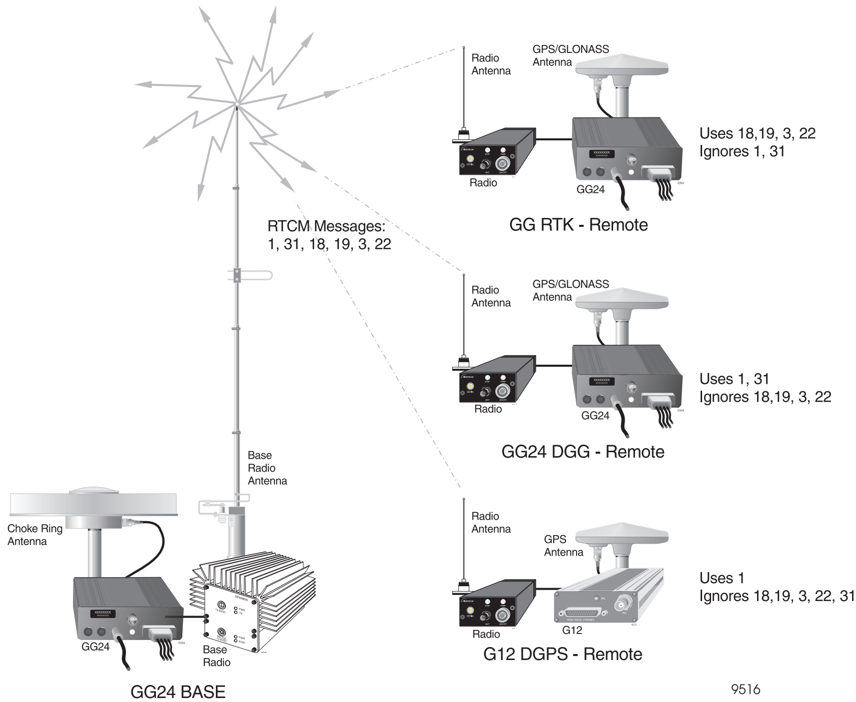

Figure 5.1: Combined Differential/RTK Base Station and Remote Operation

Ashtech remote receivers (both Differential and RTK) operate with any base station that generates the industry standard RTCM messages.

Base Data Latency

Both Differential and RTK operation are better the lower the latency of the Base-Remote data link. To minimize latency set the baud rate of the radios as high as possible, and use radios that are optimized for low latency GPS operation, such as the Ashtech SSRadio.

The actual Base-Remote data latency is given in the GGA message (whether in Differential or RTK modes).

Maximum acceptable base-remote data latency is controlled by $PASHS,RTC,MAX for both Differential and RTK modes.

Differential Accuracy vs. Base Data Latency

Figure 2 shows the growth of position error with increasing latency for DGPS and DGLONASS.

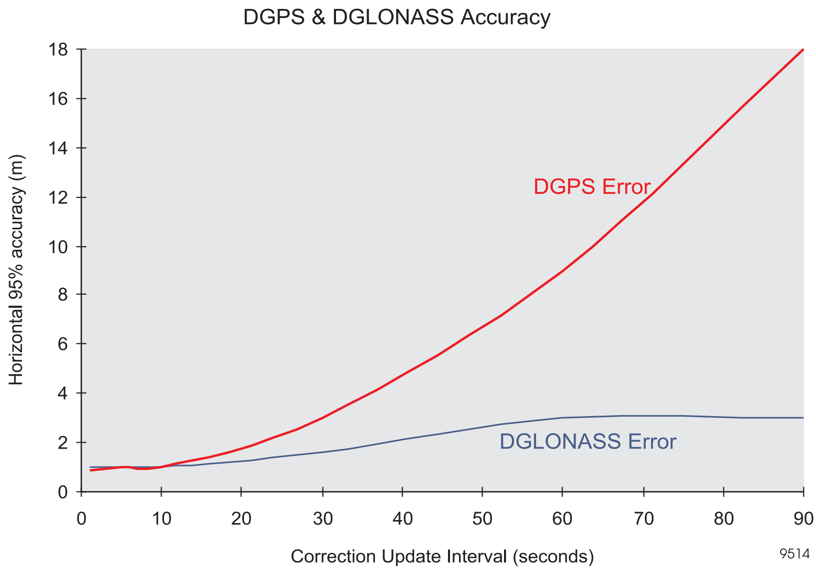

Figure 5.2: DGPS and GLONASS Accuracy

RTK Accuracy and Update Rates vs. Base Data Latency

With an RTK remote you may choose between:

1. Higher accuracy and lower update rates (Synchronized RTK)
2. Lower accuracy and higher update rates (Fast RTK)

Lower RTK accuracy still means centimeter-level accuracy

Use the command $PASHS,CPD,FST,ON/OFF to switch between the two modes.

Synchronized RTK

In this mode the remote receiver's update rate is equal to the rate at which it receives type 18 and 19 messages. (Maximum of 1Hz). The latency of position is approximately equal to the latency of the base-remote data link. Typical accuracy is

0.5cm+1ppm (1σ horizontal), and is independent of the rate at which the receiver receives type 18 and 19 messages.

Fast RTK

In this mode the remote receiver's update rate is selectable up to 5Hz, and is independent of the rate at which it receives type 18 and 19 messages. Use the command $PASHS,NME,PER to control the update rate. The latency of position is less than 100 ms. The precise latency (to 1ms resolution) is available in the LTN message. Typical accuracy (1σ horizontal) in centimeters is equal to the base-remote data latency in seconds, for data latency of up to 10 seconds. For base-remote data latency of greater than 10 seconds and less than 30 seconds, the accuracy degrades up to 2 meters. In Fast RTK mode the receiver will always provide the best possible position solution at the data rate selected by the user. If the accuracy degrades for any reason (such as cycle slips, lost radio link, etc.), this will be reflected in the GST message. By contrast, the Synchronized RTK position only provides positions when a fresh set of base station data has been received.

Fast RTK should be used when you need position updates at regular intervals, (such as in machine control). Synchronized RTK should be used when you can afford to wait a few epochs for the highest available accuracy (such as in surveying).

During Fast RTK mode the receiver runs synchronized RTK mode in the background at the same rate that it receives base station data. If the receiver detects a cycle slip, it fixes the cycle slip at the next synchronized epoch (typically within one second).

If you are using Fast RTK mode you should monitor position accuracy using the GST message.

Example: Fast RTK running at 5Hz. Type 18&19 message updates at 1Hz.

> Cycle slip occurs at time 12:00:00.1 (100 milliseconds past noon). There will be 4 epochs of Fast RTK positions with an error of a few decimeters, each will have a corresponding GST message showing that there is an error. Then, at 12:00:01.0 (1 second past noon) the cycle slip will be repaired.

Position Latency

Base data latency, discussed above, is the delay between when a base station measures the GPS&GLONASS signals and when the remote receiver receives the RTCM messages. *Position latency* is the delay between when the remote receiver measures the GPS&GLONASS signals and when the position is available at the serial port. In other words, position latency is the delay in providing the user's actual position to the user. Position latency is typically between 50 and 100 milliseconds, it varies with the number of satellites in view. The actual position latency, to one millisecond precision, is provided by the LTN message for each epoch.

Float and Fixed Solutions

When the receiver is in RTK mode the crucial difference from Differential mode is that it uses the carrier phase measurement to generate the range measurements to centimeter accuracy. The receiver can measure the fractional part of the carrier phase to centimeter accuracy, it derives the integer number of full carrier phase wavelengths by processing both the carrier and code phase measurements. This process of deriving the integer numbers is known as integer ambiguity resolution or carrier phase initialization. This carrier phase initialization is only necessary following power-on, or after the receiver has lost lock on the satellites (e.g. after passing under a bridge). The receiver performs carrier phase initialization automatically. The receiver does not have to be stationary while initializing. Once the receiver is initialized it will provide centimeter-level accuracy, while moving, in real time. The time for carrier phase initialization is a few seconds up to several minutes, depending on baseline length, number of satellites in view, and required reliability; these are discussed in the next section.

During the carrier phase initialization the receiver is said to be in "float" mode, once initialization is complete the receiver is said to be in "fixed" mode. This terminology derives from computer terminology: floating-point numbers (real numbers) and fixed numbers (integers).

When in float mode the accuracy will range from Differential accuracy (1m) down to sub-decimeter. The longer the receiver has been in float mode the higher the accuracy. The convergence to 20 cm accuracy takes approximately five minutes, convergence to 10 cm accuracy requires approximately ten minutes. Convergence time is a function of baseline length and number of satellites in view. When the receiver fixes integers, accuracy makes a quantum change to centimeter level.

The POS and GGA messages have fields which indicate whether the receiver is in float or fixed mode.

Carrier Phase Initialization

The time required for carrier phase initialization is a function of base-remote baseline length, number of satellites in view, satellite geometry, and required reliability. With a large number of satellites in view (≥14), initialization time can be as low as a few seconds. With fewer satellites in view, the receiver takes as long as necessary to guarantee the required reliability.

Reliability

The process of carrier phase initialization has a non-zero probability of error. If an error is made the receiver will fix the integers to the wrong value. This will result in floating point accuracy (typically between 10cm and 1m). After an error in fixing integers the receiver automatically detects and corrects the error when the satellite geometry changes. This may be as soon as a new satellite comes into view, or, in the worst case, when the satellites move by a few degrees in the sky, which can take from one to more than 10 minutes.

You can control the reliability that the receiver provides, this indirectly controls the speed of carrier phase initialization. The higher the reliability the longer it takes to fix integers.

The receiver offers three modes for ambiguity fixing:

a. Float solution only

b. Fixed solution, formal reliability = 99%

c. Fixed solution, formal reliability = 99.9% (default)

The command $PASHS,CPD,AFP controls the ambiguity fix parameter.

The two choices of formal reliability for fixed solution are provided to allow you to trade off speed with reliability. The AFP setting controls the internal thresholds of the receiver so that the expected statistical reliability of getting correctly fixed integers is 99% or 99.9% respectively. The receiver fixes integers two to three times faster with AFP=99 than with AFP=99.9. The actual achieved reliability has been tested under different conditions in different locations, and using two different test techniques. Under the first technique, the receiver is reset at regular intervals (every 10 minutes). Under the second technique the receiver is reset every time it has fixed integers. Results vary according to location, environmental conditions (multipath and blockage), and test method. Best and worst case results of all tests are listed in the Table 5.9.

Table 5.9: Actual achieved reliability results with AFP settings of 99 and 99.9

AFP Setting	Worst Achieved Reliabilty	Best Achieved Reliability	Median Time to Fix (50% of resets)	90% Time to Fix (90% of resets)
99	96% (3.5km baseline, 800 resets over 5 days)	99.97% (3.5km baseline, 3826 resets over 1 day)	< 1 minute[1]	10 minutes[1]
99.9	99.6% (3.5km baseline, 800 resets over 5 days)	100% (7km baseline, 829 resets over 5 days)	3 minutes[1]	> 10 minutes[1]

[1] Time to fix integers varies with number of satellites in view, and baseline length. The more satellites in view, the faster integers are fixed. The longer the baseline, the slower the integers are fixed. Values shown are typical for tests over baselines of 3.5km to 7km. Most tests last more than 24 hours, during this time there are periods of high satellite visibility when time to fix integers is much shorter than the typical times shown

The above results are for tests using Ashtech GG-Pro antennas. Similar results are not guaranteed with different antennas.

While the receiver is busy fixing integers, it gives a float solution.

Operation under trees, or in other areas with frequent blockage of satellites signals will lead to significantly degraded results.

As well as the two reliability settings for fixed solutions, there is a setting for pure floating-point mode ($PASHS,CPD,AFP,0). In this mode, the receiver always gives a floating point solution. The accuracy of the floating point solution converges to decimeter level in approximately ten minutes (depending on the baseline length and the number of satellites in view, covergance time increases with increasing baseline lengths and decreasing number of satellites). Figure 5.3 shows typical behavior of the floating point solution following start-up or obstruction-and-reacquisition for a short baseline with eleven to thirteen satellites in view.

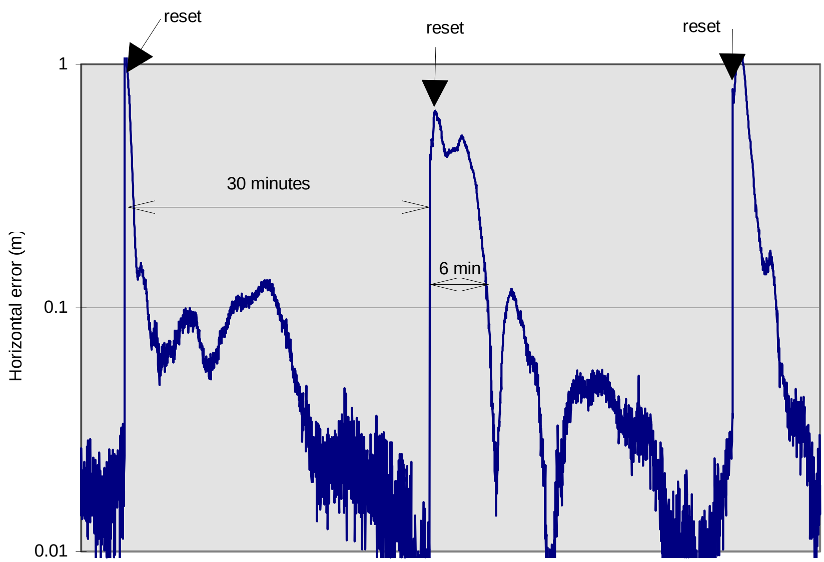

Figure 5.3: Convergence of Float Solution Following Reset

Monitoring Accuracy

Besides fixed/float status, position accuracy is the most important consideration when using the GG Surveyor for real time carrier phase positioning. The primary means of monitoring CPD “fixed” and CPD “float” accuracy is the GST message (see NMEA section for full description). Each GST message contains a UTC time tag which relates to a given epoch of position computation. The GST gives an indication of the overall quality (precision) of the CPD position by displaying the RMS value of the standard deviation of all the range inputs to the position solution. The GST message also gives a real-time estimate of the actual error in the CPD position at a 1 sigma probability by displaying the standard deviation of latitude, longitude and altitude. The actual position error of the system will be less than the standard deviations displayed in the GST approximately 68% of the time. If you multiply the standard deviations by 2, the result is a conservative estimate of actual accuracy about 95% of the time.

The quality of the GST estimates improve with increasing number of satellites. The GST estimates may be very unreliable with only 4 satellites in view. Figure 5.4 plots horizontal error estimates (from GST) and actual horizontal error (calculated using known antenna position) for typical GST performance for 10 satellites in view.The horizontal estimates are derived from:

$$\sqrt{(GSTLatError)^2 + (GSTLonError)^2}$$

GST estimates of latitude, longitude, and altitude accuracy automatically account for DOP, SNR, and many other factors. These parameters are built into the GST estimate already and do not have to be recomputed by the user.

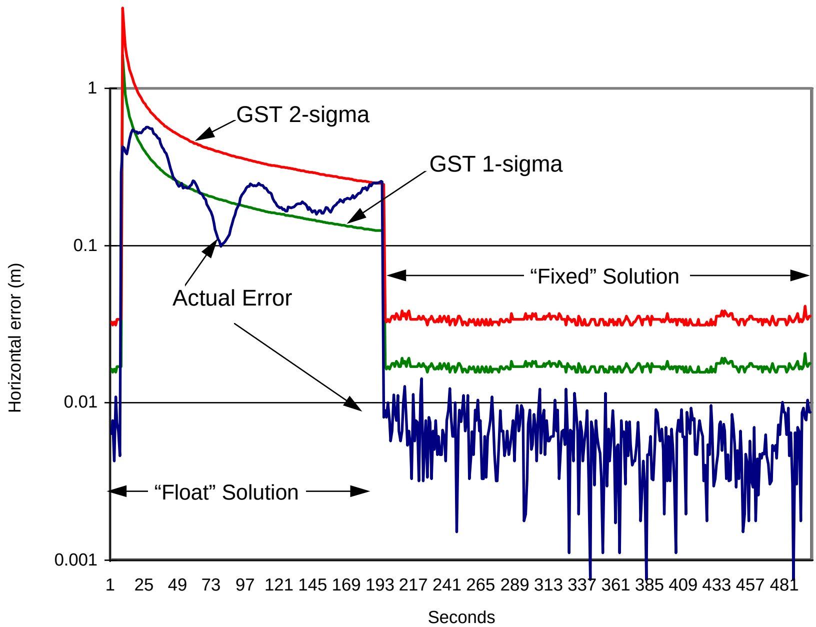

Figure 5.4: Typical GST Performance

Required Number of Satellites

The receiver requires seven or more satellites to fix integers, following power on, or obstruction and re-acquisition. If the solution is fixed with 7 or more satellites, and the number of satellites falls below 7 but stays above 3, the solution stays fixed and accuracy remains at the centimeter-level. If the solution is not fixed, but the receiver has four, five, or six satellites in view, the solution will be floating-point, and steadily converges to sub-decimeter accuracy. Positions are always three-dimensional when in RTK mode. Two-dimensional positions, using previously calculated altitudes, are not possible.

Mask Angles

At the remote station the position elevation mask is always controlled by $PASHS,PEM, whether the receiver is in Differential mode or RTK mode.

Auto Differential Mode

When a user operates a rover receiver in differential mode (either code phase or carrier phase), a failure at the base station or in the data link causes the rover receiver to cease outputting differentially corrected positions. Auto differential mode allows the user to output an autonomous position at the rover receiver if differential data from the base station is unavailable. Auto differential mode is enabled by entering the command $PASHS,RTC,AUT,Y. Table 5.10 describes how auto differential mode affects position output at the rover receiver.

Table 5.10: Auto Differential Modes and Position Output

Mode	Position Output
Code differential Auto Differential Off (Default code mode)	Differential position output if the age of corrections is less than maximum age (maximum age as defined in the rover by $PASHS,RTC,MAX,xx). No position otherwise.
Code differential Auto Differential On	Differential position is output if the age of corrections is less than maximum age, otherwise an autonomous position is output.
Carrier differential Fast CPD On Auto Differential Off (Default carrier mode)	Once the rover mode has been enabled, autonomous position outputs until it has computed the first CPD position. A CPD position solution continues to output until the age of corrections is greater than the maximum age.
Carrier differential Fast CPD On Auto Differential On	Once the rover mode has been enabled, autonomous position outputs until it has computed the first CPD position. A CPD position solution continues to output until the age of corrections is less than the maximum age, otherwise an autonomous position is output.
Carrier differential Fast CPD Off Auto Differential Off or On	Once the rover mode has been enabled, autonomous position outputs until it has computed the first CPD position. A CPD position solution continues to output until corrections stop, and no position outputs unless corrections are available.

RTCM Messages

The GG Surveyor accepts RTCM 104 version 2.1 differential formats. The GG Surveyor is set to differential mode in any of the serial ports with the set command $PASHS,RTC,str,c where str is BAS or REM and c is the port. Of RTCM message types 1 through 64, the GG Surveyor processes only: types 3, 16, 22, 32, and 36 for station location and special information; types 1, 2, 9, 31, and 34 for RTCM differential corrections, null frame type 6 and 34, and RTK data message types, 18 and 19. The differential corrections are automatically processed by the GG Surveyor. RTCM message types 3, 16, 22, 32, and 36 provide user information from the reference (base) station via the $PASHS,NME,MSG set command and the $PASHQ,MSG query command. RTCM message types 1, 9, 18, 19, 31, and 34 provide differential correction information via the $PASHS,NME,MSG set command and $PASHQ,MSG query command.

On initial power-up or after use of the $PASHS,RST reset to defaults command, the GG Surveyor default automatic differential mode is OFF, and the default is 60 seconds for the maximum age of an RTCM differential correction above which it will not be used. If the automatic mode is not enabled by the $PASHS,RTC,AUT,Y set command and the differential correction data is older than the maximum age specified by the $PASHS,RTC,MAX set command, the GG Surveyor does not return antenna position data.

In automatic mode, if no differential correction data is received or the age of data is older than the specified maximum age, the GG Surveyor does return the uncorrected raw position.

RTCM 104 Format, Version 2.2

When the GG Surveyor is used as a reference station and the RTCM base option is enabled, the GG Surveyor computes differential corrections for up to 24 satellites (12 GPS + 12 GLO), converts those corrections to RTCM format, and transmits the converted messages via its serial ports. It can generate message types 1, 2, 3, 6, 9, 16, 18, 19, 22, 31, 32, 34 null frame, 34, and 36 as detailed in Table 5.11.

Table 5.11: RTCM Message Types

GPS Message Type	Contents of Message	GLONASS Message Type	Contents of Message
1	Differential GPS corrections	31	Differential GLONASS correction
2	Delta differential corrections		
3	Reference station parameters in WGS 84	32	Reference station parameters in PZ-90
6	Null frame	34 with no parameters	Null frame
9	GPS partial correction set	34	GLONASS partial correction set
16	Special GPS text message	36	Special GLONASS text message
18	RTK carrier phase (both GPS and GLONASS)	19	RTK pseudo-ranges (both GPS and GLONASS)
22	Extended reference station parameter		

The GG Surveyor uses the six-of-eight format (data bits a1 through a6 of an eight-bit byte) for communication between the reference station and user equipment.

When the GG Surveyor is used as remote equipment and the RTCM remote option is enabled, the GG Surveyor can accept any type of RTCM message. However it decodes types 1, 2, 3, 6, 9, 16, 18, 19, 22, 31, 32, 34, and 36 uses only types 1, 2, 9, 31, and 34 for differential corrections and types 3, 18, 19, and 22 for RTK corrections. For radio communication, the GG Surveyor in remote mode can recover bit slippage.

Command/Response Formats

This chapter details the format and content of the serial port commands through which the receiver is controlled and monitored. These serial port commands set receiver parameters and request data and receiver status information. Use the REMOTE.exe software or any other standard serial communication software to send and receive messages. Note that 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 to be successfully transmitted and received. The receiver protocol is 8 data bits, 1 stop bit, and parity = none.

All commands sent by the user to the receiver are either Set Commands or Query commands. Set commands generally change receiver parameters or initiate data output. Query commands generally request receiver status information. All set commands begin with the string $PASHS and all query commands begin with the $PASHQ string. $PASHS and $PASHQ are the message start character and message header and are required for all commands. All commands must end with a <Enter> or <CR><LF> keystroke to transmit the command to the receiver. If desired, an optional checksum may precede the <Enter> characters. All response messages will end with a <CR><LF>.

In this manual, the serial commands have been separated into 5 separate groups:

- 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 data message output
- RTCM commands - commands that control RTCM differential operation
- CPD commands - commands that control carrier phase differential (CPD) 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 maybe characters or numbers depending upon the particular command. The parameter type is indicated by the symbol that is a part of the syntax. The format of these parameters are as follows:

Table 6.1: Command Parameter Symbols

Symbol	Parameter Type	Example
d	Numeric integer	3
f	Numeric real	2.45
c	1 character ASCII	N
x	1 character ASCII	A
s	character string	UDD
m	mixed parameter (integer and real)	3729.12345
h	hexadecimal digit	FD2C

For example, for the receiver command:

$PASHS,RCI,f

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

Receiver Commands

Receiver commands change or display various receiver operating parameters such as recording interval, antenna position, and PDOP mask. Commands may be sent through any available serial port.

Set Commands

The general structure of the set commands is:

$PASHS,str,x,<Enter>

where str is a 3 character string identifier, and x is one or more data parameters that will be sent to the receiver. For example, the set command to change the recording interval to 5 seconds is:

$PASHS,RCI,5<Enter>

If a set command is accepted, an acknowledgment message is returned in the form:

$PASHR,ACK*3D

If a set command is not accepted, an non-acknowledgment message is returned in the form $PASHR,NAK*30. If a command is not accepted, check that the command has been typed correctly, and that the number and format of the data parameters is correct.

Query Commands

The general structure of the query command is:

$PASHQ,str,x <Enter>

where str is a 3 character string identifier and x is the serial port where the response message will be sent. The serial port field is optional. If the serial port is not included in a query command, the response will be sent to the current port. For example, if the user is communicating with the receiver on Port A and sends the following query command:

$PASHQ,PRT <Enter>

The response will be sent to port A. However, if from the same port, the users sends the query command:

$PASHQ,PRT,B <Enter>

Then the response will be sent to port B.

The format of the response message may either be in a comma deliminated format or in a free form table format, depending upon the query command, Note that not every set command has a corresponding query command. The most useful query command to check the general status of most receiver parameters use:

$PASHQ,PAR <Enter>

Table 6.2 lists the receiver set and query commands alphabetically by function, and then alphabetically within each function. Each command is described in detail in alphabetical order.

Table 6.2: Receiver Set/Query Commands

Function	Command	Description	Page
Antenna Position	$PASHS,ALT	Set ellipsoid height of antenna	75
	$PASHS,POS	Set antenna position	98
	$PASHS,POS,CUR	Set antenna position to current computed position	98
Dilution of Precision (DOP)	$PASHS,HDP	Set HDOP mask for position computation	86
	$PASHS,PDP	Set PDOP mask for position computation	95
	$PASHS,TDP	Set GLONASS system time shift DOP mask	109
	$PASHS,VDP	Set VDOP mask for position computation	114
Ionosphere	$PASHS,ION	Include/exclude ionospheric model	89
	$PASHQ,ION	Display ionosphere data information	89
Memory	$PASHS,CLM	Clear the data files from the data card	77
	$PASHS,INI	Clear receiver memory and data	89
	$PASHS,RST	Reset User Parameters	105
	$PASHS,SAV	Save parameters in battery-backed-up memory	105
Miscellaneous Commands	$PASHS,AIM	Set RAIM mode	74
	$PASHQ,CLK	Query receiver clock status	76
	$PASHS,LTZ	Set local time zone	92
	$PASHS,POW	Set battery parameters	98
	$PASHQ,POW	Query battery parameters	99
	$PASHS,SNR	Set algorithm for SNR computation	106
	$PASHQ,SNR	Display SNR setting	106
External Frequency/ Photogrammetry/ 1PPS / Strobe	$PASHS,EXF	Set external frequency	81
	$PASHQ,EXF	Query external frequency setting	82
	$PASHS,PHE	Set photogrammetry edge	96
	$PASHQ,PHE	Display the photogrammetry parameters	96
	$PASHS,PPS	Set period and offset of 1 PPS signal	100
	$PASHQ,PPS	Display 1PPS parameters	100
	$PASHS,STB	Set measurement strobe parameters	107
	$PASHQ,STB	Display measurement strobe parameters	108

Table 6.2: Receiver Set/Query Commands (continued)

Function	Command	Description	Page
Position Computation	$PASHS,DTG	Set GLONASS system time shift relative to GPS system time	79
	$PASHS,FIX	Set altitude hold position fix mode	83
	$PASHS,GTF	Set GLONASS system time shift hold position fixed mode	85
	$PASHS,GTM	Compute/hold GLONASS system time shift	86
	$PASHS,GTP	Set priority of GLONASS system time shift if SVs = 4	86
	$PASHS,PEM	Set elevation mask for position computation	96
	$PASHS,PMD	Set position computation mode	97
	$PASHS,PPO	Point Positioning Command	100
	$PASHS,SVP	Designate satellites to used for position computation	108
	$PASHQ,SVP	Display satellites used for position computation	109
	$PASHS,USP	Select specific satellite to use for position computation	113
Receiver Configuration	$PASHS,CTS	Port protocol	78
	$PASHQ,CTS	Query port protocol settings	78
	$PASHS,DSY	Configures receiver serial ports in daisy-chain mode	78
	$PASHS,DTM	Set datum for position computation	79
	$PASHS,LPS	Set loop tracking parameters	91
	$PASHQ,LPS	Display loop tracking parameter setting	91
	$PASHS,MRX	Set transformation matrix from PZ-90 to WGS-84	92
	$PASHQ,MRX	Query transformation matrix	93
	$PASHQ,PAR	Query receiver parameters	94
	$PASHS,POP	Position computation rate	97
	$PASHQ,PRT	Request port baud rate	101
	$PASHQ,RID	Request receiver identification	103
	$PASHQ,RIO	Request for receiver ID	104
	$PASHS,SMI	Set code smoothing	105
	$PASHS,SMV	Set speed filtering	106
	$PASHS,SPD	Set speed (baud rate) of serial port	107
	$PASHS,SYS	Set system (GLONASS/GPS/Mixed)	109
	$PASHS,TSC	Set type of time scale used	110
	$PASHQ,TSC	Display time scale setting	110
	$PASHS,UDD	Set user-defined datum	110
	$PASHQ,UDD	Display user-defined datum	112

Table 6.2: Receiver Set/Query Commands (continued)

Function	Command	Description	Page
Surveying Parameters	$PASHS,ANT	Set antenna offset parameter	75
	$PASHQ,ANT	Query antenna offset parameters	76
	$PASHS,INF	Save information about current session	87
	$PASHQ,INF	Query current session	87
	$PASHS,PRJ	Set session parameters	101
	$PASHS,SIT	Set site name	105
Data Recording	$PASHS,DSC	Store event string	78
	$PASHS,ELM	Set data recording elevation mask	81
	$PASHS,EPG	Set kinematic epoch counter	81
	$PASHS,FIL	Close or delete a data file	82
	$PASHQ,FLS	Query file information	83
	$PASHQ,FSS	Query file system status	84
	$PASHS,MSV	Sets the minimum number of satellites	93
	$PASHS,RCI	Set recording interval	102
	$PASHS,REC	Enable/disable data recording	103
	$PASHS,RNG	Set data type	104
Satellites	$PASHQ,STA	Request status of satellites currently locked	107
	$PASHQ,SVS	Display satellites enabled to acquire	109
	$PASHS,SVS	Designate satellites to acquire	109
	$PASHS,USE	Designate satellites to use	112

AIM: RAIM Availability

$PASHS,AIM,s

Select the RAIM (Receiver Autonomous Integrity Monitor) mode, where s is one of the following 3-character strings representing a pre-defined alarm limit or the user can enter a user defined limit.

