GG12 OEM Board Reference Manual

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Introduction

The GG12™ is the first Ashtech GPS+GLONASS™ receiver designed to be certified for aviation. This new member of the Ashtech GPS+GLONASS family of products features twelve independent channels capable of receiving L1 carrier and C/A code signals from GPS or GLONASS satellites. The GG12 OEM receiver board can be integrated with Technical Standard Order flight management systems, ground-based reference stations for GPS aircraft landing systems (SCAT I and LAAS), and other avionic systems.

The GG12 was developed to meet RTCA DO-178B Level B, RTCA DO-208, and DO-217 (SCAT I) requirements for FAA qualification by OEM integrators. This receiver is also available in a GPS-only configuration and can operate in autonomous and differential modes, making it suitable for all phases of flight, including precision approach.

In order to receive GPS or GLONASS signals, the antenna on your receiver must have a direct line of sight to the satellites. One of the primary advantages of the GG12 GPS+GLONASS receiver architecture is the increased satellite coverage. As of October 1999, the GPS constellation contains 27 usable satellites; the GLONASS constellation has 11 usable satellites of the planned constellation of 24 satellites. With a total of 38 healthy satellites, there are more satellites available for position computation than with GPS alone. GPS+GLONASS technology can maintain high performance levels in areas with limited satellite visibility. In addition, powerful anti-jamming capabilities allow the GG12 to perform well in noisy RF environments.

To take advantage of the increased satellite availability, the GG12 has twelve configurable channels for L1 GPS and L1 GLONASS. Each channel can be programmed to track GPS satellites or GLONASS satellites. For example, you can program channels 1 through 8 to track GPS satellites and channels 9 through 12 to track GLONASS satellites. The GPS+GLONASS technology in the GG12 typically can deliver autonomous position accuracies ranging from 10 to 30 meters, compared to the 20 to 60 meter levels of accuracy achieved when using only the GPS satellites with Selective Availability in effect.

The GG12 can receive signals from both GPS and GLONASS satellites, but only GPS differential corrections. A properly equipped and optioned GG12 can compute positions with sub-meter accuracy in real-time with the aid of differential corrections.

Table 1.1. GG12 Technical Specifications

Time to First Fix (50% / 95%)	
Hot Start	13 seconds / 16 seconds
Warm Start	37 seconds / 45 seconds
Cold Start	67 seconds / 90 seconds
Position Accuracy (DGPS)	
Horizontal (95%)	90 cm (GPS only) 75 cm (GPS+GLONASS)[1]
Vertical (95%)	1.6 m (GPS only) 1.4 m (GPS+GLONASS)[1]
Position Latency	70 ms[2]
Velocity Accuracy	
Horizontal (95%)	0.1 knots
Vertical (95%)	0.1 knots
Dynamics	
Acceleration	10g
Speed	1,000 knots
Altitude	60,000 ft
Vibration	MIL-STD 810E; RTCA DO-160C
Dimensions & Weight	
Size	4.275” x 3.25” x 0.77”
Weight	3.8 ounces
Power Requirements	
Power Consumption	GG12 receiver: <3.0 watts GG12 antenna: <0.3 watts
Voltage	5 volts regulated (±5%) DC input; 50 mV point to point ripple
External Wiring	30 gauge (minimum)

Table 1.1. GG12 Technical Specifications (continued)

Back-up Battery Drain	Consult Manufacturer
Environmental Tolerances	
Operating Temperature Range	-30° C to +70° C
Storage Temperature Range	-40° C to +85° C

1 With full GLONASS constellation in place.

2 The time delay from the instant a message is time-tagged to when the receiver finishes it's transmission at 115,200 baud. Latency specification is for certain messages. Latency of other messages under different conditions may yield different results

Functional Description

Upon application of power, the GG12 runs a self-test of internal memory and periodically self-tests various functions during normal operation. Test results are stored in memory and can be obtained by issuing the query command $PASHQ,BIT.

After self-test, the GG12 initializes its battery-backed RAM. If the battery-backed RAM fails self-test (for example, due to a low power condition), the GG12 resets itself and reports the loss of stored data, then initializes the 12 channels and begins searching for all satellites within its antenna's field of view. The GG12 can track up to 12 GPS or 12 GLONASS satellites simultaneously, or it can be programmed to track any combination of 12 satellites from the GPS and GLONASS constellations. The GG12 locks onto the signals being generated by the satellites and begins downloading information on the orbital positions (ephemeris data) and the orbit schedules (almanac data) for each GPS and GLONASS satellite. This data is automatically stored in battery-backed memory. Once the ephemeris data are collected for at least five satellites from both systems (or four satellites from a single system), the GG12 can compute its own position.

The GG12 calculates three-dimensional position and velocity when tracking any combination of five satellites, as when tracking three GPS and two GLONASS satellites. When it is set to hold the GPS-GLONASS clock offset fixed, the GG12 can calculate a 3D position with any combination of four satellites (e.g., 2 GPS and 2 GLONASS). By also holding the altitude fixed, the GG12 can calculate a 2D position with any combination of three satellites.

The GG12 can compute up to five independent measurements every second, with no interpolation or extrapolation from previous solutions. The position and velocity computations are performed using all twelve channels simultaneously. The GG12 uses an instantaneous Doppler measurement technique to compute velocity, independent of the previous position computation. All computations for position, velocity, and direction of travel are referenced to the World Geodetic System WGS-84 ellipsoid.

Hardware Description

The horizontal dimensions of the GG12 receiver are shown in Figure 1.1. Functionally, the GG12 has two major sections: the radio frequency (RF) section, which decodes incoming GPS signals, and the digital section, which converts the decoded information to a digital format and then processes it.

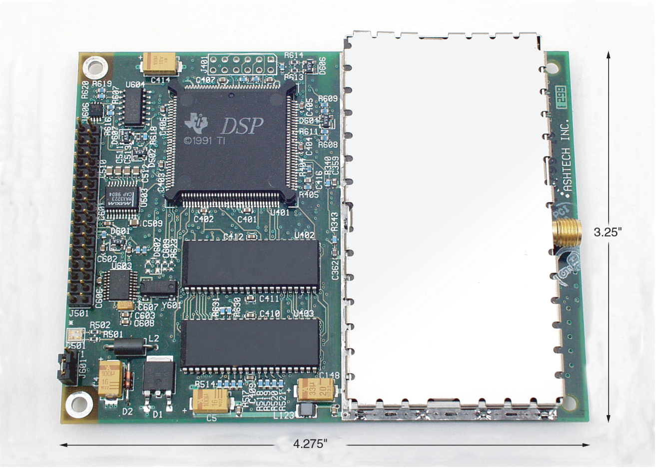

Figure 1.1. GG12 Receiver

The GG12 has two bi-directional RS-232 serial ports embedded in the J501 connector. J501 is a 32-pin dual inline (2 x 16) header connector. The RF input port is a coaxial SMA connector. Satellite data from a GPS+GLONASS antenna and LNA is sent to the RF port through a coaxial antenna cable. The GG12 sends power to the antenna and LNA through the same coaxial cable, eliminating the need of separate power for the antenna. Power consumption for the antenna and LNA is approximately 150 milliwatts (depending upon model and manufacturer).

A two-color LED is mounted on the GG12 board to indicate status for power and satellite tracking. The LED flashes red to indicate power status and green to indicate satellite tracking status. A green flash occurs for each satellite being tracked. A yellow flash (red and green flashing simultaneously) separates the GPS satellite count from the GLONASS satellite count.

An external LED can be connected to the board by wiring the common cathode to ground and wiring the anodes to LED-GRN (pin 22) and LED-RED (pin 21).

Pins 21 and 22 are routed to the processor through 100 ohm resistors in series.

Connections for Power and I/O

All power and input/output (I/O) connections are made at the J501 connector. J501 is a 32-pin male dual inline (DIN) header connector. In addition to connections for power and serial communication, J501 hosts connections for a back-up battery, manual reset, timing pulse output, and input for photogrammetric events. Figure 1.2 below lists the pin assignments for the J501 connector.

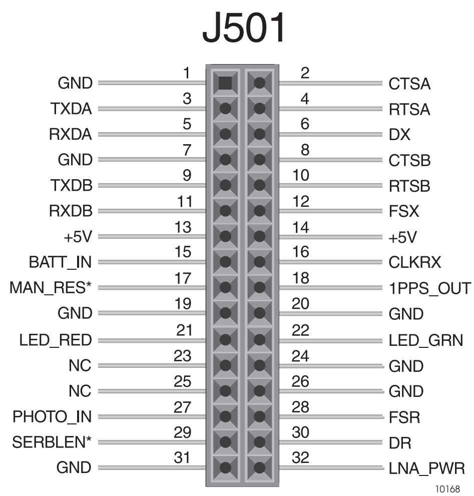

Figure 1.2. J501 Pin Assignments

CAUTION
To avoid damaging the GG12 board, turn off your power supply while connecting or disconnecting cables to the J501 connector. When connecting to J501, ensure that pin 1 of the cable is mated pin 1 of the connector.

Table 1.2. J501 Pin Descriptions

Pin	Code	Pin
1	GND	Ground connection for serial port A
2	CTSA	RS-232 port A clear to send
3	TXDA	RS-232 port A transmit data
4	RTSA	RS-232 port A request to send
5	RXDA	RS-232 port A receive data
6	DX	Ashtech internal use only (leave floating)
7	GND	Ground connection for serial port B
8	CTSB	RS-232 port B clear to send
9	TXDB	RS-232 port B transmit data
10	RTSB	RS-232 port B request to send
11	RXDB	RS-232 port B receive data
12	FSX	Ashtech internal use only (leave floating)
13	+5V	+5 VDC input
14	+5V	+5 VDC input
15	BATT_IN	Back-up battery (2.5-3.5 volt) input for memory and real-time clock
16	CLKRX	Ashtech internal use only (leave floating)
17	MAN_RES	Manual hardware reset (connect to ground)
18	1PPS_OUT	Timing pulse output (TTL) synchronized to GPS time
19	GND	GG12 chassis common ground
20	GND	GG12 chassis common ground
21	LED_RED	Anode connection for External LED
22	LED_GRN	Anode connection for External LED
23	NC	Null connection
24	GND	GG12 chassis common ground
25	NC	Null connection
26	GND	GG12 chassis common ground
27	PHOTO_IN	Photogrammetry pulse input
28	FSR	Ashtech internal use only (leave floating)
29	SERBLEN	Ashtech internal use only (leave floating)

Table 1.2. J501 Pin Descriptions (continued)

Pin	Code	Pin
30	DR	Ashtech internal use only (leave floating)
31	GND	GG12 chassis common ground
32	LNA_PWR	+5 VDC input for the low-noise amplifier

CAUTION

- **If pin 15 (BATT_IN) is not used, it should be connected to ground (GND)**
- **If pin 17 (MAN_RES) is not used, it should be left floating**
- **If pin 17 (MAN_RES) is used, the hardware reset can be triggered by pulling pin 17 to ground (GND) using a switch, or driving pin 17 to ground with an open-collector gate**

RF Connector

The RF connector is a standard 50-ohm SMA female coaxial connector wired for connection via coaxial cabling to a GPS or GPS+GLONASS antenna with integral LNA. The SMA connector shell is connected to the GG12 common ground. The SMA center pin provides +5 VDC to power the LNA (maximum 100 mA draw) and accepts 1575-1616 MHz RF input from the antenna; the RF and DC signals share the same path.

CAUTION

The GG12 may be damaged if the center pin of the RF connector is not isolated from DC ground. Provide a DC block between the center pin and ground. The DC block should have the following characteristics:

- **VSWR 1.15 maximum**
- **Insertion loss 0.2 db maximum**
- **5 VDC maximum**

Antenna

The GG12 is designed to work with an active antenna and low-noise amplifier (LNA). An external LNA power source can be used (pin 32 on connector J501) by moving the jumper J601 from position 2-3 to position 1-2 (closest to J501). The gain of the antenna/preamplifier minus the loss of the cable and connectors should be between 20 and 30 dB. Connect the antenna cable directly to the antenna connector on the GG12. A line amplifier (Line Amp) should be used with antenna cables longer than 30 meters. Line Amps with Type N coaxial connectors are available from Ashtech for applications requiring longer cables or for cables with higher signal loss.

Performance Specifications

One of the most important functions of the GG12 is providing real-time position solutions with accuracy ranging from the sub-meter level to 100 meters. Table 1.3 summarizes the positioning modes and expected accuracy.

Table 1.3. Accuracy / Mode

Positioning Mode	GPS + GLONASS	GPS Only	GLONASS Only
Real-Time Position-Autonomous	10 meters (CEP 50%) 25 meters (95%)	25 meters (CEP 50%) 100 meters (95%)	8 meters (CEP 50%) 20 meters (95%)
Real-Time Position-Code Differential	N/A	40 centimeters (CEP) 90 centimeters (95%)	50 centimeters (CEP) 1 meter (95%)
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%)

Position and velocity accuracy are for based on tests conducted in Moscow with 5° elevation mask angles, with medium to high multipath interference. The 100 meter GPS value is the 2dRMS accuracy promised by the U.S. Department of Defense. A GG24 Reference Station board was used to provide differential corrections over a short baseline. Differential data rate setting was 300 bps; the calculated HDOP < 4. Position accuracy specifications are for horizontal position. Vertical error < 2 x horizontal error.

Receiver Options

The GG12 supports a variety of internal options. The commands and features available to you depend upon the options installed in the receiver. For example, if the Timing Pulse Output option is not installed, you cannot use the set command **$PASHS,PPS** to configure and enable the output of a timing pulse.

Table 1.4 lists the available options. Each option is represented by a letter or number presented in a specific order. You can verify the installed options by issuing the **$PASHQ,RID** query command to the receiver through an external handheld controller or PC, as described in Table 1.4 . The RID response message lists the installed options in a 14 character alphanumeric string:

$PASHR,RID,GG,#I96,55OPU__L_GM__S*62

A letter or number displayed in the response message indicates an installed option. The presence of a dash (-) instead of a letter or number indicates an option that is not installed. An underscore (_) indicates a reserved option slot.

Table 1.4. GG12 Receiver Options

Option	Description
5 = 5 Hz 2 = 2 Hz	Position update rate
5 = 5 Hz 2 = 2 Hz	Raw measurement update rate
O	Raw data output
P	Carrier phase
U	Differential - remote station
L	Pulse per second (1 PPS)
G	Geoidal height
M	Magnetic variation
S	GLONASS

GG12 Development Kit

The GG12 Development Kit (Figure 1.3) contains a GG12 receiver and antenna plus the necessary hardware and software accessories you will need to evaluate the receiver.

Figure 1.3. GG12 Development Kit

2

Getting Started

This chapter discusses basic operation of the GG12, including hardware connections, power-up, serial port configuration, and status monitoring. Figure 2.1 shows the hardware connections.

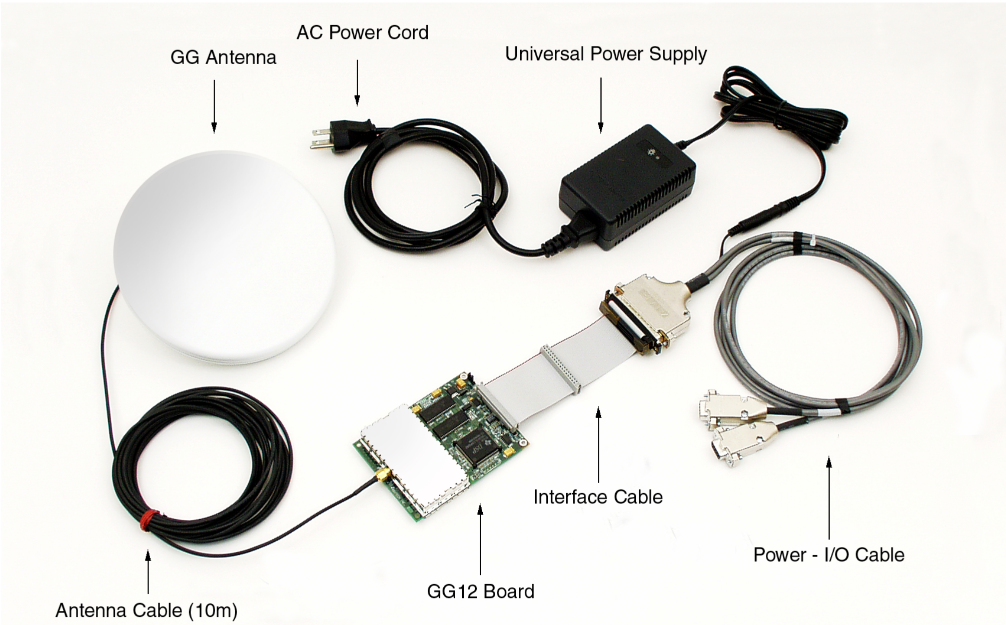

Figure 2.1. GG12 Hardware Connections

Antenna Connection

Attach the SMA connector on the antenna cable to the SMA connector on the GG12 board. Attach the TNC connector on the other end of the antenna cable to the TNC connector on the antenna. In order to receive satellite signals, the antenna must be placed in an open area with no obstructions overhead, such as the roof of a building.

Power Connection

If you plan to use the GG12 with equipment not supplied by Ashtech, it must meet the hardware specifications described in Table 1.1.

Applying power to the power input pins on the J501 connector starts GG12 operation. Removing power from the power input pins on J501 stops GG12 operation. Connect any controller devices or data logging equipment to the input/output ports of the GG12 by way before applying power.

1. Connect the female DIN32 connector on cable assembly 730094 to the male DIN32 (J501) connector on the GG12 before applying power.
2. Connect the power cable to the power supply. On power-up, the status LED (D501) lights red and continues to flash red to indicate that the unit is on but is not yet computing positions. When the GG12's automatic search results in a satellite acquisition, the status LED flashes green between the red power status flashes. Every satellite lock-on produces a green flash. A short green flash indicates the satellite is locked but not being used to compute positions; a long green flash indicates the receiver has locked on the satellite and is using it to compute positions. Once the GG12 locks to enough satellites to compute a position, the duration of the red flash also increases to indicate that positions are being computed. To differentiate between locked GPS and GLONASS satellites, the LED blinks green for each locked GPS satellite first, then blinks yellow once, and then blinks green for each locked GLONASS satellite.

CAUTION
To avoid damaging the GG12, always turn off the power supply before connecting to or disconnecting from the J501 connector.

Receiver Initialization

It is a good idea to initialize the receiver before turning it on for the first time or if a system malfunction occurs. Initialization clears the receiver's internal memory and restores the default parameter settings. Issue the command below to initialize the GG12:

$PASHS,INI,5,5,1<Enter>

This command sets the baud rate for both of the GG12's serial ports to 9600, clears the receiver's internal memory, and restores the default parameter settings.

Satellite Tracking

When the GG12 is powered on for the first time, or when the power and back-up battery have been disconnected, the receiver has no almanac or ephemeris data in its memory, and set to the default parameters. In these cases, the GG12 assigns 12 elements from a 56-element table of satellite ID numbers to its 12 channels as it begins searching for satellites. If no ephemeris data are in memory, or if the data are older than ten hours, 30 to 60 seconds are needed to collect data. The GG12 synchronizes its clock to GPS time within six seconds of locking an SV. After three or four satellites are locked and the ephemeris data collected, the GG12 computes its first position. The GG12 continuously updates almanac, ephemeris, and position data in its battery-backed memory to help optimize satellite reacquisition and time to first fix when the unit is next powered on.

At the next power-up, if the almanac and ephemeris data are available in battery-backed memory, and if the ephemeris data are less than ten hours old, the GG12 restricts its satellite search to those satellites that should be visible based on this information. Under these conditions, the GG12 on average recomputes position in 10 to 15 seconds (this is called a hot start). If the almanac and ephemeris data are available in battery-backed memory, but the ephemeris data are more than ten hours old, the GG12 needs 30 to 40 seconds on average to compute a position (warm start). If almanac and ephemeris data and a valid position are not available at power-up, the GG12 computes position in less than one minute on average (cold start).

Receiver Communication

After the GG12 has power, you must issue commands to get data from it or to change the GG12's operating parameters. The two RS-232 ports (A and B) can receive command messages from an external control device, send response messages to an external control device (such as a PC), output data to a separate data logging device, and receive differential corrections from an RTCA base station. The steps below describe how to send commands to and receive responses from the GG12 using an IBM-compatible personal computer. You can interface with the GG12 using Evaluate Software™ or standard communication programs such a ProComm or Hyperterminal. To begin, simply connect port A or B of the GG12 interface cable to COM1 on the computer.

The GG12's serial ports support full-duplex communication. The default protocol for transmitting or receiving data is 9600 baud, eight data bits, no parity, and one stop bit (8N1). In order for the GG12 to communicate with another device, the baud rate setting of the GG12 serial port and the serial port on the device with which it is interfaced must be the same.

DEFAULT SETTINGS	
Default parameters for GG12 serial ports A and B are shown below:	
Baud Rate	**9600**
Data Bits	**8**
Stop Bits	**1**
Parity	**None**

After connecting to the COM port and starting the communications program, you are now ready to send commands. Letters in the command string can be typed in upper or lower case and are sent to the receiver by pressing **<Enter>**. The commands used with the GG12 are divided into two groups: "Set" commands allow you to change the GG12's operating parameters and begin with the command string **$PASHS**. "Query" commands allow you request information from the GG12, such as the current operating parameters, current position, or differential GPS status. Query commands begin with the command string **$PASHQ**. The GG12 responds to query and set commands by issuing an acknowledgement of a change in operating parameters or by issuing the specific information requested through a query. All GG12 responses begin with the string **$PASHSR**. To become familiar with GG12 messages, try sending a few common commands to it and observe the responses:

1. Assuming that you are still connected to port A, enter the following command to query the GG12 for the communication parameters of the serial port to which you are currently connected:

   $PASHQ,PRT

   The response message displays:

   `$PASHR,PRT,A,5`

The letter A in the response message indicates that the PC is connected to port A of the GG12; the number 5 indicates that port A is using the default data rate of 9600 baud.

2. Enter the following command to set the GG12 to output comprehensive position information from port A once per second:

   $PASHS,NME,POS,A,ON,1

   After entering this command, the GG12 outputs a message similar to the one shown below once per second:

   ```
   $PASHR,POS,0,09,002701.00,3721.08661,N,12156.11611,W,-
   00054.41,,047.27,000.44,-000.13,02.0,01.1,01.7,01.2,FA00*17
   ```

   This data string contains 3D position, velocity, direction of travel, differential GPS status, and values for dilution of precision.

3. Enter the following command to set the GG12 to output comprehensive satellite tracking information from port A once every five seconds:

   $PASHS,NME,SAT,A,ON,5

   After entering this command, the GG12 will output a message like the one shown below at five-second intervals:

   ```
   $PASHR,SAT,03,03,103,56,60,U,23,225,61,39,U,16,045,02,21,U*6E
   ```

   This data string contains the number of satellites locked, the PRN number, elevation, azimuth, and signal strength for each locked satellite, and also indicates whether a given satellite is used (U) or not used (-) to compute positions. See Chapter 4, **Command/Response Formats**, for details on the commands and responses supported by the GG12.

4. Enter the command below to disable the output of the POS and SAT messages:

   $PASHS,NME,ALL,A,OFF.

3

Operation

This chapter describes GG12 operation, including command format, serial port configuration, operational status, satellite system modes, position modes, differential mode, and other aspects of receiver functionality.

System Setup

If you are using equiptment other than Magellan-supplied equipment with the GG12, it must comply with hardware specifications listed in “Hardware Description” section on page 4.

Applying power to the power input pins on the J501 connector starts GG12 operation. Before applying power, connect any controller devices or data logging equipment to the input/output pins on the J501 connector. Cutting the flow of power to the power input pins on connector J501 stops GG12 operation.

CAUTION
To avoid damaging the GG12, the power harness should always be connected to or disconnected from the J501 connector before the power supply is turned on

Message Formats

The GG12’s two RS-232 ports (A and B) can receive command messages from an external control device (such as a personal computer), send response messages to an external control device or a data logging device, and receive differential corrections from an RTCA base station.

