Z-12 Real-Time Sensor

Operation & Reference Manual

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FCC (CFR 47, Part 15.105), BS EN 55022: 1995

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to FCC, CFR 47, Part 15 Rules, and Class A ITE (Information Technology Equipment), pursuant to the European Standard EN 55022: 1995. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Manufacturer provided or recommended shielded input/output cables must be used for this equipment to comply with the regulation limits tested.

Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Changes or modifications to the equipment or cables not specifically approved, in writing, by the manufacturer may void the user's authority to operate this equipment.

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Introduction

To satisfy real-time applications (such as construction machine control, vehicle guidance, precision navigation and surveying) requiring high accuracy, fast update rates, and low latency, we have developed the Z-12 Real-Time Sensor. Based on Ashtech's Real-Time Z™ technology, the Z-12 Real-Time Sensor has been upgraded to achieve faster position updates with latencies as low as 100ms. The Z-12 Real-Time Sensor calculates new positions independently, as fast as 5Hz. The system provides the fastest available initialization time, with ambiguity resolution of seconds in kinematic mode. Once initialized, users can have confidence in precise landforming, docking, or CAT IIIB aircraft landing, due to real-time accuracy at centimeter level.

This performance comes with all the existing features that earned the Z-12 its reputation as the leading dual frequency receiver, including the Industry's best:

- Patented Z-tracking™ of satellites during periods of large ionospheric activity
- Jam immunity
- Speed and reliability of ambiguity resolution

Overview

The Z-12 Real-Time Sensor, Figure 1.1, processes signals from the Global Positioning System (GPS) satellite constellation. The sensor provides real-time position, velocity, and time measurements using twelve dedicated separate and parallel channels for Coarse/Acquisition (C/A) code-phase, and carrier-phase measurement on the L1 (1575 MHz), and Precise (P) code phase and carrier phase measurement on L1 and L2 (1227 MHz) bands. The sensor receives satellite signals via an L-band antenna and low-noise amplifier (LNA). The sensor operates stand-alone, and as a base (reference) station or remote (rover) station providing real-time differential GPS operation for code and real-time kinematic (RTK) operation for carrier phase. The sensor implements the RTCM SC 104 V2.2 standard for differential and RTK operation, including the newly defined message types 18 and 19. These features allow the sensor to achieve centimeter accuracy while being compatible for differential and RTK operation with any other receiver that implements the RTCM standard.

Figure 1.1: Z-12 Real-Time Sensor

Functional Description

The sensor is activated when power is applied to either of the two power connectors, and the power pushbutton is pushed to ON. After self test, the sensor initializes its 12 channels and begins searching for all satellites (SVs or Space Vehicles) within the field of view of the antenna.

The sensor can track all Block I and Block II GPS SVs. All 32 PRN numbers as specified in Navstar GPS Space Segment/Navigation User Interfaces, ICD-GPS-200, Revision B are coded inside the sensor/processor card. As the sensor acquires (locks onto) each SV, it notes the time and then collects the ephemeris data about the orbit of that SV, and almanac data about the orbits of all the SVs in the constellation.

The sensor features 12-parallel channel/12-SV all-in-view operation; each of up to 12 visible SVs can be assigned to a channel and then continuously tracked. Each SV broadcasts almanac and ephemeris information every 30 seconds, and the sensor automatically records this information in its non-volatile memory.

The sensor has an L1/L2-band radio frequency (RF) port and three RS-232 serial input/output (I/O) ports. Ports A and B are capable of two-way communication with external equipment. Port C is capable of RTCM operation.

With external power removed from the non-volatile part of the RAM, data storage is maintained using an internal battery.

The RF circuitry receives satellite data from a GPS antenna and LNA via a coaxial cable, and can supply power to the antenna/LNA by means of that cable. No separate antenna power cable is required. Power consumption is approximately 12 watts even when powering an LNA.

The sensor incorporates a two-color LED which lights red to indicate the power status, and flashes green to indicate the number of SVs locked.