OFF - Disables RAIM

NPA - Non-precision approach, alarm limit is 0.030 nmi (default)

TER - Terminal, alarm limit is 1.00 nmi

ERT - En route, alarm limit is 2.00 nmi

n.nn- User-defined alarm limit

where n.nn can be a value between 0.015 and 4.00 kilometers.

Example: Set RAIM mode to terminal mode.

$PASHS,AIM,TER<Enter>

ALT: Set Ellipsoid Height

$PASHS,ALT,f

This command sets the ellipsoidal height of the antenna. Where f is the height in meters, and the range is ±99999.99. The receiver uses this data in the position calculation for 2-D position computation, and when in differential base mode.

Examples: Set antenna height to +100.25 meters

$PASHS,ALT,+100.25<Enter>

Set antenna height to - 30.1 meters

$PASHS,ALT,-30.1<Enter>

ANT: Set Antenna Offsets

$PASHS,ANT,f1,f2,f3,m1,x1

Sets the antenna offsets from reference point to antenna phase center.

Table 6.3: Antenna Offsets Settings

Setting Parameter	Description	Range	Unit
f1	antenna height: height measured from the reference point to the antenna edge	0 -64.000	Meter
f2	antenna radius: the distance from the antenna phase center to the antenna edge	0.0 - 9.9999	Meter
f3	antenna offset: the offset set from the antenna phase center to the antenna ground plane.	0.0 - 99.9999	Meter
m1	Always 0	0	
x1	Always 0	0	

The implementation of this command affects message type 1, 9, 31, 34, 3, and 22 significantly. Only vertical offsets are supported by Message 22, thus the horizontal azimuth and distance fields of this command should always be 0 if in RTK or differential mode.

Example: Set antenna offsets.

$PASHS,ANT,1.678,0.1737,0.5,0000.00,0.0<Enter>

$PASHQ,ANT,c

Requests the current antenna offset parameters, where c is the output port and is not required to direct the response message to the current communication port.

Example: Query antenna offsets to port A.

$PASHQ,ANT

$PASHR,ANT,f1,f2,f3,m1,x1*cc

Returns the antenna parameters of the receiver, where Table 6.4 outlines the response format.

Table 6.4: ANT Message Structure

Return Parameter	Description	Range	Unit
f1	antenna height: height measured from the reference point to the antenna edge	0—64.000	meter
f2	antenna radius: the distance from the antenna phase center to the antenna edge	0.0—9.9999	meter
f3	antenna offset: the offset set from the antenna phase center to the antenna ground plane.	0.0—99.9999	meter
m1	Always 0	0	
x1	Always 0	0	
*cc	checksum	00-FF	n/a

CLK: Clock Status

$PASHQ,CLK

Queries the real-time clock status.

$PASHR,CLK

The response is in the format:

$PASHR,CLK,d1,d2, d, d3, d4, d5, d6, d7, d8*cc where Table 6.5 outlines the response format:

Table 6.5: CLK Response Format

Parameter	Description	Range
d1	Year	0-99
d2	Month	0-12
d3	Date	0-31
d4	Day	0-7
d5	Hour	0-23
d6	Minute	0-60
d7	Second	0-60
d8	Time Difference	
*cc	The hexadecimal checksum	0-9 and A-F

Example Response:

$PASHR,CLK,96,12,04,04,13,25,20,14*1D

Date: 4 December 1996, Wednesday

Time :13.25, 20sec;

Last write time to clock operation was at 14sec before issuing the command.

CLM: Clear Memory

$PASHS,CLM

The CLM command deletes all files from the data card and then reformats and tests the read/write capability of the card.

Example: Clear the data files from the data card.

$PASHS,CLM<Enter>

$PASHR,CLM

If the card passes the test, the response is in the form:

$PASHR,CLM,WAIT*ccc

$PASHR,PASSED*cc

If the card fails the test, the response is in the form:

$PASHR,CLM,FAILED*cc

Table 6.6 describes the parameters in the response message.

Table 6.6: CLM Message Structure

Parameter	Significance
d1	size of the data card in kilobytes
*cc	checksum

CTS: Port Protocol

$PASHS,CTS,c,s

This command enables or disables the RTS/CTS (handshaking) protocol for the specified port, where c is the port and s is ON or OFF. If the port is not specified (i.e., if c is not included in the command), the protocol is enabled or disabled for the port to which the command was sent.

Example: Disable the handshaking protocol for port A.

$PASHS,CTS,A,OFF<Enter>

$PASHQ,CTS

The associated query command is $PASHQ,CTS which requests the RTS/CTS (handshaking) protocol status.

$PASHR,CTS

The response message is in the form $PASHR,CTS,s where s is the RTS/CTS (handshaking) protocol status, ON or OFF.

DSC: Store String

$PASHS,DSC

This command stores a string as an event marker to the open current session in the 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 to the receiver the string: LightPole

$PASHS,DSC,LightPole<Enter>

DSY: Daisy Chain

$PASHS,DSY,x,y

Redirects all characters from one serial port to the other without interpreting them, where x is the source port and y is the destination port. Any combination may be chosen. 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). Table 6.7 lists the daisy chain commands and their effects.

Table 6.7: Daisy Chain Commands

Command	Effect
$PASHS,DSY,A,B<Enter>	Redirects A to B. Can issue from any port.
$PASHS,DSY,B,A<Enter>	Redirects B to A. Can issue from any port, but it cannot be issued from port A if $PASH,DSY,A,B<Enter> has been sent.
$PASHS,DSY,A,OFF<Enter>	Turns off redirection from A. Can issue from any port.
$PASHS,DSY,OFF<Enter>	Turns off daisy chain on all ports. Can issue from any port.

The DSY command also works with Ports A and C, or Ports B and C in the manner described in Table 6.7.

DTG: GLONASS Time Shift

$PASHS,DTG,f

Set GLONASS system time shift relative to GPS system time, where f is the time shift in microseconds, from 0.0000 (default) to ±500000.0000. F is the fractional part of the GPS-GLONASS system time offset, the integer seconds (leap seconds) and integer hour offsets are automatically set by the receiver.

Example: Set GLONASS system time shift to -1.3 microseconds

$PASHS,DTG,-1.3

This parameter needs to be defined close to the real time shift value for the receiver to compute position when this parameter is being used. As of September 1997, the time shift value is 1.2 microseconds.

DTM: Datum Selection

$PASHS,DTM,str

This command selects the geodetic datum used for position computation.

where str can be W84 (WGS-84), E90 (PZ-90), USR (user-defined datum), or other predefined datum as listed in Appendix B. The default is WGS-84. Parameters for a user-defined datum are entered with the $PASHS,UDD command on page 110.

GPS ephemeris are transmitted in WGS-84 reference system (default) and GLONASS ephemeris in Earth-90 system (PZ-90). The positions of GLONASS satellites are automatically transformed to the WGS-84 reference system, unless the SYS = GLO, in which case PZ-90 is used by default. If

computed positions based on a different datum are desired, select the datum from Appendix A, or issue the command $PASHS,UDD (user-defined datum).

Example: Set the datum to International 1924.

$PASHS,DTM,AST<Enter>

DUG: UTC-GPS Time Difference

$PASHQ,DUG

Displays information on the time difference between UTC and GPS system times. The response message is in the form:

$PASHR,DUG,struct

where struct is in binary format as listed in Table 6.8

Table 6.8: GPS-UTC Time Codes

Type	Size (bytes)	Content	Units	Example	
				Actual Number	Interpretation
unsigned short	2	GPS week of current GPS-UTC time correction	week numbers	897	week 897
unsigned short	2	GPS system time of current GPS-UTC time correction	seconds x 2^{12} (4096)	123	$123x2^{12}$ seconds
unsigned short	2	Current GPS-UTC time correction	seconds	11	11 seconds
unsigned short	2	GPS week of correction’s change	week numbers	834	week 834
unsigned short	2	Day of correction’s change	1...7	1	day 1
unsigned short	2	New GPS-UTC time correction	seconds	11	11 seconds
unsigned short	2	Checksum computed by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result.			
Total bytes	14				

ELM: Raw Data Elevation Mask

$PASHS,ELM,x

Sets the value of elevation under which the measurement data (MCA) for that satellite will not be output or recorded into data storage memory, where x is the elevation mask in degree. The default is 5°.

Example: Set elevation mask to 10 degrees

$PASHS,ELM,10

ELM controls the elevation mask for satellites used for raw measurement output, and Base station output of RTCM messages Type 18 & 19.

PEM controls the elevation mask for satellites used for position computation, and Base station output of RTCM messages Type 1,9,31 & 34.

EPG: Set Kinematic Epoch Counter

$PASHS,EPG,d

Sets the initial value of the counter of epochs 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 want to occupy a site for a set amount of time. When the number of epoch goes to zero, the site name will be set automatically to ???? indicating that the receiver is in motion.

Example: Sets the epoch counter to 20.

$PASHS,EPG,20<Enter>

The site name must be set with the $PASHS,SIT command before the epoch counter works.

EXF: Set Frequency Input

$PASHS,EXF,s

This command sets internal/external reference frequency input, where s is either ON, OFF or an external frequency value in Hz.

Table 6.9 outlines the structure:

Table 6.9: EXF Structure

Field	Description
ON	Turn on external reference frequency (if s=ON, the external reference frequency must be 20 MHz. If the frequency is not 20 MHz, use s=XXX)
OFF	Revert to internal oscillator (default)
XXX	Set external frequency to a value between 10,000 and 21,000,000 Hz in steps of 10,000 Hz

User settings are saved in battery-backed-up memory through power cycles, and are used until a new frequency is selected, until turned off ($PASHS,EXF,OFF) or the memory is cleared.

Example: Enable the external frequency at 20 mHz.

$PASHS,EXF,ON<Enter>

$PASHQ,EXF,c

The associated query command is $PASHQ,EXF, where c is the optional output serial port.

Example: Query the external frequency status to port A.

$PASHQ,EXF,A<Enter>

$PASHR,EXF

The response message is in the form **$PASHR,EXF,s** where s is:

Table 6.10: EXF Response Structure

Field	Description
OFF	Internal oscillator is used
s	External frequency is used, at frequency s

FIL: Close or Delete File

$PASHS,FIL,x,y

Closes the current file or deletes a designated file, where x is C for close or D for delete, and y is the file index number. The receiver can store up to 100 files. The first file is numbered 0, not 1.

Special case: command $PASHS,FIL,D,999 deletes all files including the current file, and opens a new current file.

Parameter y is available only for command $PASHS,FIL,D, not for $PASHS,FIL,C.

If the current file has zero length, command $PASHS,FIL,C does not create a new file. Instead an old file will be kept as current.

If the maximum number of files (100) is reached, command $PASHS,FIL,C is disabled (NAK returns as response for this command).

Examples: Close the current file

$PASHS,FIL,c<Enter>

Delete file number 4

$PASHS,FIL,D,3<Enter>

FIX: Altitude Fix Mode

$PASHS,FIX,x

Set altitude hold position fix mode for the altitude used (for 2- D position determination), where x is 0 or 1.

x = 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,POS command, or the last one computed when VDOP is less than VDOP mask.

x = 1, only the most recently entered altitude is used

Example: Fix using most recent altitude

$PASHS,FIX,0

FLS: Receiver 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 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 command will not be acknowledged (NAK is returned).

Example: Display file information for files 1-10.

$PASHQ,FLS,0

Display file information for files 6-15.

$PASHS,FLS,5

$PASHR,FLS

The response returns file size, name, and available memory information.

Response:

$PASHR,FLS,d1,f1,f2,n(s1,m1,f3)*cc

where n = the number of files

Table 6.11: FLS Response Structure

Field	Description
d1	Free memory in receiver memory card in Kbytes.
f1	Total number of files currently in the receiver.
f2	Number of files that match the query parameter and are displayed in the response.
s1	File 4 character site name.
m	Time of file opening in the format wwwwdhhmm where: wwww = the GPS week number d = the day in the week (0-6) hhmm = hours and minutes
f3	Size of the file in Kbytes
*cc	checksum

FSS: Get System File Status

$PASHQ,FSS

This command queries file system status, where x is the optional response port.

Example: Query the file system status, directing the response to Port B

$PASHQ,FSS,B

$PASHR,FSS

The associated response message is:

$PASHR,FSS,f,d1,d2,d3,d4,d5

where Table 6.12 outlines the response format.

Table 6.12: FSS Response Structure

Field	Description
f	internal diagnostic number (not used by user), 4 digits in hex
d1	internal diagnostic number, 2 digits
d2	internal diagnostic, 2 digits
d3	index of current file, 3 digits in range 0-99 or 999 if there is no current file
d4	total number of files, 3 digits
d5	mounting, percent done, 3 digits.

Field d5 indicates the mounting status of the file system in percent; 100 indicates the file system is fully mounted

All file system commands are available only when the system is fully mounted. Mounting takes just a moment if the internal memory was not reset (see command $PASHS,INI). If the internal memory was reset, mounting can take a few minutes. In this case, command $PASHQ,FSS (parameter d5 in particular) is a convenient way to get the current estimation of the mounting percent.

GTF: Set GLONASS Time Shift

$PASHS,GTF,d

This command sets the GLONASS system time shift hold position fixed mode, where d is 0 or 1.

d = 0 - Use the most recent computed GLONASS system time shift

d = 1 - Always use GLONASS system time shift entered by $PASHS,DTG.

Default is 0.

This command does not set the GLONASS system time shift, but just says whether to use the last computed or entered value of GLONASS system time shift in fixed mode.

GTM: GLONASS Time Shift Relative or Fixed

$PASHS,GTM,d

This command specifies whether to compute GLONASS system time shift relative to GPS system time, or hold it fixed, where d is 0, 1, or 2. Default = 1.

d = 0 - GLONASS system time shift is never held fixed

d = 1 - Compute GLONASS system time shift if number of satellite (N) is enough to compute position, but hold it fixed if number of satellites is N-1. See PMD for number of satellites required to compute position.

d = 2 - GLONASS system time shift is always held fixed.

When d = 0, if the number of satellites is less than needed, position is not computed.

GTP: Set Priority of GLONASS Time Shift

$PASHS,GTP,c

This command sets the priority of GLONASS system time shift computation against altitude computation if the number of used satellites is 4, where c sets the priority. If c = Y, time shift has priority over altitude. If c = N, altitude has priority over time shift. Default is Y.

Y sets the receiver to compute GLONASS system time shift and hold altitude fixed. N sets the receiver to compute altitude and hold GLONASS system time shift fixed.

If GPS and GLONASS satellites are used in position computation, and both PMD and GTM are set to a value different than 0, (fix altitude or time shift when fewer than 5 satellites), then with only 4 used satellites: Y (default) sets the receiver to compute GLONASS time shift and hold altitude fixed. N sets the receiver to compute altitude and hold GLONASS time shift fixed.

Example: Set to compute GLONASS system time shift and use fixed altitude

$PASHS,GTP,Y<Enter>

HDP: Horizontal Dilution of Precision

$PASHS,HDP,d

Set value of HDOP mask (default = 4), where d is a number between 0 and 99.

Example: Set HDOP mask to 6

$PASHS,HDP,6<Enter>

INF: Set Session Information

$PASHS,INF,c1,s1,s2,s3,s4,s5,f1,d1,d2,d3,d4

Sets a variety of session information parameters.

where the fields are as defined in Table 6.13.

Table 6.13: INF Command Structure

Field	Description	Range
c1	session name	1 alphanumeric char
s1	receiver serial number	3 alphanumeric char
s2	antenna number, up to 3 ASCII characters	3 alphanumeric char
s3	month and day of the session (mmdd)	01-12 month 01-31 day
s4	operator identification	3 alphanumeric char
s5	user comment	up to 9 alphanumeric char
f1	antenna height in meters	0.0000-64.000
d1	dry temperature in degrees Celsius	-99 - +99
d2	wet temperature in degrees Celsius	-99 - +99
d3	relative humidity in percent	0 - 99
d4	barometric pressure in millibars	0 - 9999

Example: Set session parameters

$PASHS,INF,A,325,401,0313,DWK,test-Proj,1.456,65,60,65,1010

$PASHQ,INF,c

Query the survey session parameters, where c is the optional output port.

Example: Query session parameters to the current port.

$PASHQ,INF<Enter>

$PASHR,INF

The response message is in the form

$PASHR,INF,f1,d2,d3,d4,c5,d6,d7,s8,c9,s10,s11,d12,s13,s14,f15,d16,d17,d18,d19,
f20,d21,d22,d23,d24

where the fields are as described in Table 6.14

Table 6.14: INF Response Structure

Return Parameter	Description	Range
f1	Data recording interval	0.5 to 999.5 seconds
d2	Minimum number of satellites for data recording	0 to 9
d3	Satellite elevation angle mask for data recording	0 to 90 degrees
d4	Type data recorded	0 or 2
c5	Recording data switch	Y or N
d6	Minimum number of satellite for kinematic alarm.	
d7	Number of epochs to go for kinematic survey	0 to 999
s8	Site name	4 alphanumeric characters
c9	Session name	1 alphanumeric character
s10	Receiver number	3 alphanumeric characters
s11	Antenna number	3 alphanumeric characters
d12	Month and day of session, mmdd	0101 to 1231
s13	Operator identification	3 alphanumeric characters
s14	User comment	up to 9 alphanumeric characters
f15	Antenna height in meters before data collection	0.0000 to 6.4000 m
d16	Dry temperature before data collection	-99 to +99°C
d17	Wet temperature before data collection	99 to +99°C
d18	Relative humidity before data collection	0 to 90%
d19	Barometric pressure before data collection	0 to 9999 millibars
f20	Antenna height **after** data collection (meters)	0.0000 - 64.000
d21	Dry temperature **after** data collection (degrees celsius)	±99
d22	Wet temperature **after** data collection (degrees celsius)	±99
d23	Relative humidity **after** data collection (percent)	0 - 99

Table 6.14: INF Response Structure (continued)

Return Parameter	Description	Range
d24	Barometric pressure **after** data collection	0 - 9999
*cc	Checksum	

INI: Receiver Initialization

$PASHS,INI,x1,x2,x3,x4,z

Reset receiver memory and serial port baud rates, where x1 through x4 are the codes for baud rate settings for ports A through D respectively (see $PASHS,SPD command for code), and z is the memory reset code defined in Table 6.15.

Table 6.15: Reset Memory Codes

Reset Memory Code z	Action
0	No memory reset
1	Reset internal memory
2	Reset external memory (data storage)
3	Reset internal and external memory.

Example: Reset baud rate of ports A, B, C, and D to 9600 baud and reset internal and external memory.

$PASHS,INI,5,5,5,5,3

ION: Set Ionospheric Models

$PASHS,ION,x

Exclude or include the ionospheric and tropospheric models from the position computation, where x = N (exclude) or Y (include). Default is N (exclude).

Example: Include ionospheric and tropospheric models

$PASHS,ION,Y

$PASHQ,ION,x

Query current ionospheric data information, where x is the port through which the response message should be output. Note that x is not required to direct the response message to the current communication port.

$PASHR,ION

The response message has the format:

$PASHR,ION,struct

where Table 6.16 outlines *struct*.

Table 6.16: Ionosphere Data Format

Type	Size	Content
float	4	a_0 ionospheric parameter (seconds).
float	4	a_1 ionospheric parameter (sec. per semicircle).
float	4	a_2 ionospheric parameter (sec. per semicircle^2).
float	4	a_3 ionospheric parameter (sec. per semicircle^3).
float	4	b_0 ionospheric parameter (seconds).
float	4	b_1 ionospheric parameter (sec. per semicircle).
float	4	b_2 ionospheric parameter (sec. per semicircle^2).
double	8	b_3 ionospheric parameter (sec. per semicircle^3)
double	8	A_0 constant (zero-order terms of GPS/UTC polynomial) (sec)
double	8	A_1 constant (first-order terms of GPS/UTC polynomial) (sec/sec)
unsigned long	4	t_{ot} reference time for UTC data (seconds)
short	2	W_{nt} UTC reference week number
short	2	Δ_{tLS} delta time due to leap-second (seconds)
short	2	WN_{LSF} Week of leap second correction
short	2	DN day of leap second correction
short	2	DtLSF Delta time between GPS and UTC (seconds)
short	2	WN Current GPS week number
unsigned long	4	TOW current time of week in seconds
short	2	bulwn current GPS week number when message was read (usually same as WN)
unsigned long	4	bultow time of week when message was read (usually same as TOW) (seconds)

Table 6.16: Ionosphere Data Format (continued)

Type	Size	Content
short	2	Checksum computed by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	76 bytes	

None of the above ionosphere data is computed by the receiver; it is all obtained from the frame data transmitted by the satellites.

LPS: Loop Tracking

$PASHS,LPS,x,y,z

Set user-selectable third-order loop tracking parameters, where x is the ratio of the carrier loop, y is the carrier loop parameter, and z is the code loop parameter (see $PASHQ,LPS below for more information). Loop setting allows you to select the tracking loop parameters based on application. The carrier and code loop parameters are set independently. Firmware uses default values until you select another setting. The user settings are saved in battery-backed memory and are used until a new setting is selected, or the memory is cleared. The default is 10, 3, 1.

Example: Change loop parameters

$PASHS,LPS,2,1,1<Enter>

$PASHQ,LPS,x

The associated query command is $PASHQ,LPS,x, where x is the optional output port.

$PASHR,LPS

The response is in the form

$PASHR,LPS,x,y,z*cc

where

x = 0-10 (ratio)

y = 1, 2, or 3 (option # for selecting carrier loop)

z = 1, 2, or 3 (option number for selecting code loop)

Loop setting values:

1. **Third-order ratio** for carrier loop x (default = 10):

x = 0	indicates ratio of 0, i.e., no third-order, the carrier loop is a regular second-order loop (with damping of 1 instead of 0.7 as in previous versions)
x = 1	indicates ratio of 0.1, for low acceleration rate
x = 10	indicates ratio of 1.0, for high acceleration rate

2. **Carrier loop parameter** y (default = 3):

y = 1	indicates noise bandwidth of 0 = 10;static, very low phase noise
y = 2	indicates noise bandwidth of 0 = 25; low dynamics, low phase noise (< 2g for x=1 and <20g for x=10)
y= 3	indicates noise bandwidth of 0 = 50; high dynamics, medium phase noise (< 6g for x=1 and <100g for x=10)

3. **Code loop parameter** z (default = 1):

z = 1	indicates noise bandwidth of 0 = 1.0; fast range availability (5 sec), medium range noise
z = 2	indicates noise bandwidth of 0 = 0.5; medium range availability (10 sec), low range noise
z = 3	indicates noise bandwidth of 0 = 0.1; slow range availability (50 sec), very low range noise

For high dynamic applications, use the setting $PASHS,LPS,10,3,1.

LTZ: Set Local Time Zone

$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 +7 hours, 0 minutes

$PASHS,LTZ,+7,0

MRX: Set Transformation Matrix from PZ-90 to WGS-84

$PASHS,MRX

Sets the transformation matrix from PZ-90 to WGS-84. The structure is

$PASHS,MRX,f1,f2,f3,f4,f5,f6,f7

where the fields are as described in Table 6.17

Table 6.17: MRX (PZ-90 to WGS-84) Structure

Field	Description
f1,f2,f3	Translation in meters from PZ-90 to WGS-84. Range -1000.000 to +1000.000.
f4,f5,f6	Datum rotations in seconds of arc from PZ-90 to WGS-84. Range -10.0000 to +10.0000. + rotation is counterclockwise, - rotation is clockwise as viewed from the positive end of the axis about which the rotation takes place.
f7	Datum scale factor in ppm from PZ-90 to WGS-84. Range -10.00 to +10.00.

Default values are:

f1 = 0.0 f2 = +2.5 f3 = 0.0

f4 = 0.0 f5 = –0.3919″= $-1.9\text{x}10^{-6}$ radians f6 = 0.0

f7 = 0

The transformation evaluates the following matrix equation:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS-84} = \begin{bmatrix} 0.0 \\ 2.5 \\ 0.0 \end{bmatrix} + (1 + 0 \times 10^{-6}) \begin{bmatrix} 1.0 & -1.9\times10^{-6} & 0.0 \\ 1.9\times10^{-6} & 1.0 & 0.0 \\ 0.0 & 0.0 & 1.0 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{PZ-90}$$

$PASHQ,MRX,c

The accompanying query command has the structure, where c is the optional output port.

$PASHQ,MRX

$PASHR,MRX

The transformation matrix response message is in the format

$PASHR,MRX,f1,f2,f3,f4,f5,f6,f7

where the fields are as described in Table 6.17

MSV: Set Minimum Satellites

$PASHS,MSV,x

Set the minimum number of satellites required for MBN or MCA messages to be output, where x is a number between 1 and 9. Default is 3.

Example: Set minimum satellites to 4

$PASHS,MSV,4

PAR: Query Receiver Parameters

$PASHQ,PAR,c

Queries the general receiver parameters, where c is the optional output port and is not requires to direct the response message to the current communications port..

Example: $PASHQ,PAR

A typical response message (default values) is shown in Figure 6.1.

```
SPDA:5 SPDB:5 SPDC:5 SPDD:5
GPS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
GLO:YYYYYYYYYYYYYYYYYYYYYYYY
SYS:MIX DTM:W84 GTM:0 GTF:0 DTG:+000000.0000 TDP:04 GTP:Y
PMD:1 FIX:0 ALT:+00000.00 PDP:40 HDP:04 VDP:04
PEM:05 UNH:N ION:N SAV:N
RTC:OFF PRT:A
NMEA: LTN AIM POS GLL GXP GGA VTG GSN MSG GSA SAT GRS RRE TTT ZDA TCM RMC GST
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTD: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PER:001.00
```

Figure 6.1. Typical $PASHR,PAR Response Message

where Table 6.18 outlines the information in the response message.

Table 6.18: $PASHR,PAR Response Message Parameters

Parameter	Description
SPDA:5	Serial port A baud rate. Default is 5 (9600).
SPDB:5	Serial port B baud rate. Default is 5 (9600).
GPS:Y	GPS satellites attempted to acquire. Default is all Y.
GLO:Y	GLONASS satellites attempted to acquire. Default is Y.
SYS:MIX	Type of navigational system used (GPS, GLONASS, or mixed). Default is MIX.
DTM:W84	Geodetic datum being used. Default is WGS-84.
GTM:0	Time shift mode for the minimum number of satellites required to compute a position. Default is 0.

Table 6.18: $PASHR,PAR Response Message Parameters (continued)

Parameter	Description
GTF:0	Time shift mode for position computation. Default is 0.
DTG:0	Time shift in microseconds. Default is 0.
TDP:04	Time dilution of precision. Mask default is 04.
GTP:Y	Time shift priority over altitude fixed for position computation. Default is Y.
PMD:1	Position mode for the minimum number of satellites required to compute a position.
FIX:0	Altitude hold position fix mode for the altitude used when computing a 2-D position. With the default value (0), the most recent antenna altitude is used.
ALT:+00000.00	Height of the antenna position in meters. Default is 0.
PDP:40	Position Dilution Of Precision. Mask default is 40.
HDP:04	Horizontal Dilution Of Precision. Mask default is 04.
VDP:04	Vertical Dilution Of Precision mask. Default is 04.
PEM:05	Position elevation mask. Elevation below which the satellite will not be used to compute a position. Default is 05 degrees.
UNH:N	Use unhealthy satellites for position computation. The default is N.
ION:N	Do not include ionospheric and tropospheric models in position computation. Default is N.
SAV:N	Save parameters in the battery-backed memory. With default value (N), at the next power cycle, the default parameters are used.
RTC:OFF	RTCM differential mode setting. OFF for disabled, BAS for base station setting, REM for remote station setting. Default is OFF.
PRT:A	Port assigned to send or receive differential corrections.
PER:001.00	Send interval of the NMEA response messages, with the exception of TTT. Default is 1 second.