GG12 Input Messages

With the exception of differential correction messages, GG12 input messages are comprised of set command messages and query command messages. These messages comply with the format defined in the NMEA 0183 standard to the following extent:

- Input messages are ASCII byte strings following a dollar sign character ($).
- Data fields are separated by commas.
- An optional checksum can be added to the end of the input message. The character delimiter for the checksum is an asterisk (*). The hexadecimal checksum is computed by exclusive OR-ing (XOR) all of the bytes in the message between, but not including, the dollar sign and the asterisk.
- Messages end with the standard NMEA message terminator characters, **<CR><LF>** (carriage return/line feed).

Input messages deviate from the NMEA standard as follows:

- Message headers are Ashtech proprietary.
- Message identifiers are Ashtech proprietary.

All Set and Query command messages must be composed in uppercase characters. All command messages are sent by pressing **<Enter>**. A valid set command causes the GG12 to return the **$PASHR,ACK*3D** (acknowledge) response message. A set command containing a valid $PASHS header followed by character combinations unrecognized by the GG12 causes the receiver to respond with **$PASHR,NAK*30**, a “not acknowledge” response message indicating that the command is invalid. Valid query messages are acknowledged by return of the requested information. A query command containing a valid $PASHQ header followed by character combinations unrecognized by the GG12 also causes the receiver to respond with **$PASHR,NAK*30.**

The GG12 receiver, like the GG24 and G12 receivers, responds to the following situations, in addition to setting the NAV flag:

- If the User Range Accuracy (URA) flag is set— produces no additional protective actions. Nagivational data are decoded and used according to standerd rules (parity check, etc.)
- If there is a parity error in three successive words of the navigation data— ignors a navigation data word in case of a parity error in the word and the navigation data are never presented to the user.
- If all bits in the navigation data are set to 1— navigation data considered invalid, and never presented to the user.
- If all bits in the navigation data alternate between 1’s and 0’s— navigation data considered invalid, and never presented to the user.

GG12 Message Output

The GG12 can be programmed to output data to another device at regular intervals. Output messages include standard NMEA messages, Ashtech NMEA-style messages, raw data messages, and ACK/NAK messages. With the exception of raw data messages, the data messages output by the GG12 comply with NMEA 0183 standards:

- NMEA ASCII byte strings following a dollar sign ($) character
- Headers are standard NMEA or Ashtech proprietary NMEA
- Message IDs are standard NMEA or Ashtech proprietary NMEA
- Standard NMEA messages and Ashtech NMEA-style messages contain hexadecimal checksum bytes
- Data items are separated by commas; successive commas indicate inapplicable or missing data (null fields)
- Messages end with **<CR><LF>**, the standard NMEA message terminator characters

Output messages deviate from the NMEA standard as follows:

- Most message headers are Ashtech proprietary.
- Most message identifiers are Ashtech proprietary.
- Some messages exceed the maximum length of eighty characters as prescribed by NMEA

Raw data messages use Ashtech proprietary headers and message identifiers, but the data in these messages is presented in binary format.

Serial Port Configuration

The GG12 receiver has two RS-232 serial ports that support two-way, full-duplex communication. On initial power-up, or after issuing the **$PASHS,RST** (restore defaults) command, the protocol for transmitting or receiving data is 9600 baud, eight data bits, no parity, and one stop bit (8N1).

In order for the GG12 to communicate with another device, the baud rate setting of the GG12 serial port and the serial port on the device with which it is interfaced must be the same.The baud rate setting of the GG12's ports can be changed by issuing the **$PASHS,SPD** (set port speed) command. The data rate for each port can be set independently. You can select any standard data rate from 300 to 115,200 baud, but the settings for data bit, stop bit and parity are always 8N1. If you need to change the baud rate on one of the GG12's serial ports, you should change the baud rate of the GG12 port first, and then change the baud rate of the external control device to match the new baud rate setting on the GG12 port.

Checking GG12 Status

Four query commands are available which prompt the GG12 to output messages containing current parameter settings:

$PASHQ,NMO,A (NMEA message output parameters, port A)

$PASHQ,NMO,B (NMEA message output parameters, port B)

$PASHQ,PPR (position computation parameters)

$PASHQ,RWO,A (raw data message output parameters, port A)

$PASHQ,RWO,B (raw data message output parameters, port B)

$PASHQ,RTC,RPS (RTCA remote station parameters)

For more information on these comands, see Chapter 4, Command/Response Formats.

On initial power-up, or after issuing the **command $PASHS,RST** (restore defaults), the GG12 reverts to its default parameter settings. The response to the query command $PASHQ,NMO,A shown below contains the default parameter settings for NMEA message output on port A:

```
$PASHR,NMO,A,5,001.0,12,LTN,000.0,POS,000.0,GGA,000.0,VTG,00
0.0,MSG,000.0,GSA,000.0,GSV,000.0,SAT,000.0,RRE,000.0,ZDA,00
0.0,RMC,000.0,GST,000.0,*73
```

This message contains the three-letter identifier for each NMEA and Ashtech NMEA-style message supported by the GG12 (LTN, POS…GST). Each message is followed by a field containing the setting for the output interval. The zeroes (000.0) appearing in the output interval fields indicate that all messages are disabled for output by default.

The response to the query command $PASHQ,PPR shown below contains the default settings for GG12 position computation parameters:

```
$PASHR,PPR,1,0,40,4,4,5,N,N,N,GPG*08
```

This message contains the settings for the PDOP, HDOP, VDOP, and position elevation masks (40,4,4,5). It also contains settings for position mode (1), fixed altitude mode(0), and satellite system mode (GPG).

The response shown below to the query command $PASHQ,RWO,A contains the default parameter settings for the output of raw data messages on port A:

```
$PASHR,RWO,A,5,001.0,10,MCA,000.0,MBN,000.0,PBN,000.0,MIS,000.0
,XYZ,000.0,DIF,000.0,SNV,000.0,SAL,000.0,SNG,000.0,SAG,000.0*6B
```

Like the NMO message, the RWO message contains the three-letter identifiers for each raw data message supported by the GG12 (MCA, MBN…SAG). Each message is again followed by a field containing the setting for output interval. As indicated by the zero values in these fields, all raw data messages are disabled for output by default.

The response to the query command $PASHS,RTC,RPS shown below contains the default parameter settings for differential operation:

```
$PASHR,RTC,RPS,0,,,N,,60,N*56
```

This message contains the setting for differential mode (0), the port used for input of differential corrections, the maximum age threshold for incoming differential corrections (60), and more. The zero appearing in the first field after the header and the empty data fields (,,,) indicate that differential operation is disabled by default.

GG12 Operating Parameters

You can choose different settings for the parameters controlling GG12 operation, including position modes, satellite system modes, fixed altitude modes, and more. For example, you can set the receiver to track GLONASS satellites only, or output NMEA messages or raw data messages at regular intervals. You can control if and when the GG12 computes 2D positions, or you can enable ionospheric modelling to compensate for delays imposed on the satellite signals as they pass through the ionosphere.

If you want to keep any of your new parameter settings, you must save them before cycling power to the receiver. Cycling power to the receiver without saving new settings causes the factory default settings to be restored for all GG12 operating parameters.

You can also restore the factory default settings for all operating parameters by issuing the command **$PASHS,RST**.

Saving Parameter Settings

When you change GG12 operating parameters, you can save the new settings by issuing the following command:

$PASHS,SAV,Y

You can verify that your new settings are in effect by issuing the query commands mentioned above to prompt the GG12 for its current status. The response messages output for each query displays the new settings instead of the default parameters.

Satellite System Modes

The GG12 can be set to use one of five satellite system modes. You can set the receiver in a single-system mode, in which it uses only GPS satellites or only the GLONASS satellites. You can select a dual-system mode that allows the receiver to track satellites from both systems. The user-defined mode allows you to set a specific number of channels to track GPS satellites, with any remaining channels automatically assigned to track GLONASS satellites.

Satellite system modes are selected using the set command **$PASHS,SYS**. In each of these modes, almanac and ephemeris data obtained from the satellites is used to determine channel assignments. For example, the satellite elevation obtained from the ephemeris data is used to prioritize the satellite search, with the highest priority given to satellites with the highest elevations (satellites at higher elevations are more likely to be visible to the receiver).

Single-System Modes

The single-system satellite modes set the GG12 to track satellites from one system only. If you select GPS mode, the receiver will search for, acquire, and track only GPS satellites. If you select GLO mode, the receiver will search for, acquire, and track GLONASS satellites only.

Three tracking priorities are used in the single-system modes. The first priority is track satellites which are visible and above the position elevation mask. The second priority is to track satellites which are above the elevation mask, but are not visible due to some obstruction in the line of sight between the GG12 antenna and the satellites. Suppose the almanac data indicates that ten satellites are above the elevation mask, but the receiver is only tracking eight of them. In this case, the GG12 will devote two channels to look for the missing satellites. The search continues until the receiver is able to acquire the satellites or the almanac indicates that the satellites are no longer visible. The third priority is to track satellites which are visible, but are below the position elevation mask. The GG12 can track satellites below the position elevation mask, but does not use data from these satellites for position computations. If the satellite rises above the elevation mask, the data from it can be incorporated seamlessly into the position computation. Use the set command **$PASHS,SYS** to change the satellite system mode.

- GPS Mode

  This mode sets the receiver to use the GPS system only. GLONASS satellites are not used. When this mode is enabled, the first priority is to track all visible GPS satellites above the elevation mask. The second priority is to track satellites which are above the elevation mask, but are not visible due an obstruction in the line of sight between the satellite and the GG12 antenna. The third priority is to track satellites which are below the elevation mask.

- GLO Mode

This mode sets the receiver to use the GLONASS system only. GPS satellites are not used. When this mode is enabled, the first priority is to track all visible GLONASS satellites above the elevation mask. The second priority is to track satellites which are above the elevation mask, but are not visible due an obstacle in the line of sight between the satellite and the GG12 antenna. The third priority is to track satellites which are below the elevation mask.

Dual-System Modes

You can select either of two dual-system modes. GPG mode treats GPS as the primary system and GLONASS as the secondary system. GLG mode treats GLONASS as the primary system and GPS as the secondary system. Six tracking priorities are used when the GG12 is set in one of the dual-system modes.

To illustrate, assume that the GG12 is set in GPG mode. Suppose the GPS satellite almanac indicates that ten satellites are visible above the position elevation mask, and the GLONASS satellite almanac indicates that four satellites are visible above the position elevation mask. Next, suppose the receiver cannot track two of the GPS satellites due to some obstruction in the line of sight between the GG12 antenna and the satellites. In this case, the receiver tracks and uses eight visible GPS satellites to compute positions, and dedicates two of its channels to look for the two missing GPS satellites. The two channels will continue to look for the missing satellites until it finds them or until it determines, based on the almanac information, that the two satellites are no longer visible. The two remaining channels are assigned to track two of the GLONASS satellites and use them in position computations.

To further illustrate satellite tracking in a dual-system mode, assume that the the GG12 is in GPG mode. This time, suppose the GPS satellite almanac indicates that seven satellites are visible above the elevation mask, and the GLONASS almanac indicates that three satellites are visible above the position elevation mask. Next, suppose that one of the GPS satellites is not visible due to an obstruction in the line of sight between the GG12 antenna and the satellite. The GG12 will use six of its channels to track and use the six GPS satellites for position computations. It will use one of its channels to search for the missing satellite, and will continue the search until it finds the satellite or until it determines that the satellite is no longer visible. Three of the five remaining channels will be used to track the three GLONASS satellites. The last two channels will be used to track any GPS satellites that are visible, but below the position elevation mask. If, based on the GPS almanac, the receiver determines that there are no GPS satellites visible below the elevation mask, it will use the last two channels to track any GLONASS satellites that are visible but below the position elevation mask.

- GPG Mode

  This is the default satellite system mode. The first priority is to track GPS satellites that are above the elevation mask. The second priority is to track GPS satellites that are above the elevation mask, but are not visible due to some obstruction in the line of sight between the GG12 antenna and the satellite. The third priority is to track GLONASS satellites that are above the elevation mask. The fourth priority is to track GLONASS satellites that are above the elevation mask, but are not visible due to some obstruction in the line of sight between the GG12 antenna and the satellite. The fifth priority is to track GPS satellites that are below the elevation mask. The sixth priority is to track GLONASS satellites that are below the elevation mask.

- GLG Mode

  The first priority is to track GLONASS satellites that are above the elevation mask. The second priority is to track GLONASS satellites that are above the elevation mask, but are not visible due to some obstruction in the line of sight between the GG12 antenna and the satellite. The third priority is to track GPS satellites that are above the elevation mask. The fourth priority is to track GPS satellites that are above the elevation mask, but are not visible due to some obstruction in the line of sight between the GG12 antenna and the satellite. The fifth priority is to track GLONASS satellites that are below the elevation mask. The sixth priority is to track GPS satellites that are below the elevation mask.

User-Defined Mode

This mode allows you set a specific number of channels to track GPS satellites, with the remaining channels automatically assigned to track GLONASS satellites. For example, if you set seven channels to track GPS satellites, the remaining five channels are automatically assigned to track GLONASS satellites. This setting has causes the GG12 to act as two independent receivers, with the channels assigned to track GPS satellites functioning like a GG12 set in GPS mode, and the channels assigned to track GLONASS satellites functioning like a GG12 set in GLO mode. That is, the channels assigned to GPS and the channels assigned to GLONASS use the same three tracking priorities that are used when the receiver is set in a single-system mode. Specifying zero channels has the same effect as setting the GG12 in GLO mode. Specifying 12 channels has the same effect as setting the GG12 in GPS mode.

- USE Mode

This mode allows you to set a specific number of channels to track GPS satellites, with any remaining channels automatically assigned to track GLONASS satellites.

DEFAULT SETTING	
SYS	GPG

When the GG12 is operating in remote differential mode, the highest satellite tracking priority is given to satellites for which valid differential corrections are available, regardless of the current setting for satellite system mode. That is, if the receiver is set in GLO mode but is getting valid differential corrections for five GPS satellites, it will track and use the five GPS satellites, while the remaining channels will continue to track GLONASS satellites.

Position Modes

You can set the GG12 to compute positions in four different modes. The position mode setting determines the conditions under which the receiver can calculate a 2D or 3D position. Use the set command **$PASHS,PMD** to change the position mode.

- Position Mode 0

This mode sets the GG12 to compute 3D positions only. When the GG12 is set in a single-system satellite tracking mode, it must track at least four satellites with elevations equal to or above the position elevation mask to compute a position. The receiver stops computing positions if the number of satellites being tracked falls below four. Two-dimensional (2D) positions are not computed in this mode.

When the GG12 is tracking satellites from both systems, it must track at least five satellites with elevations equal to or above the elevation mask to compute a position. The extra satellite is required because the receiver must solve the clock error for both satellite systems, and then calculate a time-shift value to synchronize GLONASS time to GPS time before it can compute a position. The receiver can continue computing positions when the number of satellites being tracked drops down to four if the time-shift is held to a fixed value, but stops computing positions if the number of satellites drops below four. See the following sections for more information on fixed time-shift modes.

- Position Mode 1

When the GG12 is in a single-system mode, the receiver computes 3D positions when tracking four or more satellites. When the number of satellites being tracked drops to three, the GG12 automatically begins computing a 2D position and holds the altitude to a fixed value. See the next section for information on fixed altitude modes. The receiver stops computing positions if the number of satellites being tracked falls below three.

When the GG12 is tracking satellites from both systems, the receiver computes 3D positions when tracking five or more satellites. When the number of satellites being tracked drops down to four, the GG12 automatically begins computing 2D positions, holding the altitude to a fixed value. When the number of satellites being tracked drops to three, the receiver can continue to compute 2D positions if the time-shift is held to a fixed value. See the following sections for more information on time-shift modes.

- Position Mode 2

This mode sets the GG12 to compute 2D positions only; the altitude is held to a fixed value regardless of the number of satellites being tracked. When the receiver is set in a single-system mode, it must be tracking at least three satellites with elevations equal to or above the position elevation mask to compute a position. The receiver stops computing positions if the number of satellites being tracked falls below three.

When the receiver is tracking satellites from both systems, it must be tracking at least four satellites with elevations equal to or above the elevation mask to compute a 2D position. If the number of satellites drops to three, the GG12 can continue to compute 2D positions if the time-shift is held to a fixed value. See the following sections for information on time-shift modes.

- Position Mode 3

When the GG12 is set in a single-system satellite tracking mode, the following conditions must be met in order for the receiver to compute 3D positions: it must be tracking four or more satellites with elevations equal to or above the position elevation mask, and the calculated HDOP value must be less than the HDOP mask setting. If the GG12 is tracking four or more satellites with elevations equal to or above the elevation mask, but the calculated HDOP is greater than the HDOP mask, the receiver computes 2D positions and holds the altitude to a fixed value. To compute 2D positions, the GG12 must be tracking at least three satellites with elevations equal to or above the elevation mask, and the calculated HDOP value must be higher than the HDOP mask setting. If the receiver is tracking three satellites and the calculated HDOP is greater than the HDOP mask, or if the number of satellites being tracked drops below three, the receiver stops computing positions.

When the GG12 is tracking satellites from both systems, there are two scenarios within which it can compute 3D positions:

- The receiver is tracking five or more satellites with elevations equal to or above the position elevation mask, and the calculated HDOP value is less than the HDOP mask setting.
- The receiver is tracking four satellites with elevations equal to or above the position elevation mask, the calculated HDOP value is less than the HDOP mask setting, and the time-shift is held to a fixed value.

When tracking satellites from both systems, the GG12 computes 2D positions under the following conditions:

- The receiver is tracking four satellites with elevations equal to or above the elevation mask, the calculated HDOP value is higher than the HDOP mask setting, and the time-shift value is not fixed.
- The receiver is tracking three satellites with elevations equal to or above the elevation mask, and the time-shift value is fixed.

DEFAULT SETTING	
PMD	**Mode 1**

Fixed Altitude Modes

Two modes define the altitude setting when the GG12 is in fixed altitude mode. When the GG12 is not tracking a sufficient number of satellites to compute a 3D position, it calculates a 2D position and holds the altitude to a fixed value. The **$PASHS,FIX** set command can be used to select one these modes.

- Fixed Altitude Mode 0

The most recent altitude is used. This is either the altitude entered by using the **$PASHS,ALT** set command or the altitude computed by the receiver when four or more satellites are used in the position solution and the VDOP value is below the VDOP mask, whichever is most recent.

- Fixed Altitude Mode 1

The altitude value entered through the set command **$PASHS,ALT** is used in the position fix solution.

DEFAULT SETTING	
FIX	Mode 0

On initial power-up, or after issuing the command $PASHS,RST (restore defaults), the antenna altitude value referenced in the ALT command is set to zero

Elevation Masks

You can set values for two elevation mask thresholds. The position elevation mask is one of the parameters that determines which satellites the receiver uses in the position computation. Data from a satellite with an elevation that is at or below the value chosen for the position elevation mask is not included in the position computation. Use the set command **$PASHS,PEM** to change the position elevation mask setting.

DEFAULT SETTING	
PEM	5°

The raw data elevation mask sets the threshold to determine from which satellites the receiver can get raw measurement data. The GG12 will not output raw measurement data for a satellite with an elevation at or below the value chosen for the raw data elevation mask. Use the set command **$PASHS,ELM** to change the setting for the raw data elevation mask.

DEFAULT SETTING	
ELM	5°

DOP Masks

Dilution of precision (DOP) is a measure of the error resulting from satellite geometry relative to the user’s location. In short, position computations based on data from satellites that are clustered tightly together relative to your location have higher DOP levels, which increases the amount error in the position solution. Position computations based on data from satellites that are widely spaced relative to your location have lower DOP levels, which affords more accurate position solutions.

You can set mask values for 4 dilution of precision measurements. PDOP (Position Dilution of Precision) corresponds to the 3D position measurement (that is, latitude, longitude, and altitude, or east, north, and up). Use the command **$PASHS,PDP** to change the PDOP mask setting.

DEFAULT SETTING	
PDP	**40**

HDOP (Horizontal Dilution of Precision) corresponds to the horizontal component of the 3D measurement. In simplistic terms, HDOP is like PDOP without the vertical component. Use the command **$PASHS,HDP** to change the HDOP mask value.

DEFAULT SETTING	
HDP	**4**

VDOP (Vertical Dilution of Precision) corresponds to the vertical component of the 3D measurement. Use the command **$PASHS,VDP** to change the VDOP mask value.

DEFAULT SETTING	
VDP	**4**

TDOP (Time Dilution of Precision) corresponds to the time measurement bias between the satellite clocks and the receiver clock. Use the command **$PASHS,TDP** to change the TDOP mask value.

DEFAULT SETTING	
TDP	**4**

Time-shift Mode

When the GG12 is tracking both GPS and GLONASS satellites, it must use a time-shift value in order to synchronize GLONASS time with GPS time before it can compute positions. The time-shift value is calculated automatically when the receiver is tracking at least five satellites. Use the GFT set command

$PASHS,GTF to set the GG12 to use the calculated time-shift value or the time-shift value entered through the set command **$PASHS,DTG**:

- Time-shift Mode 0

  This mode sets the receiver to use the most recently computed time-shift value.

- Time-shift Mode 1

  This mode sets the receive to use the time-shift value entered through the set command **$PASHS,DTG**.

DEFAULT SETTING	
GTF	Mode 0

The time-shift value is not applicable if the GG12 is set to track satellites from one system only.

Fixed Time-Shift Mode

When the GG12 tracks satellites from both systems, it must track at least five satellites to calculate a time-shift value. after calculating the time-shift value, the GG12 can still compute positions if the number of satellites being tracked drops to four or three by holding the time-shift value fixed, holding the altitude to a fixed value, or holding both the time-shift and the altitude to fixed values. Use the set command **$PASHS,GTM** to change the setting for fixed time-shift mode. The following three modes determine the conditions under which the time-shift is held to a fixed value:

- Fixed Time-shift Mode 0

  The GLONASS system time-shift is never held fixed. Depending on the position mode setting, the GG12 can continue to compute positions when tracking four satellites if the altitude is held to a fixed value. When this mode is selected, the receiver stops computing positions when the number of satellites being tracked drops to three.

- Fixed Time-shift Mode 1

  The GLONASS system time-shift is computed if the GG12 is tracking five satellites, or if the receiver is tracking four satellites and the altitude is held to a fixed value. When the GG12 is tracking only three satellites, it can compute positions if both the time-shift and the altitude are held to fixed values. If this mode is selected, the receiver stops computing positions when the number of satellites being tracked drops below three.

- Fixed Time-shift Mode 2

  The GLONASS system time shift is always held to a fixed value regardless of the number of satellites being tracked. This setting allows the GG12 to compute 3D positions when tracking four satellites, or 2D positions when tracking three satellites. The GG12 stops computing positions when the number of satellites being tracked drops below three.

DEFAULT SETTING	
GTM	Mode 1

These modes are not applicable if the GG12 is set to track satellites from one system only.

Computation Priority: Time-Shift Versus Altitude

When the GG12 is tracking satellites from both systems, and it is not tracking a sufficient number of satellites to compute both a 3D position and the time-shift value, it will hold either the altitude or the time-shift to a fixed value. If it is more important to compute a 3D position and the time-shift value is known, you can set the computation priority in favor of the altitude calculation and hold the time-shift to a fixed value. If your application demands an optimum time-shift value, you can set the computation priority in favor of the time-shift calculation and hold the altitude to a fixed value. Use the set command **$PASHS,GTP** to change the computation priority.

Enter the following command to set the computation priority in favor of the time-shift calculation:

$PASHS,GTP,Y

Enter the following command to set the computation priority in favor of the altitude calculation:

$PASHS,GTP,N

DEFAULT SETTING	
GTP	Y

Ionospheric and Tropospheric Modelling

The GG12 can be set to use ionospheric and tropospheric models in its position computations to compensate for errors caused by ionospheric and tropospheric delay. The **$PASHS,ION,Y** set command enables the the ionospheric modelling. The **$PASHS,TRO,Y** set command enables tropospheric modelling. This mode of operation is typically used to improve autonomous accuracy by minimizing the influence of the ionosphere or troposphere on the code phase of the GPS signal.

When the GG12 is in differential mode (base or rover), ionospheric and tropospheric modeling should be disabled because differential GPS compensates for delays associated with the ionosphere and troposphere. When the receiver is in differential mode and ionospheric/tropospheric modelling is enabled, the receiver ignore corrections computed through these models.