The sensor collects Coarse Acquisition (C/A) code-phase (pseudo-range) and full wavelength carrier phase measurement on L1 frequency (1575 MHz), Precise (P) code phase (pseudo-range) and full wavelength carrier phase on L1 and L2 frequency (1227 MHz). The sensor permits uninterrupted use even when Anti-Spoofing (AS) is turned on. When AS is on, the sensor automatically activates Ashtech patented Z-tracking mode that mitigates the effects of AS. The performance when AS is on is the same as when AS is off.

Real-Time Differential

One of the most important functions of the sensor is providing real-time position solutions with accuracy ranging from centimeter level to 100 meters. Table 1.1 summarizes the positioning modes and expected accuracy.

Table 1.1: Accuracy as Function of Mode

Positioning Mode	Tyhpical Horizontal Accuracy (rms), 5 SVs, PDOP<4	Maximum Update Rate	Maximum Operating Range
Autonomous	16 meters with SA off	1 Hz	Anywhere
RTCM differrential	<1 meter	1 Hz	Several hundred kilometers
Real-time kinematic (RTK) carrier phase differential in RTCM-RTK format or DBEN format	0.01 meter or better	5 Hz	<15 kilometers

Data Collection for Post-Processing

One independent measurement is collected per 0.2, 0.5, 1.0 second, or slower, depending upon whether the Q (Quick Position) option is installed in the sensor, with no interpolation or extrapolation from previous measurements. The measurements can be stored in internal battery-backed RAM, from which the data can be transferred later to a personal computer or output in real time via RS-232 serial ports. The data can then be post-processed to determine time, position, and velocity.

Data collected at a rate faster than 1 Hz (i.e. 2 Hz and 5 Hz) can not be post-processed; if the data is to be post-processed, use 1 Hz or slower. Determine the data collection rate by using the RCI command (refer to "$PASHS,RCI" on page 70)

Equipment

Standard

The standard Z-12 Real-Time Sensor package includes the following equipment.

- Z-12 Real-Time Sensor
- Power cable
- Serial null modem data cable (DB9 female -DB9 female)
- Communication software (**REMOTE.EXE**)

Optional

The following additional equipment is available, and may be required for your particular application.

- Marine III GPS antenna
- Antenna cable
- Hand-held controller such as Husky FS/2, or equivalent
- Battery
- Power supply
- Data link radio, Pacific Crest DD96, Freewave DGR-115H, or equivalent

Contact your authorized reseller or dealer for information on obtaining this equipment.

Specifications and Options

Technical Specifications

Table 1.2 lists the technical specifications of the sensor.

Table 1.2: Technical Specifications

Characteristic	Specifications
Tracking	12 channels L1 CA/PL1 and PL2
Size	3.9"H x 6.3"W x 8.8"D
Weight	5.5 lb
Operating temperature	-20° to +55°C
Storage temperature	-30° to +75°C
Environment	Wind-driven rain and dust to MIL-STD-810E
Case	Aluminum
Power consumption	12 watts
Power input	10-32 VDC via two power connectors
Data storage	Optional 1, 3, 6, or 10MB memory board
Interface	• One dual-color LED • Three RS-232 ports via DB9 connectors • One antenna port • Event marker and 1PPS via serial port connector
Mounting	Plate with 4 holes

Optional Features

Table 1.3 lists the available options. Each option is represented by a letter or number presented in a certain order. You can verify the installed options by issuing the following command to the sensor using an external handheld controller or PC, as described in Chapter 4, **Command Response Formats**:

- **$PASHQ,SCRN,8**

The command will display the options on the external handheld controller or PC with some non-ASCII characters at the beginning and end of the string which you can ignore. For example:

...ZM,30,4J00,C05,1C63X**DP12M-Q-LJ**....

If the letter or number is displayed in the response message, the option is available. If the letter/number is not displayed, the option is not available. Table 1.3 lists the available options when the $PASHQ,SCRN,8 command is submitted.