For NMEA messages LTM, AIM, POS, GLL, GXP, GGA, VTG, GSN, MSG, GSA, SAT, GRS, RRE, TTT, and ZDA, the default is OFF (disabled) for both ports.

PDP: Position Dilution of Precision

$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: Position Elevation Mask

$PASHS,PEM,d

This command sets the elevation mask for position computation. The structure is $PASHS,PEM,d where d is 0 to 90 degrees. Default is 5 degrees. Satellites with elevation less than the elevation mask are not used for position computation.

Example: Set position elevation mask to 15 degrees

$PASHS,PEM,15<Enter>

ELM controls the elevation angle for satellites used for raw measurement output and Base station output of RTCM messages Type 18 & 19. PEM controls the elevation angle for satellites used for positions and Base station output of RTCM messages Type 1, 9, 31 & 34.

PHE: Photogrammetry Edge

$PASHS,PHE,c

This command allows you to set the edge (rising or falling) at which the trigger signal associated with the photogrammetry event will be measured where c = R (photo rising edge), or F (photo falling edge). Default is R.

Example: Set the photogrammetry edge to falling edge.

$PASHS,PHE,F<Enter>

$PASHQ,PHE,c

The associated query command is $PASHQ,PHE,c, where c is the optional output port.

Example: Query the photogrammetry edge setting to port B.

$PASHQ,PHE,B<Enter>

$PASHR,PHE,c

The response is in the form:

$PASHR,PHE,x*cc

where c is R for rising edge, or F for falling edge, and *cc is the checksum.

PMD: Position Mode

$PASHS,PMD,d

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

Table 6.19: Position Mode Settings

Mode	Description
d = 0	minimum of 5 satellites needed (e.g., for 3-D)
d = 1	default, minimum of 4 satellites needed; with 4 satellites, altitude is held (2-D); with 5 or more, altitude is not held (3-D) (Default)
d = 2	minimum of 4 satellites needed; altitude always held (always 2-D)
d = 3	minimum 4 satellites needed; with 4 satellites, altitude is always held; with 5 satellites, altitude is held only if HDOP is greater than HDOP mask (2-D), otherwise 3-D

The number of satellites required to compute a position is based on SYS = MIX. For SYS = GPS or SYS = GLO, the number of satellites required is N - 1. Also, the description of the number of satellites required to hold altitude fixed is based on the assumption that GTP is set to Y and altitude will be held fixed before time shift.

Example: Set minimum number of satellites for 3-D computation

$PASHS,PMD,0<Enter>

POP: Position Fix Rate

$PASHS,POP,d

Set the internal update rate of the receiver, where d may be either 2 or 5 Hz, indicating that the position will be computed 2 or 5 times per second, depending upon the setting; the default is 2 Hz.

The 2 or 5 Hz rates are available only if the corresponding option has been installed in the receiver. When POP is set to 5, the number of satellites in the position computation will be reduced to 16 satellites because of CPU processing limitation. However, all satellites are tracked, even when the update rate is 5 Hz.

Example: Set the internal update rate to 5Hz

$PASHS,POP,5<Enter>

POS: Set Antenna Position

$PASHS,POS,m1,c1,m2,c2,f1

Sets the position of the antenna used in differential base mode.

Table 6.20: POS Structure

Field	Description	Range
m1	Latitude in degrees, decimal minutes (ddmm.mmmmmm)	0 - 90.0
c1	North (N) or South (S)	N, S
m2	Longitude in degrees, decimal minutes (dddmm.mmmmmm)	0 - 90.0
c2	East (E) or West (W)	E, W
f1	the ellipsoidal height in meters (+ or -) and xxxxx.xxx	± 0 - 99999.999

Example: Set antenna position

$PASHS,POS,3722.291213,N,12159.799821,W,+15.25<Enter>

POS CUR: Set Antenna to Current Computed Position

$PASHS,POS,CUR

This command is an extension of the $PASHS,POS command, setting the antenna to the current (last computed) position as base coordinates.

If the receiver is not curently computing a position, the last computed position is stored. If the receiver has not computed a position, the command is ignored.

POW: Battery Parameters

$PASHS,POW,d1,d2,f1

The POW command allows you to enter parameters associated with the external battery. The query and response uses entered parameters to compute the approximate amount of available time left on the battery.

Table 6.21: POW Parameter Table

Parameter	Description	Range
d1	battery capacity in mAh	500 - 10000

Table 6.21: POW Parameter Table

Parameter	Description	Range
d2	battery capacity in percent (percent charged)	0-100
f1	battery voltage	10.0 - 28.0

Example: Set the POW parameters of a 12 volt battery with a capacity of 5000 mAh that is 100% charged.

$PASHS,POW,5000,100,12.0 <Enter>

The data shown for the external battery is estimated based on user entered parameters and the power consumption of the receiver. The user should re-Enter the battery parameters after clearing the receiver's internal memory. Using receiver to power external devices such as radios can reduce the effectiveness of this command.

$PASHQ,POW,c

The POW query command requests current available battery power data, where c is the optional port to which the response will be sent.

$PASHR,POW

The available battery power displayed in the response is computed from the battery parameters entered and the amount of time the receiver has been on.

$PASHR,POW,d1,d2,d3,f1*cc

where Table 6.22 outlines the response format:

Table 6.22: POW Message Structure

Parameter	Description	Unit
d1	battery capacity (time)	minutes
d2	capacity remaining	minutes
d3	battery capacity (power)	mAh
f1	battery voltage	volts
*cc	checksum	n/a

PPO: Point Positioning

$PASHS,PPO,c

Enable/disable point positioning mode, where c is either Y (enable) or N (disable). Point positioning is an averaging algorithm that will improve the stand-alone accuracy of a static point after about 4 hours.

Example: Enable point positioning mode

$PASHS,PPO,Y <Enter>

PPS: 1 PPS Pulse Output

$PASHS,PPS,f1,f2,c3

The GG Surveyor GPS board can generate 1 PPS pulse (page 31) with programmable period and offset. 1 PPS is generated by default once every second with its rising or falling edge synchronized to the GPS system time (or UTC + 3 hours if SYS is set to GLO). The PPS set command allows you to change the period and the offset of the pulse, where Table 6.23 outlines the parameters:

Table 6.23: PPS Parameters

Field	Description
f1	1PPS period in seconds with a range between 0.2 and 99, depending upon the receiver update rate, which depends upon the position update or raw data update options
f2	Offset from GPS system time in milliseconds, with 100ns resolution (range between -999.9999 and +999.9999)
c3	R (Synchronize the rising edge of the pulse with GPS system time), or F (synchronize the falling edge of the pulse with GPS system time).

The precision of the PPS signal is 70 nano seconds in stand-alone mode with SA active, and 45 nano seconds in differential mode.

Example: Set 1PPS to a period of 2 seconds an offset of 500ms, and synchronize the rising edge of the pulse with GPS time.

$PASHS,PPS,.2.0,+500,R<Enter>

$PASHQ,PPS,x

The associated query command is $PASHQ,PPS,x, where x is the optional output port.

Example: Query 1PPS parameters to port A.

$PASHQ,PPS,A<Enter>

$PASHR,PPS

The receiver response message to this query command is in the form:

$PASHR,PPS,f1,f2,c3,*cc

where Table 6.24 outlines the response:

Table 6.24: PPS Response Structure

Field	Description
f1	Period in seconds
f2	Offset value
c3	R (rising) or F (falling) for the synchronization edge of the pulse
*cc	is the checksum

PRJ: Set Session Logging Information

$PASHS,PRJ,c1,s2,s3,m4,s5

This command sets the information about current project, where Table 6.25 outlines the parameters. The parameters entered with this command are saved into an S-file after downloading.

Table 6.25: PRJ Structure, Current Project Information

Parameter	Description
c1	session name, 1 character
s2	receiver serial number, up to 3 characters
s3	antenna number, up to 3 characters
m4	month of the session, up to 2 characters
s5	operator information, up to 3 characters
s6	user comment, up to 9 characters

Example: Set the session information

$PASHS,PRJ,A,004,121,0412,DWK,Test_CASE<Enter>

PRT: Port Setting

$PASHQ,PRT,c

This command displays the baud rate setting for the connected port, where c is the optional output port.

Example:

$PASHQ,PRT<Enter>

$PASHR,PRT

The response is a message in the form:

$PASHR,PRT,x,d   where

x = communication port

d = communication speed outlined in Table 6.26

Table 6.26: Serial Port Baud Rate Codes

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

RCI: Recording Interval

$PASHS,RCI,f

Sets the value of the interval at which raw data messages will be recorded or output, where f is any number between 0.2 and 999 in seconds, depending upon the raw data update rate option installed (Table 6.27). Default is 20.0.

Table 6.27: Raw Data Update Rate Options

Installed Option	RCI Range (seconds)	Increment
1 Hz	1-999	1 second

Table 6.27: Raw Data Update Rate Options (continued)

Installed Option	RCI Range (seconds)	Increment
2 Hz	0.5-999	0.5 second from 0.5 to 1 1 second from 1 to 999
5 Hz	0.2-999	0.2 second from 0.2 to 1 1 second from 1 to 999

At a 2-Hz output rate, a baud rate of 115,000 bps is required to output all the raw data (MBN, PBN, SNV, SNG, SAL, and SAG) and NMEA messages. At higher output rates, the raw data must be split between two serial ports, or some of the messages should be turned off. To receive data at high baud rates (e.g., 115,000), you must ensure that your computer has a suitable serial I/O capability. Most computers with 486 or Pentium processors and 16550 UART serial ports can support high data rates. For a 5-Hz update rate, the $PASHS,POP,5 command should have been sent previously.

Example: Set recording interval to 5 seconds

$PASHS,RCI,5<Enter>

REC: Turn Data Recording On/Off

$PASHS,REC,c

Turn data recording on or off, where c is Y (yes) or N (no). The Default is Y.

RID:Receiver ID

$PASHQ,RID,c

This query command allows you to display the receiver ID, firmware version, and installed options, where c is the optional output port.

Example: Query the receiver in to the current port.

$PASHQ,RID<Enter>

$PASHR,RID

The response to the $PASHQ,RID command is a message in the form:

$PASHR,RID,G2,s1,s2*cc

where:

G2 = GG Surveyor

s1 = firmware version

s2 = installed option

For more information on the options, see “Receiver Options” command on page 4.

Response:

$PASHR,RID,G2,GA00,25OP--1LEGM--S*1A

A- (dash) in any of the option slots indicates that the option is not installed, and an underscore indicates that it is not available.

RIO: Request for Receiver ID

$PASHQ,RIO

This command lets you query the receiver ID. The response is output through the port that received the request.

$PASHR,RIO

The response message is in the form:

$PASHR,RIO,s1,s2,s3,s4,s5*cc

where Table 6.28 outlines the response parameters:

Table 6.28: RIO Structure

Field	Description	Range
s1	Product name or receiver type	Maximum 10 characters
s2	Main processor firmware version	Maximum of 10 characters
s3	Channel firmware version	Maximum of 10 characters
s4	Option settings	Maximum of 12 characters
s5	Serial number	Maximum of 20 characters
cc	Byte-wise checksum (XOR of all characters between but excluding $ and *)	2 hex characters

Example: Query the receiver ID.

$PASHQ,RIO

Typical Response:

$PASHR,RIO,GG24,1R49,1E53,-U-1-M-Q-L-,AD00109JMEWG*35

RNG: Set Data Type

$PASHS,RNG,d

Set type of data to be recorded, where d is 0 or 2. 0 = geodetic data (B-file), 2 = position data (C-file). Default is 0. If the type of current file is different from the type entered with this command, the current file will be closed and a new one, of the new type, is created.

Example: Record a C-file (position only) in data storage.

$PASHS,RNG,2<Enter>

RST: Reset Receiver to Default Parameters

$PASHS,RST

Reset the receiver parameters to their default values. For more information, see the query commands PAR, RAW, and RTC.

Example: Reset user parameters to default values.

$PASHS,RST<Enter>

SAV: Save User Parameters

$PASHS,SAV,x

Enables or disables saving user parameters in the battery-backed-up memory (BBU), where x is Y (yes) or N (No). User parameters (entered before issuing the SAV command) are saved until commands INI or RST or SAV,N are issued. The default is N. All parameters are saved in the battery backup memory except the POP parameter.

Set commands issued after the SAV command is issued are not saved.

Example: Save user parameters to internal battery memory

$PASHS,SAV,Y<Enter>

SIT: Set Site Name

$PASHS,SIT,s

Set site name, where s is a 4 character string.

Example: Set site name to 0001

$PASHS,SIT,0001<Enter>

SMI: Code Measurement Smoothing

$PASHS,SMI,d

Sets the interval in seconds of code measurements smoothing, where d is the interval in seconds ranging from 0 to 1000. The default is 100.

Example: Set code measurement smoothing to 200 seconds.

$PASHS,SMI,200<Enter>

$PASHQ,SMI,c

The associated query command is $PASHQ,SMI,c, where c is the optional output port.

$PASHR,SMI,d

The response message is in the form:

$PASHR,SMI,*cc

where d is the smoothing interval in seconds.

SMV: Speed Filtering

$PASHS,SMV,d

This command sets the interval of speed filtering for the receiver velocity, where d is the interval ranging from 0 to 999 seconds. A filter interval of 0 seconds indicates no filtering.

SNR: Set Signal-to-Noise Ratio

$PASHS,SNR,s

Sets the algorithm used for computing signal-to-noise ratio, where s is a 3-character algorithm identifier ; algorithm identifiers are DBH and AMP. Default is AMP.

More more information about these settings, see the “Signal to Noise” section, of Chapter 4.

Example: Compute SNR using DBH algorithm

$PASHS,SNR,DBH<Enter>

$PASHQ,SNR,x

The associated query command is $PASHQ,SNR,x where x is the optional port where the reply will be sent.

$PASHR,SNR

The receiver response message is in the form $PASHR,SNR,str*cc, where str is DBH or AMP, and cc is the checksum.

SPD: Serial Port Baud Rate

$PASHS,SPD,x,d

Set the baud rate of the GG Surveyor serial port x, where d is the output port, and d is a number between 0 and 9 specifying the baud rate as shown in Table 6.29 Default is 9600 baud.

Table 6.29: Baud Rate Codes

Code	Baud Rate	Code	Baud Rate
0	300	5	9600
1	600	6	19200
2	1200	7	38400
3	2400	8	57600
4	4800	9	115200

To resume communication with the GG Surveyor after changing the baud rate using this command, change the baud rate of the command device.

Example: Set port A to 19200 baud

$PASHS,SPD,A,6<Enter>

STA: Show Status of Satellites

$PASHQ,STA,c

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

Example: Query STA to the current port.

$PASHQ,STA<Enter>

The response is a free format table that shows the current time, the PRN and signal to noise of each satellite locked.

Example:

```
TIME:   18:38:31 UTC
LOCKED: 03 23 16 39 54
COUNT:  54 26 17 31 35
```

STB: Measurement Strobe Parameters

$PASHS,STB,d1,f1,c1

This command allows you to set the period factor, the offset, and the synchronization edge of the measurement strobe. The parameters are described in Table 6.30.

The period of the strobe is a function of the period factor times the recording interval (RCI). For example, if the period factor is set to 3 and the RCI is set to 2 seconds, then the period of the strobe will be 6. The offset is offset from GPS system time if the SYS parameter is set to GPS or MIX, and to GLONASS system time (UTC+3 hours) if SYS is set to GLO. Default parameters are 1,0,0,R. The accuracy of the strobe pulse is the same as for the PPS pulse.

Table 6.30: STB Structure

Parameter	Description	Range	Default
d1	Period factor. Determines the period of the pulse in seconds by the function (d1 *RCI) where d1 is the period factory and RCI is the recording interval.	0-9999	1
f1	Offset from system time in milliseconds	+999.9999	0.0
c1	Edge setting. Synchronizes the pulse to either the rising edge ® or the falling edge (F).	'R', 'F'	R

Example: Set the measurement strobe to have a period factor of 5, and offset of 10 milliseconds, and set the synchronization edge to be the falling edge.

$PASHS,STB,5,10,0,F<Enter>

$PASHQ,STB,x

The associated query command is $PASHQ,STB,x, where x is the optional output port.

$PASHR,STB

The receiver response message is in the form:

$PASHR,STB,d1,f1,c1*cc

where the parameters are described in Table 6.30.

SVP: Select Satellite to Use in Position Computation

$PASHS,SVP,c1,c2,c3.....c56

This command selects the satellites to use in position computation, where c is Y (use) or N (not use). Up to 56 satellites may be selected, and are entered in the order of the PRN number.

Example: Use 1-15, 21-32, 38-42, and 48-56; do not use 16-20, 33-37, and 43-47

$PASHS,SVP,YYYYYYYYYYYYYYYNNNNNYYYYYYYYYYYYN
NNNNYYYYYNNNNNYYYYYYYYY<Enter>

$PASHQ,SVP

The associated query command is $PASHQ,SVP,x where x is the optional output port.

Example: Direct SVP query to port A:

$PASHQ,SVP,a<Enter>

$PASHR,SVP

The response message is in the form **$PASHR,SVP,c1,c2....c56** where each c is associated with the setting of one of the 56 PRN numbers.

SVS: Satellite Selection

$PASHS,SVS,c1,c2,c3........C56

Select satellites that the GG Surveyor attempts to acquire, where:

c= Y, satellite is used (default). x = N, satellite is not used.

Up to 56 satellites may be selected. They are entered in order of PRN number, where numbers from 1 to 32 correspond to GPS satellites, and 33 to 56 to GLONASS satellites. If fewer than 56 are specified the rest are left as they are. Only the characters Y and N are accepted.

Example: Use 1-9, 12, 13, 33-36, 39-40, 45-56 do not use 10, 11, 14-32, 37, 38, 41-44

$PASHS,SVS,YYYYYYYYYNNYYNNNNNNNNNNNNNNNNNN
NNYYYY NNYYNNNNYYYYYYYYYYYY

SYS: Set Navigational System

$PASHS,SYS,s

Set navigational system to be used for positioning, where s is GPS, GLO, or MIX:

GPS - Only GPS is used

GLO - Only GLONASS is used

MIX - Both systems are used (default)

Example: Set the receiver to use GPS only

$PASHS,SYS,GPS<Enter>

TDP: Time Shift Dilution of Precision

$PASHS,TDP,d

Set GLONASS system time shift DOP mask, where d is 0 to 99. Default is 4. This is analogous to the VDP command. The time shift is only computed when TDOP is less than the TDOP mask. If TDOP is greater than the TDOP mask, then the most recently computed time shift is used when the number of satellites is low.

Example: Set GLONASS system time shift DOP mask to 30

$PASHS,TDP,30

TSC: Set Type of Time Scale

$PASHS,TSC,s

Sets the time scale to use for output data, where s is GPS or GLO:

GPS - use GPS system time scale (default)

GLO - use GLONASS system time scale

For SYS = GPS, TSC automatically sets to GPS system time scale. For SYS = GLO, TSC automatically sets to GLO. For SYS = MIX, the default setting of TSC is GPS. The messages affected are:

NMEA messages (always output UTC time),
Raw data (time tag dependent upon TSC setting),
1 PPS/measurement strobe (time tag dependent upon TSC setting),
Photo pulse (time tag dependent upon TSC setting).

$PASHQ,TSC,x

The associated query command is $PASHQ,TSC,x where x is port the optional output port.

$PASHR,TSC,s

The associated response message is $PASHR,TSC,s   where s is GPS or GLO.

UDD: Set User-Defined Datum

$PASHS,UDD,d1,d2,f1,f2,f3,f4,f5,f6,f7,f8

Sets the user-defined datum parameters in the receiver memory, where

Table 6.31: UDD Structure

Field	Description	Range	Units	Default
d1	Geodetic datum id. Always 0 for WGS 84	0	n/a	0
d2	Semi-major axis	6300000-6400000	meters	6378137
f1	Flattening in meters	290.00000000-300.00000000	meters	298.25722356
f2	Translation in x direction	±1000.000	meters	0.0
f3	Translation in y direction	±1000.000	meters	0.0
f4	Translation in z direction	±1000.000	meters	0.0

Table 6.31: UDD Structure (continued)

Field	Description	Range	Units	Default
f5	Rotation in x axis + rotation is counter clockwise, and rotation is clockwise rotation.		radians	0.0
f6	Rotation in y axis		radians	0.0
f7	Rotation in Z axis		radians	0.0
f8	Scale factor. Range -10.00 to +10.00	±10	n/a	0.0

For these parameters to be used, the DTM parameter must be set to 'USR'.

Example: Define local datum as the WGS-72 datum

$PASHS,UDD, 0,6378135.0, 298.26,0,0,4.5,0,0,-0.554,0.23

$PASHS,DTM,USR

This implements the transformations listed in Table 6.32 and below.

Table 6.32: Ellipsoid Parameters for WGS-72 and WGS-84

Datum	Reference Ellipsoid	a[m]	1/f
WGS-72	WGS-72	6378135.0	298.26
WGS-84	WGS-84	6378137.0	298.257223563

$\Delta x = \Delta y = 0$ $\Delta z = 4.5$ meters $m = 0.23 \times 10^{-6}$

$\varepsilon_x = \varepsilon_y = 0$ $\varepsilon_z = -2.686 \times 10^{-6}$ radians $= -0.''554$

in the following equation:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS-84} = \begin{bmatrix} 0 \\ 0 \\ 4.5 \end{bmatrix} + (1 + 0.23 \times 10^{-6}) \begin{bmatrix} 1 & -2.686 \times 10^{-6} & 0 \\ 2.686 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS-72}$$

Internally, the receiver implements the transformation *from* WGS-84 *to* WGS-72. Figure 6.2 demonstrates the change in the coordinate systems.

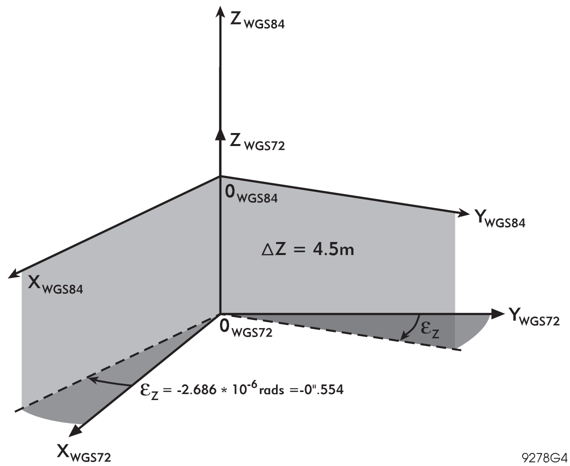

Figure 6.2: Rotation and Translation Between Coordinate Systems

$PASHQ,UDD,c

The associated query command is **$PASH,UDD,c** where c is the optional output port; and is not required to direct the response message to the current communication port.

Example: Query datum parameters to port C.

$PASHS,UDD,c<Enter>

$PASHR,UDD

The response is in the format:

$PASHR,UDD,d1,d2,f1,f2,f3,f4,f5,f6,f7,f8

where the fields are as defined in Table 6.31.

USE: Use Satellites

$PASHS,USE,d,c

Selects satellites to track or not track, where

d = ID number of satellite, 1-32 for GPS, 33-56 for GLONASS

ALL = all satellites

GPS = GPS satellites only

GLO = GLONASS satellites only

c = Y to use, N to not use

By default, all satellites are turned on (set to Y).

Example: Use (track) satellite 15

$PASHS,USE,15,Y<Enter>

USP: Select Satellite to Use in Position Computation

$PASHS,USP,d,c

This command selects an individual satellite to use in position computation, The structure is $PASHS,USP,d,c, where:

d = ID number of satellite, 1-32 for GPS, 33-56 for GLONASS

ALL = all satellites

GPS = GPS satellites only

GLO = GLONASS satellites only

c = Y to use, N to not use

By default, all satellites are turned on (set to Y)

Example: Do not use Satellite 4

$PASHS,USP,4,N

UTS: Synchronize with GPS Time

$PASHS,UTS,s

This command enables (s=ON) or disables (s=OFF) a mechanism that synchronizes measurements and coordinates with GPS system time rather than with local (receiver) clock. This means that the calculated pseudo-ranges do not depend upon the receiver clock stability. This mode simulates a configuration where the receiver has a quartz oscillator with very high stability and is synchronized with GPS. Default is OFF.

$PASHQ,UTS,x

The associated query command is $PASHQ,UTS,x, where x is the port where the reply will be sent. Note that x is not required to direct the response message to the current communication port.

If processing raw data from the receiver with your own processing algorithms, we recommend that you turn UTS on.

$PASHR,UTS,x

The receiver response message to this query command is in the form:

$PASHR,UTS,x*cc

where x is ON or OFF and *cc is the checksum.

VDP: Vertical Dilution of Precision

$PASHS,VDP,d

Set value of VDOP mask, where d is between 0 - 99. Default is 4.

Example: Set VDOP mask to 6

$PASHS,VDP,6

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,RAW command. The $PASHS,RAW command allows you to enable or disable the output of raw data messages and to set the port to which the messages will be output. The general format of the $PASHS,RAW command is:

$PASHS,RAW

where str is a 3 character string that denotes the different raw data output types, c is the output serial port, and x is the ON/OFF toggle. For example, the command:

$PASHS,RAW,MCA,A,ON<Enter>

will output MCA messages to serial port A. IF the $PASHS,RAW command is sent correctly, the receiver will respond with $PASHR,ACK acknowledgment. The message will be output to the indicated serial port at the recording interval defined by the $PASHS,RCI command. The default output frequency is every 20 seconds.

Raw data messages are disabled by sending the $PASHS,RAW command with ON/OFF toggle field set to OFF. Multiple messages may be disabled from a particular port by sending the $PASHS,RAW command with ALL in the string field.

For example the command:

$PASHS,RAW,ALL,B,OFF<Enter>

disables all raw data messages from port B. To see what raw data messages have been enabled, use the $PASHQ,RAW query.

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. See Table 6.33, Raw Data Commands for more details about the commands that control these parameters.

Query Commands

The query commands will output a single raw data message type once. The general format of the query command is:

$PASHQ,str,x

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

$PASHQ,PBN<Enter>

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

$PASHQ,MCA,C<Enter>

will output a single MCA message to port C.

There are no ACK command acknowledgments for queries. If the query has been entered properly, and the data is available (for example, MCA is not available unless the receiver is tracking enough satellites above the elevation mask), then the acknowledgment will be the data response message.

Table 6.33 lists all the available raw data commands.

Table 6.33: Raw Data Commands

Function	Command	Description	Page
Almanac Data	$PASHS,RAW,SAL	Enable/disable GPS raw almanac data.	123
	$PASHQ,SAL	Query GPS raw almanac data.	123
	$PASHS,RAW,SAG	Enable/disable GLONASS raw almanac data.	121
	$PASHQ,SAG	Query GLONASS raw almanac data.	122
Disable Message	$PASHS,RAW,ALL	Disable raw date message	115
Ephemeris Data	$PASHS,RAW,SNG	Enable/disable GLONASS raw ephemeris data.	124
	$PASHQ,SNG	Query GLONASS raw ephemeris data	124
	$PASHS,RAW,SNV	Enable/disable GPS raw ephemeris data	126
	$PASHQ,SNV	Query GPS raw ephemeris data	126
Measurement Data	$PASHS,RAW,MCA	Enable/disable raw measurement data (MCA)	117
	$PASHQ,MCA	Query raw measurements data (MCA)	117
Position Data	$PASHS,RAW,PBN	Enable/disable raw position data (PBEN)	119
	$PASHQ,PBN	Query raw position data (PBEN)	119

Table 6.33: Raw Data Commands (continued)

Function	Command	Description	Page
Raw Data Parameters	$PASHS,ELM	Set raw data output elevation mask	81
	$PASHS,MSV	Set minimum number of satellites	93
	$PASHS,RCI	Set recording interval	102
	$PASHQ,RAW	Show current settings of raw data parameters	120
	$PASHS,SIT	Set site name	105

MCA: Enable/Disable MCA Message

$PASHS,RAW,MCA,x,s

Enable/disable measurement data (MCA) messages with Ashtech type 3 structure on port x, where x is the output port and s is ON or OFF.

This message is output for those satellites with elevation equal to or greater than the elevation mask (ELM), and only if the number of locked satellites is equal to or greater than the minimum satellite mask.

Example: Enable MCA message on port A

$PASHS,RAW,MCA,A,ON

$PASHQ,MCA,x

The associated query command is $PASHQ,MCA,x. This command outputs one set of MCA measurement data response messages on port x, where x is the optional output port.

$PASHR,MCA

The response is a binary message in the format:

$PASHR,MCA,(measurement structure)

where Table 6.34 defines the measurement structure.