The ionospheric model used by the GG12 is based on the model defined in ICD-GPS-200, Revision B. Refer to the ARINC Research Corporation for more information on ICD-GPS-200:

ARINC Research Corporation

2250 E. Imperial Highway, Suite 450

El Segundo, CA 90245-3509

Tel: 310-524-1557

Web: http://www.arinc.com/products_services/gpshome.html

The tropospheric model is based on the Bean and Dutton model (Bean, Bradford R., and E.J. Dutton. *Radio Meteorology*. Dover, New York, 1986).

DEFAULT SETTING	
ION	**disabled**
TRO	**disabled**

NMEA Output

The GG12 can output twelve NMEA and Ashtech NMEA-style messages. Nine standard NMEA messages are available:

- GGA: 3D GPS Position message.
- GSA: DOP and Active Satellites message.
- GST: Pseudorange Error Statistics message.
- GSV: Satellites in View message.
- MSG: Differential Base Station Status message.
- RMC: Recommended Minimum Position and Course message.
- RRE: Satellite Range Residuals and Position Error message.
- VTG: Course and Speed Over the Ground message.
- ZDA: Time and Date message.

Three Ashtech NMEA-style messages are available:

- LTN: Position Output Latency message.
- POS: 3D Antenna Position message.
- SAT: Comprehensive Satellite Tracking Status message.

Any combination of these messages can be output through either serial port at the same time, and you can even choose to send the same message can be output through both ports.

The output interval can be set individually, or you can set a global output interval for all messages being output with the set command **$PASHS,NME,PER**. The maximum output interval is 5 Hz.Depending on the and can be set to any value between 0.2 and 999 seconds depending upon the options installed. The default setting for the output interval is one second. See Chapter 4, Command/Response Formats, for more information on NMEA messages and Ashtech NMEA-style messages.

DEFAULT SETTING	
PER	1 second.

Raw Data Output (Optional)

The GG12 has an optional feature that allows you to output raw data (also called real-time data) through serial ports A and B. Nine different messages can be output:

- MBN: Contains measurement data for each locked satellite in the Ashtech type 2 data structure.
- MCA: Contains measurement data for each locked satellite in the Ashtech type 3 data structure.
- MIS: Contains miscellaneous measurement data not available in the MBN and MCA messages.
- PBN: Contains position and velocity data.
- SAG: Contains GLONASS satellite almanac data in a proprietary format.
- SAL: Contains GPS satellite almanac data in a proprietary format.
- SNG: Contains GLONASS satellite ephemeris data
- SNV: Contains GPS satellite ephemeris data.
- XYZ: Contains 3D position data and range for each locked satellite.

All raw data messages are in binary format. The transmission protocol remains the same: 8 data bits, 1 stop bit, and no parity bit. 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 interval is set by the **$PASHS,RCI** command, which can range between 0.2 and 999 seconds depending upon the option selected for the raw measurement update rate (5 or 2 Hz). Information on the structure and content for all the above messages can be found in “Raw Data Commands” section on page 79.

DEFAULT SETTING	
RCI	1 second.

Differential Operation (Optional)

This section contains a general discussion of real-time differential operation, including basic concepts, sources of error, GG12 commands related to differential GPS, plus format and content for the RTCA correction messages supported by the GG12. Differential remote [U] operation is available as an option.

When the GG12 is set as a differential rover, the port which is designated to receive differential corrections can no longer be used to communicate with the receiver. If you have set the receiver to output RTCM corrections through port A, you will be able to communicate with the receiver through port B only. You must disable differential mode in order to resume communication with the receiver through port A.

General

Real-time differential positioning involves a reference (base) station calculating range corrections for each satellite it is tracking and transmitting the range corrections to the remote (rover) stations through a real-time data communications link. Remote receivers apply the corrections to their own range measurements and use the corrected ranges to compute positions.

The base receiver calculates a range correction by subtracting the measured range from the true range. A precise reference position must be entered in the base receiver before true range can be calculated. The reference position must have been previously surveyed using GPS or some other technique yielding comparable accuracy.

When operating as a stand-alone receiver, the GG12 can compute a position averaging ± 20 meters of accuracy with Selective Availability (SA) off. Stand-alone accuracy with SA on is worse, averaging ±100 meters. When receiving differential corrections, a GG12 operating in differential remote mode can achieve sub-meter accuracy on average even with SA on.

Real-time differential operation requires a communication link between the base and rover receivers. A wireless link, such as a radio-modem link or cellular/modem link is typically used, although any other medium that can transfer digital data can be used.

Sources of Error

The major sources of error affecting the accuracy of GPS range measurements are errors in satellite orbit estimation, errors in the satellite clock estimation, and errors introduced by the ionosphere, troposphere, multipath, and receiver noise in measuring satellite ranges. The first four sources of error are almost totally removed by differential corrections. The residual error is typically one millimeter for every kilometer of separation between base and remote receivers.

Receiver noise is not correlated between the base and the remote receiver and is not canceled by differential GPS. However, in the GG12, integrated doppler measurements are used to smooth the range measurements and reduce the errors resulting from receiver noise.

RMS noise, which is present from the moment a satellite is locked, contributes one meter of error to the range measurement each time a satellite is locked. RMS noise is reduced over time by the square root of the number of measurements computed by the receiver. For example, after 100 seconds of locking to an SV, the error resulting from rms noise is reduced by a factor of 10 (one meter of noise is reduced to 0.1 meter). The noise is further reduced with each additional measurement.

If the GG12 loses lock on a satellite and then reacquires it, the noise error goes back to one meter and smoothing starts from the one-meter level. The loss of lock to a satellite is rare in most applications, and typically happens only when the line of sight between the GG12 antenna and the satellite is blocked by some object or when the satellite goes below the horizon.

Total position error (or error-in-position) is a function of the range errors (or errors-in-range) multiplied by the PDOP (the 3D position dilution of precision). PDOP is a function of satellite geometry, which refers to the positions of the satellites in relation to one another. Satellites that are close together have poor geometry, because their proximity to one another

RTCA Messages

When operating in differential remote mode, the GG12 automatically processes RTCA differential messages through either serial port. To set the GG12 for differential remote operation and to receive differential corrections through port B, enter the following set command:

$PASHS,RTC,REM,B

At present, the GG12 supports only the RTCA Type 1 message, which contains differential corrections for individual satellites. To disable differential operation, enter the command below:

$PASHS,RTC,OFF

Although RTCA messages are in binary format, it is possible to convert them to ASCII format. You can simply querying for the MSG response message by entering the command below:

$PASHQ,MSG

You can also set the receiver to output the MSG response message at regular intervals. The command below sets the GG12 to output MSG every five seconds from port A:

$PASHS,NME,MSG,A,ON,5

On initial power-up, or after issuing the **$PASHS,RST** command (restore defaults), differential operation is disabled, automatic differential mode is disabled, and the setting for the maximum age of an RTCA differential correction is 60 seconds, meaning that an incoming correction whose age is greater than 60 seconds is not used. If differential operation is enabled and automatic differential GPS mode is disabled, the GG12 will not output positions if the differential correction data is unavailable or is older than the maximum age specified by the set command **$PASHS,RTC,MAX.** If differential operation and automatic differential mode are enabled, the GG12 will output uncorrected positions if differential correction data is unavailable or if the age of correction exceeds the maximum age setting.

Timing Pulse (Optional)

When the timing pulse option [L] is installed, the GG12 can output a timing pulse synchronized with GPS time to an accuracy of ±1 microsecond. The timing pulse is a TTL-level square wave signal output on pin 18 of the J501 connector and is fed into a 75-ohm impedance. The pulse is generated by default once every second (1PPS, or 1 pulse-per-second) with no offset from GPS time and with the rising edge of the pulse synchronized to GPS time.

Use the **$PASHS,PPS** command to change the period of the pulse from 0.2 of a second up to 60 seconds, depending upon the receiver update rate, which, in turn, is dependent upon the installed position update rate and raw data update rate options. The timing pulse may be offset from GPS time within a range of -999.9999 to +999.9999 milliseconds. GPS time can be synchronized to the rising or falling edge of the square wave pulse.

DEFAULT SETTING		
PPS	Period	1 second
	Offset	0.0000 milliseconds
	Synchronization	GPS time synchronized to the rising edge of the pulse

Figure 3.1 shows timing pulse characteristics under default conditions. The pulse occurs when the signal goes high (i.e., goes from zero to five volts). The pulse is generated within ±1 microsecond of the GPS second and remains high for 1-2

milliseconds. The precision of the epoch between pulses is ±190 nanoseconds in stand-alone mode with SA active and ±45 nanoseconds when the GG12 is receiving differential corrections. The GG12 must be computing positions and tracking a minimum of four satellites in order for the one microsecond accuracy and 45/190 nanosecond precision to be valid.

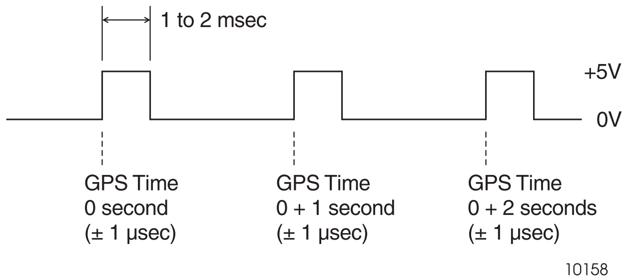

Figure 3.1. Timing Pulse Characteristics

In order to provide notification to peripheral equipment and software with respect to time tagging the occurrence of the timing pulse, it is necessary to set the output of PBN raw data message to match the period of the timing pulse. The GPS time value contained in the PBN message plus one second is the time that the next pulse will occur when the default settings are in effect (Figure 3.2). PBN time is already internally rounded to GPS time (or GLONASS time, depending on the current parameters settings), 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 latency of PBN message output is normally about 40 milliseconds after the timing pulse event.

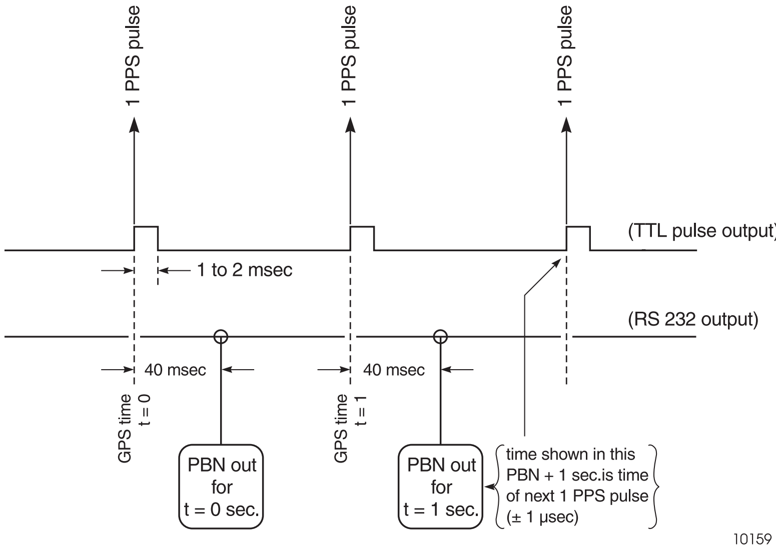

Figure 3.2. Relationship of GPS Time in PBN Record to Output of 1PPS Pulse

4

Command/Response Formats

This chapter covers the formats and content of the serial port commands through which the GG12 receiver is controlled and monitored. These serial port commands set receiver parameters and request receiver status information and other data. Use Evaluate™ software or any other standard serial communication software to communicate with the receiver. 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 responses to be successfully transmitted and received. The communication protocol is 8 data bits, 1 stop bit, and no parity.

All messages sent by the user to the receiver are either “Set” command messages or “Query” command messages. Set commands typically change receiver parameters and initiate data output. Query commands typically request receiver status information. All set commands begin with the string **$PASHS**; all query commands begin with **$PASHQ**. **$PASHS** and **$PASHQ** are the message headers. They are required for all set or query commands. All commands must end with an **<Enter>** or **<CR><LF>** (Carriage Return/Line Feed) keystroke in order to send the command to the receiver. If desired, an optional checksum may precede the **<Enter>** characters. All response messages also end with **<Enter>** or **<CR><LF>** characters. Please note that some messages are functional only if the appropriate option is installed.

When a command is sent to one of its serial ports, the GG12 responds by outputting a message indicating the acceptance or rejection of the command. In the case of query commands, the GG12 either outputs a response message containing data relevant to the query or sends a “NAK” response, indicating that the query command was invalid. All GG12 response messages begin with the string **$PASHR**, including status messages that are set for output at regular intervals.

GG12 serial port commands fall into four groups:

- Receiver Commands, page 41
- Raw data commands, page 79
- NMEA message commands, page 106
- RTCA differential commands, page 136

The following sections discuss each type of command. Within each section, the commands are listed alphabetically and described in detail. A description of the command, the command structure, the range and default states of command parameters, and an example of how a given command is used are presented for each command. These parameters may be either characters or numbers depending upon the command. Table 4.1 lists symbols and the types of data represented by them that we will use to illustrate message structures in the ASCII format:

Table 4.1. Command Parameter Symbols

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

Receiver Commands

Receiver commands allow you to change or query the status of various operating parameters such as elevation mask, antenna altitude, position mode, etc. In this context, set commands are used to change GG12 operating parameters. Query commands prompt the GG12 to output status messages for parameter settings and receiver operation. If an invalid set or query command is issued, a “not acknowledged” (NAK) response is output as shown below:

```
$PASHR,NAK*30
```

Set command messages can be accepted by either serial port. When the GG12 receives a valid set command message, it returns an "acknowledged" (ACK) message:

```
$PASHR,ACK*3D
```

The GG12 returns a NAK message if the command is invalid.

The set command **$PASHS,SAV,Y<Enter>** instructs the GG12 to save user-entered operation parameters; the GG12 returns $PASHR,ACK*3D to acknowledge that the command was valid and the instruction was carried out.

The set command **$PASHS,SAV<Enter>** is incomplete, and would cause the GG12 to flag it as an invalid command by responding with a “not acknowledged” response:

```
$PASHR,NAK*30.
```

The set command message structure is shown below:

Header,Command ID,<Command Parameters>*Checksum<Enter>

The header field always contains **$PASHS**. The command identifier field contains a three character string and is followed by the command parameters. The checksum is strictly optional. All set commands are terminated with an **<Enter>** or **<CR><LF>** keystroke. All command string elements between the dollar sign ($) and the asterisk (*), including the command parameters, are comma delimited; that is, the header, the ID string, and the individual command parameters are separated by commas.

The set command used to set the HDOP mask value is entered as shown below:

$PASHS,HDP,6<Enter>

Query commands are used to request current GPS information and receiver status information such as port, baud rate, position information, and tracking information. Query command messages can be sent to either serial port on the GG12. Some query commands allow you to designate the port from which the response message is sent. The GG12 acknowledges a valid query command message by sending the requested response message through the specified port. If the port is not specified in the query command, the response is sent from the same port which received the query. The requested information is sent once each time the command is issued and is not repeated.

The query command message format is shown below:

$PASHQ,xxx,<optional query parameter>*hh<Enter>

Table 4.2 lists the query command elements.

Table 4.2. Query Command Structure

Field	Description
$	NMEA message start character
PASHQ	Proprietary Ashtech header for query messages
xxx	Message identifier
<optional query parameter>	Designates the data port from which the query response message is to be sent
*	Checksum delimiter
hh	Hexadecimal checksum value (checksum is optional)

The query command **$PASHQ,TRO<Enter>** instructs the GG12 to output a response message indicating whether tropospheric modelling is enabled (Y) or disabled (N):

```
$PASHR,TRO,N*5F
```

The query command **$PASHQ,TR<Enter>** is incomplete, and causes the GG12 to flag it as an invalid message by outputting the NAK response.

Table 4.3 lists the receiver commands. The commands are listed alphabetically by function, and then alphabetically within each function. The commands are described in detail in the pages following Table 4.3.

Table 4.3. Receiver Commands

Function	Command	Description	Page
Antenna Position	$PASHS,ALT $PASHS,POS $PASHQ,POS	Set ellipsoidal height of antenna Set antenna position Query current antenna position	page 44 page 56 page 56
Clock Parameters	$PASHS,DTG $PASHQ,DUG $PASHS,GTF $PASHS,GTM $PASHS,GTP $PASHS,TSC $PASHQ,TSC	Set GLONASS time-shift value Query for GPS/UTC time difference Set GLONASS fixed time shift mode Enable/disable GLONASS fixed time shift Set priority for GLONASS system time shift computation. Select GPS or GLONASS time scale Query for current time scale setting	page 46 page 47 page 49 page 49 page 50 page 75 page 76
Dilution of Precision (DOP)	$PASHS,HDP $PASHS,PDP $PASHS,TDP $PASHQ,TDP $PASHS,VDP	Set HDOP mask for position computation Set PDOP mask for position computation Set TDOP mask for GLONASS time shift Query for current TDOP setting Set VDOP mask for position computation	page 51 page 54 page 73 page 73 page 78
Ionospheric, Tropospheric Modelling	$PASHS,ION $PASHQ,ION $PASHS,TRO $PASHQ,TRO	Enable/disable ionospheric modelling Query for ionospheric measurements Enable/disable tropospheric modelling Query to see if tropospheric modelling is enabled or disabled	page 52 page 52 page 74 page 74
Memory	$PASHS,INI $PASHQ,BIT $PASHS,RST $PASHS,SAV	Clear battery-backed memory Query for results of built-in test Restore default parameter settings Save parameters in battery-backed-up memory	page 51 page 45 page 68 page 68
Position Computation	$PASHS,FIX $PASHS,PEM $PASHS,PMD	Set fixed altitude mode Set elevation mask for position computation Set position computation mode	page 48 page 54 page 55

Table 4.3. Receiver Commands (continued)

Function	Command	Description	Page
Receiver Configuration	$PASHS,POP	Set the receiver's internal update rate for position and raw measurements	page 56
	$PASHQ,PPR	Query current position computation parameters	page 59
	$PASHQ,PRT	Query port baud rate	page 62
	$PASHQ,RID	Query receiver identification (Format 1)	page 63
	$PASHQ,RIO	Query receiver identification (Format 2)	page 66
	$PASHS,SPD	Set baud rate of serial port	page 68
	$PASHS,SYS	Select satellite system mode (GPS; GLO; GPG; GLG)	page 72
	$PASHS,SYS,USE	Set a specific number of channels to track GPS or GLONASS satellites	page 72
Satellite Tracking Parameters	$PASHS,SVP	Include/exclude satellites for position computation	page 69
	$PASHQ,SVP	Query for satellites enabled/disabled for position computation	page 69
	$PASHS,SVS	Include/exclude specific satellites for acquisition and tracking	page 70
	$PASHQ,SVS	Query for satellites enabled/disabled for acquisition and tracking	page 71
	$PASHS,USE	Include/exclude satellites for acquisition and tracking	page 77
	$PASHS,USP	Include/exclude satellites for position computation	page 77
Timing Pulse Output	$PASHS,PPS	Set period and offset of timing pulse	page 60
	$PASHQ,PPS	Query timing pulse parameters	page 61

Since they are required for all commands and responses, <Enter> and <CR><LF> are omitted from the examples in this chapter.

ALT: Set Ellipsoidal Height

$PASHS,ALT,f1

This command allows you to set the ellipsoidal height of the antenna, where f1 can be any value from -99999.99 to **+**99999.99. The GG12 uses the altitude value set through this command when it is computing 2D positions.

Examples

Enter the following command to set the ellipsoidal height of the antenna to +100.25 meters:

$PASHS,ALT,+100.25

Enter the following command to set the ellipsoidal height of the antenna to -30.1 meters:

$PASHS,ALT,-30.1

DEFAULT SETTING	
ALT	00000.00 meters

BIT: Query for Results of Built-in Tests

$PASHQ,BIT,c1

This command allows you to query the results of the GG12 self-test routine, also called the built-in test. The c1 parameter is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,BIT

The GG12 runs the built-in test each time it is turned on and periodically while it is operating. The built-in test routine essentially is a series of queries used to ascertain the status of several critical components and parameters. For example, the built-in test checks whether receiver parameters stored in non-volatile memory have been corrupted by querying for a checksum. If the returned checksum does not match one in a list of acceptable checksum values, the GG12 notes a failure in the BIT response message. The response message is output in the format:

```
$PASHR,BIT,c1,c2,c3*hh
```

Table 4.4 outlines the response message.

Table 4.4. $PASHR,BIT Format

Parameter	Description	Range
c1	Indicates whether the battery in the real-time clock component has failed	P(ass) F(ail)
c2	Indicates whether the receiver parameter settings stored in non-volatile memory have been corrupted	P(ass) F(ail)

Table 4.4. $PASHR,BIT Format (continued)

Parameter	Description	Range
c3	Indicates whether a fatal failure has occurred. Fatal failures include the following items: • Failures in volatile and non-volatile memory • Firmware checksum failures • Failures in serial port A or B	P(ass) F(ail)
*hh	Checksum	2-character hex

Typical BIT message:

```
$PASHR,BIT,P,P,P*57
```

Table 4.5 outlines the response message.

Table 4.5. Typical BIT Message

Field	Description
$PASHR,BIT	Header
P	Indicates that the battery in the real-time clock is functioning properly
P	Indicates that the response to the query for receiver parameters has returned a valid checksum
P	Indicates that no fatal failures have been reported
*57	Checksum

DTG: Set GLONASS Time-Shift Value Relative to GPS Time

$PASHS,DTG,f1

This command allows you to set the GLONASS system time-shift relative to GPS system time, where f1 is the time shift value in microseconds. The f1 parameter represents the fractional part of the GPS/GLONASS system time offset. The GG12 calculates the offsets for the integer seconds (leap seconds) and the integer hours automatically. The time shift value has a range of +500.0000 to -500.0000 microseconds.

Example

Enter the following command to set the GLONASS system time shift to -1.3 microseconds:

$PASHS,DTG,-1.3

DEFAULT SETTING	
DTG	000.0000

The GG12 default time-shift mode sets the receiver to use the most recently computed GLONASS system time-shift value when the receiver goes into a fixed time-shift mode. Enter the command $PASHS,GTF,1 to use the time-shift value selected through the DTG command. See the GTM command for more information on fixed time-shift modes.

When you set this parameter, the time shift value selected should be as close as possible to the actual time shift value in order for the receiver to compute positions. As of November 1999, the fractional portion of the time shift value is approximately +1.3 microseconds.

DUG: Query for GPS/UTC Time Difference

$PASHQ,DUG,c1

This command allows you to query the time difference between UTC time and GPS time; c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,DUG

The response message is output in the format:

```
$PASHR,DUG,<Binary Data String + Checksum>
```

Table 4.6 outlines the response message.

Table 4.6. $PASHR,DUG Format

Binary Type	Size	Content
unsigned short	2	Reference week
unsigned short	2	Reference time
unsigned short	2	GPS-UTC time (seconds)
unsigned short	2	GPS week number when the last leap second was added to GPS time.

Table 4.6. $PASHR,DUG Format

Binary Type	Size	Content
unsigned short	2	Julian day number when the last leap second was added to GPS time (1 to 365).
unsigned short	2	GPS-UTC time difference after correction (seconds)
unsigned short	2	Word checksum
Total bytes 14		

A time step, or leap second, was added to UTC on 12-31-98. GPS time was not physically adjusted, and is now thirteen seconds ahead of UTC. The time change is reflected in the navigation messages generated by the individual satellites as of January 1, 1999.

FIX: Set Fixed Altitude Mode

$PASHS,FIX,d1

This command allows you to set the fixed altitude mode, where d1 is 0 or 1. The GG12 uses a fixed value for the altitude when the receiver is in 2D position mode or when there are not enough visible satellites to compute a 3D position. You can view the current setting for fixed altitude mode by entering the query command **$PASHQ,PPR** and checking field d2.

- Fixed Altitude Mode 0

  The most recently recorded antenna altitude is used. The altitude value is taken either from the altitude entered through the **$PASHS,POS** command or from the last altitude computed in which the VDOP value is lower than the VDOP mask value.

- Fixed Altitude Mode 1

  Only the most recent altitude value entered through the **$PASHS,ALT** command is used.

Example

Enter the following command to set the GG12 in fixed altitude mode 1:

$PASHS,FIX,1

DEFAULT SETTING	
FIX	Mode 0

GTF: Set GLONASS Time-Shift Mode

$PASHS,GTF,d1

This command allows you to set the GLONASS system time shift mode, where d1 is zero (0) or one (1):

- Time-shift Mode 0

  This mode sets the GG12 to use the most recently computed GLONASS system time shift.