Table 1.3: Sensor Options

Option	Description
D	RTCM differential including base and remote
U	RTCM differential remote only
P	Photogrammetry event marker
1	P code, L1 option
2	P code, L2 option
M	Remote monitor option
Q	Quick position update
L	Sleep mode option
J	Real-time Z option

Memory Options

The amount of data the sensor can retain depends upon the amount of memory that is installed. You can verify the amount of memory by viewing the rear of the Sensor and noting the part number which is located on a sticker. The part number should have a dash at the end followed by two digits. These two digits represent the memory option which has been loaded into the Zensor. Table 1.4 lists the memory options which are available.

Table 1.4: Memory Options

Dash Number	Memory
00	0
01	1 MB
03	3 MB
06	6 MB
10	10 MB

Operation

Equipment Description

Antenna

The GPS antenna can be mounted on a tripod, a hand-carried pole, a vehicle, or any suitable means. Locate the GPS antenna so that it has maximum view of the sky, as far away as practical from obstructions such as trees, buildings, etc.

CAUTION
Do not mount the GPS antenna near any metal objects, since these objects will reflect the GPS satellite signals causing multipath errors. Mounting the antenna higher will usually reduce the multipath effect.

Figure 2.1 shows a typical GPS antenna.

Figure 2.1: Typical GPS Antenna

Sensor

Front Panel

The Z-12 Real-Time Sensor operates with an input voltage between 10 and 32 Vdc from an external power supply. Two POWER-IN sockets let you use two external batteries. When only one battery is connected and it comes close to discharge, a continuous tone indicates that the voltage has dropped below 10 volts.

You can connect the second battery to the second connector and continue recording data without interruption. Or you can connect two at once for long unattended observations; the receiver will operate from the battery with the higher charge.

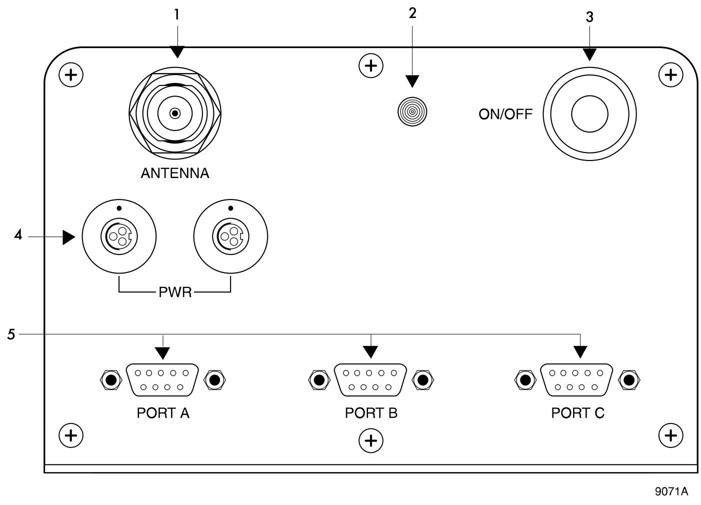

Figure 2.2: Z-12 Real-Time Sensor Front Panel

Table 2.1 describes the front panel components of the Z-12 Real-Time Sensor.

Table 2.1: Z-12 Real-Time Sensor Front Panel

Number	Component	Function
1	Antenna RF connector	The RF connector is a standard N-type female receptacle wired for connection via 50-ohm coaxial cabling to a GPS antenna with an integral LNA. The N-type connector shell is connected to the Sensor common ground. The N-type connector center pin provides +9.5 VDC (to power the LNA) and accepts 1227 and 1575.42 MHz RF input from the antenna; the RF and DC signals share the same path.
2	LED	LED which provides equipment status. Red indicates power is applied. Green flashes indicate the number of satellites the Sensor has acquired.
3	On/Off Power Button	Turns unit on and off.
4	PWR Connectors	Dual power connector which provide connections to redundant power sources.
5	• Serial Port A • Serial Port B • Serial Port C	• A complete RS-232 port with full-handshaking. Port A can be used for communications with a Husky hand-held computer, an IBM compatible PC, or a radio. Port A is used for transferring data from the receiver to a computer, from a receiver to a receiver, and all other communications to and from the receiver. • A complete RS-232 port with full-handshaking. Port B can be used for communication with the Husky hand-held computer, an IBM compatible PC, or a radio. Port B is used for transferring data from the receiver to a computer, from a receiver to a receiver, and all other communications to and from the receiver. • An abbreviated RS-232 port that has flow-control only. Port C can only be used for input/output of RTCM differential corrections.