Table 6.34: MCA Structure

Field	Bytes	Content
unsigned short	2	Sequence ID number in units of 50 ms, modulo 30 minutes
unsigned char	1	Number of remaining structures to be sent for current epoch

Table 6.34: MCA Structure (continued)

Field	Bytes	Content
unsigned char	1	Satellite PRN number (1-56). The broadcast ephemeris from a GLONASS satellite does not contain the satellite slot number. This information is derived from the almanac. When the GG Surveyor has ephemeris data for a satellite but no almanac data (after memory reset with the INI command) the satellite number is set to zero. Once the almanac has been received, the satellite number is updated.
unsigned char	1	Satellite elevation angle (degrees)
unsigned char	1	Satellite azimuth (units of 2 degrees)
unsigned char	1	Channel ID (1-24)
unsigned char	1	Warning flag Bit 1 Bit 2 0 0 Code and/or carrier phase measured 0 1 Code and/or carrier phase measured, navigation message obtained, measurement not used to compute position 1 0 Code and/or carrier phase measured ,navigation message obtained, measurement used to compute position 3 Carrier phase questionable 4 Code phase questionable 5 Code phase integration not stable 6 Not used 7 Possible loss of lock 8 Loss-of-lock counter reset NOTE: More than one bit can be set at the same time.
unsigned char	1	Goodbad flag indicates quality of position measurement: 0 = measurement not available and no additional data will be sent 22 = code and/or carrier phase measured 23 = code and/or carrier phase measured and navigation measurement obtained, but measurement not used to compute position 24 = code and/or carrier phase measured and navigation measurement obtained, measurement used to compute position
char	1	Polarity_know. This number is either 0 or 5 0 means the satellite is just locked 5 means the preamble was found and the polarity of phase tracking is known and taken into account (i.e., phase measurements can be used for ambiguity fixing).
unsigned char	1	Signal-to-noise ratio of satellite observation
unsigned char	1	Always 0 (not used)

Table 6.34: MCA Structure (continued)

Field	Bytes	Content
double	8	Full carrier phase measurement in cycles. Not available unless carrier phase option is installed.
double	8	Raw_range. Raw range to satellite in seconds. Computed by formula: receiver time - transmitted time. NOTE: If TSC is set to GPS, in GLONASS pseudoranges, due to 11-sec (currently) difference between GLONASS system time and GPS system time, raw range will have 11-sec integer part. If TSC is set to GLO, in GPS pseudoranges, due to 11-sec (currently) difference between GPS system time and GLONASS system time, raw range will have –11 sec integer part.
long	4	Doppler (10^{-4} Hz)
long	4	Smoothing. Bits 0-23-smooth correction Bit 23 (MSB) - sign Bits 0-22 - magnitude of correction (centimeters) Bits 24-31 - Smooth count, unsigned, as follows: 0 - unsmoothed 1 - least smoothed 100 - most smoothed
unsigned char	1	Computed by XORing all the bytes of the structure. (MCA only)
total bytes	37	C/A only

For a given channel expecting more than one block of data, when one of them is not yet available, its warning flag is set to 7 and the rest of the block is zeroed out.

PBN: Enable/Disable PBN Message

$PASHS,RAW,PBN,x,s

Enable/disable position data (PBN) messages on port x, where x is the output port, and s is ON or OFF.

Example: Enable PBN on port B

$PASHS,RAW,PBN,B,ON

$PASHQ,PBN,x

The associated query command is $PASHQ,PBN,x . This command outputs one PBN position data response message on port x, where x is the optional output port.

$PASHR,PBN

The response is a binary message output on every recording interval (RCI). The message is in the form:

$PASHR,PBN,(position structure)

where Table 6.35 defines the measurement structure.

Table 6.35: PBN Structure

Field	Bytes	Content
long rcvtime	4	Signal received time in milliseconds of week of GPS system time or in milliseconds of week/day of GLONASS system time (see commands $PASHS,TSC and $PASHS,SYS for more information). If GLONASS system time scale is chosen, operation (rcvtime % day) produces GLONASS system time (a time within a day) in all cases. This is the time tag for all measurements and position data.
char sitename	4	Set to user-entered string or four question marks ???? if empty
double navx	8	Antenna position ECEF x coordinate in meters.
double navy	8	Antenna position ECEF y coordinate in meters.
double navz	8	Antenna position ECEF z coordinate in meters.
float navt	4	Receiver clock offset in meters.
float navxdot	4	The antenna x velocity in meters per second.
float navydot	4	The antenna y velocity in meters per second.
float navzdot	4	The antenna z velocity in meters per second.
float navtdot	4	Receiver clock drift in meters per second.
unsigned short PDOP	2	PDOP multiplied by 100.
unsigned short checksum	2	The checksum is computed by breaking the structure into 27 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	56	

RAW: Setting Query Command

$PASHQ,RAW,x

Show current settings of raw data parameters, where c is the optional output port.

Example:

$PASHQ,RAW

Typical Response Message

```
RCI:020.00  MSV:3  ELM:05  SIT:????
RAW:  MBN PBN SNV SAL MCA  SNG  SAG
PRTA: OFF OFF OFF OFF OFF  OFF  OFF
PRTB: OFF OFF OFF OFF OFF  OFF  OFF
```

where Table 6.36 outlines the response parameters:

Table 6.36: $PASHQ,RAW Response Parameters

Field	Description
RCI:020.00	This is the output interval of the data in seconds. Default is once every 20 seconds.
MSV:3	Minimum number of satellites for the data to be output. Default is 3.
ELM:05	Data elevation mask. Elevation below which data from that satellite will not be output.
SIT:????	Four-character site name.
RAW:	Raw data types: MBN, PBN, SNV, SAL, MCA, SNG, SAG.
PRTA PRTB PRTC	Communication Ports A, B, and C.
OFF/ON	OFF indicates that the RAW data message is not sent to the port. ON indicates the RAW data message is sent to the communication port.

SAG: Enable/Disable GLONASS Satellite Almanac Message

$PASHS,RAW,SAG,x,s

Enable/disable GLONASS almanac data (SAG) messages on port x, where x is the output port, and s is ON or OFF.

Example: Disable SAG message on port A

$PASHS,RAW,SAG,A,OFF<Enter>

Almanac data for all satellites is output once every hour, with one satellite output at each recording interval (RCI).

$PASHQ,SAG,x

The associated query command is $PASHQ,SAG,x. This command outputs the SAG almanac data response message on port x, where x is the optional output port.

$PASHR,SAG

The response is a binary message in the form:

$PASHR,SAG,(structure)

where Table 6.37 defines the measurement structure.

Table 6.37: SAG (GLONASS Almanac) Structure

Field	Bytes	Content
short	2	Satellite number [1,...,24]
short	2	Satellite GLONASS frequency number [-7,...,24]
short	2	Satellite health 0=bad, 1=good
float	4	Eccentricity ε_n^A
long	4	Reference day number N^A (days in range 1 to 1461)
float	4	Correction to inclination Δi_n^A (semicircles)
float	4	Longitude of first ascension node λ_n^A (semicircles)
float	4	Reference time of longitude of first node $t_{\lambda n}^A$ (seconds)
float	4	Argument of perigee ω_n^A (semicircles)
float	4	af_0 correction to mean value (43200 sec) of Draconic period ΔT_n^A (seconds)
float	4	af_1 = d(af_0)/dt (sec/sec)
float	4	Satellite clock offset (seconds)
unsigned short	2	Checksum computed by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	44	

SAL: Enable/Disable GPS Satellite Almanac Message

$PASHS,RAW,SAL,x,s

Enable/disable GPS almanac data (SAL) messages on port x, where x is the output port, and s is ON or OFF.

Example: Disable SAL message on port A

$PASHS,RAW,SAL,A,OFF<Enter>

Almanac data for all satellites is output once every hour, with one satellite output at each recording interval (RCI).

$PASHQ,SAL,x,

The associated query command is $PASHQ,SAL,x. This command outputs the SAG almanac data response message on port x, where x is the optional output port.

$PASHR,SAL

The response is a binary message in the form:

$PASHR,SAL,(almanac structure)

where Table 6.38 defines the measurement structure.

Table 6.38: SAL (Almanac) Structure

Field	Bytes	Content
short prn	2	Satellite PRN number [0,...,31]
short health	2	Satellite health.
float	4	e eccentricity
long	4	toa reference time for orbit (sec).
float	4	i0 inclination angle (semicircles)
float	4	omegadot rate of right ascension (semicircles/sec)
double	8	roota Square root of semi-major axis (meters 1/2)
double	8	omega0 longitude of ascending node (semicircles)
double	8	omega augment of perigee (semicircles)
double	8	m0 mean anomaly at reference time (semicircles)
float	4	af0 clock correction (sec)
float	4	af1 clock correction (sec/sec)
short	2	wna almanac week number

Table 6.38: SAL (Almanac) Structure (continued)

Field	Bytes	Content
short	2	wn week number
long	4	tow seconds of GPS week (sec) [0,...,604799]
unsigned short	2	Checksum computed by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	70	

SNG: Enable/Disable GLONASS Ephemeris Data

$PASHS,RAW,SNG,x,s

Enables or disables GLONASS ephemeris data on port x, where x is the output port and s is ON or OFF.

Example: Output GLONASS ephemeris data on port A

$PASHS,RAW,SNG,A,ON<Enter>

Ephemeris data is output once every 15 minutes with one satellite output at each recording interval (RCI).

$PASHQ,SNG,x

The associated query command is $PASHQ,SNG,x. This command outputs the SNG ephemeris data response message on port x, where x is the optional output port.

$PASHR,SNG

The response is one binary message per locked satellite in the form:

$PASHR,SNG,(ephemeris structure)

where Table 6.39 defines the measurement structure.

Table 6.39: SNG GLONASS Ephemeris Data Structure

Type	Size in Bytes	Content
long	4	Start time of the 30-second frame in satellite time scale t_k from which the ephemeris data is derived; time modulo one day (seconds)
short	2	Day number of 30-second frame; modulo four-year period counting from beginning of last leap year, which corresponds to parameter t_b (t_b is set within this day number) . This parameter varies within the range 1 to 1461. If day number = 0, the day number is unknown (absent in navigation frame).
long	4	Ephemeris data reference time within the day expressed in GLONASS system time scale = UTC + 3 hours (seconds)
float	4	Frequency offset γ_η of the on-board frequency standard at t_b (dimensionless)
float	4	Bias t_n between satellite time scale and GLONASS system time scale at t_b (seconds)
double	3*8	Satellite ECEF (PZ-90) X, Y, Z coordinates (km)
float	3*4	Satellite ECEF (PZ-90) velocity X′, Y′, Z′(km/sec)
float	3*4	Satellite perturbation acceleration X″, Y″, Z″ due to moon and sun (km/sec/sec)
double	8	Bias between GLONASS system time scale and UTC + 3 hours time scale τ_c (seconds)
char	1	Age of ephemeris parameter E_n (interval from moment when ephemeris data was last uploaded to t_b)
char	1	Combined 3-bit flag (contains Ï1, Ï2, Ï3, see GLONASS ICD)
char	1	Satellite health status flag (0 = good, 1 = bad)
char	1	Satellite frequency channel number [-7,...,24]
short	2	Satellite system number (satellite number [1,...,24])
unsigned short	2	Word checksum computed by breaking the structure into 40 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total	82 bytes	(95 for structure plus header and <CR><LF>)

If both GPS and GLONASS satellites are locked during a session and the absolute current time is available from GPS data download, then the day number can be calculated through WN (GPS week number).

If only GLONASS satellites are locked and processed during a session, the receiver checks whether a GLONASS almanac is available. If there is no GLONASS almanac or it is too old, the day number is taken as zero. If an adequate GLONASS almanac is available, the receiver determines on which day within the range [$-3 + N^A$, $3 + N^A$] the satellite coordinates at t_b based on the almanac data fit best with known ephemeris coordinates.

The broadcast ephemeris from a GLONASS satellite does not contain the satellite slot number. This information is derived from the almanac. When the GG Surveyor has ephemeris data for a satellite but no almanac data (this occurs at startup, before the almanac has been fully transmitted), the satellite number is set to zero. Once the almanac has been received, the satellite number is updated.

SNV: Enable/Disable GPS Ephemeris Data

$PASHS,RAW,SNV,x,s

Enable/disable ephemeris data (SNV) messages on port x where x is the output port, and s is ON or OFF.

Example: Enable SNV on port A

$PASHS,RAW,SNV,A,ON<Enter>

Ephemeris data is output once every 15 minutes or each time the IODE changes, whichever comes first, with one satellite output at each recording interval (RCI).

$PASHQ,SNV,x

The associated query command is $PASHQ,SNV,x. This command outputs the GPS SNV ephemeris data response message on port x, where x is the optional output port.

$PASHR,SNV

The response is one binary message per locked satellite in the form:

$PASHR,SNV,(ephemeris structure)

where Table 6.40 defines the measurement structure.

Table 6.40: SNV (Ephemeris) Structure

Field	Bytes	Content
short wn	2	GPS week number [0,...,1023]
long tow	4	Seconds of GPS week [0,...604799]
float tgd	4	Group delay ($\pm 127 * 2^{-31}$) (seconds)
long aodc	4	Clock data issue
long toc	4	Clock data reference time [0,...,604784] (LSB = 2^4 seconds)

Table 6.40: SNV (Ephemeris) Structure (continued)

Field	Bytes	Content
float af2	4	Clock correction (sec/sec^2).
float af1	4	Clock correction (sec/sec).
float af0	4	Clock correction (sec).
long aode	4	Orbit data issue.
float deltan	4	Mean anomaly correction (semicircles/sec).
double m0	8	Mean anomaly at reference time (semicircles).
double e	8	Eccentricity.
double roota	8	Square root of semi-major axis ($meters^{1/2}$).
long toe	4	Reference time for orbit (sec).
float cic	4	Harmonic correction term (radians).
float crc	4	Harmonic correction term (meters).
float cis	4	Harmonic correction term (radians).
float crs	4	Harmonic correction term (meters).
float cuc	4	Harmonic correction term (radians).
float cus	4	Harmonic correction term (radians).
double omega0	8	Longitude of ascending node (semicircles).
double omega	8	Argument of perigee (semicircles).
double i0	8	Inclination angle (semicircles).
float omegadot	4	Rate of right ascension (semicircles/sec).
float idot	4	Rate of inclination (semicircles/sec).
short accuracy	2	User range accuracy (URA), coded 0-15. 0 = 2 m 6 = 16 m 12 = 1024 m 1 = 2.8 m 7 = 32 m 13 = 2048 m 2 = 4 m 8 = 64 m 14 = 4096 m 3 = 5.7 m 9 = 128 m 15 = no prediction possible 4 = 8 m 10 = 256 m 5 = 11.3 m 11 = 512 m
short health	2	Satellite health.
short fit	2	Curve fit interval (0 or 1) 0=>interval = 4 hours 1=>interval = 6 hours
char prnnum	1	Satellite PRN number minus 1 (0 to 31)

Table 6.40: SNV (Ephemeris) Structure (continued)

Field	Bytes	Content
char res	1	Reserved character.
checksum	2	The checksum is computed by breaking the structure into 65 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	132	

NMEA Data 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 Ashtech 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 0.2 and 999 seconds.

Maximum NMEA update rate is dependent on receiver options.

For each NMEA message type there is a set command, a query command and a response message. The set command is used to continuously output the NMEA response message at the period defined by the $PASHS,NME,PER command. The query will output a NMEA response message only once.

Set Commands

The general structure of the NMEA set commands is:

$PASHS,NME,str,x,s <Enter>

where x is the serial port to which response message should be sent (A, B, or C), and s is either ON or OFF. ON will enable the message and OFF will disable the message. The str is a 3 character strings that depicts the NMEA message to be output. The available strings are:

AIM, GGA, GLL, GRS, GSA, GSN, GST, GXP, LTN, MSG, POS, RMC, RRE, SAT, TCM, TTT, VTG, and ZDA

When a set command is sent correctly, the receiver will send a $PASHR,ACK (command acknowledge) message. If the command is sent incorrectly or the syntax is wrong, the receiver will sent a $PASHS,NAK (command not acknowledged) message. Once acknowledged, the receiver will output the corresponding NMEA data message at the interval defined by the $PASHS,NME,PER command, unless a necessary condition for the message to be output is not present. For example, the GGA message will not be output unless a position is being computed.

To disable all set NMEA message, use the $PASHS,NME,ALL command.

To see what NMEA messages have been enabled, use the $PASHQ,PAR command.

Example: Enable GGA message on port A

$PASHS,NME,GGA,A,ON <Enter>

Output enabled NMEA messages every 5 seconds

$PASHS,NME,PER,5 <Enter>

Query Commands

While the set commands will continuously output response messages at a set interval, the query command will output a single response message. 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 optional output serial port. The serial port field is optional. If a port is not specified, the receiver sends the response to the current port.

Example: Query POS message and send the response to port D

$PASHQ,POS,D <Enter>

Query GSA message and send the response to the current port.

$PASHQ,GSA <Enter>

Response message

The response message is the information sent back from the receiver in response to a set or query command.

The generic NMEA response message format is:

$<header><data items> *cc

where Table 6.41 outlines the response format:

Table 6.41: NMEA Response Structure

Field	Description
$	NMEA message start character
<header>	standard response message header
<data items>	data field dependent upon header
*cc	checksum

Data items are separated by commas; successive commas indicate data not available. For example, two successive commas indicate one missing data item, while three successive commas indicate two missing items.

The following is an example of an NMEA sentence.

$GPGLL,4728.3100,N,12254.2500,W*FF

where Table 6.42 outlines the response format:

Table 6.42: GLL Structure

Field	Description
$	Start of sentence
GPGLL	GP = GPS, GLL = latitude/longitude message type
4728.3100	Latitude 47°28.3 1’
N	Latitude direction (north)
12254.2500	Longitude 122°54.25’
W	Longitude direction (west)
*FF	checksum

Refer to *NMEA 0183 Standard for Interfacing Marine Electronic Navigational Devices* for more details on sentence format protocols.

The Ashtech proprietary NMEA style response message format applies to the AIM, LTN, POS, RRE, SAT, and TTT messages, where the format is:

$PASHR,str,<data items>*cc

replacing the standard header with an Ashtech proprietary header and adding Ashtech proprietary message information.

Table 6.43 lists the NMEA data message commands. Only the set command for each NMEA message type is listed, as the description for the set, query and response message to each NMEA message are grouped together.

Table 6.43: NMEA Data Message Commands

	Command	Description	Page
Disable NMEA Messages	$PASHS,NME,ALL	Disable all messages	132
Latency Information	$PASHS,NME,LTN	Enable/disable the latency message	148
Differential Information	$PASHS,NME,MSG	Enable/disable base station message	149
	$PASHS,NME,TCM	Enable/disable RTCM rover status	170
Output Rate Parameter	$PASHS,NME,PER	Set send interval of NMEA response message	162
Photogrammetry	$PASHS,NME,TTT	Enable/disable photogrammetry message	171

Table 6.43: NMEA Data Message Commands (continued)

	Command	Description	Page
Position Information	$PASHS,NME,GGA	Enable/disable GPS position response message	134
	$PASHS,NME,GLL	Enable/disable lat/lon message	137
	$PASHS,NME,GXP	Enable/disable position computation with time of fix information	147
	$PASHS,NME,POS	Enable/disable position message	162
	$PASHS,NME,RMC	Enable/disable declination message	
RAIM Information	$PASHS,NME,AIM	Enable/disable RAIM message	132
Residual Information	$PASHS,NME,RRE	Enable/disable satellite residual and position error	166
	$PASHS,NME,GRS	Enable/disable satellite range residual	138
	$PASHS,NME,GST	Enable/disable position error message	
Satellite Information	$PASHS,NME,GSA	Enable/disable satellites used message	134
	$PASHS,NME,GSN	Enable/disable signal strength/satellite number	143
	$PASHS,NME,SAT	Enable/disable satellite status message	
Time and Date	$PASHS,NME,ZDA	Enable/disable time and date message	174
Track, Speed	$PASHS,NME,VTG	Enable/disable velocity/course message	172

ALL: Disable All NMEA Messages

$PASHS,NME,ALL,x,OFF

Disable ALL NMEA message types on port x, where x is the output port.

Examples: Turn off all NMEA messages for Port A.

$PASHS,NME,ALL,A,OFF <Enter>

AIM: Receiver Autonomous Integrity Monitor Message

$PASHS,NME,AIM,x,s

Enable/disable RAIM message on port x, where x is the output port, and s is ON or OFF. This message is not output unless a position is computed.

Example: Enable RAIM message on port B.

$PASHS,NME,AIM,B,ON<Enter>

$PASHQ,AIM,x

The associated query command is $PASHQ,AIM,x. This command outputs the AIM response message on port x, where x is the optional output port. This message is not output unless a position is computed.

Example:

$PASHQ,AIM,A

$PASHR,AIM

The response message to the set or query command is in the form:

$PASHR,AIM,s1,d1,n(d2-d3)*cc

n = number of channel - SV pairs

Table 6.44 outlines the structure of the RAIM response message.

Table 6.44: RAIM Response Message Structure

Field	Description
s1	Current RAIM mode (3-character) OFF - Turns RAIM off NPA - Non-precision approach, alarm limit is 0.030 nmi TER - Terminal, alarm limit is 1.00 nmi ERT - En route, alarm limit is 2.00 nmi n.nn - user-selectable alarm limit between 0.015 and 4.00 km
d1	Value returned by RAIM gives: 0 - no errors detected 1 - error detected and corrected 2 - error detected, correction not possible 3 - detection not available (lack of satellite or poor geometry) 4 - error detected, rest of satellite set not available
d2-d3	d2-d3 represents a pair of excluded channel and its corresponding satellite, where d2 is the number of the excluded channel and d3 is the number of the corresponding satellite

Example:

$PASHR,AIM,NPA,1,10-12,05-20*FF

where:

NPA = non-precision approach mode

1 = error detected and corrected

10-12 = channel 10, satellite 12 excluded

05-20 = channel 5, satellite 20 excluded

When RAIM returns 0, no errors exceed the alarm limit. All computed satellite ranges are used in the position velocity calculation.

If the value returned is 1, RAIM has detected errors, and has excluded satellites with large range errors and corrected the position and velocity. If the quantity of channel-satellite pairs does not exceed 1, the corrected position and velocities are acceptable for applications with a probability of 0.999. If the quantity of channel - satellite pairs exceeds 1, then there is no assurance that the positions and velocities have been properly corrected. However, in many cases, RAIM corrects the results satisfactorily even under unfavorable conditions.

If the value returned is 2, RAIM has detected a problem but can not eliminate the questionable satellites because of too few satellites (e.g., 5 satellites in view). In this case, the computed data (position and velocity) does not meet the probability of 0.999.

If the value returned is 3, the satellite geometry is poor and detection is unavailable. This value is always returned if the number of satellites is less than 5.

Finally, if the value returned is 4, RAIM indicates that errors exist (the response contains channel-satellite pairs), but fails to correct positions and velocities. In such cases, you can exclude questionable satellites by using the $PASHS,USE or $PASHS,SVS commands.

GGA: GPS Position Message

$PASHS,NME,GGA,x,s

Enable/disable NMEA GPS position response message on port x, where x is the output port A, B, or C, and s is ON or OFF.

Example: Enable GGA on port A

$PASHS,NME,GGA,A,ON

$PASHQ,GGA,x

The associated query command is $PASHQ,GGA. This command outputs the GGA response message on port x, where x is the optional output port.

Example: Output GGA message on port B

$PASHQ,GGA,B

$GPGGA

The response message is in the form:

$GPGGA,m1,m2,c1,m3,c2,d1,d2,f1,f2,M,f3,M,f4,d3 *cc

Table 6.45 outlines the GGA structure.

Table 6.45: GGA Structure

Field	Description	Range
m1	Current UTC time of position fix in hours, minutes and seconds (hhmmss.ss).	00 to 235959.50
m2	Latitude component of position in degrees, minutes and fraction of minutes (ddmm.mmmmmm).	0 to 90°
c1	Latitude sector, N = North, S = South.	‘N’ or ‘S’
m3	Longitude component of position in degrees, minutes and fraction of minutes (dddmm.mmmmmm).	0 to 180°
c2	Longitude sector, E = East, W = West.	‘E’ or ‘W’
d1	Position Type, n 1 = Autonomous position 2 = position differentially corrected 3 = RTK float 4 = RTK fixed	1, 2, 3, 4
d2	number of GPS satellites used in position computation.	3 to 24
f1	HDOP - horizontal dilution of precision	0 to 99.9
f2	Altitude in meters above the geoid. For 2-D position computation this item contains the altitude held fixed.	0 to 30000.000
M	Altitude units, M = meters.	‘M’
f3	Geoidal separation (value output only if Geoidal Height option (G) is installed in the receiver).	±999.999
M	Geoidal separation units, M = meters.	‘M’
f4	Age of the differential corrections, sss, in seconds.	±999.999
d3	Base station ID (RTCM only)	0 to 1023
*cc	checksum	

If there is no valid position, GGA still provides: time, position flag, number of satellites, HDOP, age of corrections, and base station ID

If there are not enough satellites to compute HDOP, then the HDOP field is null. If the receiver is not in Differential or RTK mode, then the age of corrections, base station ID fields are null.

When running in the 5 Hz option, the GG Surveyor limits the number of available used satellites to 16.

Example:

Query: $PASHQ,GGA,C or

Set: $PASHS,NME,GGA,A,ON

In order to provide high resolution on time and position information, the GGA message may extend beyond the maximum message length of 82 characters recommended by the NMEA 0183 standard.

Typical Response:

$GPGGA,183805.50,3722.36223,N,12159.827 41,W,2,03,02.8,
+00016.12,M,0031.24,M,005,000 1 *6F

Table 6.46 outlines the GGA response message structure.

Table 6.46: Typical GGA Response Message

Item	Significance
$GPGGA	Header
183805.50	Time of position fix
3722.36223	Latitude
N	North
12159.82741	Longitude
W	West
2	Differentially corrected position
03	Number of satellites used in position computation
02.8	HDOP
+00016.12	Altitude above the geoid
M	Meters. Units of altitude
0031.24	Geoidal separation
M	Meters. Units of the geoidal separation
005	Age of differential corrections
0001	Base station ID
6F	Message checksum in hexadecimal

When no position is available, a typical response might look like:

$GPGGA,015454.00,,N,,W,0,2,99.9,,M,,M,,*6F

GLL: Latitude, Longitude Message

$PASHS,NME,GLL,x,s

Enable/disable NMEA latitude/longitude response message on port x, where x is the output port, and s is ON or OFF.

Example: Enable GLL message on port A

$PASHS,NME,GLL,A,ON

$PASHQ,GLL,x

The associated query command is $PASHQ,GLL,x. This command outputs the GLL message on port x, where x is the optional output port.

Example: Output GLL message on port B

$PASHQ,GLL,B

$GPGLL

The response message is in the form:

$GPGLL,m1,c1,m2,c2,m3,c3*cc

Table 6.47 outlines the GLL structure.

Table 6.47: GLL Structure

Field	Significance	Range
m1	Latitude component of position (ddmm.mmmmmm) in degrees, minutes and fraction of minutes	0 to 90°
c1	Latitude sector, N = North, S = South	‘N’ or ‘S’
m2	Longitude component of position (dddmm.mmmmmm) in degrees, minutes and fraction of minutes.	0 to 180°
c2	Longitude sector, E = East, W = West	‘E’ or ‘W’
m3	UTC of position (hours, minutes, seconds)	00 to 235959.5
c3	Status, A= data valid, V= data invalid	A or V

If position is not valid, GLL provides: time, and position flag, for example:

$GPGLL,,,,,174645:30,V*cc

Example:

Query: $PASHQ,GLL,B [or]

Set: $PASHS,NME,GLL,C,ON

Response: $GPGLL,3722.36223,N,12159.82741,W,170003,A*7F

Table 6.48 outlines a typical GLL response message.

Table 6.48: Typical GLL Response Message

Item	Significance
$GPGLL	Header
3722.36223	Latitude
N	North
12159.82741	Longitude
W	West
170003	UTC of position
A	Valid
7F	Message checksum in hexadecimal

GRS: Satellite Range Residual Message

$PASHS,NME,GRS,x,s

Enable/disable NMEA satellite range residual response message to port x, where x is the output port, and s is ON or OFF. This message is not output unless a position is computed.

Example: Enable GRS message on port B

$PASHS,NME,GRS,B,ON

$PASHQ,GRS,x

The associated query command is $PASHQ,GRS,x where x is the optional output port. This message does not output unless a position is computed.

Example: Output GRS message on port B

$PASHQ,GRS,B

$GPGRS/$GLGRS

The response message for the set and query commands is output in two messages with different headers. The first message contains GPS residual information, and is in the form:

$GPGRS,m1,d1,n(f1)*cc

The second message contains GLONASS residual information, and is in the form:

$GLGRS,m1,d1,n(f1)*cc

Range residuals are recomputed after the GGA position is computed. Therefore the mode m is always 1. There will be a range residual sxx.x for each satellite used in position computation, where range residuals for GPS satellites are included in the GPGRS message, and range residuals for GLONASS satellites are included in the GLGRS message.