- Time-shift Mode 1

  This mode sets the GG12 to use the GLONASS system time shift value selected through the **$PASHS,DTG** command.

Example

Enter the following command to set the GG12 to use the GLONASS system time shift value selected through the **$PASHS,DTG** command:

$PASHS,GTF,1

DEFAULT SETTING	
GTF	Mode 0

The GTF command does not set the GLONASS system time shift value. This command determines what value is used for the time-shift when the GG12 is in a fixed time-shift mode. This is either the most recently computed time shift value or the time shift value selected through the DTG command.

GTM: Set GLONASS Fixed Time-Shift Mode

$PASHS,GTM,d1

This command allows you to set the fixed time shift mode, where d1 is 0, 1, or 2. This setting is applicable only when the GG12 is tracking both GPS and GLONASS satellites. See GG12 Operating Parameters on page 21 for more information on the different mode settings and how they are related. The fixed time-shift modes are described below:

- Fixed Time-shift Mode 0

  The GLONASS system time-shift value is never held fixed. When set in this mode, the GG12 uses the most recently computed time shift value. The GG12 must be tracking a sufficient number of satellites (n) in order to compute the time-shift value. When this mode is selected, the GG12 stops computing positions if the number of satellites tracked drops to (n-1).

- Fixed Time-shift Mode 1

This mode sets the GG12 to compute the GLONASS system time shift if it is tracking a sufficient number (n) of satellites to compute a position. If the number of satellites being tracked by the GG12 is (n-1), the most recent GLONASS system time-shift value that was computed while tracking (n) satellites is held fixed. In this mode, the receiver will continue to use this time-shift value until it is once again tracking (n) satellites.

- Fixed Time-shift Mode 2

The GLONASS system time-shift is always held fixed. This setting allows the GG12 to continue computing positions even when the number of satellites tracked drops to (n-1). When this mode is selected, the receiver stops computing positions when the number of satellites being tracked drops to (n-2).

Example

Enter the following command below to select Fixed Time-shift Mode 2:

$PASHS,GTM,2

DEFAULT SETTING	
GTM	Mode 1

GTP: Set Computation Priority for Time Shift Vs. Altitude

$PASHS,GTP,c1

This command allows you to set either the priority of GLONASS system time-shift computation against altitude computation, where c1 is Y or N. Entering 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.

Example

Enter the following command to set the altitude calculation as the computation priority:

$PASHS,GTP,N

DEFAULT SETTING	
GTP	Y

If GPS and GLONASS satellites are used in position computation, and both PMD and GTM are set to a value other than 0, (fix altitude or time shift when fewer than 5 satellites), the following conditions apply when GG12 is tracking 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.

HDP: Set HDOP Mask Value

$PASHS,HDP,d1

This command allows you to set the mask value for the Horizontal Dilution of Precision (HDOP), where d1 is a number between 0 and 99. If the HDOP value computed by the GG12 is higher than the HDOP mask value, the receiver will automatically go into fixed altitude mode. You can view the current HDOP mask value by entering the query command $PASHQ,PPR and checking field d4.

Example

Enter the following command to set an HDOP mask value of 6:

$PASHS,HDP,6

DEFAULT SETTING	
HDP	4

INI: Initialize the Receiver

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

This command allows you to clear receiver memory and reset serial port baud rates, where d1 and d2 are baud rate setting codes for ports A and B, and d3 is the memory reset code. Table 4.7 and Table 4.8 below contain the code numbers and the settings associated with them.

Table 4.7. Serial Port Baud Rate Codes

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

Table 4.8. Memory Reset Codes

Reset Memory Code	Action
0	No memory reset
1	Reset internal memory (battery-backed RAM)

Example

Enter the following command to set Port A with a baud rate of 4800, Port B with a baud rate of 19200, and reset internal memory:

$PASHS,INI,4,6,1

ION: Enable/Disable Ionospheric Modelling

$PASHS,ION,c1

This command enables or disables the use of ionospheric modelling, which is used to compensate for delays that occur as the GPS signals travel through the ionoshpere, where c1 is either N (disable) or Y (enable). You can see whether ionospheric modelling is enabled or disabled by entering the query command **$PASHQ,PPR.**

Example

Enter the following command to enable ionospheric modelling:

$PASHS,ION,Y

DEFAULT SETTING	
ION	N

Ionospheric modelling should be enabled when the receiver is functioning in stand-alone mode (autonomous mode). Ionospheric modelling is ignored when the receiver is set as an RTCA rover, regardless of the current ION setting, since differential corrections already compensate for ionospheric delays.

$PASHQ,ION,c1

This command allows you to query for current ionospheric data generated by the GPS satellites, where c1 is the optional output serial port. If an output port is not designated, the response is output from the same port that received the query.

$PASHR,ION

The response message is output in binary format:

```
$PASHR,ION,<Binary Data String + Checksum>
```

Elements in the binary data string are described in Table 4.9:

Table 4.9. $PASHR,ION Format

Type	Size	Contents
float	4	α_0 ionospheric parameter (seconds).
float	4	α_1 ionospheric parameter (sec. per semicircle).
float	4	α_2 ionospheric parameter (sec. per semicircle).
float	4	α_3 ionospheric parameter (sec. per semicircle).
float	4	β_0 ionospheric parameter (seconds).
float	4	β_1 ionospheric parameter (sec. per semicircle).
float	4	β_2 ionospheric parameter (sec. per semicircle).
double	8	β_3 ionospheric parameter (sec. per semicircle).
double	8	A_0 Constant term of GPS/UTC polynomial.
double	8	A_1 Constant term of GPS/UTC polynomial.
unsigned long	4	t_{ot} Reference time.
short	2	W_{nt} reference week.
short	2	Δt_{LS} Delta UTC-GPS time at reference time.
short	2	WN_{LSF} Week of leap second correction.
short	2	DN day of leap second correction.
short	2	Δt_{LSF} Delta time between GPS and UTC.
short	2	WN Current GPS week number.
unsigned long	4	tow Current time of week.
short	2	bulwn Current GPS week number when message was read.
unsigned long	4	bultow Time of week when message was read.
short	2	Word checksum
Total characters = 76 bytes		

Commands

The GG12 does not calculate ionospheric parameters on its own. The ionosphereic data shown in Table 4.9 are obtained from subframe 4 of the GPS navigation message.

PDP: Set PDOP Mask Value

$PASHS,PDP,d1

This command allows you to set the mask value for the Position Dilution of Precision (PDOP), where d1 is a number between 0 and 99. The receiver stops computing positions when the calculated PDOP value exceeds the PDOP mask value. You can view the current PDOP mask setting by entering the query command **$PASHQ,PPR** and checking field d3.

Example

Enter the following command to set the PDOP mask to 30:

$PASHS,PDP,30

DEFAULT SETTING	
PDP	40

PEM: Set Position Elevation Mask Value

$PASHS,PEM,d1

This command allows you to set elevation mask for position computation, where d1 is 0 to 90 degrees. Default is 5 degrees. A satellite with elevation which is less than the elevation mask setting is excluded from position computations. You can view the current position elevation mask value with the **$PASHQ,PPR** query command and checking the PEM field.

Example

Enter the following command to set the elevation mask to 15 degrees:

$PASHS,PEM,15

DEFAULT SETTING	
PEM	5°

Although the GG12 does not use satellites in the position computation which have gone below the position elevation mask (PEM), you can still obtain raw data from these satellites as long as they are not below the raw data elevation mask (ELM).

PMD: Set Position Mode

$PASHS,PMD,d1

This command allows you to set the position mode. The position mode determines the minimum number of satellites required to compute a position, whether the receiver switches automatically from 2-D to 3-D positioning or is manually locked in 2-D or 3-D positioning mode, and, in 2-D mode, whether the altitude used is the most recently computed “good” altitude or a fixed altitude value set by the ALT command. Enter 0, 1, 2, or 3 for d1. You can view the current position mode by entering the query command $PASHQ,PAR and checking the PMD field. See the section in chapter 3 entitled “Position Modes” for more information on the position mode settings.

- Position Mode 0: Manual 3-D Mode

  Sets the receiver for 3-D position computation. The receiver must be tracking a minimum of four satellites in order to compute a position.

- Position Mode 1: Automatic 3-D Mode

  The receiver must track a minimum of three satellites to compute a position. With three satellites, latitude and longitude are computed and altitude is held to a fixed value (2-D positioning). With four satellites or more, altitude is computed (3-D positioning).

- Position Mode 2: Manual 2-D Mode

  The receiver must track a minimum of three satellites to compute a position. This mode locks the receiver to 2-D positioning, meaning latitude and longitude are computed and altitude is always held fixed regardless of the number of satellites tracked.

- Position Mode 3: Automatic 2-D Mode

  The receiver must track a minimum of three satellites to compute a position. With 3 satellites, longitude and latitude are computed and altitude is held fixed (2-D positioning). With 4 satellites, altitude is computed (3-D positioning) unless the calculated HDOP value is greater than HDOP mask setting.

Example

Enter the following command to select Position Mode 3:

$PASHS,PMD,3

DEFAULT SETTING	
PMD	1

Commands

POP: Set Position & Raw Data Update Rate

$PASHS,POP,d1

This command allows you to set the GG12's internal update rate for position and raw data, where d1 is 2 or 5 (Hz). Two indicates that position and raw data will be computed internally twice per second; five indicates that position and raw data will be computed internally five times per second. The default is 2. Changes made to the POP setting are not saved with the **$PASHS,SAV,Y** command.

DEFAULT SETTING	
POP	**2**

POS: 3-D Antenna Position

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

This command allows you to optimize the GG12's satellite search pattern by entering a 3-D antenna reference position into the receiver. This command is typically used when the receiver is turned on for the first time, or when the receiver has been moved more than 500 miles from the location in which it was last powered on. It is not necessary to use exact coordinates. Inputting approximate coordinates for your current position enables the receiver to restrict its satellite search to pattern to include only those satellites which should be visible in that particular area at that particular time. In the example above, m1 is the latitude, c2 is the latitude sector, m3 is the longitude, c4 is the longitude sector, and f5 is the altitude.

$PASHQ,POS,c1

This command allows you to query the receiver's current 3-D position, where c1 is the optional port designator for the output of the response message. If a port is not specified, the receiver sends the response to the current port.

$PASHR,POS

The response message is output in the format shown below:

```
$PASHR,POS,d1,d2,m3,m4,c5,m6,c7,f8,,f9,f10,f11,f12,f13,f14,f
15, s16*hh
```

Table 4.10 outlines the response message.

Table 4.10. $PASHR,POS Message Format

Parameter	Description	Range
d1	Indicates whether the position solution has been computed autonomously or with the aid of RTCA differential corrections: •0: Autonomous position •1: Corrected position	0, 1
d2	Indicates the number of satellites used in computing positions	0-12
m1	Current time (UTC)	00-235959.50
m2	Current latitude measured in degrees, minutes, and decimal minutes (ddmm.mmmmm)	0°-90°
c1	Latitude sector	N / S
m3	Current longitude measured in degrees, minutes, and decimal minutes (dddmm.mmmmm)	0°-180°
c2	Longitude sector	E / W
f1	Current altitude in meters referenced to the WGS-84 ellipsoid. In 2-D positioning mode, this field contains the fixed altitude value	-30000.000 to +30000.000
,,	Reserved data field.	
f2	Course over the ground (ttt.tt); referenced to true north.	0.00°-359.99°
f3	Speed over the ground (knots)	000.00 to 999.99
f4	Vertical velocity (meters per second)	-999.9 to +999.9
f5	Current computed PDOP value	0.00-99.9
f6	Current computed HDOP value	00.0-99.9
f7	Current computed VDOP value	0.00-99.9
f8	Current computed TDOP value (seconds)	0.00-99.9
s1	Firmware version code	4-character ASCII
hh	Checksum	2-character hex

Typical POS response message:

```
$PASHR,POS,0,09,002701.00,3721.08661,N,12156.11611,W,
-00054.41,,047.27,000.44,-000.13,02.0,01.1,01.7,01.2,FA00*17
```

Table 4.11 outlines the response message.

Table 4.11. Typical POS Response Message

Item	Description
$PASHR	Header.
POS	Message identifier.
0	Indicates that the position is computed autonomously (computed without the aid of differential corrections)
09	Indicates that the receiver is using nine satellites to compute a position
164152.90	UTC time reference (00:27:01.00)
3721.06962	Current latitude (37°21.08661')
N	Latitude sector
12156.11611	Current longitude (121°56.11611')
W	Longitude sector
-00054.41	Current altitude (referenced to the WGS-84 ellipsoid)
,,	Reserved data field
047.27	Current course over the ground (that is, 47.27° from true north)
000.44	Current speed over the ground (knots)
+000.13	Current vertical velocity (this indicates that the receiver is ascending at a rate of 0.13 meters per second)
02.0	Current PDOP
01.1	Current HDOP
01.7	Current VDOP
01.2	Current TDOP
FA00	Firmware version number
*17	Checksum

If the GG12 is unable to compute a position, the POS response message is in the format:

```
$PASHR,POS,0,,,,,,,,,,,,,,,,GH00*05
```

The GG12 uses the WGS-84 ellipsoid only. The PZ-90 ellipsoid, which is the ellipsoid reference for the GLONASS system, is not used.

PPR: Query for Position Computation Parameters

$PASHQ,PPR,c1

This command allows you to query the receiver's current position computation parameters, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,PPR

The response message contains the current settings for position mode, fixed altitude mode, satellite system mode, HDOP, PDOP, VDOP, and position elevation masks, and an indicator that shows whether ionospheric modelling is enabled or disabled. The response is output in the format:

```
$PASHR,PPR,d1,d2,d3,d4,d5,d6,c7,c8,c9,s10*hh
```

Table 4.12 outlines the response message.

Table 4.12. $PASHR,PPR Message Format

Field	Description	Range
d1	Position mode setting	0 - 3
d2	Fixed altitude mode setting	0, 1
d3	PDOP mask setting	0 - 99
d4	HDOP mask setting	0 - 99
d5	VDOP mask setting	0 - 99
d6	Position elevation mask (PEM) setting; measured in degrees	0 - 90
c7	Indicates whether point positioning mode is enabled or disabled (always N)	Y (enabled) N (disabled)
c8	Indicates whether unhealthy satellites are included or excluded for position computation (always N)	Y (excluded) N (included)
c9	Indicates whether ionospheric modelling is enabled or disabled	Y (enabled) N (disabled)
s10	Indicates the current satellite system mode	GLO, GPS, GLG, GPG, USE
*hh	Checksum	2-character hex

Typical PPR response message:

```
$PASHR,PPR,1,0,40,4,4,5,N,N,N,GPG*08
```

Table 4.13 outlines the response message.

Table 4.13. Typical PPR Response Message

Parameter	Description
$PASHR,PPR	Header
1	Indicates that the GG12 is set in position mode 1
0	Indicates that the GG12 is set in fixed altitude mode 0
40	Indicates that the current PDOP mask setting is 40
4	Indicates that the current HDOP mask setting is 4
4	Indicates that the current VDOP mask setting is 4
5	Indicates that the current position elevation mask setting is five degrees
N	Indicates that point positioning mode is disabled
N	Indicates that unhealthy satellites are excluded from position computations
N	Indicates that ionospheric modelling is disabled
GPG	Indicates that GPG is the current satellites system mode
*08	Checksum

PPS: Timing Pulse Parameters

$PASHS,PPS,f1,f2,c1

The GG12 can generate a timing pulse with programmable period and offset. The timing pulse is generated by default once every second (1PPS) with its rising or falling edge synchronized to the GPS time. This command allows you to change the period and the offset (from the current time scale reference) of the pulse, where f1 is the period of the pulse in seconds with a range between 0.2 and 99.95. The minimum setting depends upon the receiver update rate, which is dependent upon the installed position update rate or raw data update options. The f2 parameter is the offset from GPS time in milliseconds, with 10ns resolution (range between -999.9999 and +999.9999). The c3 parameter determines whether the GPS time is synchronized with the rising edge of the pulse (R) or the falling edge of the pulse (F).

Example

Enter the command below to configure the timing pulse output to have a period of 2 seconds, an offset of 10 milliseconds, and to be synchronized with the falling edge of the pulse:

$PASHS,PPS,2,10,F

$PASHQ,PPS,c1

This command allows you to query for timing pulse parameters, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,PPS

The response message is output in the format:

```
$PASHR,PPS,f1,f2,c3*hh
```

Table 4.14 outlines the response message.

Table 4.14. $PASHR,PPS Message Format

Field	Description	Range
f1	Timing pulse output interval (seconds). Timing pulse output is disabled when this parameter is set to zero	0 - 99.95
f2	Timing pulse offset value (milliseconds)	-999.9999 to +999.9999
c3	Timing pulse synchronization point	R(ising edge) F(alling edge)
*hh	Checksum	2-character

Typical PPS response message:

```
$PASHR,PPS,1.0000,000.0000,R*58
```

Table 4.15 outlines the response message.

Table 4.15. Typical PPS Response Message

Parameter	Description
1.0000	Indicates that the period of the timing pulse is set to one second
000.0000	Indicates that there is not offset from the current time scale reference
R	Indicates that the synchronization with the rising edge of the pulse
*hh	Checksum

DEFAULT SETTING	
PPS	**R**

See Timing Pulse (Optional) on page 36 for more information on the conditions surrounding the generation and accuracy of the timing pulse.

PRT: Query Serial Port Baud Rate

$PASHQ,PRT,c1

This command allows you to query the baud rate code of the GG12 serial port to which you are currently connected, where c1 is the optional serial port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. Issue the query command **$PASHQ,PAR** to see the baud rate codes for both serial ports.

$PASHR,PRT

The response is output in the format:

```
$PASHR,PRT,c1,d2*hh
```

Table 4.16 outlines the response message.

Table 4.16. $PASHR,PRT Message Format

Parameter	Description	Range
c1	Identifier for the serial port to which you are currently connected.	A, B

Table 4.16. $PASHR,PRT Message Format (continued)

Parameter	Description	Range
d2	Baud rate code (see Table 4.17 below).	1 - 9
hh	Checksum	2-character hex

Table 4.17 lists the baud rate codes and the corresponding baud rates:

Table 4.17. GG12 Baud Rate Codes

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

DEFAULT SETTING	
PRT	**9600**

The data rate for GG12 serial ports is set by using the command SPD command.

RID: Query Receiver Identification Parameters (Format 1)

$PASHQ,RID,c1

This command allows you to query for receiver identification parameters, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,RID

The response message contains a receiver type code, a firmware version number, and a list of installed options; it is output in the format:

```
$PASHR,RID,s1,s2,s3*hh
```

Table 4.18 outlines the response message.

Table 4.18. $PASHR,RID Fields

Field	Description
s1	Receiver model identifier
s2	Firmware version number
s3	List of installed options
hh	Checksum

Fourteen options are available for the GG12. Each option is represented by a letter or number in a definite order. The presence of a given option is indicated by the presence of the corresponding letter or number. A dash (“-”) indicates that a given option is not installed. An underscore (“_”) indicates a reserved option slot.

Table 4.19 lists the letters and numbers in conjunction with the options they represent and the options available for the GG12:

Table 4.19. Available GG12 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 tracking
[U]	Differential - remote station
[_]	Reserved option field
[_]	Reserved option field
[L]	Timing pulse output (1PPS)
[_]	Reserved option field
[G]	Geoid model
[M]	Magnetic variation model
[_]	Reserved option field

Table 4.19. Available GG12 Options (continued)

Option	Description
[_]	Reserved option field
[S]	GLONASS tracking

The absence of dashes in the RID response message indicate that all of the available options have been installed:

```
$PASHR,RID,GG,FA00,55OPU__L_GM__S*00
```

Table 4.20 outlines the response message.

Table 4.20. $PASHR,RID Fields

Field	Description
$PASHR	Header
RID	Message identifier
GG	Receiver type identifier
#I96	Firmware version number
5	5 Hz update rate (0.2 seconds) installed for raw data update option
5	5 Hz update rate (0.2 seconds) installed for position update option
O	Raw data output option installed
P	Carrier phase tracking option installed
_	Reserved option field
_	Reserved option slot
L	Timing pulse output option installed
_	Reserved option field
G	Geoid model option installed
M	Magnetic variation model option installed
_	Reserved option field
_	Reserved option field
S	GLONASS tracking option installed
*00	Checksum

RIO: Query Receiver Identification Parameters (Format 2)

$PASHQ,RIO,c1

This command allows you to query for receiver identification parameters, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,RIO

The response message contains the receiver model name, a firmware version number, a list of installed options, and a receiver serial number. The response is output in the format:

```
$PASHR,RIO,s1,s2,s3,s4,f5*hh
```

Table 4.21 outlines the response message.

Table 4.21. RIO Structure

Field	Description
s1	Receiver model name (maximum 10 characters)
s2	Main processor firmware version number (maximum 10 characters)
s3	Channel Firmware version number (maximum 10 characters). This field is empty for the GG12
s4	Option list (maximum 42 characters). ASCII characters represent options not available. For option definitions, see Table 4.19
s5	Receiver serial number (maximum 20 characters). Underscores represent blank fields
*hh	Checksum. XOR of all characters between the dollar sign ($) and the asterisk (*), but not including the dollar sign and asterisk

Typical RIO response message:

```
$PASHR,RIO,GG12,FA00,,55OPU__L_GM__S,00000000000000000000*08
```

Table 4.22 outlines the response message.

Table 4.22. $PASHR,RIO Fields

Field	Description
$PASHR	Header
RIO	Message identifier
GG12	Receiver model identifier
FA00	Firmware version number
,,	Reserved data field
5	5 Hz update rate (0.05 seconds) installed for raw data update option
5	5 Hz update rate (0.05 seconds) installed for position update option
O	Raw data output option installed
P	Carrier phase tracking option installed
U	Differential remote option installed
_	Reserved option field
_	Reserved option field
L	Timing pulse output option installed
_	Reserved option field
G	Geoid model option installed
M	Magnetic variation model option installed
_	Reserved option field
_	Reserved option field
S	GLONASS tracking option installed
000…0	Receiver serial number
*6A	Checksum

See Table 4.19 for more information on available options for the GG12.

RST: Restore Default Parameters

$PASHS,RST

This command allows you to restore GG12 parameters to their default values. After issuing the RST command, you can query PAR (general receiver parameters), RAW (raw data output parameters), and RTC (RTCA and differential GPS parameters) to obtain GG12 default settings.

SAV: Save Parameter Settings

$PASHS,SAV,c1

This command allows you to enable or disable saving of user-entered parameters in battery-backed memory, where c1 is Y (save) or N (don't save). If c1 is set to Y, user-entered parameters are saved until default settings are restored through the RST or INI commands. If c1 is set to N, default parameter settings will be restored each time power is cycled. You can determine if user-entered parameters have been saved by entering the query command **$PASHQ,???**.

User-enter parameters cannot be saved unless a back-up battery is wired to appropriate pins on the J501 connector. Without a back-up battery, user-entered parameters will be lost after each power cycle even if the SAV parameter is set to Y.

SPD: Set Serial Port Baud Rate

$PASHS,SPD,c1,d1

This command allows you to set the baud rate for the GG12's serial ports, where c1 is port A or B and d1 is a code number between 0 and 9 corresponding to the baud rates listed in Table 4.23. The default baud rate is 9600.

Table 4.23. GG12 Baud Rate Codes

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

Examples:

Enter the command as shown below to set the baud rate of port A to 19200:

$PASHS,SPD,A,6

Enter the command below to set the baud rate of port B to 4800:

$PASHS,SPD,B,4

If you change the baud rate of the GG12's serial port, be sure that the serial port of the device to which the GG12 port is connected is set to the same baud rate.

Use the query command $PASHQ,PRT to obtain the baud rate setting for the GG12 serial port to which you are connected.

SVP: Include/Exclude Satellites for Position Computations

$PASHS,SVP,c1c2c3...c56

This command allows you to include and exclude specific satellites for use in position computations, where c is Y (include) or N (exclude). Unlike most of the other set commands, the c parameters are not separated by commas. A satellite which has been excluded can still be acquired and tracked, but is not used in computing positions. All satellites are included for position computation by default. The parameters c1 through c32 correspond to GPS satellites PRN numbers 1 through 32; parameters c33 through c56 correspond to GLONASS satellite PRN numbers 1 through 24. It is not necessary to enter a setting for all 56 satellites when using this command.