Operation

RF Connector

The RF connector is a standard N-type female receptacle wired for connection via 50-ohm coaxial cabling to a GPS antenna with integral LNA. The N-type connector shell is connected to the Z-12 Real-time Sensor common ground. The N-type connector center pin provides +9.5 VDC (to power the LNA) and accepts 1575 MHz or 1227.60 MHz RF input from the antenna; the RF and DC signals share the same path.

CAUTION
The current is limited to 150 mA out of the RF center conductor. It is short-circuited protected. If using a splitter or other RF network, use an inner DC block suitable for 1-2 GHz, 50 ohms, maximum voltage 25 V to protect the Sensor from external voltages.

Power Input Connections

Two 3-pin Fischer connectors wired in parallel provide the power input interface. Table 2.2 defines the pinout of the power connector. Figure 2.3 shows the pin layout of the power connector.

Table 2.2: Power Connector Pinouts

Pin	Signal	Description
1	V_{IN}	Power input 10-32 Vdc
2	GND	Ground
3	NC	No Connection

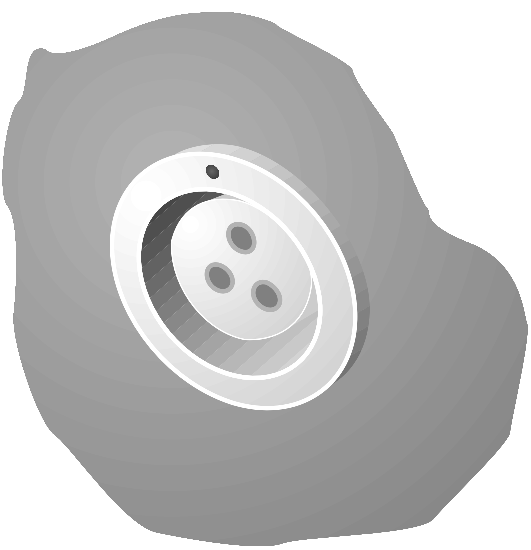

Figure 2.3: Power Connector pin layout

The voltage input range is 10-32 volts, with a power rating of 12 watts.

> **WARNING**
>
> **Do not connect or disconnect power or signal cables from the Z-12 Real-Time Sensor while power applied. Possible injury and equipment damage may occur.**

Serial Port Configuration

The Sensor provides three RS-232 serial ports with two-way full-duplex communication. Ports A and B are full-capability RS-232 ports used with external devices such as a handheld controller, PC, or modem. Port C is a restricted capability RS-232 port used for RTCM differential in/out, communication link (radio), or reset plug. Three male DB9 connectors provide the interface for the three RS-232 channels. Pin 9 of port A is used for the 1 PPS interface. Pin 9 of port B is used for the event marker. Figure 2.4 shows the DB9 pin configuration.

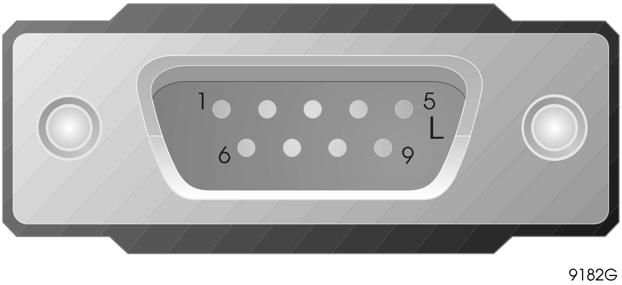

Figure 2.4: DB9 Pin Configuration

Table 2.3 lists the signal parameters for the three DB9 connectors.