Table 6.49 outlines the GRS message structure.

Table 6.49: GRS Structure

Field	Description
m1	Current UTC time, (hhmmss.ss), of GGA position fix in hours, minutes, and seconds hh = Hours (00 to 23) mm = Minutes (00 to 59) ss.ss = Seconds (00.00 to 59.99)
d1	Mode, used to compute range residuals 0 - Residuals were used to calculate the position given in the matching GGA line 1 - residuals were recomputed after the GGA position was computed
f1	Range residuals (sign s = + or -, and magnitude xx.x) for each satellite used in position computation.

Example:

Query: $PASHQ,GRS,A or

Set: $PASHS,NME,GSN,A,ON

Response: $GPGRS,180257.50,1,+00.3,-00.4,+00.2,+00.5,+00.7,-00.8*64

$GLGRS,180257.50,1,-00.2,+00.4,+00.3,-00.6,+00.5*38

Table 6.50 outlines a typical GPGRS response message. Table 6.51 outlines a typical GLGRS response message.

Table 6.50: Typical GPGRS Response Message

Field	Significance
$GPGRS	Header
180257.50	Time of position fix
1	Mode
+00.3	Range residual for first GPS satellite
-00.4	Range residual for second GPS satellite
+00.2	Range residual for third GPS satellite
+00.5	Range residual for fourth GPS satellite

Table 6.50: Typical GPGRS Response Message (continued)

Field	Significance
+00.7	Range residual for fifth GPS satellite
-00.8	Range residual for sixth GPS satellite
*36	Message checksum in hexadecimal

Table 6.51: Typical GLGRS Response Message

Field	Significance
$GLGRS	Header
180257.50	Time of position fix
1	Mode
-00.2	Range residual for first GLONASS satellite
+00.4	Range residual for second GLONASS satellite
+00.3	Range residual for third GLONASS satellite
-00.6	Range residual for fourth GLONASS satellite
+00.5e	Range residual for fifth GLONASS satellite
*64	Message checksum in hexadecimal

GSA: DOP and Active Satellites Message

$PASHS,NME,GSA,x,s

Enable/disable DOP and active satellite message to be sent out to the serial port, where x is the output port, and s is ON or OFF. This message is output even if a position is not computed.

Example: Enable GSA message on port B

$PASHS,NME,GSA,B,ON

$PASHQ,GSA,x

The associated query command is $PASHQ,GSA,x where x is the optional output port.

Example: Output GSA message on port B

$PASHQ,GSA,B

$GPGSA/$GLGSA

The response message is output in two messages with different headers. The first message contains GPS satellite information in the form:

$GPGSA,c1,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,f1,f2,f3*cc

The second message contains GLONASS satellite information in the form:

$GLGSA,c1,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,f1,f2,f3*cc

The satellite PRN displayed in each of the ss fields of the GPGSA message is associated with one of the 12 GPS channels in the receiver, where the first ss field corresponds to the satellite locked to channel 1 and the last corresponds to the satellite locked to channel 12. The satellite PRN displayed in each of the ss fields of the GLGSA message is associated with one of the 12 GLONASS channels in the receiver, where the first ss field corresponds to the satellite locked to channel 13, and the last corresponds to the satellite locked to channel 24.

Table 6.52 outlines the GSA response message structure.

Table 6.52: GSA Structure

Field	Significance
c1	Mode M: manual A: Automatic
d1	Mode 2: 2D 3:3D
d2-d13	Satellites used in position computation (range 1 to 32 for $GPGSA message, and 33 to 56 for $GLGSA message)
f1	PDOP (range 0 - 99.9 for mixed constellation)
f2	HDOP (range 0 - 99.9 for mixed constellation)
f3	VDOP (range 0 - 99.9 for mixed constellation)

Examples:

$GPGSA,M,3,15,,20,01,22,14,21,25,,,,29,01.8,01.0,01.5*O F

Table 6.53 outlines the GPGSA response message.

Table 6.53: Typical GPGSA Response Message

Item	Significance
$GPGSA	Header
M	Manual mode

Table 6.53: Typical GPGSA Response Message (continued)

Item	Significance
3	3D mode
15	Satellite 15 used for position computation
empty field	No locked satellite in this channel or locked satellite not used in position solution
20	Satellite 20 used
01	Satellite 1 used
22	Satellite 22 used
14	Satellite 14 used
21	Satellite 21 used
25	Satellite 25 used
empty field	No locked satellite in this channel or locked satellite not used in position solution
empty field	No locked satellite in this channel or locked satellite not used in position solution
empty field	No locked satellite in this channel or locked satellite not used in position solution
29	Satellite 29 used
01.8	PDOP = 1.8
01.0	HDOP = 1.0
01.5	VDOP = 1.5
0F	Message checksum in hexadecimal

Example:

$GLGSA,M,3,33,54,,,41,38,,,42,51,48,,01.8,01.0,01.5*A B

Table 6.54 outlines the GLGSA response message.

Table 6.54: Typical GLGSA Response Message

Item	Significance
$GLGSA	Header
M	Manual mode
3	3D mode
33	Satellite 33 used for position computation

Table 6.54: Typical GLGSA Response Message (continued)

Item	Significance
54	Satellite 54 used for position computation
empty field	No locked satellite in this channel or locked satellite not used
empty field	No locked satellite in this channel or locked satellite not used
41	Satellite 41 used
38	Satellite 38 used
empty field	No locked satellite in this channel or locked satellite not used in position solution
empty field	As above
42	Satellite 42 used
51	Satellite 51 used
48	Satellite 48 used
empty field	No locked satellite in this channel or locked satellite not used in position solution
01.8	PDOP = 1.8
01.0	HDOP = 1.0
01.5	VDOP = 1.5
AB	Message checksum in hexadecimal

GSN: Signal Strength/Satellite Number Message

$PASHS,NME,GSN,x,s

Enable/disable the signal strength/satellite number response message on port x, where x is the output port, and s is ON or OFF. This message outputs even if a position is not computed.

Example: Enable GSN message on port B

$PASHS,NME,GSN,B,ON

$PASHQ,GSN,x

The associated query command is $PASHQ,GSN,x, where x is the optional output port.

Example: Output GSN message on port B

$PASHQ,GSN,B

$GPGSN/$GLGSN

The response message for the set and query commands is output in two messages with different headers.

The first message contains GPS satellite information in the form:

$GPGSN,d1,n(d2,d3)d4*cc

The second message contains GLONASS satellite information in the form:

$GLGSN,d1,n(d2,d3)d4*cc

when n is equal to the number of locked satellites.

Table 6.55 outlines the GPGSN message response structure.

Table 6.55: GSN Structure

Field	Significance
d1	Number of satellites locked, number of satellites in message
d2	Satellite PRN number, 1 to 32 in the $GPGSN message, 33 to 56 in the $GLGSN message
d3	Satellite signal strength/signal-to-noise ratio, 00 to 99
d4	999 ends the message if no RTCM age is reported. If RTCM age is reported then it displays the GPS satellite correction mean value in the $GPGSN message, and the GLONASS satellite corrections mean value in the $GLGSN message.

Example:

Query: $PASHQ,GSN,A or

Set: $PASHS,NME,GSN,A,ON

Response: $GPGSN,03,03,060,23,039,16,021,999 *7D

Table 6.56 outlines the GPGSN response message.

Table 6.56: Typical GPGSN Response Message

Field	Significance
$GPGSN	Header
03	Number of satellites locked
03	PRN number of the first GPS satellite
060	Signal strength of the first GPS satellite
23	PRN number of the second GPS satellite
039	Signal strength of the second GPS satellite

Table 6.56: Typical GPGSN Response Message (continued)

Field	Significance
16	PRN number of the third GPS satellite
021	Signal strength of the third GPS satellite
999	Termination with no RTCM information
7D	Message checksum in hexadecimal

Example:

$GLGSN,04,38,040,46,056,53,025,40,033,999*BA

Table 6.57 outlines the GLGSN response message.

Table 6.57: Typical GLGSN Response Message

Item	Significance
$GLGSN	Header
04	Number of locked satellites
38	ID number of the first GLONASS satellite
040	Signal strength of the first GLONASS satellite
46	ID number of the second GLONASS satellite
056	Signal strength of the second GLONASS satellite
53	ID number of the third GLONASS satellite
025	Signal strength of the third GLONASS satellite
40	ID number of the fourth GLONASS satellite
033	Signal strength of the fourth GLONASS satellite
999	Termination with no RTCM information
BA	Message checksum in hexadecimal

GST: Position Error

$PASHS,NME,GST,x,c

Enables/disables the GST message where x is the serial port, and c is ON or OFF. The GST message provides a real time estimate (1 sigma) of the position error. The GST message is output only if the position is computed.

Example: Enable GST message on port C

$PASHS,NME,GST,C,ON

$PASHQ,GST,x

The associated query command the $PASHQ,GST,x where x is the optional output port.

$GPGST

The return message is in the form:

$GPGST,f1,f2,f3,f4,f54,f6,f7,f8*cc

where Table 6.58 outlines the GST message response structure.

Table 6.58: GST Message Structure

Parameters	Description	Range
f1	UTC time of the GGS fix associated with this sentence (hhmmss.ss)	000000.00-235959.95
f2	RMS value of the standard deviation of the range inputs to the navigation process. This field is related to the other fields in the following way: (RMS value of standard deviation range inputs)^2* (HDOP)^2 = (standard deviation of latitude error)^2 + (standard deviation of longitude error)^2 (RMS value of standard deviation range inputs)^2* (VDOP)^2 = (standard deviation of altitude error)^2	0.00-99.99
f3	Standard deviation of semi-major axis of error ellipse (meters) This field is not implemented.	N/A
f4	Standard deviation of semi-minor axis of error ellipse (meters) This field is not implemented.	N/A
f5	Orientation of semi-major axis of error ellipse (degrees from true north) This field is not implemented.	N/A
f6	Standard deviation of latitude error (meters)	0.00-99.99
f7	Standard deviation of longitude error (meters)	0.00-99.99
f8	Standard deviation of altitude error (meters)	0.00-99.99
*cc	The hexadecimal checksum	

Example:

Query: $PASHS,GST

Response: $PASHR,GST,174640.00,06.660,,,,04.103,03.545,11.821*75 where Table 6.59 outlines a typical GST message.

Table 6.59: Typical GST Response

Item	Description
174640.00	UTC time (hhmmss.ss)
06.660	RMS value (1 sigma position error)
null	
null	
null	
04.103	Standard deviation of the latitude error (meters)
03.545	Standard deviation of the longitude error (meters)
11.821	Standard deviation of the altitude error (meters)
*75	checksum

GXP: Position Horizontal Message

$PASHS,NME,GXP,x,s

Enable/disable position horizontal message on port x, where x is the output port, and s is ON or OFF. This message is not output unless position is computed.

Example: Output GXP message on port B

$PASHS,NME,GXP,B,ON

$PASHQ,GXP

The associated query command is

$PASHQ,GXP,x

where x is the optional output port. This message is not output unless position is computed.

$GPGXP

The response message for the set and query commands is in the following form:

$GPGXP,m1,m2,c1,m3,c2

Table 6.60 outlines the GXP response message structure.

Table 6.60: GXP Structure

Field	Description
m1	Current UTC time, (hhmmss:ss) of position fix in hours, minutes and seconds
m2	Latitude component of position, (ddmm.mmmmmmm), in degrees, minutes and fraction of minutes
c1	Latitude sector, N - North, S - South
m3	Longitude component of position, (dddmm.mmmmmmm), in degrees, minutes and fraction of minutes
c2	Longitude sector, E - East, W - West

Example:

Query:$PASHQ,GXP,B or

Set: $PASHS,NME,GXP,A,ON

Typical Response:

$GPGXP,183805.00,3722.36221,N,12159.82742,W*5C

Table 6.61 outlines the GXP response message.

Table 6.61: Typical GXP Response Message

Item	Description
$GPGXP	Header
183805.00	Time of position fix
3722.362210	Latitude
N	North
12159.827420	Longitude
W	West
5C	Message checksum in HEX

LTN: Latency Message

$PASHS,NME,LTN,x,s

Enable/disable message containing latency information on port x, where x is the output port, and s is ON or OFF.

Example: Output LTN message on port B

$PASHS,NME,LTN,B,ON

$PASHQ,LTN,x

The associated query command is $PASHQ,LTN,x, where x is the optional output port. This message is not output if a position is not computed.

$PASHR,LTN

The response message for the set and query commands is a one-field message that contains information on the number of milliseconds it takes the receiver to compute a position (from the measurement tag time) and prepare data to be transmitted through the serial port. This number is dependent upon the number of locked satellites. This response message is in the form:

$PASHR,LTN,d*cc

where d in the latency value in milliseconds.

Example:

Query: $PASHQ,LTN,A or

Set: $PASHS,NME,LTN,A,ON

Typical Response:$PASHR,LTN,76*03

Then response message indicates that the latency is 76 milliseconds.

MSG: RTCM Message

$PASHS,NME,MSG,x,s

Enable/disable message containing RTCM reference (base) station message types 01, 03, 09, 16, 18, 19, 31, 32, 34, and 36 on port x, where x is the output port, and s is ON or OFF.

Unless the GG Surveyor is sending or receiving differential corrections, this command is ignored.

Example: Enable MSG on port A

$PASHS,NME,MSG,A,ON

$PASHQ,MSG,x

The associated query command is $PASHQ,MSG,x, where x is the optional output port.

$GPMSG

The response message format depends upon the RTCM message type enabled: types 1 and 31 are enabled by default; types 3, 9, 16, 32, 34, and 36 must be enabled by the $PASHS,RTC,TYP set command.

The format for RTCM message types 1, 9, 31, and 34 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,d5,d7,f2,f3,d8*cc

Message types 1 and 9 output correction information for GPS satellites, while message types 31 and 34 output correction information for GLONASS satellites.

Differential GPS Corrections (Type1) and GPS Partial Correction Set (Type 9)

Table 6.62 outlines the $GPMSG response structure.

Table 6.62: $GPMSG Structure for RTCM Message Types 1 and 9

Field	Description
d1	RTCM type, 01, 09, 31, or 34
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	Current UTC time of position computation in hours, minutes, and seconds
d6	User differential range error (UDRE)
d7	Satellite PRN number. GPS satellites for message types 1 and 31 and GLONASS satellites for message types 9 and 34.
f2	Pseudo-range correction (PRC) in meters
f3	Range rate correction (RRC) in meters/sec
d8	Issue of data (IODE) for message types 1 and 9, and reference time of GLONASS ephemerides (TB) for message types 31 and 34.
*cc	Message checksum in hexadecimal

Message types 1/31 and 9/34 are identical except for the fact that message type 1/31 has correction information (fields 9, 10, 11, 12, 13) for all GPS+GLONASS satellites, and each message type 9/34 has correction information for up to 3 GPS+GLONASS satellites per transmission. Note that for message types 01 and 09, GPS PRN numbers are between 1 and 32, and for message types 31 and 34, GLONASS ID numbers are between 1 and 24 (GLONASS slot numbers).

Example:

$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,-0.005, 145*7A

where Table 6.63 outlines the $GPMSG response format.

Table 6.63: $GPMSG Response for RTCM Messages 1, 31, and 9, 34

Item	Description
$GPMSG	Header
01	RTCM message
0000	Station ID
2220.0	Z count in seconds and tenths
1	Sequence number
0	Station health
127	Total number of characters of the time item
003702.00	Current time in hours, minutes, and seconds
2	UDRE for SV 12
12	Satellite PRN number
-0081.30	PRC for SV 12
+0.026	RRC for SV 12
235	IODE for SV 12
2	UDRE for SV 13
13	Satellite PRN number
+0022.86	PRC for SV 13
+0.006	RRC for SV 13
106	IODE for SV 13
2	UDRE for SV 26
26	Satellite PRN number
-0053.42	PRC for SV 26
-0.070	RRC for SV 26
155	IODE for SV 26
2	UDRE for SV 26
02	Satellite PRN number

Table 6.63: $GPMSG Response for RTCM Messages 1, 31, and 9, 34 (continued)

Item	Description
+0003.56	PRC for SV 02
+0.040	RRC for SV 02
120	IODE for SV 02
2	UDRE for SV 02
27	Satellite PRN number
+0047.42	PRC for SV 27
-0.005	RRC for SV 27
145	IODE for SV 27
7A	Message checksum in hexadecimal

The format for RTCM message type 3 and 32 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,f1,f2,f3,*cc

Format and contents of message types 3 and 32 are identical except for the fact that message type 32 displays the base coordinates in the PZ-90 coordinate system, while message type 3 uses the WGS-84 coordinate system.

GPS Reference Station Parameters (Type 3) and GLONASS Reference Station Parameters (Type 32):

Table 6.64 outlines the $GPMSG structure.

Table 6.64: $GPMSG Structure for RTCM Message Types 3 and 32

Field	Description
d1	RTCM type, 03 or 32
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	current GPS system time of position computation in hours, minutes and seconds

Table 6.64: $GPMSG Structure for RTCM Message Types 3 and 32 (continued)

Field	Description
f1	metric x - distance from geocenter (x component of station) using WGS-84 in message type 3, and SGS-90 in message type 32
f2	metric y - distance from geocenter (y component of station) using WGS-84 in message type 3, and SGS-90 in message type 32
f3	metric z - distance from geocenter (z component of station) using WGS-84 in message type 3, and SGS-90 in message type 32
*cc	Message checksum in hexadecimal

Example:

$GPMSG,03,0000,1200.0,7,0,038,231958.00,-2691561. 37,-4301271.02,+3851650.89*6C

Table 6.64 outlines the $GPMSG response structure.

Table 6.65: $GPMSG Response for RTCM Message Type 3

Item	Description
03	RTCM type
0000	Station ID
1200.0	Z count in seconds and tenths
7	Sequence number
0	Station health
038	Total number of characters after the time item
231958.00	Current time in hours, minutes and seconds
-2691561.37	Station X component using WGS-84
-4301271.02	Station Y component using WGS-84
+3851650.89	Station Z component using WGS-84
*6C	Message checksum in hexadecimal

The format for RTCM message types 16 and 36 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,s1*cc

Message types 16 and 36 are identical except for the text. The text displayed by type 16 is the one defined by command $PASHS,RTC,MSG, while the text displayed by type 36 is the one defined by command $PASHS,RTC,M36.

GPS Special Text Message (Type 16) and GLONASS Special Text Message (Type 36).

Table 6.66 outlines $GPMSG structure for message types 16 and 36.

Table 6.66: $GPMSG Structure for RTCM Message Types 16 and 36

Field	Description
d1	RTCM type 6 or 16
d2	station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	sequence number, 0 to 7
d4	station health, 0 to 7
d5	total number of characters after the time item, 000 to 999
m1	current GPS system time of position computation in hours, minutes and seconds
s1	text message
*cc	Message checksum in hexadecimal

Example:

$GPMSG,16,0000,1209.6,5,0,038,232008.00,THIS IS A MESSAGE SENT FROM BASE*5C

Table 6.67 outlines the $GPMSG response message for message type 16.

Table 6.67: $GPMSG Response, RTCM Message Type 16

Item	Description
$GPMSG	Header
16	RTCM type
0000	Station ID
1209.6	Z count in seconds and tenths
5	Sequence number
0	Station health
038	Total number of characters after the time item

Table 6.67: $GPMSG Response, RTCM Message Type 16 (continued)

Item	Description
232008.00	Current time in hours, minutes and seconds
THIS IS A....	Message content
5C	Message checksum in hexadecimal

RTCM type 18 is the uncorrected carrier phase message used to transmit data to the rover for RTK processing. The format for RTCM type 18 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,s1,d6,d7,n(d8,d9,d10,d11,f2)*cc

Table 6.68 outlines the $GPMSG response message structure for RTK Uncorrected Carrier Phases (Type 18)

Table 6.68: $GPMSG Structure for RTCM Message Type 18

Field	Description
d1	RTCM type, 18
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	Current UTC time of position computation in hours, minutes, and seconds
s1	GPS / GLONASS Constellation Indicator
d6	Frequency Indicator: “00”: L1 message, “01”: L2 message, “10”,”11” :Reserved
d7	GNSS Time of measurement (GPS or GLONASS time) (added to Z-Count)
	The following data is displayed for each Satellite in the message:
d8	Multiple message indicator (1 = more messages will follow with same time tag, 0 = last message)
d9	GPS (PRN Range 0-31) or GLONASS (Slot number 1-24) Satellite ID
d10	Data Quality Indicator (See RTCM Paper 88-97/SC104-156 Version 2.2)

Table 6.68: $GPMSG Structure for RTCM Message Type 18 (continued)

Field	Description
d11	Cumulative loss of continuity indicator (unfixed cycle slips or loss of lock)
f2	Uncorrected Carrier Phase (Cycles)
*cc	Message checksum in hexadecimal

Typical Example 4:

> $GPMSG,18,0000,1747.8,4,0,170,202908.50,GLO,0,200000,0,0,20,4,01,-8259701.2187,0,0,04,4,01,+5708064.4921,0,0,16,4,05,-1803924.6250,0,0,14,4,01,-0383075.2578,0,0,15,4,01,-7205926.2500,0,0,06,4,01,-0607101.0039*33

Table 6.69 outlines the $GPMSG structure for message type 18.

Table 6.69: $GPMSG Response for RTCM Message 18

Item	Description
$GPMSG	Header
18	RTCM message
0000	Station ID
1747.8	Z count in seconds and tenths
4	Sequence number
0	Station health
170	Total number of characters of the time item
202908.50	Current time in hours, minutes, and seconds
GLO	GLONASS Constellation
0	L1 Frequency indicator
200000	GPS system time of measurement basis
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
20	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-8259701.2187	Carrier phase (cycles)

Table 6.69: $GPMSG Response for RTCM Message 18 (continued)

Item	Description
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
04	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
+5708064.4921	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
16	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
05	Cumulative loss of continuity error (cycle slips)
-1803924.6250	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
14	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-0383075.2578	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
15	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-7205926.2500	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
06	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)

Table 6.69: $GPMSG Response for RTCM Message 18 (continued)

Item	Description
-0607101.0039	Carrier phase (cycles)
*33	Message checksum in hexadecimal

RTCM type 19 is the uncorrected code phase message used to transmit data to the rover for RTK processing. The format for RTCM type 19 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,s1,d6,d7,d8,n(d9,d10,d11,d12,f2)*cc

Table 6.70 outlines the $GPMSG response message format for RTK Uncorrected Pseudoranges (Type 19):

Table 6.70: $GPMSG Structure for RTCM Message Type 19

Field	Description
d1	RTCM type, 19
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	Current UTC time of position computation in hours, minutes, and seconds
s1	GPS / GLONASS Constellation Indicator
d6	Frequency Indicator: "00": L1 message, "01": L2 message, "10","11" :Reserved
d7	Smoothing Interval (0=1 min, 1 = 1..5 min, 2=5..15 min, 3=undefined)
d8	GNSS Time of measurement (GPS or GLONASS time) (added to Z-Count)
	The following data is displayed for each Satellite in the message:
d9	Multiple message indicator (1 = more messages will follow with same time tag, 0 = last message)
d10	GPS (PRN Range 0-31) or GLONASS (Slot number 1-24) Satellite ID
d11	Data Quality Indicator (See RTCM Paper 88-97/SC104-156 Version 2.2)

Table 6.70: $GPMSG Structure for RTCM Message Type 19 (continued)

Field	Description
d12	Pseudorange multipath error indicator quantization (See RTCM Ver 2.2)
f2	Uncorrected Pseudorange (meters)
*cc	Message checksum in hexadecimal

Typical Example 5:

$GPMSG,19,0000,1747.8,6,0,148,202908.50,GLO,0,3,200000,0,20,14,15,
21322294.20,0,04,14,15,23304544.46,0,16,14,15,22933427.40,0,14,14,15,
22844988.16,0,15,14,15,21307216.00,0,06,14,15,21096086.06*2B

Table 6.71 outlines the $GPMSG response structure:

Table 6.71: $GPMSG Response for RTCM Message 19

Item	Description
$GPMSG	Header
19	RTCM message
0000	Station ID
1747.8	Z count in seconds and tenths
6	Sequence number
0	Station health
148	Total number of characters of the time item
202908.50	Current time in hours, minutes, and seconds
GLO	GLONASS Constellation
0	L1 Frequency indicator
3	Smoothing Interval (3=undefined)
200000	GPS system time of measurement basis
0	Last message for this SV and Time Tag
04	GLONASS slot number (ID)
14	Data quality indicator (≤5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
21322294.20	Uncorrected Pseudorange (meters)

Table 6.71: $GPMSG Response for RTCM Message 19 (continued)

Item	Description
0	Last message for this SV and Time Tag
20	GLONASS slot number (ID)
14	Data quality indicator (≤5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
23304544.46	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
16	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
22933427.40	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
14	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
22844988.16	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
15	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
21307216.00	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
06	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
21096086.06	Uncorrected Pseudorange (meters)
*2B	Message checksum in hexadecimal

RTCM type 22 provides additional station position information and antenna height information. The format for RTCM type 22 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,f1,f2,f3,f4*cc

Table 6.72 outlines the response structure for Extended Reference Station Parameters (Type 22):

Table 6.72: $GPMSG Structure for RTCM Message Type 22

Field	Description
d1	RTCM type, 22
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	current GPS system time of position computation in hours, minutes and seconds
f1	L1 ECEF DELTA-X (meters)
f2	L1 ECEF DELTA-Y (meters)
f3	L1 ECEF DELTA-Z (meters)
f4	Antenna L1 phase center height (meters)
*cc	Message checksum in hexadecimal

Example:

$GPMSG,22,0000,1717.2,2,0,045,202908.50,+0.000664,+0.004180,-0.002461,+0.000000*69

Table 6.73 defines the response format for a typical RTCM type 22 message.

Table 6.73: $GPMSG Response for RTCM Message Type 22

Item	Description
22	RTCM type
0000	Station ID
1717.2	Z count in seconds and tenths
2	Sequence number
0	Station health
045	Total number of characters after the time item
202908.50	Current UTC time of position calculation in hours, minutes, and seconds

Table 6.73: $GPMSG Response for RTCM Message Type 22

Item	Description
+0.000664	L1 ECEF DELTA-X (meters)
+0.004180	L1 ECEF DELTA-Y (meters)
-0.002461	L1 ECEF DELTA-Z (meters)
+0.000000	Antenna L1 phase center height (meters)
69	Message checksum in hexadecimal

PER: Set NMEA Send Interval

$PASHS,NME,PER,x

Set send interval of the NMEA response messages in seconds, where x is a value between 0.2 and 999, depending upon position update rate option installed (5, 2, or 1 Hz).

Example: Set send interval to 10.0 seconds

$PASHS,NME,PER,10.0

Table 6.74 outlines the PER (NMEA output rate) range options.

Table 6.74: PER (NMEA Output Rate) Range Options

Installed Option	PER Range (seconds)	Increment
1 Hz	1-999	1 second
2 Hz	0.5-999	0.5 second from 0.5 to 1 1 second from 1 to 999
5 Hz	0.2-999	0.2 second from 0.2 to 1 1 second from 1 to 999

For 5-Hz update rate, the $PASHS,POP,5 command should have been previously sent.

POS: Position Message

$PASHS,NME,POS,x,c

Enable/disable NMEA position response message on output port x, and c is ON or OFF. If no position is computed, an empty message outputs.

Example: Enable position message on port B

$PASHS,NME,POS,B,ON

$PASHQ,POS,x

The associated query command is $PASHQ,POS,x where x is the optional output port.

$PASHR,POS

The response is a message containing information on the most recently computed position. This response message is in the form:

$PASHR,POS,d1,d2,m1,m2,c1,m3,c2,f1,f2,f3,f4,f5,f6,f7,f8,f9,s*cc

Table 6.75 defines the POS response structure.

Table 6.75: POS Response Structure

Field	Description	Range
d1	position type: 0 = autonomous 1 = position differentially corrected with RTCM code 2 = position differentially corrected with CPD float solution 3 = position is CPD fixed solution	0 to 3
d2	Number of satellites used in position computation	3 to 12
m1	Current UTC time, (hhmmss), of position computation in hours, minutes and seconds	00 to 235959.50
m2	Latitude component of position in degrees, minutes, and fraction of minutes (ddmm.mmmm)	0 to 90°
c1	Latitude sector: N = North, S = South	‘N’ or ‘S’
m3	Longitude component of position in degrees, minutes, and fraction of minutes	0 to 180°
c2	Longitude sector: E = East, W = West	W or E
f1	Altitude in meters above WGS-84 reference ellipsoid. For 2-D position computation this item contains the altitude held fixed.	± 30000.00
f2	Reserved	
f3	True track/true course over ground in degrees (000.00 to 359.99 degrees)	0 to 359.9
f4	Speed over ground in knots	0 to 999.9
f5	Vertical velocity in meters per second	± 999.9
f6	PDOP - position dilution of precision	0 to 99.9
f7	HDOP - horizontal dilution of precision	0 to 99.9
f8	VDOP - vertical dilution of precision	0 to 99.9

Table 6.75: POS Response Structure (continued)

Field	Description	Range
f9	TDOP - time dilution of precision	0 to 99.9
s1	Firmware version ID	4 character string

If there is no valid position, POS provides: number of satellites, time, DOPs, firmware version ID. All other fields are null.