Examples

To exclude satellites 10 and 15 from the position computation, you could enter the following command:

$PASHS,SVP,YYYYYYYYYNYYYYN

This command excludes satellites 10 and 15 from the position computation, but does not change the settings for satellites 16 through 56

To set the GG12 to exclude satellites 51 and 56 (GLONASS PRN numbers 19 and 24) from position computations:

**$PASHS,SVP,YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
YYYYYYYYYYYNYYYYN**

$PASHQ,SVP,c1

This command allows you to query the current SVP settings, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SVP

The response message contains the current SVP settings for all 56 satellites. The format of the response message is nearly identical to the format used in the SVP set command:

```
$PASHR,SVP,c1c2c3…c56*hh
```

Table 4.24 outlines the response message.

Table 4.24. $PASHR,SVP Message Format

Field	Description	Range
c1 - c56	Indicates whether a satellites is included (Y) or excluded (N) for position computations	Y, N
*hh	Checksum	2-character hex

Typical SVP message:

```
$PASHR,SVP,YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
YYYYYYY*0D
```

Table 4.25 outlines the response message.

Table 4.25. $PASHR,SVP Message Format

Parameter	Description
$PASHR,SVP	Header
YYY…Y	Indicates that all 56 PRN numbers are included for position computations
*0D	Checksum

DEFAULT SETTING	
SVP	**Y (all satellites included)**

SVS: Include/Exclude Satellites for Acquisition and Tracking

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

This command allows you to include and exclude specific satellites for acquisition and tracking, where c is Y (include) or N (exclude). Like the SVP set command, the c parameters are not separated by commas. The receiver will not track a satellite which has been excluded through this command. All satellites are included for acquisition and tracking by default. The parameters c1 through c32 correspond to GPS satellites PRN numbers 1 through 32; parameters c33 through c56 correspond to GLONASS satellite PRN numbers 1 through 24. It is not necessary to enter a setting for all 56 satellites when using this command.

Examples

To exclude satellites 4 and 7 from the position computation, enter the following command:

$PASHS,SVS,YYYNYYN

This command excludes satellites 4 and 7 from being acquired and tracked, but does not change the settings for satellites 8 through 56

Enter the following command to set the GG12 to exclude satellites 48 and 55 (GLONASS PRN numbers 16 and 23):

$PASHS,SVS,YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY YYYYYYYYNYYYYYYN

$PASHQ,SVS,c1

This command allows you to query the current SVS settings, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SVS

The response message contains the current SVP settings for all 56 satellites. The format of the response message is nearly identical to the format used in the SVP set command:

```
$PASHR,SVS,c1c2c3…c56*hh
```

Table 4.26 outlines the response message.

Table 4.26. $PASHR,SVS Message Format

Field	Description	Range
c1 - c56	Indicates whether a satellites is included (Y) or excluded (N) for acquisition and tracking	Y, N
*hh	Checksum	2-character hex

Typical SVS message:

```
$PASHR,SVS,YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
YYYYYYY*0E
```

Table 4.27 outlines the response message.

Table 4.27. $PASHR,SVS Message Format

Parameter	Description
$PASHR,SVP	Header
YYY…Y	Indicates that all 56 PRN numbers are included for acquisition and tracking
*0E	Checksum

DEFAULT SETTING	
SVS	**Y (all satellites included)**

SYS: Set Satellite System Mode

$PASHS,SYS,s1

This command allows you to set the satellite system tracking mode. The s1 string can be any of the following:

- GLO—This string sets the GG12 to track satellites from the GLONASS system only.
- GPS—This string sets the GG12 to track satellites from the GPS system only.
- GLG—This string sets the GG12 to track satellites from both systems, with GLONASS set as the primary system and GPS as the secondary system.
- GPG—This string sets the GG12 to track satellites from both systems, with GPS set as the primary system and GLONASS as the secondary system.

Example

Enter the following command to set the GG12 to track GPS satellites only:

$PASHS,SYS,GPS

$PASHS,SYS,USE,d1

This command allows you to set a specific number of channels to track GPS satellites. Any remaining channels are automatically assigned to track GLONASS satellites. For example, if d1 is 7, channels 1 through seven are assigned to track GPS satellites, and channels 8 through 12 are assigned to track GLONASS satellites. If d1 is 12, all twelve channels are assigned to track GPS satellites, which has the same effect as entering the command **$PASHS,SYS,GPS**.

Entering zero for d1 has the same effect as entering the command **$PASHS,SYS,GLO**. You can obtain the current setting for satellite system mode by entering the query command **$PASHQ,PPR** and checking field s10.

DEFAULT SETTING	
SYS	GPG

TDP: Set Time DOP Mask

$PASHS,TDP,d1

This command allows you to set the mask value for the Time Dilution of Precision (TDOP), where d1 is a number between 0 and 99. The TDOP value is used is not applicable if the GG12 is tracking satellites from one system only. If the TDOP value calculated by the GG12 is higher than the TDOP mask value, the receiver will automatically go into fixed time-shift mode.

Example

Enter the following command to set the TDOP mask value to 6:

$PASHS,TDP,6

$PASHQ,TDP,c1

This command allows you to query the current TDOP mask value, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,TDP

The response message is output in the format:

```
$PASHR,TDP,d1*hh
```

Table 4.28 outlines the response message.

Table 4.28. $PASHR,TDP Message Format

Parameter	Description	Range
d1	TDOP mask value	0 - 99
*hh	Checksum	2-character hex

Typical TDP response message:

```
$PASHR,TDP,4*2C
```

Commands

Table 4.29 outlines the response message.

Table 4.29. Typical TDP message

Field	Description
$PASHR,TDP	Header
4	Indicates that the TDOP mask value is set to 4
*2C	Checksum

DEFAULT SETTING	
TDP	**4**

TRO: Enable/Disable Tropospheric Modelling

$PASHS,TRO,c1

This command allows you enable or disable tropospheric modelling, where c1 is Y (enable) or N (disable). Tropospheric modelling is used to compensate for the delays imposed on the satellite signals as they pass through the troposphere.

Example

Enter the command below to enable tropospheric modelling:

$PASHS,TRO,Y

$PASHQ,TRO,c1

This command allows you to query to see whether tropospheric modelling is enabled or disabled, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,TRO

The response message is output in the format:

```
$PASHR,TRO,c1*hh
```

Table 4.30 outlines the response message.

Table 4.30. $PASHR,TRO Message Format

Parameter	Description	Range
c1	Indicates whether tropospheric modelling is enabled or disabled	Y (enabled) N (disabled)
*hh	Checksum	2-character hex

Typical TRO response message:

```
$PASHR,TRO,N*5F
```

Table 4.31 outlines the response message.

Table 4.31. Typical TRO message

Field	Description
$PASHR,TRO	Header
N	Indicates that tropospheric modelling is disabled
*5F	Checksum

DEFAULT SETTING	
TRO	**N**

TSC: Set Time Scale Reference

$PASHS,TSC,s1

This command allows you to set the time scale reference for GG12 data output, where s1 is GPS (GPS system time) or GLO (GLONASS system time). The TSC command sets the time reference of the output interval for NMEA message, Ashtech NMEA-style messages, raw data messages, and the output of the timing pulse.

The time scale setting determines whether the signal received time appearing in the PBN message is milliseconds of the week (GPS) or milliseconds of the day (GLONASS). The time scale setting does not affect time values in NMEA messages. Time values in NMEA messages are referenced to UTC (Universal Time Coordinated).

Example

Enter the command below to set the time scale reference to GLONASS system time:

$PASHS,TSC,GLO

$PASHQ,TSC,c1

This command allows you to query the current time scale setting, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,TSC

The TSC response message is output in the format below:

```
$PASHR,TSC,s1*hh
```

Table 4.32 outlines the response message.

Table 4.32. $PASHR,TSC Message Format

Parameter	Description	Range
s1	Indicates whether the time scale is referenced to GPS system time or GLONASS system time	GPS, GLO
*hh	Checksum	2-character hex

Typical TSC response message:

```
$PASHR,TSC,GPS*58
```

Table 4.33 outlines the response message.

Table 4.33. Typical TSC message

Field	Description
$PASHR,TSC	Header
GPS	Indicates that time scale is referenced to GPS system time
*58	Checksum

DEFAULT SETTING	
TSC	GPS

USE: Select Satellites for Acquisition and Tracking

$PASHS,USE,d1,c2

This command can be considered a short-hand version of the SVS command. Like the SVS command the USE command allows you to exclude specific satellites from being acquired and tracked by the GG12, where d1 is the satellite number (01 through 56) and c2 is Y (include) or N (exclude). Satellite numbers 1 through 32 correspond to GPS PRN numbers 1 through 32; satellite numbers 33 through 56 correspond to GLONASS PRN numbers 1 through 24. All satellites are included for tracking by default.

The USE command is more direct than the SVS command. In order to exclude satellite 56 with the SVS command, you would have to enter a string with 56 characters in it, entering a Y for characters 1 through 55 and an N for character 56. To exclude satellite 56 with the USE command requires far fewer characters:

$PASHS,USE,56,N

$PASHS,USE,s1,c1

This version of the USE command allows you to include or exclude satellites on a global and semi-global basis, where s1 is ALL, GPS, or GLO; and c1 is Y (include) or N (exclude). When s1 is ALL, you can choose to include or exclude the entire set of GPS and GLONASS satellites. When s1 is GPS, you can choose to include or exclude the entire set of GPS satellites. When s1 is GLO, you can choose to include or exclude the entire set of GLONASS satellites.

Enter the command below to exclude all GLONASS satellites:

$PASHS,USE,GLO,N

DEFAULT SETTING	
USE	All satellites included

USP: Select Satellites Used in Position Computation

$PASHS,USP,d1,c2

This command can be considered a short-hand version of the SVP command. Like the SVP command, the USP command allows you to include or exclude specific satellites for position computations, where d1 is the satellite number (01 through 56) and c2 is Y (include) or N (exclude). Satellite numbers 1 through 32 correspond to GPS PRN numbers 1 through 32; satellite numbers 33 through 56 correspond to GLONASS PRN numbers 1 through 24. All satellites are included for position computations by default.

The USP command is more direct than the SVP command. In order to exclude satellite 45 with the SVP command, you would have to enter a string with 45 characters in it, entering a Y for characters 1 through 44 and an N for character 45.

To exclude satellite 45 with the USP command requires a much shorter command string:

$PASHS,USP,45,N

$PASHS,USP,s1,c1

This version of the USP command allows you to include or exclude satellites on a global and semi-global basis, where s1 is ALL, GPS, or GLO; and c1 is Y (include) or N (exclude). When s1 is ALL, you can choose to include or exclude the entire set of GPS and GLONASS satellites. When s1 is GPS, you can choose to include or exclude the entire set of GPS satellites. When s1 is GLO, you can choose to include or exclude the entire set of GLONASS satellites.

Example

Enter the following command to exclude all GPS satellites:

$PASHS,USP,GPS,N

DEFAULT SETTING	
USP	All satellites included

VDP: VDOP Mask

$PASHS,VDP,d1

This command allows you to set the mask value for the Vertical Dilution of Precision (VDOP), where d1 is a number between 0 and 99. If the VDOP value computed by the GG12 is higher than the VDOP mask value, the receiver will automatically go into fixed altitude mode. You can view the current VDOP mask value by entering the query command $PASHQ,PPR and checking field d5.

Example

Enter the following command to set the VDOP mask value to 6:

$PASHS,VDP,6

DEFAULT SETTING	
VDP	4

Raw Data Commands

Raw data commands allow you to set and query raw data parameters and raw data messages, including enabling or disabling the output of raw data messages, setting thresholds for the output of raw data messages, and setting the output interval for raw data messages. All raw data messages are disabled for output by default.

The general format for the set commands controlling the output of raw messages is as follows:

$PASHS,RAW,s1,c1,s2,f1

In this context, set commands are used to enable the output of raw data messages at regular intervals or to disable output of raw messages, where s1 is a three character message identifier (SNV, MBN, DIF, etc.), c1 is the port designator for message output, s2 is ON or OFF, and f1 is the numeric output interval setting supporting a range of 0.2 to 999 seconds. Query commands prompt the receiver to output the corresponding response message once only. Message output prompted by a query command occurs independently of any related message output settings.

To enable the output of the MBN message on port A at five second intervals, enter the command:

$PASHS,RAW,MBN,A,ON,5

To disable the output of the MBN message on port B, enter the command:

$PASHS,RAW,MBN,B,OFF

To query the MBN message and designate port B for the output of the response message, enter the command:

$PASHQ,MBN,B

As with the other query commands, the port designator (B) is optional. If a port is not specified, the receiver sends the response to the current port.

Message Structure

Real-time messages are output in binary format:

HEADER,MESSAGE ID,DATA + CHECKSUM<CR><LF>

The header field always contains **$PASHR**. The message identifier field contains the three-character message identifier (MBN, PBN, SAL, etc.) and is followed by a field containing the binary data string. The header, identifier, and data string fields are comma delimited. Depending on the message selected, the checksum is contained in the last one or two bytes of the binary data string. All real-time messages are terminated with a Carriage Return/Line Feed **<CR><LF>** delimiter. The MBN message output is as follows:

$PASHR,MPC,<Binary Data String + Checksum><CR><LF>

Table 4.34 lists the raw data commands:

Table 4.34. Raw Data Commands

Function	Command	Description	Page
Almanac data	$PASHQ,SAG $PASHQ,SAL	Query for GLONASS almanac data Query for GPS almanac data	page 98 page 100
Differential GPS data	$PASHQ,DIF	Query for differential status data	page 80
Ephemeris data	$PASHQ,SNG $PASHQ,SNV	Query for GLONASS ephemeris data Query for GPS ephemeris data	page 101 page 103
Measurement data	$PASHQ,MBN $PASHQ,MCA $PASHQ,MIS	Query for raw measurement data in the Ashtech type 2 data structure Query for raw measurement data (MCA) in the Ashtech type 3 data structure Query for miscellaneous raw measurement data	page 83 page 86 page 89
Position data	$PASHQ,PBN $PASHQ,XYZ	Query the receiver's raw position data Query the raw position data for each satellite being tracked	page 93 page 104
General command for controlling raw data output	$PASHS,RAW $PASHS,RAW,ALL	Enable/disable output of raw data messages Disables the output of all raw messages on an individual serial port	page 94 page 94
Raw Data Parameters	$PASHS,ELM $PASHS,MSV $PASHQ,RWO $PASHS,RCI	Set elevation mask for raw data output Set minimum number of satellites for raw data output. Query for raw data parameters. Set output interval for raw data messages.	page 83 page 92 page 96 page 95

DIF: Diagnostic Data for Differential Operation

$PASHQ,DIF,c1

This command allows you to query for status of differential operation, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,DIF

The DIF message contains the time at which the satellite signals were received and a variety of flags indicating specific errors in differential operation. For example, the GG12 will not use a differential correction if the age of corrections exceeds the receiver's maximum age setting, or when there is an IOD (Issue of Data) mismatch between the ephemeris data in the correction message and the ephemeris data obtained directly from the satellites. The setting for Automatic Differential Mode ($PASHS,RTC,AUT) determines whether the GG12 stops outputting positions or outputs autonomous positions when invalid differential corrections are received. If the auto differential mode is enabled, the receiver outputs autonomous positions when a received differential correction is invalid. If auto differential mode is disabled, the receiver will stop outputting positions until it receives valid corrections for four or more of the satellites it is tracking. Issue the query command $PASHQ,RTC,RPS to see whether auto differential is enabled or disabled.

The message is output in the format:

```
$PASHR,DIF,<Differential operation status data + checksum>
```

Table 4.35 outlines the response message.

Table 4.35. $PASHR,DIF Data String

Field	Bytes	Content
long [rcvtime]	4	Time at which the signal was received in milliseconds of the week according to GPS system time or in milliseconds of the week according to GLONASS system time. (See the $PASHS,SYS and $PASHS,TSC for more information on satellite system and time scale selection.)
unsigned short [DiffModeStatus]	2	Bits 10 through 15 are used as flags to indicate whether the received differential corrections were used in the position computation. A non-zero state for any of bits 10-15 indicates that the receiver has ignored the correction. Each of bits 10-15 also denotes the specific error condition which caused the corrections to be ignored. • Bit 15 - Differential correction not applied because the age of correction exceeds the maximum age value set through the $PASHS,RTC,MAX command • Bit 14 - Differential correction not applied because corrections are available for fewer than four of the satellites being tracked by the receiver • Bit 13 - Differential correction not applied due to unhealthy base station (AEB=111) • Bit 12 - Differential correction not applied due to an unbounded acceleration error (AEB=110) • Bit 11 - Differential correction not applied because the calculated PDOP value exceeds the PDOP mask value set through the $PASHS,PDP command • Bit 10 - The most recently received RTCA type 1 message is ignored because it failed the CRC check. The receiver will continue outputting corrected positions using the most recent RTCA type 1 message having a valid CRC • Bits 0 through 9 are reserved

Commands

Table 4.35. $PASHR,DIF Data String (continued)

Field	Bytes	Content
unsigned long [GpsIodExcSats]	4	Each bit is used as a flag to indicate whether an IOD mismatch has occurred for a given GPS satellite (1-32), with the most significant bit corresponding to PRN 32. The receiver stops using a satellite for position computation when the ephemeris IOD received from the satellite does not match the ephemeris IOD for that satellite contained in the correction message. The receiver then sets the bit representing that particular satellite to a non-zero state
usigned long [GloIodExcSats]	4	Each bit is used as a flag to indicate whether an IOD mismatch has occurred for a given GLONASS satellite (1-32), with the most significant bit corresponding to PRN 32. The receiver stops using a satellite for position computation when the ephemeris IOD received from the satellite does not match the ephemeris IOD for that satellite contained in the correction message. This condition causes the receiver to set the bit representing that particular satellite to a non-zero state
unsigned long [GpsInvExcSats]	4	Each bit is used as a flag to indicate whether corrections are invalid for a given GPS satellite (1-32), with the most significant bit corresponding to PRN 32. The receiver excludes a satellite from position computation when the bits used to define UDRE (User Differential Range Error) in the RTCA type 1 message indicate that corrections for that satellite are invalid. Corrections for a given satellite are invalid when the six bits corresponding to UDRE are all in a non-zero state (UDRE=111111). This condition causes the receiver to set the bit representing that particular satellite to a non-zero state
unsigned long [GloInvExcSats]	4	Each bit is used as a flag to indicate whether corrections are invalid for a given GLONASS satellite (1-32), with the most significant bit corresponding to PRN 32. The receiver excludes a satellite from position computation when the bits used to define UDRE (User Differential Range Error) in the RTCA type? message indicate that corrections for that satellite are invalid. Corrections for a given satellite are invalid when the six bits corresponding to UDRE are all in a non-zero state (UDRE=111111). This condition causes the receiver to set the bit representing that particular satellite to a non-zero state
checksum	2	The checksum is computed by breaking the structure into 11 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total chars: 24		

ELM: Set Elevation Mask for Output of Raw Measurements

$PASHS,ELM,d1

This command allows you to set the minimum elevation for the output of raw measurement data (MBN, MCA, etc.), where d1 is a number between 0 and 90. The receiver can be set to output raw measurement data for each satellite it is tracking that is above the elevation mask. It stops outputting raw measurement data for any satellite at or below the elevation mask. If the elevation mask is set to 10°, the receiver will output raw measurement data for all tracked satellites with an elevation of 11° or higher, but will not output raw measurement data for any tracked satellites with an elevation of 10° or lower. You can view the current raw data elevation mask setting **$PASHQ,RAW** and checking the ELM field.

Examples:

Enter the following command to set the elevation mask at ten degrees:

$PASHS,ELM,10

Enter the following command to set the elevation mask at fifteen degrees:

$PASHS,ELM,15

DEFAULT SETTING	
ELM	5°

MBN: Raw Measurements (Ashtech Type 2 Data Structure)

$PASHQ,MBN,c1

This command allows you to query for raw satellite measurement data contained in the Ashtech type2 data structure, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,MBN

This message does not output unless the receiver is tracking at least one satellite. The MBN message contains measurement information for doppler, carrier phase, and satellite transmit time, as well as satellite PRN number, signal strength, elevation, and azimuth. A separate MBN message is output for each satellite being tracked.

The structure of the message:

```
$PASHR,MBN,<Astech type 2 data string + checksum>
```

Commands

Table 4.36 outlines the response message.

Table 4.36. $PASHR,MBN Data String

Field	Bytes	Content
char [datatype]	1	Always equal to 1
char [count]	1	Number of measurement structures to follow after this one (The GG12 outputs a separate MBN data string for each satellite it is tracking)
char [svprn]	1	Satellite PRN number (1 - 56)
char [chnind]	1	Channel (1 - 12) assigned to the satellite.
long [lost_lock_ctr]	4	Continuous counts accumulated from the time the satellite referenced in [svprn] is locked. This number is incremented about 500 times per second
char [polarity_known]	1	This number is either zero or five: • 0 - the satellite has just been locked • 5 - meaning the first frame of the navigation message has been found
unsigned char [goodbad]	1	This number indicates the quality of the position measurement: • 0 - Measurements not available; no additional data will be sent • 21 - Satellite referenced in [svprn] was not used due to low elevation • 22 - Satellite referenced in [svprn] was not used because it is unhealthy, or because differential corrections are not available for it, or because it was manually disabled by the user • 23 - Code and carrier phase were measured and the navigation measurement was obtained for the satellite referenced in [svprn], but these data were not used in the position computation • 24 - Code and carrier phase were measured and the navigation measurement was obtained for the satellite referenced in [svprn], and the data were used in the position computation
unsigned char [warning]	1	See Table 4.37 below for information on warning flags

Table 4.36. $PASHR,MBN Data String (continued)

Field	Bytes	Content
unsigned char [ireg]	1	Signal to noise measurement (dbHz) for the satellite referenced in [svprn]
double [raw_range]	8	The fractional part of the transmit time (seconds) for the satellite referenced in [svprn]. The integer part of this number is ignored
long [doppler]	4	doppler measurement (10^{-4} Hz) for the satellite referenced in [svprn]
double [full_phase]	8	Full carrier phase (measured in cycles) of the satellite referenced in [svprn]. This data is available only if the carrier phase option is installed
short [carphase1]	2	Not available with the GG12
short [carphase2]	2	Not available with the GG12
unsigned short [elevation]	2	elevation in units of 0.01 degrees for the satellite referenced in [svprn]
unsigned short [azimuth]	2	Azimuth angle (degrees) of the satellite referenced in [svprn]
unsigned short [checksum]	2	The checksum is a bytewise exclusive OR (XOR)of all bytes from [datatype] to the last byte in [azimuth]
Total bytes: 40		

The MBN message is output in binary format according to the setting chosen for the recording interval ($PASHS,RCI). One MBN message is output for each locked satellite with an elevation equal to or greater than the elevation mask ($PASHS,ELM), and only if the number of locked satellites is equal to or greater than minimum satellite mask ($PASHS,MSV).

Table 4.37 outlines the response message for the MBN warning flag.

Table 4.37. MBN Warning Flag Format

Index of Bits		Description
1	2	Combination of bit 1 and bit 2:
00		Code and/or carrier phase have been measured for the satellite referenced in [svprn]

Table 4.37. MBN Warning Flag Format (continued)

Index of Bits		Description
01		Code and/or carrier phase have been measured, and the navigation message was obtained for the satellite referenced in [svprn], but these data were not used in the position computation
10		Code and/or carrier phase have been measured, the navigation message was obtained, and these data were used in the position computation
1	2	Combination of bit 1 and bit 2
3		Symbols in the navigation message have not been synchronized
4		Pseudo-range measurement is not smoothed
5		Reserved
6		A loss of lock has occurred on the code and/or carrier phase of the satellite signal
7		Reserved
8		A loss of continuity has occurred (this error flag is present when the receiver has reacquired lock on the code and/or carrier phase of the satellite signal. It also occurs after the polarity becomes known)

MCA: Raw Measurements (Ashtech Type 3 Data Structure)

$PASHQ,MCA,c1

This command allows you to query for raw satellite measurement data contained in the Ashtech type 3 data structure, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,MCA

This message does not output unless the receiver is tracking at least one satellite. The MCA message contains some of the same measurement information as is contained in the MBN message: doppler, raw pseudorange, satellite PRN number, elevation, and azimuth. A separate MCA message is output for each satellite being tracked.