Table 2.3: DB9 RS-232 Connector Pinouts

Port	Pin	Signal	Description
A	1	DCD1	Data Character Detect for port 1
	2	RXD1	Receive Data for port 1
	3	TXD1	Transmit Data for port 1
	4	+12V1	Supply output for radio. Acts as DTR if necessary.
	5	GND1	Signal Ground for port 1
	6	DSR1	Data Set Ready for port 1
	7	RTS1	Request To Send for port 1
	8	CTS1	Clear To Send for port 1
	9	1PPS	One Pulse Per Second output. Synchronized with GPS time.
B	1	DCD2	Data Character Detect for port 2
	2	RXD2	Receive Data for port 2
	3	TXD2	Transmit Data for port 2
	4	+12V2	Supply output for radio. Acts as DTR if necessary.
	5	GND2	Signal Ground for port 2
	6	DSR2	Data Set Ready for port 2
	7	RTS2	Request To Send for port 2
	8	CTS2	Clear To Send for port 2
	9	EVENT	Event marker input. This is a high pulse to time-tag the output log data.
C	1	NC	No connection
	2	RXD3	Receive Data for port 3
	3	TXD3	Transmit Data for port 3
	4	+12V3	Supply output for radio. Acts as DTR if necessary.
	5	GND3	Signal Ground for port 3
	6	NC	No connection
	7	RTS3	Request To Send for port 3
	8	CTS3	Clear To Send for port 3
	9	BOOT	Force boot load: • Open or high—no action • Low or power on—initiates a memory reset or a boot load through port 1. See firmware description for more information.

Serial Null Modem Data Cable

Table 2.5 shows the wiring information for the Null Modem data cable.

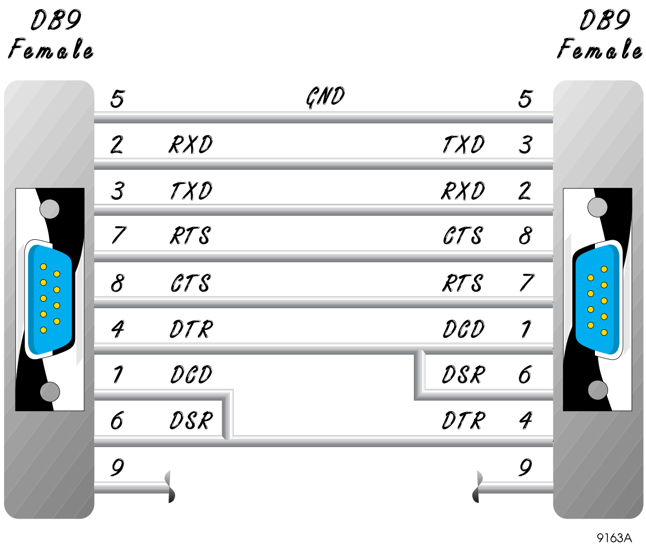

Figure 2.5: Null Modem Data Cable

Default Parameters

The default transmit/receive protocol is 9600 baud, eight data bits, no parity, and one stop bit (8N1). When you first establish communications with the Sensor, your communications interface must use this protocol.

The baud rate of the serial ports is adjustable using the **$PASHS,SPD** (speed) set command, as described in Chapter 4, **Command Response Formats**; the data bit, stop bit and parity protocol is always 8N1.

On initial power-up or after an internal reset, or after using the reset plug, the Sensor default is 9600 baud for all three RS-232 serial ports A, B, and C.

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

To resume communication after changing the baud rate using the **$PASHS,SPD** set command, you must change the baud rate of the command device.

Data Output Options

All the default data output commands are set to OFF. The Sensor will not output any data until you send a message commanding it to do so. Refer to “$PASHS,OUT” on page 87 for more information.

Configuration Defaults

To determine whether the Sensor has the Q option installed, refer to Table 1.3 on page 6. Table 2.4 lists the default settings for the Sensor operating configuration.