If there are not enough satellites to compute DOP, then the DOP field is null.

Example 1:

Query: $PASHQ,POS,A or

Set: $PASHS,NME,POS,B,ON

Typical Response:

$PASHR,POS,0,06,183805:00,3722.36221,N, 12159.82742, W,+00016.06,,179.22,021.21,+003.96+34,06.1,04.2,03.2,01.4,GA00*cc

Table 6.76 outlines a typical POS response message.

Table 6.76: Typical POS Response Message

Item	Description
$PASHR,POS	Header
0	Position is autonomous
06	Number of satellites used in position computation
183805.00	Time of position computation
3722.36221	Latitude
N	North
12159.82742	Longitude
W	West
+00016.06	Altitude in meters
empty field	Reserved
179.22	Course over ground in degrees (True)
021.21	Speed over ground in knots
+003.96	Vertical velocity in meters per second
06.1	PDOP
04.2	HDOP

Table 6.76: Typical POS Response Message (continued)

Item	Description
03.3	VDOP
01.4	TDOP
GA00	Version number
cc	Message checksum in hexadecimal

RMC: Recommended Minimum Course

$PASHS,NME,RMC,x,c

Enables/disables the magnetic declination message where x is the serial port, and c is ON or OFF.

Example: Enable RMC message on port C

$PASHS,NME,RMC,C,ON

$PASHQ,RMC,x

The associated query command the $PASHQ,RMC,x where x is the optional output port.

$GPRMC

The return message is in the form:

$GPRMC,m1,c2,m3,c4,m5,c6,f7,f8,d9,f10,c11*cc

Table 6.77 outlines the response structure.

Table 6.77: RMC Response Structure

Parameters	Description	Range
m1	UTC time of the GGA fix associated with this sentence (hhmmss.ss)	000000.00-23559.95
c2	Status	A => Data Valid V => Navigation Receiver Warning
m3	Latitude (ddmm.mmmm)	0000.0000-8959.9999
c4	Latitude direction	N => North S => South
m5	Longitude (dddmm.mmmm)	00000.0000-17959.9999
c6	Longitude direction	E => East W => West

Table 6.77: RMC Response Structure (continued)

Parameters	Description	Range
f7	Speed over ground, knots	000.00-999.99
f8	Course Over Ground, degrees True	000.00-359.99
d9	date, mmddyy	010100-123199
f10	Magnetic Variation, degrees	0.00-99.99
c11	Direction of Variation Easterly variation (E) subtracts from True course. Westerly variation (W) adds to True course	E => East W =>West
*cc	The hexadecimal checksum	

RRE: Satellite Residual and Position Error Message

$PASHS,NME,RRE,x,c

Enable/disable satellite residual and position error message to port x, where x is the output port, and c is ON or OFF. This message is not output unless a position is computed.

Example: Enable RRE message on port A

$PASHS,NME,RRE,A,ON

$PASHQ,RRE,x

The associated query command is $PASHQ,RRE,x, where x is the optional output port.

Example:

$PASHQ,RRE,A

$GPRRE/$GLRRE

The response message is output in two messages with different headers. The first message contains GPS satellite information in the form:

$GPRRE,d1,n(d2,f1)f2,f3

The second message contains GLONASS satellite information in the form:

$GLRRE,d1,n(d2,f1)f2,f3

where n is equal to the number of satellites used to compute a position.

Table 6.78 outlines the RRE response structure.

Table 6.78: RRE Response Structure

Field	Description
d1	Number of satellites used to compute position
d2	PRN number for each of the satellites used in position computation. GPS satellite ranging from 1 to 32 in the $GPRRE message and GLONASS satellite ranging from 33 to 56 in the $GLRRE message
f1	Range residuals magnitude in meters for each satellite used in position computation: GPS satellites in message.
f2	Horizontal RMS position error for mixed constellation in meters
f3	Vertical RMS position error for mixed constellation in meters

Example:

Query: $PASHQ,RRE,A or

Set:$PASHS,NME,RRE,A,ON

Typical Responses:

$GPRRE,05,18,+000.2,29,+000.2,22,-000.1,19,- 000.1,28, +000.5,0002.0,0001.3*76

$GLRRE,03,45,+000.4,36,+000.2,52,-000.2,0002.0,0001.3*A1

Table 6.79 outlines the typical $GPRRE response message.

Table 6.79: $GPRRE Response Message

Item	Description
$GPRRE	Header
05	Number of satellites used to compute position
18	PRN of first satellite
+000.2	Range residual for first satellite in meters
29	PRN of second satellite
+000.2	Range residual for second satellite in meters
22	PRN of third satellite
-000.1	Range residual for third satellite in meters
19	PRN of fourth satellite
-000.1	Range residual for fourth satellite in meters

Table 6.79: $GPRRE Response Message (continued)

Item	Description
28	PRN of fifth satellite
+000.5	Range residual for fifth satellite in meters
0002.0	Horizontal position error in meters
0001.3	Vertical position error in meters
76	Message checksum in hexadecimal

Table 6.80 outlines the $GLRRE response message.

Table 6.80: $GLRRE Response Message

Item	Description
$GLRRE	Header
03	Number of satellites used to compute position
45	PRN of first GLONASS satellite
+000.4	Range residual for first GLONASS satellite in meters
36	PRN of second GLONASS satellite
+000.2	Range residual for second GLONASS satellite in meters
52	PRN of third GLONASS satellite
-000.2	Range residual for third GLONASS satellite in meters
0002.0	Horizontal position error in meters
0001.3	Vertical position error in meters
A1	Message checksum in hexadecimal

SAT: Satellite Status Message

$PASHS,NME,SAT,x,y

Enable/disable satellite status message on port x, where x is the output port, and y is ON or OFF. This message is output even if no position is computed.

Example: Enable SAT message on port B

$PASHS,NME,SAT,B,ON

$PASHQ,SAT,x

The associated query command is $PASHQ,SAT,x, where x is the optional output port.

Example:

$PASHQ,SAT,B

$PASHR,SAT

The response is a message in the form:

$PASHR,SAT,d1,n(d2,d3,d4,d5,c1)*cc

where n is equal to the number of satellites locked.

Table 6.81 outlines the SAT field structure.

Table 6.81: SAT Structure

Field	Description
d1	Number of satellites locked, number of satellites in message, range 0-24
d2	Satellite PRN number, range 1 to 56 (1 to 32 for GPS, 33 to 56 for GLONASS)
d3	Satellite azimuth angle, 000 to 359 degrees
d4	Satellite elevation angle, 00 to 90 degrees
d5	Satellite signal strength/signal-to-noise ratio, 00 to 99
c1	Satellite used/not used in position computation U = Satellite used in position computation - = Satellite not used in position computation

Example 1:

Query: $PASHQ,SAT,B or

Set: $PASHS,NME,SAT,B,ON

Typical Response:

$PASHR,SAT,04,03,103,56,60,U,23,225,61,39,U,16,045,02,21,U,40,160,46,50,
U*6E

Table 6.82 outlines the response format.

Table 6.82: Typical SAT Response Message

Item	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

Table 6.82: Typical SAT Response Message (continued)

Item	Description
60	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
61	Elevation of the second satellite in degrees
39	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
21	Signal strength of the third satellite
U	Satellite used in position computation
40	PRN number of fourth satellite
160	Azimuth of fourth satellite in degrees
46	Elevation of fourth satellite in degrees
50	Signal strength of fourth satellite
U	Satellite used in position computation
6E	Message checksum in hexadecimal

TCM: Enables/Disables RTCM Rover Data Message

$PASHS,NME,TCM,x,c

This command enables or disables the RTCM rover data message, where x is the port, A, B, or C, and c is ON or OFF.

$PASHQ,TCM

The associated query command is $PASHQ,TCM,x where x is the optional output port.

$PASHR,TCM

The response message has the structure

$PASHR,TCM,d1,d2,d3,d4,f5,d6,d7

where Table 6.83 outlines the response format.

Table 6.83: TCM Response Structure

Field	Description	Range
d1	Synchronization indicator. 0 = sync between base and remote has not been established or has been lost 1 = sync between base and remote has been established	0 or 1
d2	RTCM message type	1, 2, 3, 6, 9, 16
d3	Reference station ID, transmitted by reference station	0 through 1023
d4	Reference station health, transmitted by reference station. 0 = UDRE scale factor 1 1 = UDRE scale factor 0.75 2 = UDRE scale factor 0.5 3 = UDRE scale factor 0.3 4 = UDRE scale factor 0.2 5 = UDRE scale factor 0.1 6 = reference station transmission not monitored 7 = reference station not working	0 through 7
f5	Modified Z count	0 - 3599.4 seconds
d6	Quality factor for communication, defined as 100 x number of good measurements divided by total number of measurements	0 through 100
d7	Age of received messages, types 1, 2, 9 only	00 through 99 seconds

TTT: Event Marker Message

$PASHS,NME,TTT,x,c

Enable/disable event marker message on port x, where x is the output port, and c is ON or OFF. This message is not output unless a photogrammetry pulse is being input, and the photogrammetry option (E) is available in the receiver.

Example: Enable TTT message on port A

$PASHS,NME,TTT,A,ON

There is no query command for TTT.

$PASHR,TTT

The response message is in the form:

$PASHR,TTT,d1,m1*cc

The time displayed in the TTT message depends upon the selected constellation. If SYS=MIX, the time depends upon the setting of the TSC parameter. If SYS=GPS, the time is GPS. IF SYS=GLO, the time is UTC + 3 hours.

Table 6.84 outlines the TTT response message structure.

Table 6.84: TTT Message Structure

Field	Description
d1	Day of GPS week, 1 to 7, where Sunday = 1
m1	Time in hours, minutes, seconds (hh:mm:ss.sssssss)

Example: Enable TTT event marker on port A

Set: $PASHS,NME,TTT,A,ON

Typical Response: $PASHR,TTT,6,20:41:02.0000000*OD

Table 6.85 outlines the example TTT response message.

Table 6.85: Example TTT Response Message

Item	Description
$PASHR,TTT	Header
6	Day of week (Friday)
20:41:02.000000 0	Time
OD	Message checksum in hexadecimal

VTG: Velocity/Course Message

$PASHS,NME,VTG,x,c

Enable/disable the velocity/course message on port x, where x is the output port, and c is ON or OFF. This message is not output unless position is computed.

Example: Enable VTG message or port B

$PASHS,NME,VTG,B,ON

$PASHQ,VTG,x

The associated query command is $PASHQ,VTG,x where x is the optional output port. This message does not output unless position is computed.

$GPVTG

The response message is in the form:

$GPVTG,f1,T,f2,M,f3,N,f4,K

Table 6.86 outlines the VTG structure.

Table 6.86: VTG Structure

Field	Description
f1	True track/true course over ground, ttt.tt = 000.00 to 359.99 degrees
T	T = true course
f2	Magnetic track/magnetic course over ground, (000.00 to 359.99) degrees. (Output only if magnetic variation option (M) is installed in receiver)
M	Magnetic course over ground marker, M = magnetic course
f3	Speed over ground, 000 to 999.99 knots
N	Speed over ground units, N = nautical miles per hour
f4	Speed over ground, = 000 to 999.99 kilometers per hour
K	Speed over ground units, = K (kilometers per hour)

Example:

Query:$PASHQ,VTG,B or

Set: $PASHS,NME,VTG,A,ON

Typical Response:$GPVTG,179.21,T,1934.4,M,000.11,N,000.20,K*3E

Table 6.87 outlines the example VTG response message.

Table 6.87: Typical VTG Response Message

Item	Description
$GPVTG	Header
179.21	Course over ground in degrees
T	True course over ground marker
193.44	Magnetic course over ground
M	Magnetic course over ground marker
000.11	Speed over ground in knots
N	Knots
000.20	Speed over ground in kilometers/hour

Table 6.87: Typical VTG Response Message (continued)

Item	Description
K	Kilometers/hour marker
3E	Message checksum in hexadecimal

ZDA: Time and Date Message

$PASHS,NME,ZDA,x,c

Enable/disable the time and date message or port x, where x is the output port, and c is ON or OFF. This message is output even if a position is not computed.

Example: Disable ZDA message on port A

$PASHS,NME,ZDA,A,OFF

$PASHQ,ZDA,x

The associated query command is $PASHQ,ZDA,x , where x is the optional output port.

$GPZDA

The response message is in the form:

$GPZDA,m1,d1,d2,d4,d5

Table 6.88 outlines the ZDA structure.

Table 6.88: ZDA Structure

Field	Description
m1	UTC time (hhmmss.ss) (hours, minutes, seconds)
d1	Current day 01 - 31
d2	Current month 01 - 12
d3	Current year 0000-9999
d4	Local zone offset from UTC time where s = sign and hh = hours Range 00 - ±13
d5	Local zone offset from UTC time where mm = minutes with same sign as shh

Example:

Query: $PASHQ,ZDA,A or

Set: $PASHS,NME,ZDA,A,ON

Typical Response: $GPZDA,132123.00,10,03,1996,+07,00*ss

Table 6.89 outlines the example ZDA response message.

Table 6.89: Typical ZDA Response Message

Item	Description
$GPZDA	Message header
123123.00	UTC time
10	Current day
03	Current month
1996	Current year
+07	Local zone
*22	Checksum in hexadecimal

RTCM Response Message 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 parameters and general parameters 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 Chapter 5, **Differential and RTK Operations**.

Set Commands

All RTCM commands but one are set commands. 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. If the set command is sent correctly, the receiver will respond with the $PASHS,ACK acknowledgment. If a parameter is out of range or the syntax is incorrect, then the receiver will respond with a $PASHS,NAK to indicate that the command was not accepted.

Query Commands

There is only one query command: $PASHQ,RTC. Use this command to monitor the parameters and status of RTCM differential operations. The query command has an optional port field. If the query is sent with the port field left empty, then the response will be sent to the current port. If the port field contains a valid port (A-C), then the response will be output to that port. For example, the query:

$PASHQ,RTC<Enter>

Will output an RTCM status message to the current port. The command:

$PASHQ,RTC<Enter>

Will output an RTCM status message to port C.

Table 6.90 lists the RTCM commands.

Table 6.90: RTCM Commands

Function	Command	Description	Page
Base Parameters	$PASHS,RTC,BAS	Set receiver to operate as differential base station	178
	$PASHQ,RTC,M36	Defines RTCM type 36 message	178
	$PASHS,RTC,MSG	Defines RTCM type 16 message	178
	$PASHS,RTC,SPD	Sets baud rate of base station	182
	$PASHS,RTC,STH	Sets health of reference station	182
	$PASHS,RTC,TYP	Enables type of message	183
Remote Parameters	$PASHS,RTC,AUT	Turns auto differential mode on or off	177
	$PASHS,RTC,MAX	Set max age of RTCM differential corrections	178
	$PASHS,RTC,QAF	Sets quality threshold	179
	$PASHS,RTC,REM	Set receiver to operate as differential remote station	179
	$PASHS,RTC,SEQ	Checks sequence number of received messages	181
General Parameters	$PASHQ,RTC	Requests base or remote differential mode parameters and status	179
	$PASHS,RTC,OFF	Disable differential mode	178
	$PASHQ,TCM	Query RTCM station data	170

AUT: Enable/Disable Auto Differential Mode

$PASHS,RTC,AUT,x

Turns auto differential mode on or off where x is Y (on) or N (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. Used only in REMOTE mode.

When the receiver is in CPD (RTK) mode and fast CPD mode is off ($PASHS,CPD,FST,OFF), then the rover receiver does not generates any positions if data from the base station is unavailable.

Example: Turn auto differential mode on

$PASHS,RTC,AUT,Y<Enter>

BAS: Set Receiver as Differential Base Station

$PASHS,RTC,BAS,x

Set the receiver to operate as an RTCM differential base station, where x is the port through which corrections will be sent.

Example: Set to differential base mode using port B

$PASHS,RTC,BAS,B<Enter>

M36: RTCM Type 36 Message

$PASHS,RTC,M36,s

Define RTCM type 36 message, where s is a character string up to 90 characters long that will be sent from the base to the remote. Used only if message type 36 is enabled.

Example: Define RTCM message "This is a test message"

$PASHS,RTC,M36,This is a test message<Enter>

MAX: Set Maximum Age of RTCM Differential Corrections

$PASHS,RTC,MAX,d

Set the maximum age in seconds of an RTCM differential correction above which it will not be used, where d is any number between 1 and 1199. Default is 60. Used only in REMOTE mode.

Example: Set maximum age to 30 seconds

$PASHS,RTC,MAX,30<Enter>

MSG: RTCM Type 16 Message

$PASHS,RTC,MSG,s

Define RTCM type 16 message, where s is a character string up to 90 characters long that will be sent from the base to the remote. Used 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 Differential Mode

$PASHS,RTC,OFF

Disables base or remote differential mode.

Example:

$PASHS,RTC,OFF<Enter>

QAF: Set Quality Threshold

$PASHS,RTC,QAF,d

Sets the number of received differential correction frames in RTCM differential mode above which the quality factor is reset to 100%, 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. The QA value can be seen using the $PASHQ,RTC query command. Default is 100. Used only in REMOTE mode.

Example: Set quality factor to 200

$PASHS,RTC,QAF,200<Enter>

REM: Set Receiver as Differential Remote

$PASHS,RTC,REM,x

Set the GG Surveyor to operate as a differential remote station using RTCM format, where x is port through which corrections will be received.

Example: Set receiver as differential remote using port B

$PASHS,RTC,REM,B

RTC: RTCM Differential Parameters

$PASHQ,RTC,c

Request differential mode parameters, where c is the optional serial port. The response message is a free form response looks like:

```
STATUS:
   SYNC:   TYPE:00 STID:0000 STHE:0
   AGE:+999 QA:100.0% OFFSET:00
SETUP:
   MODE:OFF PORT:A AUT:N
   SPD:000300 STI:0000 STH:0
   MAX:0060 QAF:100 SEQ:N
   TYP:1  2  3  6   9  16 18 19 22 31 32 6G  34 36
   FRQ:99 00 00 OFF 00 00 00 00 00 99 00 OFF 00 00
BASE:   LAT:0000.000000,N LON:00000.000000,E ALT:+00000.000 W84
MSG:
MSG(GLO):
```

where Table 6.91 outlines the response message format:

Table 6.91: RTC Response Message Structure

Field	Description
STATUS:	
SYNC	Indicates with an * that synchronization between base and remote has been established. Valid only for REMOTE mode.
TYPE	Indicates type of message being sent (base) or received (remote).
STID	Displays the station ID or received from the base station.
STHE	Displays the station health or received from the base station.
AGE	In BASE mode, displays the elapsed time in seconds between the beginning of the transmission of Type 1 or 9 messages. In REMOTE mode, displays the age of the received messages in seconds.
QA	Displays the communication quality factor between base and remote. • Defined as 100 x number of good messages/total number of messages Valid for REMOTE mode only.
OFFSET:	Displays the number of bits from the beginning of the RTCM byte (in case of a bit slippage).
SETUP:	
MODE:OFF	Displays differential mode either base (BAS), remote (REM) or disabled (OFF).
PORT:A	Displays port used to send or receive RTCM corrections.
AUT:N	Displays auto differential mode. Default is N. Used only in REMOTE mode.
SPD:0300	RTCM bit rate. The number of bits per second sent to the differential serial port. Used only in BASE mode.
STI:0000	User-supplied station ID. Default is 0000.
STH:0	User-set reference station health. Default is 0. Used only in BASE mode.
MAX:0060	Maximum age, in seconds, allowed for a message to be used to compute a differentially corrected position. Default is 60. Used only in REMOTE mode.
QAF:100	The criteria to be applied when evaluating the quality of communication between base and remote. Used in computing QA. Default is 100. Used only in REMOTE mode.
SEQ:N	Indicates if there is a check for sequential received message number for the message to be accepted. Default is N. Used only in REMOTE mode.
TYP	Indicates the RTCM message types the receiver can generate. Messages available are 1, 3, 6, 9, 16, 31, 32, 6G, 34, and 36. Message 2 is not generated. Used only in BASE mode.

Table 6.91: RTC Response Message Structure (continued)

Field	Description
FRQ	Indicates the output period for message types 1, 2, 3, 9, 16, 31, 32, 34, and 36. A 0 indicates message disabled, a 99 indicates continuous output, and any other number specifies the number of seconds between transmissions for message types 1, 9, 31, and 34, and the number of minutes between transmissions for all other messages. Default for message types 1 and 31 is 99, for types 6 and 6G is OFF, and for all other messages is 00.
BASE	For base mode, displays the antenna position of the base station in latitude, longitude, altitude above reference ellipsoid, and reference coordinates to use when computing corrections. Antenna position is entered with commands POS.
MSG	For base mode, contains the text message, up to 90 characters, that is sent from the base to the remote when message type 16 is enabled. In REMOTE mode, displays the text message, up to 90 characters, that is received from the base.
MSG(GLO)	For base mode, contains the text message, up to 90 characters, that is sent from the base to the remote when message type 36 is enabled. In REMOTE mode, displays the text message, up to 90 characters, that is received from the base.

If changed parameter values are saved by the $PASHS,SAV,Y set command, after the next power-up, the response to the $PASHQ,RTC query command will display the saved quantities instead of the defaults. $PASHS,RST always reinstates the defaults.

SEQ: Check Sequence Number

$PASHS,RTC,SEQ,c

Checks sequence number of received messages and, if sequential, accept corrections; if not, don't use correction, where c is Y (check) or N (do not check). Default is N. Used only in REMOTE mode. Valid only at beginning of differential operation. After two sequential RTCM corrections have been received, differential operation begins.

Example: Check sequence number

$PASHS,RTC,SEQ,Y<Enter>

SPD: Set RTCM Bit Rate

$PASHS,RTC,SPD,d

Set 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. Default is 300 bits per second. Used only in BASE mode. Table 6.92 lists the bit rate codes.

Table 6.92: Bit Rate Codes

Code	0	1	2	3	4	5	6	7	8	9
Rate	25	50	100	110	150	200	250	300	1500	Burst Mode

Example: Set bit rate to 110 bits/sec

$PASHS,RTC,SPD,3<Enter>

STH: Health of Reference Station

$PASHS,RTC,STH,d

Set the health of the reference station, where d is any value between 0 and 7. Used only in BASE mode. Default is 0. Table 6.93 lists the codes for the station health.

Table 6.93: Reference Station Health Codes

Code	Health Indication
7	Reference station not working.
6	Reference station transmission not monitored.
5	Specified by service provider.
4	Specified by service provider.
3	Specified by service provider.
2	Specified by service provider.
1	Specified by service provider
0	Specified by service provider.

Example: Set health to "Reference station not working"

$PASHS,RTC,STH,7<Enter>

STI: Set Station Identification

$PASHS,RTC,STI,d

Set user station identification (user STID) to any value between 0000 and 1023. In RTCM differential mode, corrections will not be applied if the station ID between base and rover are different, unless rover is set to zero. If user STID of rover station is set to zero, the GG Surveyor will attempt to use the differential corrections it receives, regardless of STID of base station. Default is 0000.

Example: Set site identification to 0001

$PASHS,RTC,STI,0001<Enter>

TYP: Enable Type of Message

$PASHS,RTC,TYP,x,s

Enables the type of message to be sent by the base station and the period at which it will be sent, where x is the type and s is the period. Used only in BASE mode. Table 6.94 lists the type of messages available and the period range setting.

Table 6.94: Base Station Message Types and Period Ranges

Type	Range
1	0-99 seconds, where 0 is disabled and 99 is generated continuously
2	Delta differential GPS corrections
3	0-99 minutes, where 0 is disabled and 99 is generated continuously
6	ON or OFF Default = OFF
9	0-99 seconds, where 0 is disabled and 99 is generated continuously
16	0-99 minutes, where 0 is disabled and 99 is generated continuously
18	0-99 seconds, where 0 is disabled and 99 is generated continuously
19	0-99 seconds, where 0 is disabled and 99 is generated continuously
22	0-99 minutes, where 0 is disabled and 99 is generated continuously
31	0-99 seconds, where 0 is disabled and 99 is generated continuously
32	0-99 minutes, where 0 is disabled and 99 is generated continuously
6G	ON or OFF Default is OFF
34	0-99 seconds, where 0 is disabled and 99 is generated continuously
36	0-99 minutes, where 0 is disabled and 99 is generated continuously

Example: Enable type 1, sent out every second

$PASHS,RTC,TYP,1,1<Enter>

When the command $PASHS,RTC,BAS,is sent, message types 1 and 31 are generated continuously by default.

CPD Commands

The CPD commands allow you to control and monitor CPD (carrier phase differential) operations. The commands are either general parameter or query commands, base set commands or rover set commands. The rover set commands are only available if the CPD Rover option (J) is installed in the receiver, For a more detailed discussion of CPD differential, refer to the Understanding CPD section in this manual.

Set Commands

Through the set commands you can modify and enable a variety of CPD operating parameters. Certain set commands are applicable only to the base station and certain set commands only apply to the remote station. The general format of the set commands is:

$PASHS,CPD,str,x<Enter>

where str is the 3 character command identifier, and x is the parameter to be set. If the set command is sent correctly, the receiver will respond with the $PASHR,ACK acknowledgment. If a parameter is out of range or the syntax is incorrect, then the receiver will respond with a $PASHR,NAK to indicate that the command was not accepted.

Query Commands

The query commands are used to monitor the setting of individual parameters and the status of CPD operations. The general format of the query command is:

$PASHQ,CPD,str,x<Enter>

where str is the 3 character command identifier, and x is the port to which the response message will be output. The port field is optional. If the query is sent with the port field left empty, then the response will be sent to the current port. If the port field contains a valid port (A-C), then the response will be output to that port. For example, the query:

$PASHQ,CPD<Enter>

outputs a CPD status message to the current port. The query:

$PASHQ,CPD,C <Enter>

output a CPD status message to port C.

where Table 6.95 lists the CPD commands.

Table 6.95: CPD Commands

Function	Command	Description	Page
General Set Commands	$PASHS,CPD,MOD	Set CPD mode	195
General Query Commands	$PASHQ,CPD $PASHQ,CPD,ANT $PASHQ,CPD,DLK $PASHQ,CPD,INF $PASHQ,CPD,MOD $PASHS,RST	Query CPD related setting Query base station antenna settings (from Rover) Query data link status Query CPD satellite information Query CPD mode settings Query base position from Rover	186 188 190 193 195
Rover Only Set Command	$PASHS,CPD,AFP $PASHS,CPD,ANT $PASHS,CPD,FST $PASHS,CPD,MAX $PASHS,CPD,POS $PASHQ,CPD,POS $PASHS,CPD,UBP	Set ambiguity fixing confidence parameter Set base antenna parameters from Rover Enable/disable fast CPD mode. Set maximum age of corrections. Set reference position of the base receiver from Rover Reset CPD processing Select which base position to use in ROVER mode	188 188 193 194 196 196 197 197 197

$PASHQ,CPD,c

The general CPD query command is $PASHQ,CPD,c where c is the optional serial port. Use this query to monitor CPD settings and status.

Example: Query CPD parameters

$PASHQ,CPD<Enter>

The response message is in free form format. A typical response appears as follows:

```
STATUS:
 RST_TIME:000000 FIX_TIME:000000
 LATENCY:0046 AMB:FIXED LENGTH:00000.0011 VELOCITY:000.0037
 ROV_SV: 04 14 16 18 19 22 25 29 42 - 44 52
 BAS_SV: 04 14 16 18 19 22 25 29 42 43 44 52
 BASE POSITION:RECEIVED 3759.729431 N  12159.549345 W  -4.790 ID:0000
 BASE_DELTA:RECEIVED
SETUP:
 MODE:ROV PORT:B SYS:MIX PEM:10
 FST:ON FST_RATE:02 AFP:99.0 MAXAGE:30
```

Table 6.96 outlines the response format.