The structure of the message:

```
$PASHR,MCA,<Ashtech type 3 data string + checksum>
```

Table 4.38 outlines the response message.

Table 4.38. $PASHR,MCA Data String

Field	Bytes	Content
unsigned short [sequence tag]	2	Sequence ID number in units of 50 ms, modulo 30 minutes
unsigned char [left]	1	Number of remaining MCA messages to be sent for current epoch (the GG12 outputs a separate MCA message for each satellite it is tracking)
unsigned char [svprn]	1	Satellite PRN number (1 - 56)
unsigned char [elev]	1	Elevation angle (degrees) of the satellite referenced in [svprn]
unsigned char [azim]	1	Azimuth angle of the satellite referenced in [svprn] in increments of 2°
unsigned char [chnind]	1	Channel (1 - 12) assigned to the satellite referenced in [svprn]
Measurement data derived from the C/A code (29 bytes):		
unsigned char [warning]	1	See Table 4.39
unsigned char [goodbad]	1	Indicates the quality of the position measurement: •0 - Measurement not available; no additional data will be sent. •21 - The satellite is below the PEM elevation mask. •22 - Code and/or carrier phase has been measured. •23 - Code and/or carrier phase has been measured, and navigation message was obtained, but measurement(s) not used to compute position. •24 - Code and/or carrier phase measured, navigation message was obtained, and measurement(s) used to compute position
char [polarity_known]	1	This number is either zero or five: • 0 - the satellite has just been locked • 5 - meaning the first frame of the navigation message has been found
unsigned char [ireg]	1	Signal-to-noise measurement (db Hz) for the satellite referenced in [svprn]
unsigned char [qa_phase]	1	Not used; always zero

Commands

Table 4.38. $PASHR,MCA Data String (continued)

Field	Bytes	Content
double [full phase]	8	Full carrier phase (measured in cycles) of the satellite referenced in [svprn]. This data is available only if the carrier phase option is installed
double [raw_range]	8	Raw range (in seconds) to the satellite referenced in [svprn] using the following formula: receiver time - transmitted time = raw range (Note: There is an eleven second difference between GPS system time and GLONASS system time. If the time scale is set to GPS, the [raw_range] measurement for GLONASS satellites will contain an extra eleven second integer. If the time scale is set to GLONASS, the [raw_range] measurement for GPS satellites will have an extra eleven second integer
long [doppler]	4	doppler measurement (10^{-4} Hz) for the satellite referenced in [svprn]
long [smoothing]	4	Bits 31-24 represent the [smooth_count]. They are unsigned and normalized, and indicate the amount of smoothing: • 0 - Unsmoothed • 1 - Least smoothed • 100 - Most smoothed Bits 23-0 represent [smooth_corr]. Bit 23 (most significant bit) is the sign and bits 22 through 0 are the least significant bits representing the magnitude of the correction in centimeters
unsigned short [checksum]	1	The checksum is a bytewise exclusive OR (XOR) of all bytes from sequence_tag (just after header) to the last byte in [smoothing]
Total Bytes: 37		

The MCA message is output in binary format according to the setting chosen for the recording interval ($PASHS,RCI). One MCA message is output for each locked satellite with an elevation equal to or greater than the elevation mask ($PASHS,ELM), and only if the number of locked satellites is equal to or greater than minimum satellite mask ($PASHS,MSV).

Table 4.39 outlines the MCA warning flag message.

Table 4.39. MCA Warning Flag Format

Index of Bits		Description
1	2	Combination of bit 1 and bit 2:
00		Code and/or carrier phase have been measured for the satellite referenced in [svprn]
01		Code and/or carrier phase have been measured, and the navigation message was obtained for the satellite referenced in [svprn], but these data were not used in the position computation
10		Code and/or carrier phase have been measured, the navigation message was obtained, and these data were used in the position computation
1	2	Combination of bit 1 and bit 2
3		Symbols in the navigation message have not been synchronized
4		Pseudo-range measurement is not smoothed
5		Reserved
6		A loss of lock has occurred on the code and/or carrier phase of the satellite signal
7		Reserved
8		A loss of continuity has occurred (this error flag is present when the receiver has reacquired lock on the code and/or carrier phase of the satellite signal. It also occurs after the polarity becomes known)

MIS: Miscellaneous Raw Measurements

$PASHQ,MIS,c1

This command allows you to query for miscellaneous raw measurement data, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,MIS

This message does not output unless the receiver is tracking at least one satellite. The MIS message contains a miscellany of raw measurement data not available in the other messages, such as the number of GPS and GLONASS satellites used in the position computation, a modified Z count, and the current GLONASS time shift. This message also contains eight bytes which are used to indicate whether a given GPS or GLONASS satellite has been excluded from position computations. The cause for exclusion is not detailed in this message as it is in the MBN, DIF, and MCA.

The structure of the MIS message:

```
$PASHR,MIS,<Miscellaneous raw measurements + checksum>
```

Table 4.40 outlines the response message.

Table 4.40. $PASHR,MIS Data String

Field	Bytes	Content
long [RcvTime]	4	Time at which the signal was received in milliseconds of the week referenced to GPS system time, or milliseconds of the day referenced to GLONASS system time. This time tag is used as a reference for all position and time measurements
unsigned short [RcvTimeFrac]	2	The fractional portion of [rcvtime] calculated in microseconds (0 - 999 µsecs)
unsigned short [NumGpsSatsUsed]	1	Number of GPS satellites used in the position computation
unsigned short [NumGloSatsUsed]	1	Number of GLONASS satellites used in the position computation
unsigned short [NumGpsSatsTrkd]	1	Number of GPS satellites being tracked
unsigned short [NumGloSatsTrkd]	1	Number of GLONASS satellites being tracked
unsigned short [PositionMode]	2	See below Warning flag: •Bit 1 set - See note below •Bit 2 set - See note below •Bit 3 set - Carrier phase questionable •Bit 4 set - Code phase questionable •Bit 5 set - Code phase integration questionable •Bit 6 set - Not used •Bit 7 set - Possible loss of lock •Bit 8 set - Loss of lock; counter reset The interpretation of bits 1 and 2 is as follows: [Bit 1, Bit 2] [0, 0] Same as 22 in good/bad flag (see next field) [1, 0] Same as 23 in good/bad flag [0, 1] Same as 24 in good/bad flag Note that more than one bit may be set at the same time, e.g., if bits 1, 3, and 6 are set at the same time, the warning flag is 37 (1 + 4 + 32)

Table 4.40. $PASHR,MIS Data String (continued)

Field	Bytes	Content
signed short [GeoidalSeparation]	2	Geoidal separation in meters multiplied by 100
unsigned short [hdop]	2	HDOP value multiplied by 100
unsigned short [vdop]	2	VDOP value multiplied by 100
unsigned short [ModZcnt]	2	Modified Z count taken from the RTCA type 1 message (see note below)
float [GloTimeShift]]	4	Current GLONASS time shift relative to GPS system time with a range of +5000000.0000µsecs to -5000000.0000µsecs
unsigned long [GpsNavFlags]	4	Each bit is a *GPS Nav flag* for a GPS satellite. The most significant bit corresponds to PRN 32. As the GG12 collects navigation data from a GPS satellite, the GPS Nav flag sets for any of the following reasons: • the User-Range Accuracy (URA) flag is set (*accuracy alert*- bit 18 of the *HandOver-Word* (HOW) - GPS SPS Signal Specification, paragraph 2.4.2.2) • a parity error on three successive words of the navigation data • all data bits in subframes 1, 2, or 3 are set to 0's • default navigation data (alternate 1's and 0's) are transmitted in words 3 through 10 of subframe 1, 2, or 3 for the satellite (GPS SPS Signal Specification, paragraph 2.4.1.3)
unsigned long [GloNavFlags]	4	Each bit is a *GLONASS Nav flag* for a GLONASS satellite. The most significant bit corresponds to PRN 32, thus bit 23 corresponds to PRN 24. As the GG12 collects navigation data from a GLONASS satellite, the GLONASS Nav flag sets for any of the following reasons: • a parity error on three successive words of the navigation data • ephemeris time offset (time scale shift) equals zero • all three components of the satellite ephemeris coordinates or velocity vector equal zero • all data bits in a string in any frame 1, 2, 3, 4, or 5 are 0's
unsigned long [GpsExcSats]	4	Each bit is used as a flag to indicate whether a given GPS satellite has been excluded from position computations, with the most significant bit corresponding to PRN 32. When a satellite has been excluded from being used in position computations, the bit representing it in [GpsExcSats] is set to a non-zero state

Table 4.40. $PASHR,MIS Data String (continued)

Field	Bytes	Content
unsigned long [GloExcSats]	4	Each bit is used as a flag to indicate whether a given GLONASS satellite has been manually excluded from position computations, with the most significant bit corresponding to PRN 32 (that is, bit 23 corresponds to PRN 24). When a satellite has been excluded from being used in position computations, the bit representing it in [GloExcSats] is set to a non-zero state
checksum	2	The checksum is computed by breaking the structure into 20 unsigned shorts, adding them together, and taking the least significant 16 bits of the result
Total Bytes: 42		

After decoding the first set of valid ephemeris, the GG12 continuously decodes additional ephemeris as they arrive. If a new ephemeris is confirmed faulty, the GG12 rejects the corrupted/erroneous frames and sub-frames, does not use them to replace existing ephemeris in memory, and sets the Nav flag bits to reflect the problem with the newly receive ephemeris. The previously received good ephemeris continues as valid and is used in the navigation solution. The Nav flag resets only when a new set of good ephemeris is received.

The modified Z count provides the reference time for all parameters in the RTCA type 1 message. It is calculated to a resolution of 0.2 seconds over the acceptable range of twenty minutes. For more information on the modified Z count as it is used in the RTCA type 1 message, see Appendix A in Document No. RTCA/DO-217: *Minimum Aviation System Performance Standards DGNSS Instrument Approach System: Special Category I (SCAT I)*.

MSV: Set Minimum Satellites for Raw Measurement Output

$PASHS,MSV,d1

This command allows you to set the minimum number of satellites the receiver is required to track in order for it to output raw measurement data (MBN, MCA, etc.), where d1 is a number between 1 and 9. The receiver will stop outputting measurement data if the number of satellites it is tracking falls below this minimum. You can view the current setting for minimum satellites by entering the query command $PASHQ,RAW and checking the MSV field.

Examples:

Enter the following command to set the minimum number of satellites to 4:

$PASHS,MSV,4

Enter the following command to set the minimum number of satellites to 1:

$PASHS,MSV,1

DEFAULT SETTING	
MSV	**3**

PBN: Raw Position Data

$PASHQ,PBN,c1

This command allows to query for raw position data, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,PBN

The PBN message contains raw position data, including the time at which the data was received, antenna position, antenna velocity, receiver clock offset, and PDOP.

The message is output in the format:

```
$PASHR,PBN,<Raw position data + checksum>
```

Table 4.41 outlines the response message.

Table 4.41. PBN Data String

Field	Bytes	Content
long [rcvtime]	4	Time at which the signal was received in milliseconds of the week referenced to GPS system time, or milliseconds of the day referenced to GLONASS system time. This time tag is used as a reference for all time and position measurements
char [sitename]	4	4 character ASCII string entered by the user
double [navx]	8	X coordinate of the antenna position (ECEF) 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 (error) 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.

Table 4.41. PBN Data String (continued)

Field	Bytes	Content
float navtdot	4	Receiver clock drift in meters per second.
unsigned short PDOP	2	PDOP multiplied by 100.
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 bytes: 56		

RAW: Enable/Disable Output of Raw Data Messages

$PASHS,RAW,s1,c2,s3,d4

This command allows you to enable or disable the output of raw data messages at regular intervals, where s1 is any one of the three-letter message identifiers (MBN, NCA, PBN, MCA, etc.), c2 is the port designator for message output, s3 is ON or OFF, and d4 is the optional output rate in seconds. If no output rate is specified, then the message outputs with the current RCI. The default setting for raw message output is 000.0 (off) for all messages. Only one raw message at a time can be enabled for output in a single command line; however, all raw messages can be disabled from being output with a single command line.

Examples

Enter the following command to enable output of the MBN message on port A with an output interval of five seconds:

$PASHS,RAW,MBN,A,ON,5

You can disable the output of one message without affecting the other messages being output. Enter the following command to disable the output of the MBN message while leaving the output of DIF and PBN unaffected on port A:

$PASHS,RAW,MBN,A,OFF

The *global* command allows you to disable the output of all raw messages simultaneously on a single port. Enter the following command below to disable the output of all raw messages on port A:

$PASHS,RAW,ALL,A,OFF

The interval for raw message output is set through the RCI command. The default setting for the raw message output interval is one second.

RCI: Set Output Interval for Raw Messages

$PASHS,RCI,f1

This command allows you to set a global output interval for all raw messages, where f1 is the value for the output interval (Table 4.42). This command overrides individual settings for output interval. That is, if the SNG message is enabled for output at intervals of two seconds and the MBN message is enabled for output at intervals of ten seconds, using the RCI command to set an output interval of five seconds will reset the output interval of both messages to five seconds. You can view the current raw data output interval setting by entering the query command **$PASHQ,RWO** and checking the third field after the message identifier.

Table 4.42. Raw Data Update Rate Options and Settings

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

DEFAULT SETTING	
RCI	1

The GG12 is designed to synchronize raw message output with the hour rollover, so that messages output from multiple receivers can be synchronized regardless of when they were turned on. An output interval of 0.7 seconds is not allowed because it overlaps the hour rollover, which corrupts synchronization between multiple receivers.

Almanac data for all satellites is updated once every hour, with one almanac message output for each satellite in the constellation. The almanac messages are output at interval prescribed by the set command $PASHS,RCI.

Example

Enter the following command to set the global raw data output interval to 5 seconds:

$PASHS,RCI,5

RWO: Query for Raw Data Message Output Parameters

$PASHQ,RWO,c1,c2

This command allows to query for raw data message output parameters, where c1 identifies the port for which you are requesting raw data output parameters and c2 is the port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

Examples

Enter the following command to set the GG12 to send a response message from port A which contains raw data output parameters for port B:

$PASHQ,RWO,B,A

Enter the following command to set the GG12 to send response message from port A which contains raw data output parameters for port A:

$PASHQ,RWO,A,A

Enter the following command to set the GG12 to send a response message containing raw data output parameters for the port to which you are currently connected:

$PASHQ,RWO

If you enter this command while connected to port A, the response message contains raw data output parameters for port A. If you enter this command while connected to port B, the response message contains raw data output parameters for port B.

$PASHR,RWO

The response message contains the serial port identifier, the baud rate code for the serial port, the global output interval setting (RCI), the number of raw data messages available for output, the three-letter identifier for each raw data message supported by the GG12 (MCA, MBN…SAG), and the output interval for each message.

The response is output in the format:

```
$PASHR,RWO,c1,d2,f3,d4,((s5,f6) x d4)*hh
```

Table 4.43 outlines the response message.

Table 4.43. $PASHR,RWO Message Format

Field	Description	Range
c1	Serial port reference for raw data message output parameters	A, B
d2	Baud rate code for the referenced serial port (see SPD command)	0 - 9
f3	Global output interval setting (seconds; see RCI command)	0.2 - 999
d4	The number of raw data messages that can be output by the GG12. Ten messages are supported at present	10
s5	The three-letter message identifier for each raw data message supported by the GG12	LTN, POS, GGA, VTG, MSG, GSA, GSV, SAT, RRE, ZDA, RMC,GST
f6	Individual output interval setting for each raw data message	0.2 - 999
*hh	Checksum	2-character hex

Typical RWO response message:

$PASHR,RWO,A,5,001.0,10,MCA,000.0,MBN,010.0,PBN,001.0,MIS,000.0,XYZ,000.0,DIF,000.0,SNV,000.0,SAL,000.0,SNG,000.0,SAG,000.0*6B

Table 4.44 outlines the response message.

Table 4.44. Typical RWO Response Message

Parameter	Description
$PASHR,RWO	Header
A	Indicates that serial port A is being referenced in the response
5	This code number indicates that the data rate for port A is 9600 baud
0001.0	Global output interval setting for raw data messages
10	Indicates that ten raw data messages are available for output
MCA	Raw measurement data message in the Ashtech type 3 data structure

Table 4.44. Typical RWO Response Message

Parameter	Description
000.0	Indicates that the MCA message not enabled for output
MBN	Raw measurement data message in the Ashtech type 2 data structure
010.0	Indicates that the MBN message is enabled for output once every ten seconds
PBN	Raw position data message
001.0	Indicates that the PBN message is enabled for output once each second
MIS	Miscellaneous measurement data message
000.0	Indicates that the MIS message not enabled for output
XYZ	3D satellite position message
000.0	Indicates that the XYZ message not enabled for output
DIF	Differential diagnostic message
000.0	Indicates that the DIF message not enabled for output
SNV	GPS ephemeris data message
000.0	Indicates that the SNV message not enabled for output
SAL	GPS satellite almanac data message
000.0	Indicates that the SAL message not enabled for output
SNG	GLONASS ephemeris data message
000.0	Indicates that the SNG message not enabled for output
SAG	GLONASS satellite almanac data message
000.0	Indicates that the SAG message not enabled for output
*6B	Checksum

SAG: GLONASS Satellite Almanac Data

$PASHQ,SAG,c1

This command allows you to query for GLONASS satellite almanac data, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SAG

This message does not output until the GG12 has completed downloading the current GLONASS almanac file. The receiver begins downloading the almanac file automatically, which takes about two or three minutes. Alternatively, with the aid of software, a current GLONASS almanac file from another receiver can be manually downloaded into the GG12. A separate almanac message is output for each satellite being tracked. The SAG message contains information on satellite health, the almanac week number, and a variety of orbital measurements.

The response is output in the format:

```
$PASHR,SAL,<GLONASS satellite almanac data + checksum>
```

Table 4.45 outlines the response message.

Table 4.45. SAG Data String

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)

Commands

Table 4.45. SAG Data String (continued)

Field	Bytes	Content
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: GPS Satellite Almanac Data

$PASHQ,SAL,c1

This command allows you to query for GPS satellite almanac data, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SAL

The GG12 does not output this message until the GG12 has completed downloading the current GPS almanac file. The receiver begins downloading the almanac file automatically, which takes about twelve minutes. With the aid of software, a current almanac file from another receiver can be manually downloaded into the GG12. A separate almanac message is output for each satellite being tracked. The SAL message contains information on satellite health, the almanac week number, and a variety of orbital measurements.

The response is output in the format:

```
$PASHR,SAL,<GPS satellite almanac data string + checksum>
```

Table 4.46 outlines the response message.

Table 4.46. $PASHR,SAL Data String

Field	Bytes	Content
short prn	2	Satellite PRN number -1.
short health	2	Satellite health.
float e	4	Eccentricity
long toa	4	Reference time for orbit (sec).
float i0	4	Inclination angle (semicircles).
float omegadot	4	Rate of right ascension (semicircles/sec).
double roota	8	Square root of semi-major axis (meters 1/2).

Table 4.46. $PASHR,SAL Data String (continued)

Field	Bytes	Content
double omega0	8	Longitude of ascending node (semicircles).
double omega	8	Argument of perigee (semicircles).
double m0	8	Mean anomaly at reference time (semicircles).
float af0	4	Clock correction (sec).
float af1	4	Clock correction (sec/sec).
short wna	2	Almanac week number
short wn	2	Week number.
long tow	4	Seconds of GPS week.
checksum	2	The checksum is computed by breaking the structure into 34 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total Bytes: 70		

SNG: GLONASS Satellite Ephemeris Data

$PASHQ,SNG,c1

This command allows you to query for ephemeris data from each GLONASS satellite being tracked, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SNG

One SNG message is output for each GLONASS satellite being tracked. This message does not output unless the receiver is locked on at least one GLONASS satellite. SNG messages contain some of the same data found in the SAG message, but also contains clock correction parameters and harmonic correction parameters.

The message is output in the format:

```
$PASHR,SNG,<Ephemeris data + checksum>
```

Table 4.47 outlines the response message.

Table 4.47. SNG Data String

Type	Bytes	Content
long [k]	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 [Dn]	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 [Tb]	4	Ephemeris data reference time within the day expressed in GLONASS system time scale = UTC + 3 hours (seconds)
float [Gn]	4	Frequency offset γ_η of the on-board frequency standard at t_b (dimensionless)
float [tn]	4	Bias t_n between satellite time scale and GLONASS system time scale at t_b (seconds)
double [r(3)]	8*3	Satellite ECEF (PZ-90) X, Y, Z coordinates (km)
float [rt(3)]	4*3	Satellite ECEF (PZ-90) velocity X', Y', Z'(km/sec)
float [rtt(3)]	4*3	Satellite perturbation acceleration X", Y", Z" due to moon and sun (km/sec/sec)
double [Tc]	8	Bias between GLONASS system time scale and UTC + 3 hours time scale τ_c (seconds)
char [En]	1	Age of ephemeris parameter E_n (interval from moment when ephemeris data was last uploaded to t_b)
char [P]	1	Combined 3-bit flag (contains Ï1, Ï2, Ï3, see GLONASS ICD)
char [Bn]	1	Satellite health status flag (0 = good, 1 = bad)
char [freq_num]	1	Satellite frequency channel number [-7,...,24]
short [sys_num]	2	Satellite system number (satellite number [1,...,24])

Table 4.47. SNG Data String (continued)

Type	Bytes	Content
unsigned short [checksum]	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>)

SNV: GPS Satellite Ephemeris Data

$PASHQ,SNV,c1

This command allows you to query for ephemeris data from each GPS satellite being tracked, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SNV

One SNV message is output for each GPS satellite being tracked. This message does not output unless the receiver is locked on at least one GPS satellite. SNV messages contain some of the same data found in the SAL message, but also contain clock correction parameters and harmonic correction parameters.

The message is output in the format:

```
$PASHR,SNV,<Ephemeris data string + checksum>
```

Table 4.48 outlines the response message.

Table 4.48. SNV Data String

Field	Bytes	Content
short wn	2	GPS week number.
long tow	4	Seconds of GPS week.
float tgd	4	Group delay (seconds).
long aodc	4	Clock data issue.
long toc	4	Clock data reference time in seconds.
float af2	4	Clock correction (sec/sec2).
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).

Table 4.48. SNV Data String (continued)

Field	Bytes	Content
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.
short health	2	Satellite health.
short fit	2	Curve fit interval.
char prnnum	1	Satellite PRN number minus 1 (0 to 31)
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 Bytes: 132		

XYZ: 3D Satellite Positions

$PASHQ,XYZ,c1

This command allows you to query the three-dimensional position for each tracked satellite, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,XYZ

In addition to satellite positions, the XYZ message also contains the time at which the satellite signals were received and a pseudorange value which has been corrected to eliminate atmospheric delays and uncertainties resulting from the differences in velocity between the GG12 and the satellites (relativistic errors).

The XYZ message is output in the format below:

```
$PASHR,XYZ<Satellite position data string + checksum>
```

Table 4.49 outlines the response message.

Table 4.49. XYZ Data String

Field	Bytes	Content
long [rcvtime]	4	Time at which the signal was received in milliseconds of the week referenced to GPS system time, or milliseconds of the day referenced to GLONASS system time. This time tag is used as a reference for all time and position measurements
short [Total Satellites]	2	The total number of satellites appearing in the message
short [sv_1]	2	The PRN number of the satellite (1 - 56) being tracked on channel 1 of the GG12
double [satx_1]	8	The x coordinate of the satellite being tracking on channel 1 of the GG12; referenced to WGS-84
double [saty_1]	8	The y coordinate of the satellite being tracking on channel 1 of the GG12; referenced to WGS-84
double [satz_1]	8	The z coordinate of the satellite being tracking on channel 1 of the GG12; referenced to WGS-84
double [range_1]	8	The corrected pseudorange of the satellite referenced in [sv_1]
(These rows are repeated for each channel that is tracking a satellite. That is, if the GG12 is tracking seven satellites, these rows are repeated seven times; if the GG12 is tracking twelve satellites, these rows are repeated twelve times.)		
checksum	2	The checksum is computed by breaking the structure into unsigned shorts, adding them together, and taking the least significant 16 bits of the result
Total bytes: minimum = 42; maximum = 416		

NMEA Commands

NMEA commands allow you to set the output parameters for NMEA messages and Ashtech NMEA-style messages. These commands can be sent to the GG12 through either serial port. All NMEA messages and Ashtech NMEA-style messages are disabled by default. The general format for the set commands used to control the NMEA message output is as follows:

$PASHS,NME,s1,c2,s3

In this context, set commands are used to enable the output of NMEA messages at regular intervals or to disable message output, where s1 is a three character message identifier (GGA, VTG, SAT, etc.), c1 is the port designator (A or B) for message output, and s2 is ON or OFF. Query commands prompt the receiver to output the corresponding response message once only. Message output prompted by a query command occurs independently of any related message output settings.