Table 6.96: $PASHQ,CPD Response Descriptions

Item	Description	Range
RST TIME	GPS seconds of week when the CPD engine was last reset	000000-604800
FIX TIME	GPS seconds of week the COD engine last fixed carrier phase ambiguities.	000000-604800
LATENCY	RTK solution latency in milliseconds (Rover mode only)	0000-9999
AMB	RTK solution type (Rover mode only)	<FLOAT,FIXED>
LENGTH	Length of the baseline currently computed by the RTK engine (Rover mode only)	00000.0000-99999.9999
VELOCITY	Velocity of the rover antenna currently computed by the CPD engine. (Rover mode only)	000.0000-999.9999
ROV SV	PRN numbers of the satellites that are currently usable for CPD positioning in the rover receiver (Rover mode only)	
BAS SV	Should display the PRN numbers of the satellites for which corrections are being received by the Rover (Rover mode only)	
BASE POSITION	Part 1 of this field displays the method from which corrections are being received by the rover (Rover mode only) Part 2 of this field displays the WGS84 geographic coordinate clauses (rover mode only)	<NO, COMPUTER, RECEIVED, ENTERED>
ID	Base station ID	<0000-1023> 0000 (Default)
BASE DELTA	Type 22 message reception indicator	<NO, RECEIVED, ENTERED>
MODE	Mode of CPD operation	<OFF,BAS,ROV> OFF (Default)
PORT	Current port of CPD operation	<A,B,C,D> B (Default)
SYS	Current satellite system for positioning	<GPS,GLO,MIX> MIXS (Default)
PEM/ELM	Elevation mask governing the current mode of RTK positioning PEM should be displayed in this field if the MOD is set to ROV or OFF. ELM should be displayed in this field if the MOD is set to BAS.	<0-90> 10° (Default)
FST	Fast CPD operation flag <ON, OFF>	ON (Default)
FST RATE	The maximum update rate of the receiver in Hz for fast CPD mode.	<1,2,5> 2 (Default)

Table 6.96: $PASHQ,CPD Response Descriptions (continued)

Item	Description	Range
AFP	Ambiguity fix confidence percentage	<0, 95.0, 99.0, 99.9> 99.0 (Default)
MAXAGE	The maximum age of corrections that will be used in fast CPD mode.	<1-1199> 30 (Default)

AFP: Ambiguity Fixing

$PASHS,CPD,AFP,f

This command sets the confidence level for ambiguity fixing, where f is the confidence level in percent. The higher the confidence level, the more certainty that the ambiguities are fixed correctly, however the longer it will take to fix the ambiguities. 0 is float solution. The default is 99.0.

Table 6.97: CPD,AFP Parameter Table

Parameter	Description	Range
f	Ambiguity Fixing Parameter, i.e. the confidence levels for the reliability of the ambiguity fixed solution. 0 = Float Solution only	95.0 99.0 99.9 0

Example: Set the confidence level to 99.9.

$PASHS,CPD,AFP,99.9<Enter>

ANT: Antenna Parameters

$PASHS,CPD,ANT,f1,f2,f3,m1,f4

Sets the antenna parameters of base receiver from the rover receiver.

Since this is only valid when using a base position entered at the rover, set $PASHS,CPD,UBP,0 before entering $PASHS,CPD,ANT.

where Table 6.98 defines the parameters.

Table 6.98: CPD,ANT Parameter Table

Parameter	Description	Range	Units
f1	Antenna height (measured from the point to the antenna edge). (Survey mark to edge of antenna)	0 - 6.4000	meter
f2	Antenna radius	0 - 6.4000	meter
f3	Vertical offset (phase center to ground plane)	0 - 99.9999	meter
m4	Always 0	0	
f5	Always 0	0	

Example: Set antenna parameters of base station.

$PASHS,CPD,ANT,6.4,0.13,0.02,0,0<Enter>

$PASHQ,CPD,ANT,c

The associated query command is $PASHQ,CPD,ANT,c where c is the optional output port. The command queries the Base station from the Rover. This command is only valid from the Rover. If this command is sent when the receiver is in Base mode, the response will be $PASHR,NAK.

Example: $PASHQ,CPD,ANT <Enter>

$PASHR,CPD,ANT

The message returns the Base station parameters from the Rover. It is in the form:

$PASHR,CPD,ANT,f1,f2,f3,m4,f5*cc

where Table 6.99 outlines the response format.

Table 6.99: CPD,ANT Message Structure

Field	Description	Range	Units
f1	Antenna height (measured from the point to the antenna edge). (Survey mark to edge of antenna)	0 - 6.4000	meter
f2	Antenna radius	0 - 6.4000	meter
f3	Vertical offset (phase center to ground plane)	0 - 99.9999	meter
m4	Always 0	0	
f5	Always 0	0	
cc	checksum		

Example:$PASHQ,CPD,ANT

$PASHR,CPD,ANT,01.0242,0.2000,01.0000,17430.00,05.0006*6E

BAS: Base Mode

$PASHQ,CPD,BAS

```
STATUS:
 RST_TIME:000000 FIX_TIME:000000
 ROV_SV:
 BAS_SV:
 BASE POSITION:NO
 BASE_DELTA:NO
SETUP:
 MODE:BAS PORT:B SYS:MIX ELM:09
 FST:ON FST_RATE:02 AFP:99.0 MAXAGE:30
```

DLK: Data Link Status

$PASHQ,CPD,DLK,c

This command queries the data link status message, where c is the optional output port. If the port is not specified, the message is output to the port from which this command was received

Example: Query the data link status message to port A.

$PASHQ,CPD,DLK,A

$PASHR,CPD,DLK

This response message is different for base and rover receiver.

The response message is in the form:

$PASHR,CPD,DLK,s1,d1,d2,n(d3c1),s3,s4,d4,d5,d6,c1*cc

where Table 6.100 outlines the response format.

Table 6.100: CPD,DLK Message Structure

Field	Description	Range	Unit
s1	receiver CPD mode	‘BAS’, ‘ROV’, ‘OFF’	n/a
	The remainder of the message is only available when receiver is not in ‘OFF’ mode		
d1	BPS message warning flag	bit1 - set if base station antenna parameters are all zeros bit0 - set if the base station coordinates are not entered	

Table 6.100: CPD,DLK Message Structure (continued)

Field	Description	Range	Unit
d2	Number of satellites represented in current RTCM messages	0 - 24	n/a
n	Number of Satellites		n/a
d3c1	Satellite PRN number and warnings. Satellite PRN Warning field description: + - no warnings C - warning in L1 measurements	 1-56 '+' 'C'	n/a
s3	Reserved		n/a
	The following message is only available if the receiver is in ROV mode		n/a
s4	Reserved		n/a
d4	BPS message age (999 if no base position received)		sec
d5	percentage of good RTCM message reception		%
d6	the correction message age		ms
c1	the communication port status: '+' data is in the communication port '-' no data in the communication port	'+', '-'	
*cc	Checksum		

The following examples will illustrate the difference between the $PASHR,DLK response message from a Rover station receiver and from a base station receiver.

From the Rover station:

$PASHR,CPD,DLK,ROV,10,9,22+,21+,17+,06+,03+,54+,48+,41+,38+,??
??,????,053,100,00500,+*37

where Table 6.101 outlines the response format.

Table 6.101: CPD,DLK Response Message Example - Rover

Field	Significance
ROV	Receiver CPD mode = rover
10	BPS warning flag - base station antenna parameters are all zeros
9	Number of satellites in current DBEN message = 10

Table 6.101: CPD,DLK Response Message Example - Rover (continued)

Field	Significance
22+	Satellite 22, warning = none
21+	Satellite 21, warning = none
17+	Satellite 17, warning = none
06+	Satellite 06, warning = none
03+	Satellite 03, warning = none
54+	Satellite 54, warning = none
48+	Satellite 48, warning = none
41+	Satellite 41, warning = none
38+	Satellite 38, warning = none
????	Reserved
????	Reserved
053	age of base coordinates reception
100.00	Percentage of good correction message reception
00500	correction message age in millisecond
+	Data is in the communication port
*37	checksum

From the Base station:

$PASHR,CPD,DLK,BAS,02,09,02+,03+,10+,18+,19C,34+,44+,48+,52+?
???*12

where Table 6.102 outlines the response format.

Table 6.102: CPD,DLK Response Message Example - Base Station

Field	Significance
BAS	Receiver CPD mode = base
02	BPS warning flag - base station antenna parameters are all zeros
05	Number of satellites in current correction message = 5
02+	Satellite 02, warning = none
03C	Satellite 03, warning - L1 measurement warning
10+	Satellite 10, warning = none

Table 6.102: CPD,DLK Response Message Example - Base Station (continued)

Field	Significance
18+	Satellite 18, warning = none
19C	Satellite 19, warning = L1 measurement warning
34+	Satellite 34, warning = none
44+	Satellite 44, warning = none
48+	Satellite 48, warning = none
52+	Satellite 52, warning = none
*12	checksum

FST: Fast CPD Mode

$PASHS,CPD,FST,s

Enables/disables fast CPD mode, where s is either ON or OFF. If this mode is set to ON, the rover receiver provides a fast CPD position solution. This command is relevant for ROVER receiver only. The default is ON.

Fast CPD ON means faster update rates, lower latency (typically 50-100 ms), and lower accuracy (typically about 2 cm horizontal 95% (i. e. 2RMS) confidence accuracy).

Fast CPD OFF means lower update rates limited to the rate at which corrections are received from the base; Position latency is approximately equal to the interval between position updates plus a delta; Accuracy is higher (typically about 1 cm horizontal 95% (i.e. 2RMS confidence accuracy).

Example: Turn fast CPD OFF

$PASHS,CPD,FST,OFF<Enter>

INF: CPD Information

$PASHQ,CPD,INF,c

This command queries the INF message where c is the optional output port. This message contains base and rover satellite status information.

Example: Query the CPD satellite information message to the current port.

$PASHQ,CPD,INF<Enter>

$PASHR,CPD,INF

The response message is in the form:

$PASHR,CPD,INF,s1,d1,n(d2,c1),d3,m(d4,c2),d5,d6,d7*cc

where Table 6.103 outlines the response format.

Table 6.103: INF Message Structure

Field	Description	Range	Units
s1	CPD mode	OFF, BAS, ROV	
d1	Number of satellites in base station. This determines how many fields to be followed.	0 - 24	
n	Number of satellites in the base receiver.		
d2	Satellite PRN for the satellites in base receiver	1-56	
c1	Warning field description: + - no warnings C - warning in L1 measurements	 ‘+’ ‘C’	
...	repeats for other satellites in base station		
d3	Number of satellites in the rover station. This determines the number of fields to follow.	0-24	
m	Number of satellites in the rover receiver.		
d4	Satellite PRN for the satellites in the rover receiver	1-56	
c2	Warning field description: + - no warnings C - warning in L1 measurements	 ‘+’ ‘C’	
...	repeats for other satellites in rover station		
d5	Last base coordinates message time		sec
d6	Last correction message time		ms
d7	Always 0		
*cc	Checksum		

Typical Response:

$PASHR,CPD,INF,ROV,12,01+,26+,23+,22+,21+,17+,06+,03+,54+,48+,
41+,38+,12,01+,26+,22+,23+,21+,17+,06+,03+,54+,41+,38+,48+,
319873000,319893000,00*0B

MAX: Maximum Age

$PASHS,CPD,MAX,d

Sets the maximum age in seconds of RTK base station data above which it will not be used by the rover to compute an RTK position, where d is any number between 1 and 30. The default is 30 seconds. This command is only used by the remote receiver in RTK mode.

Example: Set maximum age of RTK base station data to 20 seconds.

$PASHS,CPD,MAX,20 <Enter>

319873000,319893000,00*0B

MOD: CPD Mode

$PASHS,CPD,MOD,s

This command selects the CPD mode, where s is a string that defines the mode.

where Table 6.104 defines the response format.

Table 6.104: CPD,MOD Parameter Table

Parameter	Character String	Description
s	ROV OFF	CPD ROVER mode Disable CPD mode

Example: Set receiver to rover CPD mode

$PASHS,CPD,MOD,ROV <Enter>

$PASHQ,CPD,MOD,c

Queries for the current CPD setting, where c is the optional output port. This message contains information about current CPD mode. If the port is not specified, the message is output to the port from which this command was received.

Example: Query the receiver for CPD mode information.

$PASHQ,CPD,MOD

$PASHR,CPD,MOD

The response is in the form:

$PASHR,CPD,MOD,s1,s2,c1,f1,d1,d2,s3,s4,f2,s5,d3,s6,f3*cc

where Table 6.105 outlines the response format.

Table 6.105: CPD,MOD Message Structure

Field	Description	Range
s1	Mode	‘BAS’,’ROV’,’OFF’
s2	Fast CPD mode	’FST’, ‘OFF’
c1	Port	‘A’, ’B’, ...
f1	CPD update period	0.2 - 1.0
d1	Reserved	n/a

Table 6.105: CPD,MOD Message Structure (continued)

Field	Description	Range
d2	Reserved	n/a
s3	Correction type	'RTC'
s4	Reserved	n/a
f2	Reserved	n/a
s5	Which base position to use (entered/received)	'ETD','XIT'
d3	Reserved	n/a
s6	Which solution to output	'CPD'
f3	Ambiguity fixing confidence level	0 (always float), 95.0, 99.0, 99.9

Example: Response message with CPD mode information.

$PASHR,CPD,MOD,ROV,FST,B,0.50,,,RTC,,,XIT,,CPD,99.0

POS: Set Base Position

$PASHS,CPD,POS,m1,c1,m2,c2,f1

This command sets the base point position from the rover receiver

where Table 6.106 defines the parameters.

Table 6.106: CPD,POS Parameter Table

Parameter	Description	Range
m1	Latitude of base position in degrees and decimal minutes (ddmm.mmmmmmm).	0-8959.9999999
c1	Direction of latitude N = North, S = South	'S', 'N'
m2	Longitude of base position in degrees and decimal minutes (ddmm.mmmmmmm)	0-17959.9999999
c2	Direction of longitude E = East, W = West	'E', 'W'
f1	Reference point altitude (always have + or - sign) (in meters)	±9999.9999

Only implemented in Rovers, to allow the user to Enter the base station position at the rover. This position is only used if the command $PASHS,CPD,UBP,0 is sent.

If UBP is entered without a CPD,POS information having been entered ahead of time, the RTK engine will not send out a position. A base position MUST be entered before UBP can be used.

Example: Set base position from the rover receiver

$PASHS,CPD,POS,3722.2432438,N,12350.5438423,W,+34.5672

$PASHQ,CPD,POS,c

This command queries the base position from the rover, where c is the optional serial port. If the port is not specified, the message is output to the port from which this command was received.

Example: Query base position set at the rover receiver

$PASHQ,CPD,POS

$PASHR,CPD,POS

The response message is in the form:

$PASHR,CPD,POS,m1,c1,m2,c2,f1

The description of these parameters can be found in Table 6.106.

Example: Query the base position from the rover receiver

$PASHQ,CPD,POS

$PASHR,CPD,POS,3722.2432438,N,12350.5438423,W,+34.5672*53

If UBP is 0, the returned position will be the base station position entered at the rover. If UBP is 1, the returned position will be the base station position from Type 3 or 22 messages received from the base station. If no base station position has been received or entered, an empty response will be returned.

RST: Reset CPD

$PASHS,CPD,RST

Reset the CPD processing. This command is relevant in remote CPD mode only.

Example: $PASHS,CPD,RST<Enter>

UBP: Use Base Position

$PASHS,CPD,UBP,d1

This command selects the base position to use in ROVER mode, where d1 indicates the desired base position. This command is relevant for ROVER mode only. Default is 1.

Table 6.107 outlines the parameter structure.

Table 6.107: CPD,UBP Parameter Table

Parameter	Description	Range	Default
d1	Base position to use: 0 = Use entered base position 1 = Use transmitted base position	0,1	1

Example: Use entered base station position.

$PASHS,CPD,UBP,0<Enter>

If the user sends $PASHS,CPD,UBP,0 then Message types 3 and 22 will be ignored. The user must then Enter all base station antenna parameters (POS and ANT) at the rover, using $PASHS,CPD,POS and $PASHS,CPD,ANT.

If UBP is entered without prior entering of CPD,POS information, the receiver will return “NAK” message. A base position MUST be entered before UBP can be used.

GPS and GLONASS Concepts

When the Global Positioning System (GPS) became operational in 1993, it promised to provide a new utility as pervasive and as useful as the telephone. However, GPS has certain limitations that become apparent in certain applications. These limitations are dramatically reduced by the augmentation of GPS with the Russian GLObal NAvigation Satellite System (GLONASS). The Ashtech GG Surveyor™ GPS+GLONASS receiver uses the 13 healthy GLONASS satellites in addition to the 26 healthy GPS satellites, providing a system even more reliable and more accurate than either system alone.

Ashtech's GG Surveyor is the world's first fully integrated GPS+GLONASS receiver for easy integration with electronic displays, vehicle tracking, flight management survey, and mapping systems.

Background

There are three primary benefits of adding GLONASS to GPS: availability, integrity, and accuracy.

Availability

A navigation system is “available” when it produces valid position fixes. The availability of a valid and accurate GPS position fix depends strongly on the visibility of enough satellites. A GPS receiver needs to “see” at least four satellites to calculate latitude, longitude and altitude. This is easy in a perfect environment. With 26 GPS satellites orbiting the earth, there are usually seven satellites visible 10 degrees or more above the horizon. But if there is a mountain, building, tree, or other obstruction nearby, the number of visible satellites may fall to four, three or fewer, with the possibility that the GPS receiver has too few satellites to compute position.

Integrity

A navigation system has “integrity” when it can warn the user that the position fix is in error. It’s even better if the system can remove the error and provide a correct solution. A GPS receiver must use five satellites (and an integrity algorithm) to detect a problem. To remove the satellite that is causing the problem, a sixth satellite must be used. With the addition of GLONASS there are twice as many satellites available, and so twice as much chance that an integrity algorithm can operate correctly. The GG Surveyor has built-in Receiver Autonomous Integrity Monitoring (RAIM) to detect and remove faulty GPS or GLONASS satellites.

Accuracy

Because GLONASS has no Selective Availability (SA), accuracy of autonomous (non-differential) GPS+GLONASS positions are 5-10 times better than GPS-only, and GLONASS autonomous velocity accuracy is more accurate than Differential GPS velocity accuracy.

Differential Position Accuracy

Because there are more satellites in view, the DOPs (Dilution Of Precision) typically decrease by 20%-50%, and differential accuracy improves by a similar amount. In fact, there is no limit to how much the DOPs can change. At times of bad GPS satellite visibility the GPS DOPs may be tens to hundreds of times worse than the combined GPS+GLONASS DOPs, at these times the GPS+GLONASS differential accuracy will be tens to hundreds of times better than GPS differential accuracy.

Also, because SA causes GPS errors to change constantly and rapidly, Differential GPS corrections must be sent every few seconds. GLONASS errors are natural errors (such as orbit errors) and these change very slowly, so Differential GLONASS corrections need to be sent much less frequently than those for DGPS (Figure A.1)

Basic Concepts

GPS and GLONASS both work on the principle of triangulation: if you know your distance from several known points, then you can compute your position. The known points for both systems are the satellites. The distance to a satellite is measured by timing how long the satellite signal takes to reach you; multiply this time by the speed of light and you have the distance.

The GPS satellite clocks are all synchronized. Similarly, the GLONASS satellites are all synchronized with each other, but GPS time is not synchronized with GLONASS time. Thus, the receiver clock has two errors: the error with GPS time, and the error with GLONASS time. These two clock errors, plus latitude, longitude, and altitude, give 5 unknowns, which are solved by having 5 satellites (or more) in view.

The GG Surveyor fixes the altitude, if the altitude of the antenna is known; this removes one unknown, and only four satellites are needed. The GG Surveyor also determines the offset between GPS and GLONASS time. You can command the receiver to fix the time offset; this eliminates another unknown, thus only three satellites are needed for a 2D position, or four for a 3D position. Any combination of GPS & GLONASS satellites work, the GG Surveyor seamlessly integrates the two systems into one 48-satellite constellation.

Signal Structure

GPS and GLONASS have similar signal structures.

- Both transmit on two frequency bands, LI and L2
- Both have PRN codes in the LI frequency band, known as Coarse/ Acquisition (C/A) code for GPS, and standard (S) code for GLONASS
- Both transmit almanac and ephemerides at a data rate of 50 bus. The GG Surveyor tracks the LI C/A and S codes from both GPS and GLONASS
- Both have PRN codes that repeat every one millisecond (C/A for PS and S for GLONASS)

Differences in Signal Structure

The difference between GPS and GLONASS signal structures is that GPS uses the same frequencies but different PRN codes for each satellite (CDMA, Code Division Multiple Access). GLONASS uses the same PRN codes for each satellite, but different frequencies within the LI and L2 bands (FDMA, Frequency Division Multiple Access). A PRN code identifies each GPS satellite. GPS PRN codes are numbered from 1 through 32, 24 of which are used for the full constellation. GLONASS satellites are identified by their orbital slot number. There are 24 orbital slots, numbered sequentially 1 through 24. The satellite takes the slot number it occupies.

Differences in Implementation

The major difference in implementation between GPS and GLONASS is that GPS has SA on both C/A and P codes. The codes are deliberately degraded by dithering the transmit time. GLONASS has no deliberate degradation. GPS encrypts the P code on both L1 and L2; the encrypted code is secret, this is known as AS (Anti-Spoofing). GLONASS has no encryption.

GPS and GLONASS satellites transmit orbit information about the satellites in almanacs. Each satellite transmits an almanac which tells the receiver which satellites are operating and where they are. This is how the receiver knows which satellites are above the horizon. GPS satellites are identified in their almanac by their PRN numbers, while GLONASS satellites are identified by their orbital slot (ID) numbers. Each slot number has an associated carrier number in the almanac which tells the GG Surveyor receiver which frequency the satellite is on.

Each GPS satellite transmits at an L1 frequency of 1575.42 MHz, and at an L2 frequency of 1227.60 MHz. Each GLONASS satellite transmits at an L1 frequency of 1602 + K(9/16 MHz), and at an L2 frequency of 1246 + K(7/16 MHz). K is the carrier number given in the almanac for each satellite. Currently K is in the range 1 through 24. The GG Surveyor is an L1-only receiver.

Changes are planned for the GLONASS frequency plan:

- **Stage 1—**Present to 1998 -The carrier numbers will be assigned in such a way as to avoid the frequencies in the band 1610.6-1613.8 MHz used in Radio Astronomy. This means the carrier number assignments K= 16, 17, 18, 19, 20 will not be used. To compensate for the lost frequencies, identical frequencies will be used for two satellites on opposite sides of the earth.
- **Stage 2**—1998 to 2005 - The next Generation of GLONASS-M satellites will use the carrier number assignments 1 through 12.
- **Stage 3**—beyond 2005 - The GLONASS-M satellites will use the carrier number assignments (-7 through +4). Carriers 5 and 6 will be used for interaction with the ground control segment.

Any or all of these changes in frequency will have no effect on the GG Surveyor GPS+GLONASS receiver, because the capability to handle any of the carrier number assignments is built in, and the satellite almanac always tells the receiver which assignment to use for each satellite.

The satellite ephemerides are like a high-precision almanac, they tell the receiver precisely where the satellite is. Each satellite (both GPS and GLONASS) transmits its own ephemerides. The GPS satellites provide their positions in terms of the WGS- 84 (World Geodetic System, 1984) while the GLONASS satellites provide positions in the PZ-90 reference system (sometimes called PE-90 Parameters of the Earth, 1990 or E90). The GG Surveyor translates the two systems into a single user-selectable reference system. The default is WGS- 84, and by default, the GG Surveyor converts GLONASS satellite positions into WGS-84 coordinates and computes positions in WGS-84 coordinates.

Satellite orbits

The orbits of GPS and GLONASS are similar. GPS satellites orbit in 6 planes, 4 satellites per plane. GLONASS uses 3 planes, 8 satellites per plane. The GLONASS inclination is slightly higher (64.8°) than GPS (55°). The orbits of both systems are circular, and with similar radii.

Geoid Model

The GG Surveyor uses the OSU-91 geoid model. Grid size is 5 x 5 degrees, and the interpolation technique is similar to the GPS ICS algorithm. Expected accuracy when the actual position is on a grid point is 0.5 to 0.6 meters, in accordance with the OSU-91 specification. Expected accuracy when the actual position is halfway between grid points is better than 8 meters.

Magnetic Model

The receiver uses the WMM-95 magnetic model. Grid size is 5 x 5 degrees, and the interpolation technique is similar to the GPS ICD algorithm. Expected accuracy depends upon the geomagnetic latitude. The errors are least at the equator, and greatest at the magnetic poles, and equal to 0.5 degrees (RMS) when the actual position is on a grid point. Expected accuracy when the actual position is halfway between grid points is better than 2.5 degrees (RMS). In arctic and antarctic regions, deviations from model values are frequent and persistent.

Comparison of GPS and GLONASS

Table A.1 compares the operating characteristics of GPS and GLONASS.

Table A.1: Comparison of GPS and GLONASS

Parameter	GPS	GLONASS
SIGNAL STRUCTURE		
C/A Code (L1)		
Code rate	1.023 MHz	0.511 MHz
Chip length	293 m	587 m
Selective availability	Yes	No
P Code		
Code rate	10.23 MHz	5.11 MHz
Chip length	29.3 m	58.7 m
Selective availability	Yes	No
Encryption (anti-spoofing)	Yes	No
Signal separation	CDMA	FDMA
Carrier frequency	• 1575.42 MHz • 1227.60 MHz	• 1602 + Kx9/16 MHZ, where K is within the range -7 to +24 • 1246 + Kx7/16 MHz, where K is within the range -7 to +24
SATELLITES		
Number	24	24
Planes	6	3

Table A.1: Comparison of GPS and GLONASS (continued)

Parameter	GPS	GLONASS
Satellites per plane	4, unevenly spaced	8, evenly spaced
Orbital inclination	55°	64.8°
Orbital radius	26560 km	25510 km
Orbital period	11 hours 58 minutes	11 hours 15 minutes
NAVIGATION MESSAGE		
Duration	12.5 minutes	2.5 minutes
Capacity	37500 bits	7500 bits
Time reference	UTC (US Naval Observatory)	UTC (SU, Russia)
Geodetic datum	WGS-84	PZ-90

GPS and GLONASS System Time

GPS system time is equal to UTC time + the number of leap seconds added since 1980 (currently 12 seconds). GLONASS system time is equal to UTC time + 3 hours. There is an additional GLONASS time shift relative to GPS time of approximately -28.6 microseconds. Therefore, when UTC time equals 00:00:00.000000, GPS system time equals 00:00:12.000000, and GLONASS system time equals 00:02:59.9999714. In other words, GLONASS system time leads GPS system time by 3 hours minus the number of leap seconds plus the sub-second time shift value, which is currently equal to 2:59:47.9999714 (as of 30 June 1997).

GPS+GLONASS Standards

Two standards are used widely and successfully for GPS applications. These are

RTCM (Radio Technical Commission for Maritime Services) standard for differential corrections

NMEA (National Marine Electronics Association) standard for reporting position, velocity and satellite data.

Although both these standards were initially for marine use, they have been adopted worldwide for all applications of GPS.

RTCM SC-104

The RTCM Special Committee 104 (SC-104) has defined differential correction messages that are used worldwide for GPS. The messages that carry the GPS corrections are message types l and 9. Similar messages for GLONASS differential corrections are message types 31, GLONASS equivalent to GPS message type 1, and GLONASS type 34, GLONASS equivalent to GPS message type 9.

Other RTCM messages carry information about reference station parameters, satellite health, etc. These have been defined for both GPS and GLONASS.

Other messages are being developed to improve further the operation of GPS+GLONASS systems in differential mode. A GLONASS-GPS time offset message has been proposed, which allows the reference station to report the time offset between the two systems so that the GPS+GLONASS receiver does not have to calculate it. See $PASHQ,DUG on page 80 for more information. Table 1.2 lists the RTCM SC-104 messages for GPS and GLONASS, which the GG Surveyor supports, both as a reference station and a rover.

Table A.2: RTCM SC-104 Messages for GPS and GLONASS

Parameter	GPS Message Type	GLONASS Message Type
Differential corrections	1	31
Reference station parameters	3	32
Null frame (filler)	6	6
Partial satellite set differential corrections	9	34
Special message	16	36
RTK Uncorrected Carrier Phases	18	19
RTK Uncorrected Pseudoranges	19	19
Extended reference station parameters	22	22

NMEA 0183

The National Marine Electronics Association Standard NMEA 0183 defines interfacing standards for marine electronic devices. The following messages apply specifically to GPS, and are supported by the GG Surveyor.

- GGA—Global positioning system fix data
- GSA—GPS DOP and active satellites
- GRS—GPS range residuals for each satellite

As of January 1997, the NMEA 0183 Standards Committee was in the process of finalizing the definition of messages for GLONASS information. When these messages are finalized, Ashtech will comply with NMEA GLONASS standards in the GG Surveyor. For more information on NMEA messages and decisions, see the NMEA web page, *http://www.coastalnet.com/nmea/*.

Navigation Modes (Availability & Accuracy)

The GG Surveyor has 12 parallel channels for tracking GPS satellites, and 12 parallel channels for tracking GLONASS satellites. With this capability, the GG Surveyor always uses the best available constellation to provide the most accurate position. The greatest accuracy is obtained when differential corrections are available for both GPS and GLONASS satellites. The GG Surveyor can be used as a reference station to generate RTCM corrections for GPS and GLONASS, and a GG Surveyor can use RTCM corrections for both systems. If differential corrections are available for only one satellite system (either GPS or GLONASS) the GG Surveyor automatically uses only those measurements for which it has corrections. If GG Surveyor has no differential corrections, it automatically uses all available healthy satellites, from both constellations, to compute a position. If one satellite system is shut down or jammed, or if satellites become unhealthy (generating incorrect data), the GG Surveyor automatically uses the satellites which are operating correctly based on the signal-to-noise ratio.

Table A.3 lists the expected accuracies in various operating configurations.

Table A.3: Accuracy as a Function of Constellation

Available Constellation	GG Surveyor Mode	Typical (50%) Accuracy* at Radio Data Rate of 1200 bps	95% Accuracy at Radio Data Rate of 1200 bps
Differential GPS & Differential GLONASS	D(GPS+GLONASS)	35 cm	75 cm
GPS & Differential GLONASS	DGLONASS	50 cm	1 m
GLONASS & Differential GPS	DGPS	40 cm	90 cm
GPS & GLONASS	GPS & GLONASS	7 m	16 m
GLONASS	GLONASS	8 m	20 m
GPS	GPS	25 m	100 m

*Differential GPS accuracy is affected by the radio data rate. If the data rate is slow, SA causes errors to grow while the corrections are being transmitted. Figure A.1 shows actual 95% accuracy measured in tests with DGPS and DGLONASS.

The graph shows how position precision decays as the age of corrections increases. For each particular age, 95% of the position errors sampled were less than or equal to the value on the graph. Approximately 400 positions were sampled for each age.

Test conditions: 10o elevation mask, correction rate: 90 seconds, HDOP less than or equal to 4, number of GLONASS satellites used in position computation greater than or equal to 4.

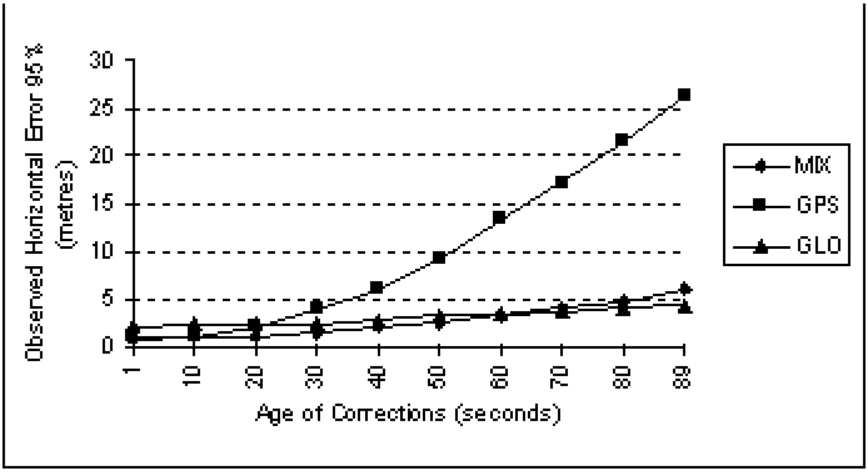

Figure A.1: GG Surveyor Code Differential Horizontal Position Decay

When a position is not differentially corrected, SA degrades the position accuracy from the GPS constellation to about 100 meters (2-sigma, 95%). The GLONASS constellation does not implement SA, so position accuracy improves as GLONASS satellites are added to a mixed system. The attained accuracy is proportional to the number of healthy GLONASS satellites above the elevation mask. When the number of healthy GLONASS satellites is fewer than five, accuracy is degraded. The approximate stand-alone position error attainable by a mixed GPS+GLONASS system with an HDOP close to 1 is presented in Table A.4.

Table A.4: Approximate Position Error, Mixed GPS+GLONASS

Number of GPS Satellites	Number of GLONASS Satellites	50%	95%
≥0	≥5	~ 7 m	~16 m
≥1	4	~10 m	~20 m
≥2	3	~15 m	~30 m
≥3	2	~20 m	~40 m

Table A.4: Approximate Position Error, Mixed GPS+GLONASS (continued)

Number of GPS Satellites	Number of GLONASS Satellites	50%	95%
≥4	1	~25 m	~100 m (no improvement over stand-alone GPS)

With the full 24-satellite GLONASS constellation, more than 5 GLONASS satellites are in view above 10° elevation almost all the time. Check the GLONASS almanac for exact numbers at any particular time.

By holding the GPS-GLONASS clock error fixed, the GG Surveyor calculates a 3D position with any combination of 4 satellites (e.g., 2 GPS and 2 GLONASS). By holding the altitude fixed, the GG Surveyor calculates a 2D position with any combination of 3 satellites. See Chapter 6, **Command/Response Formats** for more information.

Reference Datums and Ellipsoids

The following tables list geodetic datums and reference ellipsoid parameters.

Table B.1: Available Geodetic Datums

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
ADN	Clarke 1880	-162, -12, 206	Adindan (Ethiopia,Mali,Senegal,Sudan)
ARF	Clarke 1866	-143, -90, -294	ARC 1950 (Botswana,Lesotho,Malawi,Swaziland,Zaire,Zambia,Zimbabwe
ARS	Clarke 1866	-160, -8, -300	ARC 1960 (Kenya,Tanzania)
AST	International 1924	-104, -129, 239	Camp Area Astro (Antarctica)
AUA	Australian National	-133, -48, 148	Australian Geodetic Datum 1966(Australia, Tasmania Island)
AUG	Australian National	-134, -48, 149	Australian Geodetic Datum 1984 (Australia, Tasmania Island)
BOO	International 1924	307, 304, -318	Bogota Observatory (Columbia)
BUK	Bessel 1841	-384, 664, -48	Bukit Rimpah (Indonezia)
CAI	International 1924	-148, 136, 90	S. American Campo Inchauspe (Argentina)
CAP	Clarke 1866	-136, -108, -292	Cape (South Africa)
CGE	Clarke 1866	-263, 6, 431	Carthage (Tunisia)
CHI	International 1924	175, -38, 113	Chatham 1971 (Chatham,New Zeland)
CHU	International 1924	-134, 229, -29	S. American Chua Astro (Paraguay)
CNA	Clarke 1866	0, 125, 194	N. American Central America
COA	International 1924	-206, 172, -6	S. American Corrego Alegre (Brazil)
CRB	Clarke 1866	-7, 152, 178	N. American Caribbean
DJK	Bessel 1841	-377, 681, -50	Djacarta (Indonesia)
E90 or PZ-90	Earth-90	0, 0, 4	Earth-90 (GLONASS Coordinate system)

Reference

Table B.1: Available Geodetic Datums (continued)

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
EUA	International 1924	-87, -96, -120	European 1950 (Western Europe:Austria,Denmark,France,F.R. of Germany, Netherlands, Switzerland)
EUE	International 1924	-104, -101, -140	European 1950 (Cyprus)
EUF	International 1924	-130, -117, -151	European 1950 (Egypt)
EUH	International 1924	-117, -132, -164	European 1950 (Iran)
EUJ	International 1924	-97, -88, -135	European 1950 (Sicily)
EUM	International 1924	-87, -98, -121	European 1950 mean
EUS	International 1924	-86, -98, -119	European 1979 (Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland)
FAH	Clarke 1880	-346, -1, 224	Oman
GAA	International 1924	-133, -321, 50	Gandajika Base (Rep. of Maldives)
GEO	International 1924	84, -22, 209	Geodetic Datum 1949 (New Zealand)
GUA	Clarke 1866	-100, -248, 259	Guam 1963 (Guam Island)
HAW	International 1924	89, -279, -183	Hawaiian Hawaii (Old)
HJO	International 1924	-73, 46, -86	Hjorsey 195 (Iceland)
HNK	International 1924	-156, -271, -189	Hong Kong 1963
HRN	International 1924	-333, -222, 114	Herat North (Afghanistan)
HTS	International 1924	-634, -549, -201	Hu-Tzu-Shan (Taiwan)
INA	Everest	214, 836, 303	Indian (Thailand, Vietnam)
INM	Everest	289, 734, 257	Indian (India,Nepal,Bangladesh)
IRL	Modified Everest	506, -122, 611	Ireland 1965
KAN	Everest	-97, 787, 86	Kandawala (Sri Lanka)
KAU	International 1924	45, -290, -172	Hawaiian Kauai (Old)

Table B.1: Available Geodetic Datums (continued)

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
KEA	Modified Everest	-11, 851, 5	Kertau 1948 (West Malayzia, Singapore)
KRS	Krasovsky	26, -139, -80	Krassovsky 1942 (Russia)
LIB	Clarke 1880	-90, 40, 88	Liberia 1964
LUZ	Clarke 1880	-133, -77, -51	Luzon (Philippines excluding Mindanoa Is.)
MAS	Bessel 1841	639, 405, 60	Massawa (Eritrea,Ethiopia)
MAU	International 1924	65, -290, -190	Hawaiian Oahu (Old)
MER	Clarke 1880	31, 146, 47	Merchich (Morocco)
MIN	Clarke 1880	-92, -93, 122	Minna (Nigeria)
MND	Clarke 1866	-133, -79, -72	Mindanao Island
MXC	Clarke 1866	-12, 130, 190	N. American Mexico
NAC	Clarke 1880	-8, 160, 176	N. American CONUS 1927 (North America)
NAD	Clarke 1880	-5, 135, 172	N. American Alaska 1927 (Alaska)
NAE	Clarke 1880	-10, 158, 187	N. American Canada 1927 (Canada incl. Newfoundland Island)
NAH	Clarke 1880	-231, -196, 482	Nahrwan (Saudi Arabia)
NAN	Clarke 1880	-6, 127, 192	Central America (Belize,Costa Rica,El Salvador, Guatemala, Honduras, Nicaragua, Mexico)
NAR	GRS1980	0, 0, 0	North American 1983
OAH	International 1924	56, -284, -181	Hawaiian Oahu (Old)
OEG	Helmert 1906	-130, 110, -13	Old Egyptian
OGB	Airy 1830	375, -111, 431	Ordnance Survey of Great Britain 1936 (England,Isle of Man,Scotland,Shetland Islands, Wales)
OHA	Clarke 1866	61, -285, -181	Old Hawaiian

Table B.1: Available Geodetic Datums (continued)

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
PIT	International 1924	185, 165, 42	Pitcairn Astro 1967 (Pitcairn Island)
PRV	International 1924	-288, 175, -376	S. American (Provisional 1956)
PUE	Clarke 1866	11, 72, -101	Puerto Rica and Virgin Islands
QAT	International 1924	-128, -283, 22	Qatar National (Qatar)
QUO	International 1924	164, 138, -189	Qornoq (South Greenland)
SAN	South American 1969	-57, 1, -41	S. American 1969 (Argentina,Bolivia,Brazil,Chile,Colombia,Ecuador,Guyan,Paraguay,Peru, Venezuela,Trinidad,Tobago)
SCK	Bessel 1841 Namibia	616, 97, -251	Schwarzeck (Namibia)
SEG	International 1924	-403, 684, 41	Gunung Segara (Kalimantan-Indonesia)
SRD	International 1924	-225, -65, 9	Rome 1940 Sardinia Island
TAN	International 1924	-189, -242, -91	Tanarive Observatory 1925 (Madagascar)
TIL	Everest	-689, 691, -46	Timbalai 1948 (Brunei,East Malaysia, Sarawak,Sabah)
TOY	Bessel 1841	-128, 481, 664	Tokyo (Japan,Korea,Okinawa)
TRI	International 1924	-632, 438, -609	Tristan Astro 1968 (Tristan du Cunha)
USR	WGS84	0, 0, 0	User defined
VIT	Clarke 1866	-51, 391, -36	Viti Levu 1916 (Fiji Islands)
W72	WGS72	0, 0, 4.5	World Geodetic System - 72
W84	WGS84	0, 0, 0	World Geodetic System - 84
YAC	International 1924	-155, 171, 37	S. American Yacare (Uruguay)
ZAN	International 1924	-265, 120, -358	Zanderij (Surinam)

PZ-90 is the official designation of the GLONASS Coordinate System, which is sometimes referred to as Earth-90, E90, or PE-90.

Table B.2: Reference Ellipsoids

Ellipsoid	a (metres)	1/f	f
Airy 1830	6377563.396	299.3249647	0.00334085064038
Modified Airy	6377340.189	299.3249647	0.00334085064038
Australian National	6378160.0	298.25	0.00335289186924
Bessel 1841	6377397.155	299.1528128	0.00334277318217
Clarke 1866	6378206.4	294.9786982	0.00339007530409
Clarke 1880	6378249.145	293.465	0.00340756137870
Earth-90	6378136.0	298.257839303	0.00335280374301
Everest (india 1830)	6377276.345	300.8017	0.00332444929666
Everest (W.Malaysia&Singapore)	6377304.063	300.8017	0.00332444929666
Geodetic Reference System 1980	6378137.0	298.257222101	0.00335281068118
Helmert 1906	6378200.0	298.30	0.00335232986926
International 1924	6378388.0	297.00	0.00336700336700
Krasovsky	6378245.0	298.3	0.00335232986925
South American 1969	6378160.0	298.25	0.00335289186924
World Geodetic System 1972 (WGS-72)	6378135.0	298.26	0.00335277945417
World Geodetic System 1984 (WGS-84)	6378137.0	298.257223563	0.00335281066475

Multipath Mitigation

Overview

Multipath occurs when GPS signals arrive at the receiver after being reflected off some object. The reflected signals always travel a longer path length than the direct signal. This leads to measurement errors in the receiver which is trying to measure the direct path length to the satellite. The techniques for rejecting the reflected signals are know as multipath mitigation.

The GG Surveyor implements two types of correlators for multipath mitigation: Edge Correlator™ and Strobe Correlator™. Both these correlators improve multipath mitigation over the traditional correlator schemes with standard (1-chip) correlator spacing and narrow (1/10 chip) correlator spacing.

The Edge Correlator is standard with all products from the GG family. The performance of an Edge correlator is slightly better than a narrow correlator with 1/10 chip spacing. The Strobe Correlator (patent pending) implements a significantly different scheme than any prior multipath mitigation scheme. The result is a multipath mitigation as good as the best known techniques, but without the need for banks of correlators closely associated with high-quality multipath mitigation techniques.

A detailed description of Edge and Strobe Correlation is given in Garin, van Diggelen, and Rousseau (1996).

Evaluating Correlator Performance

Theoretical analysis of the different multipath mitigation techniques is a straightforward analysis of how much error hypothetical multipath signals would cause. A plot of multipath mitigation performance is made by assuming a reflected signal with a certain power (usually half the power of the direct signal) and a certain delay. The induced error on the range measurement is then calculated and plotted. Figure B.1 shows the errors induced by a multipath signal half the strength of the direct signal. The x-axis shows the multipath delay, which is the extra distance that the reflected signal travels compared to the direct signal. The y-axis shows the induced range error caused by a multipath signal with the indicated delay.

From this figure, you can see that typical narrow correlator performance and Edge Correlator performance are similar, while Strobe Correlator performance is much better, almost totally cancelling any multipath with a delay of more than 37m.

In a real situation, multipath is usually a combination of many reflections, all with different delays and different power. Real-life multipath is often described as either close-in multipath or far multipath. Close-in multipath occurs when the reflecting surface is close to the satellite antenna direct line, and the delay is small; usually, these reflections come from a surface near the antenna, for example, an antenna on a tripod on the ground would pick up close-in multipath from reflections off the ground below and around the tripod. Choke-ring antennas are probably the best cure for close-in multipath. Correlator-based multipath techniques, as shown in Figure C.1, are all bad at rejecting very close-in multipath mitigation.

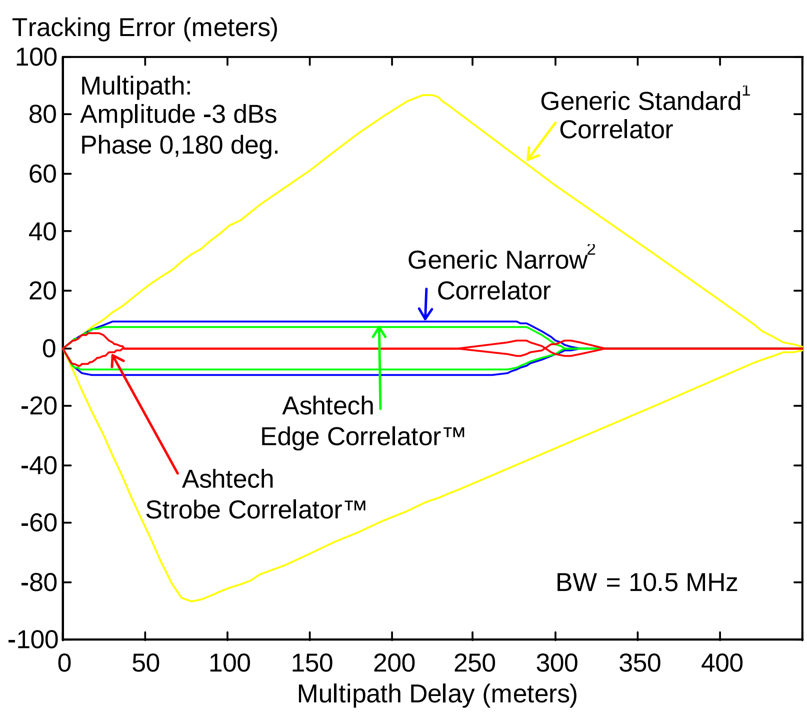

Figure C.1: Relative Performance of Multipath Mitigation Techniques

Very close-in multipath causes only a small change in the ideal correlation function, so it is almost impossible for the correlator-base multipath integration to determine the error. Far multipath can cause very large errors if a good multipath mitigation technique is not used.

Far multipath occurs when there is a reflecting surface at some distance from the antenna, such as a building, a mast, a mountain, etc. Metal surfaces cause the strongest reflections. Far multipath signals can be very nearly eliminated by good correlator-based multipath mitigation techniques. In an environment where there is a lot of far multipath, Strobe Correlation will be as good as or better than a choke ring.

The bottom line on multipath mitigation is that the errors, or lack or errors, are seen in the position accuracy. Test results for the Strobe Correlator are described in van Diggelen (1996).

Garin, Lionel, van Diggelen, Frank, Rousseau, Jean-Michel ,1996, *Strobe & Edge Correlator Multipath Mitigation for Code*, Proceedings of ION-GPS'96, Sept. 17-19 1996, Kansas City, Missouri

van Diggelen, Frank, 1996, *The Ashtech GG Family of Products*, Proceedings on ION-GPS'96, Sept. 17-19 1996, Kansas City, Missouri

Floating Point Data Representation

The GG Surveyor stores the floating point data types using the IEEE single and double precision format. The formats contain a **sign bit field**, an **exponent field**, and a **fraction field**. The value is represented in these three fields.

Sign Bit Field

The sign bit field of the number being represented is stored in the sign bit field. If the number is positive, the sign bit field contains the value 0. If the number is negative, the sign bit field contains the value 1. The sign bit field is stored in the most significant bit of a floating point value.

Exponent Field

The exponent of a number is multiplied by the fractional value of the number to get a value. The exponent field of the number contains a biased form of the exponent. The bias is subtracted from the exponent field to get the actual exponent. This allows both positive and negative exponents.

Fraction Field

The IEEE floating point format stores the fractional part of a number in a normalized form. This form assumes that all non-zero numbers are of the form:

1.xxxxxx (binary)

The character ‘x’ represents either a 0 or 1 (binary).

Because all floating point binary numbers begin with 1, the 1 becomes the implicit normalized bit and is omitted. It is the most significant bit of the fraction, and the binary point is located immediately to its right. All bits after the binary point represent values less than 1 (binary). For example, the number 1.625 (decimal) can be represented as:

1.101 (binary) which is equal to:

2^0 + 2^-1 + 2^-3 (decimal) which is equal to:

1 + 0.5 + 0.125 (decimal) which is equal to:

1.625 (decimal).

The Represented Value

The value of the number represented is equal to the exponent multiplied by the fractional value, with the sign specified by the sign bit field.

If both the exponent field and the fraction field are equal to zero, the number being represented will also be zero.

Note that in some systems (Intel-based PCs in particular) the order of the bytes will be reversed.

Single-Precision Float

The single precision format uses four consecutive bytes, with the 32 bits containing a sign bit field, an 8-bit biased exponent field, and a 23-bit fraction field. The exponent has a bias of 7F (hexadecimal). The fraction field is precise to 7 decimal digits. The single-precision format can represent values in the range 1.18*10^-38 to 3.4*10^38 (decimal), as presented in Table D.1.

Table D.1: Single-Precision Format

31-28	**27-24**	**23-20**	**19-16**	**15-12**	**11-8**	**7-4**	**3-0**	
S EXPONENT		FRACTION						VALUE
0000	0000	0000	0000	0000	0000	0000	0000	0.0
0011	1111	1000	0000	0000	0000	0000	0000	1.0
1111	1111	1111	1111	1111	1111	1111	1111	NAN (not a number)
0011	1111	0100	0000	0000	0000	0000	0000	0.75

In Table D.1, the value 1.0 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 7F (hexadecimal). The exponent is calculated by subtracting the bias value (7F) from the exponent field value. The result is 0.

   7F - 7F = 0

   The exponent multiplier is equal to 2^0, which is equal to 1 (decimal).
3. The fraction field is equal to .0. After adding the implicit normalized bit, the fraction is equal to 1.0 (binary). The fraction value is equal to 2^0 (decimal), which is equal to 1 (decimal).
4. The value of the number is positive 1*1= 1.0 (decimal).

In Table D.1, the value 0.75 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 7E (hexadecimal). The exponent is calculated by subtracting the bias value (7F) from the exponent field value. The result is -1 (decimal).

   7E - 7F = -1

   The exponent multiplier is equal to 2^-1, which is equal to 0.5 (decimal).
3. The fraction field is equal to .1 (binary). After adding the implicit normalized bit, the fraction is equal to 1.1 (binary). The fraction value is equal to 2^0 + 2^-1 (decimal), which is equal to 1 + 0.5 (decimal), which is equal to 1.5 (decimal).
4. The value of the number is positive 0.5*1.5 = 0.75 (decimal).

Double-Precision Float

The double-precision format uses eight consecutive bytes, with the 64 bits containing a sign bit field, an 11-bit biased exponent field, and a 52-bit fraction field. The exponent has a bias of 3FF (hexadecimal). The fraction field is precise to 15 decimal digits. The double-precision format can represent values in the range 9.46*10^-308 to 1.79*10^308 (decimal), as presented in Table D.2.

Table D.2: Double-Precision Format

63-60	**59-56**	**55-62**	**51-48**	**47-44**	**43-40**	**...**	**15-12**	**11-8**	**7-4**	**3-0**	
S EXPONENT		FRACTION									VALUE
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.0
0011	1111	1111	0000	0000	0000	...	0000	0000	0000	0000	1.0
1111	1111	1111	1111	1111	1111	...	1111	1111	1111	1111	NAN (not a number)
0011	1111	1110	1000	0000	0000	...	0000	0000	0000	0000	0.75

In Table D.2, the value 1 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 3FF (hexadecimal). The exponent is calculated by subtracting the bias value (3FF) from the exponent field value. The result is 0 (decimal).

   3FF - 3FF = 0

   The exponent multiplier is equal to 2^0, which is equal to 1 (decimal).

3. The fraction field is equal to .0 (binary). After adding the implicit normalized bit, the fraction is equal to 1.0 (binary). The fraction value is equal to 2^0 (decimal), which is equal to 1 (decimal).
4. The value of the number is positive 1*1 = 1.0 (decimal).

In Table D.2, the value 0.75 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 3FE (hexadecimal). The exponent is calculated by subtracting the bias value (3FF) from the exponent field value. The result is -1 (decimal).

   3FE - 3FF = -1
3. The fraction field is equal to .1 (binary). After adding the implicit normalized bit, the fraction is equal to 1.1 (binary). The fraction value is equal to 2^0 + 2^-1 (decimal), which is equal to 1 + 0.5 (decimal), which is equal to 1.5 (decimal).
4. The value of the number is positive 0.5*1.5 = 0.75 (decimal).

Global Product Support

If you have any problems or require further assistance, the Customer Support team can be reached through the following:

- telephone
- email
- Ashtech BBS system
- Internet

Please refer to the documentation before contacting Customer Support. Many common problems are identified within the documentation and suggestions are offered for solving them.

Ashtech customer support:

Sunnyvale, California, USA

800 Number: 1-800-229-2400

Local Voice Line: (408) 524-1680

Fax Line: (408) 524-1500

Email: support@ashtech.com

Ashtech Europe Ltd. Oxfordshire UK

TEL: 44 1 993 883 3533

Fax : 44 1 993 883 3977

Solutions for Common Problems

- Check cables and power supplies. Many hardware problems are related to these simple problems.
- If the problem seems to be with your computer, re-boot it to clear the system's RAM memory.
- If you are experiencing receiver problems, power cycle the receiver or try a different port.
- Verify the batteries are charged.

If none of these suggestions solves the problem, contact the Customer Support team. To assist the Customer Support team, please ensure the following information is available:

Table E.1 GPS Product Information

Information Category	Your actual numbers
Receiver model	
Receiver serial #	
Software version #	
Software key serial #	
Firmware version #	
Options*	
A clear, concise description of the problem.	
* The firmware version # and options can be obtained using the $PASHQ,RID (receiver identification) command.	

Corporate Web Page

You can obtain data sheets, GPS information, application notes, and a variety of useful information from Ashtech's Internet web page. In addition, you can access the BBS through the web site, and locate additional support areas such as frequently asked questions and training previews. The Internet address is:

http://www.ashtech.com

Ashtech Bulletin Board

General

If your computer contains a modem and communications software, you can access information from Ashtech's computer Bulletin Board System (BBS). Two data lines are available 24 hours a day, 7 days a week, except for short periods when the system is off-line for maintenance. The Ashtech BBS uses the TBBS BBS software and provides several important services. You can download a current almanac, get the status of the GPS satellites, get NANUS (Notices Advisory to Navstar Users), and look at solar and geomagnetic data from SESC (Space Environment Services Center) in Boulder, Colorado. On occasion, the BBS has been used to carry software updates and document files.

The first time you call, you will be able to log on and browse for up to 30 minutes, but you will not be able to download. During this initial logon, you will be asked for identifying information and a password; anonymous callers will not be given access to the system. Remember exactly how you entered your name and how you spelled your password; write them on paper, they will be your entry into the system in the future.

After you have logged on and registered, the SYSOP verifies your status as a customer, and establishes your security code commensurate with the hardware and software you are using.

The BBS phone numbers are:

- Line 1 408-524-1527 2400 to 28800 baud
- Line 2 Automatic rollover 2400 to 14400 baud if line 1 is busy

Parameters: N,8,1 (No parity, 8 bits, 1 stop bit, full duplex)

Supported Protocols

Table E.2 lists the protocols supported by the Customer Support BBS**.**

Table E.2 Protocols

Protocol	Description
XMODEM	Widely supported, uses 128-byte blocks. Good for moderately noisy lines. May cause file integrity problems by rounding.
XMODEM-1k	Uses 1024-byte blocks. Supposedly better for 2400 baud+. May cause file integrity problems by rounding.
YMODEM	Also known as YMODEM Batch, passes filename and size, eliminating rounding problems. Capable of multiple file transfer (batch).
YMODEM-G	Fast protocol for use only with error-free data links. Not recommended.
SEAlink	Passes filename and size, eliminating rounding problems. Capable of file transfer (batch). Good for noisy line conditions and links where delays occur (satellite-based long distance, or packet-switched networks).
KERMIT	Slow, but works with almost any transmission medium.
SuperKERMIT	Same as KERMIT, but faster. Good for noisy line conditions and where delays occur (satellite-based long distance, or packet-switched networks).
ZMODEM	Newer protocol that supports batch and exact file size. Good for noisy conditions. Includes all ZMODEM-90Ô extensions.
ASCII	Only for users with no other protocols available. No error checking, not recommended.

The preferred protocols are ZMODEM, SEAlink, YMODEM.

Training Courses

We provide a full range of GPS training courses for the novice and advanced user. Arrangements can be made for customized, on-site training to fit your specific needs.

Ashtech training courses:

- Conventional GPS Surveying
- Solving Problem Data Sets
- Real-Time Z Applications
- Reliance for GPS/GIS

For detailed information, call or email Ashtech, or contact your local Ashtech dealer. The Ashtech WWW pages contains information on course dates, costs, and content.

Technical Support

Repair Centers

In addition to repair centers in California and England, authorized distributors in 27 countries can assist you with your service needs.

Ashtech Inc., Sunnyvale, California

Voice: (408) 524-1680

or (800) 229-2400

fax: (408) 524-1500

Ashtech Europe Ltd. Oxfordshire UK

TEL: 44 1 993 883 3533

fax: 44 1 993 883 3977

Index

Symbols

Numerics

A

Index

B

C

D

H

I

L

M

N

O

P

Q

R

Index

S

T

U

V

W

Z