To enable the output of the POS message on port A at five second intervals, enter the following command:

$PASHS,NME,POS,A,ON,5

To disable the output of the GGA message on port B, enter the following command:

$PASHS,NME,GGA,B,OFF

To query the POS message and designate port B for the output of the response message, enter the following command:

$PASHQ,POS,B

As with the other query commands, the port designator (B) is optional. If a port is not specified, the receiver sends the response to the current port. If a port is not specified, the receiver sends the response to the current port.

Message Structure

Standard NMEA messages output as a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards (version 2.1). Astech's NMEA-style messages also output in a comma-delimited string of ASCII characters, but may deviate slightly from NMEA standards. For example, the maximum length of a standard NMEA message is eighty characters, but the length of some Ashtech messages are variable (i.e., SAT) and may go beyond eighty characters. One message which deviates significantly from NMEA standards is the XYZ message, which outputs in binary format. Both NMEA messages and Ashtech NMEA-style messages begin with a dollar sign ($) and end with a Carriage Return/Line Feed <CR><LF> delimiter. Any combination of these messages can be output through different ports at the same time. The output rate can be set to any value between 0.2 and 999 seconds. The default output interval is one second.

Standard NMEA messages have the following structure:

HEADER,DATA*CHECKSUM<CR><LF>

The comma after the header is followed by the ASCII data string and the message checksum. An asterisk separates the checksum from the data string. Both standard and non-standard NMEA messages use a dollar sign ($) to indicate the beginning of a message, and both types are terminated with a <CR><LF> delimiter.

Data items in NMEA messages and Ashtech NMEA-style messages are separated by commas Successive commas indicate that data is not available or the data field is reserved. Two successive commas indicate one missing data item; three successive commas indicate two missing items.

GGA, which is a standard NMEA message, outputs as shown follows:

$GPGGA,DATA*CHECKSUM<CR><LF>

The structure of non-standard NMEA messages:

HEADER,MESSAGE ID,DATA*CHECKSUM<CR><LF>

Standard NMEA messages include the message identifier in the header. Non-standard messages, which have an Ashtech proprietary format, have the message identifier in a separate field. SAT, a non-standard message, outputs as follows:

$PASHR,SAT,DATA*CHECKSUM<CR><LF>

The data types that appear in NMEA messages can be integers, real numbers (decimal), hexadecimal numbers, alphabetic characters, and alphanumeric character strings.

Table 4.50 lists the NMEA commands.

Table 4.50. NMEA Data Message Commands

Function	Command	Description	Page
General command for controlling NMEA message output	$PASHS,NME	Used to enable or disable output of NMEA messages and Ashtech NMEA-style messages, set interval for message output.	page 122
	$PASHS,NME,ALL	Disables the output of all NMEA and Ashtech NMEA-style messages on an individual serial port	page 124
Latency information	$PASHQ,LTN	Query position output latency	page 119
NMEA output parameters	$PASHQ,NMO	Query for current NMEA output parameter settings	page 124

Table 4.50. NMEA Data Message Commands (continued)

Function	Command	Description	Page
Position data	$PASHQ,GGA $PASHQ,POS $PASHQ,RMC $	Query GPS position information Query for comprehensive position message Query for minimum position, course/speed message	page 108 page 56 page 126
Differential base station data	$PASHQ,MSG	Query for differential base station data	page 120
Residual data	$PASHQ,RRE	Query satellite residual and position error information	page 128
Satellite data	$PASHQ,GSA $PASHQ,GST $PASHQ,GSV $PASHQ,SAT	Query for DOPs/satellite used Query for pseudorange error statistics Query for all satellites in view Query for satellite status information	page 110 page 114 page 116 page 131
Time and date	$PASHQ,ZDA	Query for time and date information	page 134
Course and speed	$PASHQ,VTG	Query for velocity/course information	page 133

Refer to the *NMEA 0183 Standard for Interfacing Marine Electronic Navigational Devices* for more details on protocols and message formats.

GGA: 3-D GPS Position

$PASHQ,GGA,c1

This command allows you to query the GGA position message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$GPGGA

This message does not output unless positions are being computed. In addition to a 3-D position (latitude/longitude/altitude), the GGA message contains information on the type of position fix (i.e., autonomous or differentially corrected), HDOP, and current time. The GG12 can be set to output the GGA message at regular intervals by using the command **$PASHS,NME**.

The GGA message output is in the format:

```
$GPGGA,m1,m2,c3,m4,c5,d6,d7,d8,f9,c10,d11,c12,d13,d14*hh
```

Table 4.51 outlines the message format.

Table 4.51. $GPGGA Message Format

Parameter	Description	Range
m1	UTC time (hhmmss.ss) of the position fix	000000.00 to 235959.90
m2	Latitude of the position fix (ddmm.mmmmm)	0° - 90°
c3	Latitude sector	N(orth) S(outh)
m4	Longitude of the position fix (dddmm.mmmmm)	0° - 180°
c5	Longitude sector	E(ast) W(est)
d6	Position fix type: • 1 - Autonomous position • 2 - Corrected position (code differential)	1, 2
d7	Number of satellites used in position computation	3 - 12
d8	HDOP (horizontal dilution of precision)	00.0 - 99.9
f9	Altitude above Mean Sea Level (geoidal height)	-1000.00 to 18000.00
c10	Altitude unit of measure (always M)	M(eters)
d11	Geoidal separation value	-9999.9 to +9999.9
c12	Geoidal separation unit of measure (always M)	M(eters)
d13	Age of differential corrections (seconds)	0 - 99
d14	Differential base station ID number	0 - 1023
hh	Checksum	2-character hex

Typical GGA message:

```
$GPGGA,220620.00,3721.08482,N,12156.11302,W,1,12,00.9,
+00039.10,M,-0031.33,M,,,*4E
```

Table 4.52 outlines the message format.

Commands

Table 4.52. Typical GGA Message

Item	Description
$GPGGA	Header
220620.00	Time of position fix (22:06:20.00)
3721.08482	Latitude (37°21.08482′)
N	North
12156.11302	Longitude (121°56.11302′)
W	West
1	Indicates that the position was computed autonomously
12	Number of satellites used in position computation
00.9	HDOP
+00039.10	Altitude
M	Altitude unit of measure (meters)
-0031.33	Geoidal separation value
M	Geoidal separation unit of measure (meters).
,,	Age of differential corrections (this field is empty because the position was computed autonomously)
,*	Base station ID number (this field is empty because the position was computed autonomously)
*4E	Checksum

GSA: DOP and Active Satellites

$PASHQ,GSA,c1

This command allows you to query the GSA message, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. The GG12 outputs two GSA messages. One of the messages contains information for the GPS satellites, the other contains information for the GLONASS satellites.

$GPGSA

This version of the GSA message lists the indicators for current position mode ($PASHS,PMD,d1 on page 55), the GPS satellites used for the position computation, and the values for PDOP, HDOP, and VDOP. This message does not output until positions are computed.

The response is output in the format:

```
$GPGSA,c1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,d14,d15,d1
6,d17*hh
```

Table 4.53 outlines the message format.

Table 4.53. $GPGSA Message Format

Parameter	Description	Range
c1	Position mode indicator: • A - Automatic mode • M - Manual mode	A, M
d1	Position mode indicator: • 2 - 2D mode • 3 - 3D mode	2, 3
d3-d14	These twelve fields represent the receiver's twelve channels listed in ascending order. The number 17 appearing in field d5 indicates that GG12 channel 3 is locked on GPS satellite 17. If a given channel is not locked on a satellite, the corresponding field is empty	1 - 32
d15	Current PDOP value	0 - 99.9
d16	Current HDOP value	0 - 99.9
d17	Current VDOP value	0 - 99.9
*hh	Checksum	2-character hex

Typical $GPGSA message:

```
$GPGSA,A,3,18,01,14,19,22,04,16,27,03,24,,,01.4,00.9,01.1*08
```

Table 4.54 outlines the message format.

Table 4.54. Typical $GPGSA Message

Field	Description
$GPGSA	Header
A	Indicates automatic 2-D/3-D switching mode
3	Indicates 3D position mode
18	GG12 channel 1 locked on GPS satellite 18; satellite 18 used in position computations

Table 4.54. Typical $GPGSA Message (continued)

Field	Description
01	GG12 channel 2 locked on GPS satellite 1; satellite 1 used in position computations
14	GG12 channel 3 locked on GPS satellite 14; satellite 14 used in position computations
19	GG12 channel 4 locked on GPS satellite 19; satellite 19 used in position computations
22	GG12 channel 5 locked on GPS satellite 22; satellite 22 used in position computations
04	GG12 channel 6 locked on GPS satellite 4; satellite 4 used in position computations
16	GG12 channel 7 locked on GPS satellite 16; satellite 16 used in position computations
27	GG12 channel 8 locked on GPS satellite 27; satellite 27 used in position computations
03	GG12 channel 9 locked on GPS satellite 3; satellite 3 used in position computations
24	GG12 channel 10 locked on GPS satellite 24; satellite 24 used in position computations
,,	Indicates that this channel (11) is not locked on a GPS satellite or that the locked satellite is not being used in position computations
,,	Indicates that this channel (12) is not locked on a GPS satellite or that the locked satellite is not being used in position computations
01.4	Current PDOP value
00.9	Current HDOP value
01.1	Current VDOP value
*08	Checksum

$GLGSA

This version of the GSA message also contains the two position mode indicators and the current values for PDOP, HDOP, and VDOP, but lists the GLONASS satellites being used to compute position. In addition, leading zeroes in the DOP fields are suppressed in this version of the message. This message does not output until positions are being computed. The GLONASS version of the GSA message has the format listed in Table 4.53.

Typical $GLGSA message:

```
$GLGSA,A,3,,,,,,,,,,,45,54,1.4,0.9,1.1*22
```

Table 4.55 outlines the message format.

Table 4.55. Typical $GLGSA Message

Field	Description
$GPGSA	Header.
A	Indicates automatic 2-D/3-D switching mode.
3	Indicates 3D position mode.
,,	Indicates that this channel (1) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (2) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (3) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (4) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (5) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (6) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (7) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (8) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (9) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations
,,	Indicates that this channel (10) is not locked on a GLONASS satellite or that the locked satellite is not used in position computations.
45	GG12 channel 11 locked on GLONASS satellite 24; satellite 24 used in position computations

Table 4.55. Typical $GLGSA Message (continued)

Field	Description
54	GG12 channel 12 locked on GLONASS satellite 24; satellite 24 used in position computations
1.4	Current PDOP value
0.9	Current HDOP value
1.1	Current VDOP value
*22	Checksum

GST: Pseudorange Error Statistics

$PASHQ,GST,c1

This command allows you to query the GST message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$GPGST

The GST message contains UTC time, the RMS value of the standard deviation for satellite range measurements, and the corresponding standard deviation values for latitude, longitude, and altitude.

The message format is output in the format:

```
$GPGST,m1,f2,f3,f4,f5,f7,f8,f9*hh
```

Table 4.56 outlines the message format.

Table 4.56. $GPGST Message Format

Parameter	Description	Range
m1	UTC time (hhmmss.ss) of the position fix	000000.00 to 235959.95
f2	RMS value of the standard deviation of the satellite range inputs to the navigation processor. This field is related to remaining fields as follows: • (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 of 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 NOT IMPLEMENTED	N/A
f4	Standard deviation of semi-minor axis of error ellipse (meters). THIS FIELD NOT IMPLEMENTED	N/A
f5	Orientation of semi-major axis of error ellipse (degrees from true north). THIS FIELD NOT IMPLEMENTED	N/A
f6	Standard deviation of latitude error (meters)	0000.00 to 9999.99
f7	Standard deviation of longitude error (meters)	0000.00 to 9999.99
f8	Standard deviation of altitude error (meters)	0000.00 to 9999.99
*hh	Checksum	2-character hex

Commands

Typical GST message:

```
$GPGST,220632.00,0022.29,,,,0016.98,0009.12,0023.08*70
```

Table 4.57 outlines the message format.

Table 4.57. Typical GST Message

Field	Description
$GPGST	Header
220632.00	UTC time of the position fix
0022.29	RMS value of the standard deviation of satellite range inputs (1sigma position error)
empty field	THIS FIELD NOT IMPLEMENTED
empty field	THIS FIELD NOT IMPLEMENTED
empty field	THIS FIELD NOT IMPLEMENTED
0016.98	Standard deviation of the latitude error (meters)
0009.12	Standard deviation of the longitude error (meters)
0023.08	Standard deviation of the altitude error (meters)
*70	Checksum

Standard deviation values in the GST message have a precision of one centimeter (two digits past the decimal mark). A zero value (0000.00) in any of the standard deviation fields indicates that the estimate of the standard deviation is less than five millimeters.

GSV: Satellites in View

$PASHQ,GSV,c1

This command allows you to query the GSV message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$GPGSV

The GSV message contains the PRN number, elevation, azimuth, and signal to noise ration for each visible satellite. This message contains data for a maximum of four satellites. If seven satellites are visible, two GSV messages are output; if ten satellites are visible, three GSV messages are output.

The message is output in the format:

```
$GPGSV,d1,d2,d3,d4,d5,d6,f7,d8,d9,d10,f11,d12,d13,d14,f15,d1
6, d17,d18,f19*hh
```

Table 4.58 outlines the message format.

Table 4.58. $GPGSV Message Format

Parameter	Description	Range
d1	Total number of GSV messages to be output	1 - 3
d2	Message number	1 - 3
d3	Total number of satellites in view	1 - 12
d4	Satellite PRN number	1 - 56
d5	Elevation (degrees)	0° - 90°
d6	Azimuth (degrees)	0° - 359°
d7	Signal to noise ration (dbHz)	00.0 - 99.9
d8	Satellite PRN number	1 - 32
d9	Elevation (degrees)	0° - 90°
d10	Azimuth (degrees)	0° - 359°
d11	Signal to noise ration (dbHz)	00.0 - 99.9
d12	Satellite PRN number	1 - 32
d13	Elevation (degrees)	0° - 90°
d14	Azimuth (degrees)	0° - 359°
d15	Signal to noise ration (dbHz)	00.0 - 99.9
d16	Satellite PRN number	1 - 32
d17	Elevation (degrees)	0° - 90°
d18	Azimuth (degrees)	0° - 359°
d19	Signal to noise ration (dbHz)	00.0 - 99.9
*hh	Checksum	2-character hex

Typical GSV message:

```
$GPGSV,3,1,10,18,59,322,51.4,1,39,98,47.4,14,33,169,45.6,19,
46, 267,50.4*75
```

Table 4.59 outlines the message format.

Table 4.59. Typical GSV Message

Field	Description
$GPGSV	Header
3	Indicates that three GSV messages will be output
1	Indicates that this is the first GSV message
10	Indicates that ten satellites are visible
18	Indicates GPS satellite 18 is visible
59	Elevation of satellite 18
322	Azimuth of satellite 18
51.4	Signal to noise ratio of PRN 18
1	Indicates GPS satellite 1 is visible
39	Elevation of satellite 1
98	Azimuth of satellite 1
47.4	Signal to noise ratio of satellite 1
14	Indicates GPS satellite14 is visible
33	Elevation of satellite 14
169	Azimuth of satellite 14
45.6	Signal to noise ratio of satellite 14
19	Indicates GPS satellite 19 is visible
46	Elevation of satellite 19
267	Azimuth of satellite 19
50.4	Signal to noise ration of satellite 19
*75	Checksum

LTN: Position Output Latency

$PASHQ,LTN,c1

This command allows you to query the LTN message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,LTN

This single-field message is output even if a position is not computed. Latency is defined as the number of milliseconds it takes the receiver to compute a position (from the position fix tag time) and prepare data to be output through the serial port. The latency range is typically between 20 and 40 milliseconds, depending on the number of satellites tracked and the number of satellites used in the position solution.

The message response is output in the format below:

```
$PASHR,LTN,d1*hh
```

Table 4.60 outlines the message format.

Table 4.60. $PASHR,LTN Message Format

Parameter	Description	Range
d1	Latency value (milliseconds)	20 - 40
*hh	Checksum	2-character hex

Typical LTN message:

```
$PASHR,LTN,38*05
```

Table 4.60 outlines the message format.

Table 4.61. $PASHQ,LTN Query Response

Field	Significance
$PASHR,LTN	Header
38	Latency value (milliseconds)
05	Checksum

MSG: Differential Base Station Data

$PASHQ,MSG,c1

This command allows you to query the MSG message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port. This command is ignored if the GG12 is not sending or receiving differential corrections.

$GPMSG

The MSG messages contain base station status data for incoming RTCA messages, including base station ID number, current Z count, current GPS time, base station health status, pseudorange correction values (PRC), range rate correction values (RRC), ephemeris data (IODE), and user differential range error values (UDRE) referenced to the PRN number for each locked satellite. This message can be set for output in one second increments.

The MSG messages generated for RTCA message type 1, fields d8 through d12 are repeated "n" times; n is the number of locked satellites when the GG12 outputs the message.

The MSG format for RTCA message type 1 is shown below:

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

Table 4.62 outlines the message format.

Table 4.62. Common MSG Data Fields

Fields	Description	Range
d1	RTCM message type	1, 2, 3, 6, 9, 16
d2	Station Identifier	0 - 1023
f3	Z count	0 - 9999.9
d4	Sequence number	0 - 9
d5	Station health	0 - 7
d6	Total number of characters following the time tag (including commas and <CR><LF> characters)	0 - 999
m7	Current GPS time of position fix (hhmmss.ss)	00-235959.90
d8	User differential range error (UDRE)	0-9
d9	Satellite PRN number	1-32
f10	Pseudo range correction (PRC) in meters	±9999.99

Table 4.62. Common MSG Data Fields (continued)

Fields	Description	Range
f11	Range rate correction (RRC) in meters/ sec	±9.999
d12	Issue of data ephemeris (IODE)	0-999
*hh	Checksum	2-character hex

Typical MSG message for RTCA type 1:

```
$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
```

Table 4.63 outlines the message format.

Table 4.63. Typical MSG message for RTCA Type 1

Parameter	Description
$GPMSG	Header
01	RTCM message type
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 satellite 12
12	Satellite PRN number
-0081.30	PRC for satellite 12
+0.026	RRC for satellite 12
235	IODE for satellite 12
2	UDRE for satellite 13
13	Satellite PRN number
+0022.86	PRC for satellite 13
+0.006	RRC for satellite 13

Table 4.63. Typical MSG message for RTCA Type 1 (continued)

Parameter	Description
106	IODE for satellite 13
2	UDRE for satellite 26
26	Satellite PRN number
-0053.42	PRC for satellite 26
-0.070	RRC for satellite 26
155	IODE for satellite 26
2	UDRE for satellite 02
02	Satellite PRN number
+0003.56	PRC for satellite 02
+0.040	RRC for satellite 02
120	IODE for satellite 02
2	UDRE for satellite 27
27	Satellite PRN number
+0047.42	PRC for satellite 27
-0.005	RRC for satellite 27
145	IODE for satellite 27
7A	Checksum

NME: Enable/Disable NMEA Message Output and Interval

$PASHS,NME,s1,c1,s2,f1

This command allows you to control the output of NMEA messages and Ashtech NMEA-style messages. Use the **$PASHQ,NMO** query command (page 124) to view the messages available to output. All messages are disabled for output by default. Each message is enabled for output individually.

The s1 parameter is the three-letter message identifier (GGA, LTN, POS, etc.), c1 is the port designator for message output, s2 is ON or OFF, and f1 is the value for the message output interval. The range of the value for the output interval depends on the output option selected. The f1 parameter allows you to set the output interval for each individual message. You can set the GGA and VTG messages to be output every two seconds, but have the SAT message output at ten second intervals. Table 4.64 below outlines the options and ranges for the output interval:

Table 4.64. Output Interval Settings for NMEA Messages

Installed Option	Output Range (seconds)	Increments
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

TThe GG12 is designed to synchronize NMEA message output with the hour rollover, so that message output from multiple receivers can be synchronized regardless of when they were turned on. An output interval of 0.7 is not allowed because it overlaps the hour rollover, which corrupts the synchronization of message output between multiple receivers.

Example

Enter the following command to output the POS message from port B at five second intervals:

$PASHS,NME,POS,B,ON,5

Enter the following command to disable the output of the POS message on port B:

$PASHS,NME,POS,B,OFF

$PASHS,NME,PER,f1

This command allows you to set a global output interval for all NMEA messages and Ashtech NMEA-style messages currently enabled for output, where f1 is the value for the output interval. This command overrides individual settings for output interval. That is, if the GGA message is enabled for output at intervals of two seconds and the SAT message is enabled for output at intervals of ten seconds, using the PER command to set an output interval of five seconds resets the output interval of both messages to five seconds.

Example

Enter the following command to set the global NMEA output interval to five seconds:

$PASHS,PER,5

$PASHS,NME,ALL,c1,s1

This command allows you to globally disable the output of all NMEA messages and Magellan NMEA-style messages on a single port, where c1 is the port designator (A or B) and s1 is OFF.

Example

Enter the command below to disable the output of all NMEA messages on port A:

$PASHS,NME,ALL,A,OFF

Enter the command below to disable the output of all NMEA messages on port B:

$PASHS,NME,ALL,B,OFF

The $PASHS, NME commands in this example must be entered in order to disable the output of all NMEA messages and Ashtech NMEA-style messages on both ports.

NMO: Query for NMEA Output Parameters

$PASHQ,NMO,c1

This command allows you to query the output parameters of NMEA messages and Ashtech NMEA-style messages, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,NMO

The response contains the parameter settings for NMEA message output, including the a serial port being used, the baud rate of the serial port, a three-letter identifier for each NMEA and Ashtech NMEA-style message supported by the GG12, and the output interval setting for each message.

The message is output in the format:

```
$PASHR,NMO,c1,d2,f3,d4,((s5,f6) x d4)*hh
```

Table 4.65 outlines the message format.

Table 4.65. $PASHR,NMO Message Format

Field	Description	Range
c1	Serial port reference for NMEA message output parameters	A, B
d2	Baud rate code for the referenced serial port (see SPD command)	0 - 9
f3	Global output interval setting (seconds; see PER command)	0.2 - 999

Table 4.65. $PASHR,NMO Message Format (continued)

Field	Description	Range
d4	The number of NMEA messages and Ashtech NMEA-style messages that can be output by the GG12. Twelve messages are supported at present	12
s5	The three-letter message identifier for each NMEA and Ashtech NMEA-style message supported by the GG12	LTN, POS, GGA, VTG, MSG, GSA, GSV, SAT, RRE, ZDA, RMC,GST
f6	Individual output interval setting for each NMEA and Ashtech NMEA-style message	0.2 - 999
*hh	Checksum	2-character hex

Typical NMO response message:

```
$PASHR,NMO,A,5,001.0,12,LTN,000.0,POS,000.0,GGA,005.0,VTG,
005.0,MSG,000.0,GSA,000.0,GSV,000.0,SAT,000.0,RRE,000.0,ZDA,
000.0, RMC,000.0,GST,000.0,*70
```

Table 4.66 outlines the message format.

Table 4.66. Typical NMO Response Message

Parameter	Description
$PASHR,NMO	Header
A	Indicates that serial port A is referenced in the response
5	This code number indicates that the data rate for port A is 9600 baud
0001.0	Global output interval setting for NMEA messages and Ashtech NMEA-style messages
12	Indicates that twelve NMEA and Ashtech NMEA-style messages are available for output
LTN	Position output latency message
000.0	Indicates that the LTN message not enabled for output
POS	3D antenna position message
000.0	Indicates that the POS message not enabled for output
GGA	3D GPS position message
005.0	Indicates that the GGA message is enabled for output at five-second intervals
VTG	Course and Speed Over the Ground message

Table 4.66. Typical NMO Response Message (continued)

Parameter	Description
005.0	Indicates that the VTG message is enabled for output at five-second intervals
MSG	Differential Base Station Status message
000.0	Indicates that the MSG message not enabled for output
GSA	DOP and Active Satellites message
000.0	Indicates that the GSA message not enabled for output
GSV	Satellites in View message
000.0	Indicates that the GSV message not enabled for output
SAT	Comprehensive Satellite Tracking Status message
000.0	Indicates that the SAT message not enabled for output
RRE	Satellite Range Residuals and Position Error message
000.0	Indicates that the RRE message not enabled for output
ZDA	Time and Date message
000.0	Indicates that the ZDA message not enabled for output
RMC	
000.0	Indicates that the RMC message not enabled for output
GST	Pseudorange Error Statistics message
000.0	Indicates that the GST message not enabled for output
*70	Checksum

RMC: Recommended Minimum Position & Course

$PASHQ,RMC,c1

This command allows you to query the RMC message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$GPRMC

This message contains UTC time, date, position status, latitude, longitude, course and speed over the ground, and magnetic variation. The RMC message does not output unless positions are being computed.

The message is output in the format:

```
$GPRMC,m1,c2,m3,c4,m5,c6,f7,f8,d9,f10,c11*hh
```

Table 4.67 outlines the message format.

Table 4.67. $GPRMC Message Format

Parameter	Description	Range
m1	UTC time of the position fix (hhmmss.ss)	000000.00 to 235959.90
c2	Status of the position fix (always A) • A - Position data is valid • V - Position data is invalid	A, V
m3	Latitude (ddmm.mmmmmm)	0000.000000° to 8959.999999°
c4	Latitude sector	N(orth) S(outh)
m5	Longitude (dddmm.mmmmmm)	00000.000000° to 17959.999999°
c6	Longitude sector	E(ast W(est)
f7	Speed over the ground (knots)	000.00 - 999.99
f8	Course over the ground (degrees); referenced to true north	000.00° - 359.99°
d9	Date (ddmmyy)	010100 - 123199
f10	Magnetic variation (degrees)	00.00° - 99.99°
c11	Direction of magnetic variation: • Easterly variation - subtract this value from true north course. • Westerly variation - add this value to true north course	E (ast) W (est)
*hh	Checksum	2-character hex

Typical RMC message:

```
$GPRMC,220701.00,A,3721.08310,12156.11521,W,000.23,256.46,21
1099,15.19,E*4A
```

Table 4.68 outlines the message format.

Table 4.68. Typical RMC Message

Parameter	Description
220701.00	UTC time of the position fix (hhmmss.ss)
A	Valid position

Commands

Table 4.68. Typical RMC Message

Parameter	Description
3721.08310	Latitude
N	Latitude sector
12156.11521	Longitude
W	Longitude Sector
000.23	Speed over ground (knots)
256.46	Course Over Ground (degrees True)
211099	21 October 1999
15.19	Magnetic Variation, degrees
W	Easterly variation (subtract from the True course)
*4A	Checksum

RRE: Satellite Range Residuals and Position Error

$PASHQ,RRE,c1

This command allows you to query the RRE message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port. The GG12 outputs two RRE messages: **$GPRRE** and **$GLRRE**. **$GPRRE** contains information for the GPS satellites. **$GLRRE** contains information for the GLONASS satellites.

$GPRRE

This message contains residual error values for the each pseudorange measurement and RMS values for horizontal and vertical position error for the GPS satellites. The satellites are listed in the order in which they were acquired. The RRE message does not output unless positions are being computed. Residual errors and position errors are computed only if a minimum of 5 locked satellites are used to compute position; otherwise zero values are registered in the data fields.

The message is output in the format below:

```
$GPRRE,d1,((d2,f1)*d1),f2,f3*hh
```

The data fields for satellite number (d2) and residual range error (f1) are repeated for each locked satellite, with the d1 value acting as a multiplier. Table 4.69 outlines the message format.

Table 4.69. RRE Message Format

Parameter	Description	Range
d1	The number of satellites used to compute position	0 - 12
d2	PRN number for each of the satellites used in the position computation	1 - 32
f1	Magnitude of the residual range error (meters) for each satellite used in the position computation	-999.9 to +999.9
f2	RMS value for the horizontal position error (meters)	-9999.9 to +9999.9
f3	RMS value for the vertical position error (meters)	

Typical $GPRRE message:

```
$GPRRE,10,18,-038.9,01,+018.4,14,-006.5,19,001.7,22,+015.3,0
4,+032.5,16,+005.1,27,-014.5,03,+000.1,24,-010.6,0018.8,0022
.7*74
```

Table 4.70 outlines the message format.

Table 4.70. Typical $GPRRE Message

Field	Description
$GPRRE	Header for GPS-based RRE message
10	Number of GPS satellites used to compute positions
18	PRN number of the first GPS satellite acquired
-038.9	Range residual of first GPS satellite (meters)
01	PRN number of the second GPS satellite acquired
+018.4	Range residual for second satellite (meters)
14	PRN number of the third GPS satellite acquired
-006.5	Range residual of the third satellite (meters)
19	PRN number of the fourth GPS satellite acquired
+001.7	Range residual of the fourth satellite (meters)
22	PRN number of the fifth GPS satellite acquired
+015.3	Range residual of the fifth satellite (meters)
04	PRN number of the sixth GPS satellite acquired

Table 4.70. Typical $GPRRE Message (continued)

Field	Description
+032.5	Range residual of the sixth satellite (meters)
16	PRN number of the seventh GPS satellite acquired
+005.1	Range residual of the fifth satellite (meters)
27	PRN number of the eighth GPS satellite acquired
-014.5	Range residual of the eighth satellite (meters)
03	PRN number of the ninth GPS satellite acquired
+000.1	Range residual of the ninth satellite (meters)
24	PRN number of the tenth GPS satellite acquired
-010.6	Range residual of the tenth satellite (meters)
0018.8	Horizontal position error (meters)
0022.7	Vertical position error (meters)
*76	Checksum

$GLRRE

This message contains residual error values for the each pseudorange measurement and RMS values for horizontal and vertical position error for the GLONASS satellites. The satellites are listed in the order in which they were acquired. As with the GPS version, this message does not output unless positions are being computed. Residual errors and position errors are computed only if a minimum of 5 locked satellites are used to compute position; otherwise zero values are registered in the data fields.

The message is output in the format:

```
$GLRRE,d1,((d2,f1)*d1),f2,f3*hh
```

The data fields for satellite number (d2) and residual range error (f1) are repeated for each locked satellite, with the d1 value acting as a multiplier.

Typical $GLRRE message:

```
$GLRRE,2,45,+004.6,54,-000.3,0018.8,0022.7*51
```

Table 4.71 outlines the message format.

Table 4.71. Typical $GLRRE Message

Field	Description
$GLRRE	Header for GLONASS-based RRE message
10	Number of GLONASS satellites used to compute positions

Table 4.71. Typical $GLRRE Message (continued)

Field	Description
18	PRN number of the first GLONASS satellite acquired
-038.9	Range residual of first GLONASS satellite (meters)
01	PRN number of the second GLONASS satellite acquired
+018.4	Range residual for second satellite (meters)
0018.8	Horizontal position error (meters)
0022.7	Vertical position error (meters)
*76	Checksum

SAT: Comprehensive Satellite Tracking Data

$PASHQ,SAT,c1

This command allows you to query the SAT message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SAT

The SAT message contains information on the number of visible satellites, whether the satellite is being used in position computations, plus elevation, azimuth, and signal to noise measurements for each satellite.

The message is output in the format:

```
$PASHR,SAT,d1,((d2,d3,d4,d5,c6)*d1)*hh
```

The data fields for PRN number (d2), azimuth (d3), elevation (d4), signal to noise ration (d5), and the used/not used flag (c6) are repeated for each satellite, using the value in the d1 field as a multiplier.

Table 4.72 outlines the message format.

Table 4.72. $PASHR,SAT Message Format

Field	Description	Range
d1	The number of satellites locked by the receiver	1 - 12
d2	Satellite PRN number	1 - 32
d3	Satellite azimuth angle	0° - 359°
d4	Satellite elevation angle	0° - 90°
d5	Satellite signal-to-noise ratio (dbHz)	0 - 99

Table 4.72. $PASHR,SAT Message Format (continued)

Field	Description	Range
c6	Indicates whether the locked satellite is used in position computations: • A "U" indicates that the satellite is being used in position computations • A dash (-) indicates that the satellite is not being used in position computations	U, -
*hh	Checksum	2-character hex

Typical SAT message:

```
$PASHR,SAT,03,03,103,56,60,U,23,225,61,39,U,16,045,02,21,U*6E
```

Table 4.73 outlines the message format.

Table 4.73. Typical SAT Message

Field	Description
$PASHR,SAT	Header
03	Number of satellite locked
03	PRN number of the first satellite
103	Azimuth of the first satellite in degrees
56	Elevation of the first satellite in degrees
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
6E	Checksum

VTG: Course and Speed Over Ground

$PASHQ,VTG,c1

This command allows you to query the VTG message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$GPVTG

This message does not output unless positions are computed. The VTG contains course over the ground (COG) referenced to both true and magnetic north and speed over the ground (SOG) in kilometers per hour and nautical miles per hour (knots).

The message is output in the format:

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

Table 4.74 outlines the message format.

Table 4.74. $GPVTG Response Structure

Field	Description	Range
f1	Course over ground; referenced to true north	000.0° - 359.99°
c2	North reference indicator (always T; true north)	T
f3	Course over the ground; referenced to magnetic north	000.0° - 359.99°
c4	North reference indicator (always M; magnetic north)	M
f5	Speed over ground (knots)	000.00 - 999.99
c6	Speed unit of measure (always N; nautical miles per hour)	N
f7	Speed over ground (kilometers per hour)	000.00 - 999.99
c8	Speed unit of measure (always K; KPH)	K
*hh	Checksum	2-character hex

Typical VTG message:

```
$GPVTG,179.00,T,193.00,M,000.11,N,000.20,K*3E
```

Table 4.75 outlines the message format.

Table 4.75. Typical VTG Message

Field	Description
$GPVTG	Header
179.00	Course over ground (degrees)
T	True course over ground marker
193.00	Magnetic course over ground
M	Magnetic course over ground marker
000.11	Speed over ground (knots)
N	Nautical miles per hour
000.20	Speed over ground in kilometers/hour
K	Kilometers per hour
*3E	Checksum

ZDA: Time and Date

$PASHQ,ZDA

This command allows you to query the ZDA message, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$GPZDA

This message does not output until the receiver has locked on at least one satellite. The ZDA message contains UTC time, the current date, and offset values for converting UTC time to local time.

The message is output in the format:

```
$GPZDA,m1,d2,d3,d4,d5,d6*hh
```

Table 4.76 outlines the message format.

Table 4.76. $GPZDA Message Format

Field	Description	Range
m1	UTC time	000000.00 to 235959.90
d2	Current day	01 - 31

Table 4.76. $GPZDA Message Format

Field	Description	Range
d3	Current month	01 - 12
d4	Current year	0000 - 9999
d5	Local time zone offset from UTC time (hours)	-13 to +13
d6	Local time zone offset from UTC time (minutes). This value has the same sign [+\-] as d5, but the sign is not displayed for this field.	00 - 59
*hh	Checksum	2-character hex

Typical ZDA message:

```
$GPZDA,222835.10,21,07,1999,-07,00*4D
```

Table 4.77 outlines the message format.

Table 4.77. Typical ZDA Message

Field	Description
$GPZDA	Message header
222835.10	Current UTC time
21	Current day
07	Current month
1999	Current year
-07	Local time zone offset from UTC (hours)
00	Local time zone offset from UTC (minutes)
4D	Checksum

RTCA Commands

RTCA commands allow you control and monitor the operation of the GG12 in GPS-only remote differential mode. These commands are available even if the remote differential option [U] is installed.

All but one of the RTCA commands are set commands. The set commands allow you to enable and modify a variety of parameters affecting differential operation.

There is only one query command: **$PASHQ,RTC,RPS**. This command is used to monitor differential parameters and status.

Table 4.78 lists the RTCA commands. The GG12 can accept RTCA type 1 messages only.

Table 4.78. RTCA Commands

Function	Command	Description	Page
Remote station parameters	$PASHS,RTC,AUT	Enables/disables auto differential mode	page 136
	$PASHS,RTC,MAX	Sets maximum age of RTCA differential corrections	page 137
	$PASHS,RTC,REM	Sets receiver to operate as differential remote station	page 138
	$PASHQ,RTC,RPS	Query for RTCA remote station parameter settings	page 138
	$PASHS,RTC,OFF	Disables differential mode	page 137
	$PASHS,RTC,STI	Sets station identification of base or remote	page 140

AUT: Enable/Disable Automatic Differential Mode

$PASHS,RTC,AUT,s1

This command allows you to enable or disable automatic differential mode, where s1 is Y (enabled) or N (disabled).

When auto differential mode is enabled, the receiver outputs raw positions automatically if differential corrections are older than the maximum age setting, or when differential corrections are not available.

When auto differential mode is disabled, the receiver stops outputting positions when the age of the differential correction exceeds the maximum age setting or when differential corrections are not available, and does not resume position output until it receives RTCA corrections with age values lower than the maximum or differential mode is disabled.

The automatic differential setting applies to remote differential stations only. You can view the current automatic differential setting by entering the query command **$PASHQ,RTC** and checking the AUT field.

Example

Enter the following command to enable auto differential mode:

$PASHS,RTC,AUT,Y

DEFAULT SETTING	
RTC,AUT	Y

MAX: Set Maximum Age Threshold for Differential Corrections

$PASHS,RTC,MAX,d1

This command allows you to set the maximum age for incoming RTCA differential corrections, where d1 is any number between 1 and 1199. The receiver ignores incoming corrections whose age exceeds the maximum age setting. The default value is 60. The maximum age setting applies to remote differential stations only.

You can view the current maximum age setting by entering the query command **$PASHQ,RTC** and checking the MAX field.

Example

Enter the command below to set the maximum age to 30 seconds:

$PASHS,RTC,MAX,30

DEFAULT SETTING	
RTC,MAX	60

OFF: Disable Differential Operation

$PASHS,RTC,OFF

This command allows you to disable differential operation, when the receiver is set as a base station or a remote station.

You can view the current RTCA mode setting by entering the query command **$PASHQ,RTC** and checking the MODE field.

REM: Set Receiver in Differential Remote Station Mode

$PASHS,RTC,REM,c1

This command allows you to set the GG12 to operate as an RTCA differential remote station. The c1 parameter designates the input port (A or B) for differential corrections.

You can view the current RTCA mode setting by entering the query command **$PASHQ,RTC,RPSC** and checking the first field after the header.

Example

Enter the following command to set receiver as a differential remote station with port B designated as the input port for RTCA differential corrections:

$PASHS,RTC,REM,B

RPS: Query RTCA Rover Operating Parameters

$PASHQ,RTC,RPS,c1

This command allows you to query for remote differential operational status, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,RTC,RPS

This message contains information on the current operating mode, the maximum age setting for incoming differential corrections, whether automatic differential mode is enabled or disabled, and more.

The message is output in the format:

```
$PASHR,RTC,RPS,d1,c2,d3,c4,d5,d6,c7,*hh
```

Table 4.79 outlines the message format.

Table 4.79. $PASHR,RTC,RPS Message Format

Field	Description	Range
d1	Current operating mode: • 0 - Autonomous mode • 1 - Remote differential mode	0,1
c2	Indicates which port is being used to receive differential corrections	A, B

Table 4.79. $PASHR,RTC,RPS Message Format (continued)

Field	Description	Range
d3	Remote differential station ID number. A sequence of 0000 indicates that the receiver can accept corrections from any RTCA base station. Any other sequence indicates that the receiver can only receive corrections from an RTCA base station programmed with the same sequence	0000 - 1023
c4	Current automatic differential mode: • Y - Automatic differential mode is enabled • N - Automatic differential mode is disabled	Y, N
d5	The communication quality factor between the differential base station and the differential remote station. This value is defined as follows: (the number of good messages/the total number of messages) x 100	000.0% - 100.0%
d6	The maximum age (seconds) setting for incoming differential correction messages. Incoming messages whose age is at or below the max age threshold are used; incoming messages whose age is above this threshold are ignored. The default maximum age setting is 60 seconds	0 - 9999
c7	Always N. Indicates whether the receiver is checking (Y) or not checking the sequence number of incoming correction messages	Y, N
*hh	Checksum	2-character hex

Typical $PASHR,RTC,RPS message:

```
$PASHR,RTC,RPS,1,B,ABCD,N,,60,N*11
```

Table 4.80 outlines the message format.

Table 4.80. Typical $PASHR,RTC,RPS Message

Field	Description
$PASHR,RTC,RPS	Message header
1	Indicates that the GG12 is in remote differential mode
B	Indicates that the GG12 is set to receive corrections on port B
0000	Indicates that the GG12 can receive RTCA corrections from any RTCA base station
Y	Indicates that automatic differential mode is enabled
	Null field
60	Indicates that the maximum age setting for incoming correction messages is 60 seconds
N	Indicates that message sequence checking is disabled
*	Checksum

STI: Set Differential Remote Station ID

$PASHS,RTC,STI,d1

This command allows you to set differential station identification numbers, where d1 is any number between 0000 and 1023. A remote station with the ID number 0000 can receive corrections from any RTCA base station; otherwise, the remote station must be programmed with the same ID number as the base station in order to receive corrections from that base station.

Example

Enter the following command to set the differential station ID number to 0001.

$PASHS,RTC,STI,0001

DEFAULT SETTING	
RTC,STI	0000

A

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 GG12™ GPS+GLONASS receiver uses GLONASS satellites in addition to GPS satellites, providing a system even more reliable and more accurate than either system alone.

Ashtech's GG12 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.

Accuracy

The accuracy of the GPS system is intentionally degraded through the implementation of Selective Availability (SA). However, the accuracy of the GLONASS system is not degraded. As a result, the accuracy of autonomous (non-differential) GPS+GLONASS positions are approximately 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 DOP (Dilution Of Precision) values 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. Periods of poor GPS satellite visibility can cause the GPS DOPs to be tens to hundreds of times worse than the combined GPS+GLONASS DOPs; at the same time, the GPS+GLONASS differential accuracy is 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 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: 10° 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.

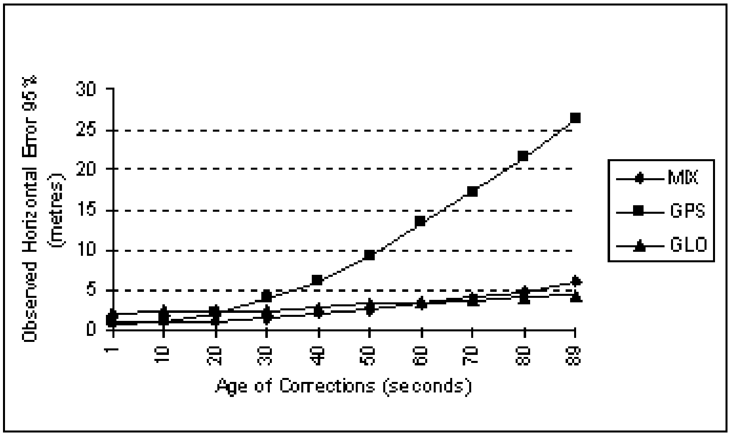

Figure A.1. GG12 Code Differential Horizontal Position Decay

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 degrades.

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 measuring the how long the satellite signal takes to reach you. Multiply this time by the speed of light and you have the range from the antenna to the satellite.

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 must solve for 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.

If the altitude is known, the GG12 can be set to hold the altitude to a fixed value. This removes one unknown, and only four satellites are needed to compute positions. The GG12 also determines the time offset, or time-shift, between GPS and GLONASS time. You can set the receiver to hold the time-shift to a fixed value, which eliminates another unknown. In this case, only three satellites are needed for a 2D position, or four for a 3D position. Any combination of GPS & GLONASS satellites work. The GG12 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 GG12 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 GPS 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, or Code Division Multiple Access). GLONASS uses the same PRN codes for each satellite, but different frequencies within the LI and L2 bands (FDMA, or 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 number of the orbital slot 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, and the encrypted code is classified. 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 GG12 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 GG12 is an L1-only receiver.

Changes are planned for the GLONASS frequency plan:

- **Stage 1—**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**—2000 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.

These changes in frequency will have no effect on the GG12, because the capability to handle any of the carrier number assignments is built-in, and the satellite almanac always tells the receiver which carrier number 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 GG12 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 GG12 uses the OSU-91A 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. For more information on OSU91A, please refer to:

Rapp, R.H., Y.M. Wang and N.K. Pavlis, 1991: The Ohio State 1991 Geopotential and Sea Surface Topography Harmonic Coefficient Models, Report No. 410. Columbus: Department of Geodetic Science and Surveying, The Ohio State University.

The Ohio State University
Department of Civil and Environmental Engineering and Geodetic Science
470 Hitchcock Hall
2070 Neil Avenue
Columbus, OH 43210
Tel: 614-292-2771
Fax: 614-292-3780
Web: http://www-ceg.eng.ohio-state.edu

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 smallest 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.

For more information on WMM-95, please refer to:

USGS National Geomagnetic Information Center
Box 25046, Mailstop 968
Denver Federal Center
Denver, CO 80225-0046
Tel: 1-303-273-8475
Fax: 1-303-273-8450
Web: http://geomag.usgs.gov

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
Satellites per plane	4, unevenly spaced	8, evenly spaced
Orbital inclination	55°	64.8°

Table A.1. Comparison of GPS and GLONASS (continued)

Parameter	GPS	GLONASS
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 13 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).

NMEA 0183 Standards

The National Marine Electronics Association Standard NMEA 0183 defines interfacing standards for marine electronic devices. Although this standard was initally for marine use, it has been adopted worldwide for all applications of GPS.

The following messages apply specifically to GPS, and are supported by the GG12.

- 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 GG12. For more information on NMEA messages and decisions, see the NMEA web page, *http://www.coastalnet.com/nmea/*.

B

Floating Point Data Representation

The GG12 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 being 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), Table B-1.

Table B.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 B-1, the value 1.0 is calculated by the following method:

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 B-1, the value 0.75 is calculated by the following method:

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), Table B-2.

Table B.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 B-2, the value 1 is calculated by the following method:

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 B-2, the value 0.75 is calculated by the following method:

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).

C

Global Product Support

If you have any problems or require further assistance, the Customer Support team can be reached through the following channels:

- telephone
- email
- Internet

Please refer to the reference documentation before contacting Customer Support. Many common problems are identified within the documentation, and suggestions are offered for solving them.

Ashtech customer support:

471 El Camino Real

Santa Clara, California

USA, 95050-4300

Toll-free Voice Line: 1-800-229-2400

Local and International Voice Line: (408) 615-3980

Fax Line: (408) 615-5200

Email: support@ashtech.com

Ashtech Europe Ltd., Reading, UK

Voice: 44-118 931 9600

Fax: 44-118 931 9601

Solutions for Common Problems

- Check cables and power supplies. Many hardware problems result from failures in these components.
- If the problem seems to be with your computer, reboot the computer to clear its RAM memory.
- If you are experiencing receiver problems, reset the receiver. The reset command (**$PASHS,RST**) clears receiver memory and resets operating parameters to factory default values.
- Verify that batteries, including the backup battery for RAM memory, have adequate charge.
- Verify that the antenna is oriented skyward and is unobstructed by trees, buildings, or other objects overhead.

If these suggestions don't solve the problem, contact the Customer Support team. To assist the Customer Support team, please have the following information in hand:

Table C.1. GPS Product Information

Information Category*	Your actual numbers
Receiver model	
Receiver serial #	
Firmware version #	
Options	
A brief description of the problem	
* The receiver model name, the firmware version number, the receiver serial number, and a list of installed options can be obtained by issuing the query command $PASHQ,RIO (request receiver identification)	

Corporate Web Page

You can obtain data sheets, news on upcoming products and product updates, GPS status information, application notes, and other useful information from Ashtech's Internet web page. Helpful features such as answers to frequently asked questions (FAQs) and list of authorized distributors are included on the web page. Use the following URL:

http://www.ashtech.com

Repair Centers

In addition to repair centers in California and England, authorized distributors in 27countries can assist you with your service needs.

Magellan Corporation, Ashtech Precision Products, Santa Clara, California

Voice: (408) 615-3980

or (800) 229-2400

Fax: (408) 615-5200

Ashtech Europe Ltd., Reading, UK

Voice: 44-118 931 9600

Fax: 44-118 931 9601

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