Table 2.4: Operating Configuration Defaults

Parameter	Without Q Option *	With Q Option *
NAV cycle	1	0.5
Data recording interval	20	0.5
NMEA output interval	5	0.5
DBEN data output interval	1	1
***Units of measure are in seconds.**		

Getting Started

Hardware Setup

Perform the following steps to connect all cables to the Z-12 Real-Time Sensor. Figure 2.6 shows the Sensor cables and their destinations.

1. Connect the RF cable from the GPS antenna to the RF connector on the front of the Sensor. Refer to “RF Connector” on page 9 for more information.
2. Connect necessary serial cables to the serial ports on the front of the Sensor.

   For more information concerning which port to attach the serial cable (dependent on the data you need), refer to “Serial Port Configuration” on page 11.

   For example, to interface between a PC and the Sensor, connect the supplied cable from the PC’s COM port to port A on the Sensor.
3. Connect the power cable from the power source to one of the power connectors on the front of the Sensor. Refer to “Power Input Connections” on page 10 for more information.

The Sensor incorporates two parallel PWR connectors. If the Sensor is operating from a single battery and the battery is approaching discharge, you are at risk of losing data. The second connector allows you to connect a second (fresh) battery to the Sensor before disconnecting the first

battery, thus maintaining data integrity. You can also operate the Sensor from two parallel batteries for longer sessions.

If operating from a 110-120 volt AC power source, connect the power supply to one of the PWR connectors on the Sensor using the supplied power cable. Plug the power supply into the 110-120 volt AC source. If operating in the field from a battery, connect the battery to one of the PWR connectors on the Sensor using the supplied power cable; the white wire on the power cable connects to the + terminal of the battery, the black wire connects to the - terminal of the battery. There are two power connectors in parallel to allow for redundancy when using the Sensor. Should you have two power sources and two power cables, connect both to allow extended operational time.

The Sensor is internally protected in case the battery connections are unintentionally reversed.

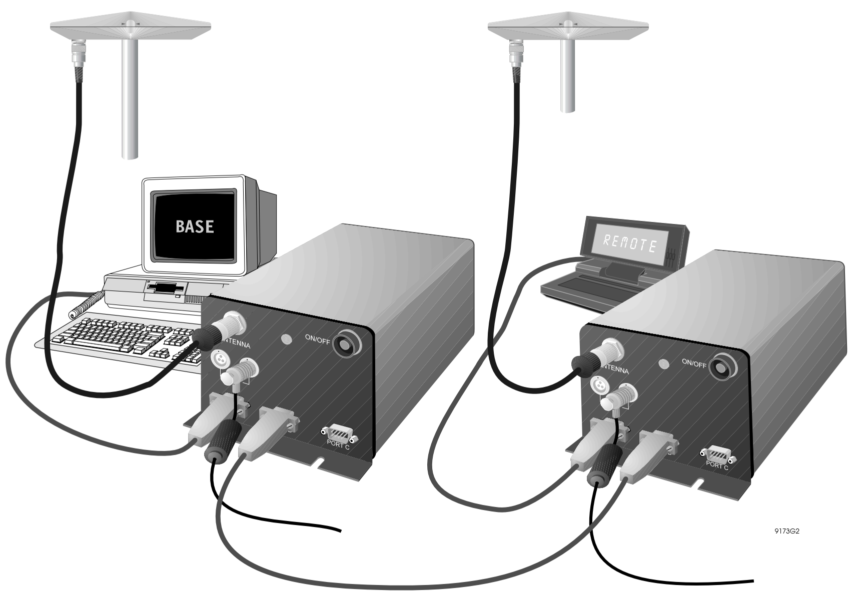

Figure 2.6: Equipment cable connections in Differential Setup

Powering On the Sensor

1. After Sensor has been properly cabled, press the **On/Off** button to apply power.

Receiver Memory Reset

2. It is good practice to reset the Sensor to its factory defaults prior to operating it for the first time or when a system malfunction occurs. A reset of the internal memory clears the memory and restores the factory defaults. You can reset the Sensor internally using the reset plug supplied with the Sensor, or externally by issuing a command to the Sensor with an IBM-compatible personal computer (PC).

   Reset Using Plug—With the Sensor off, insert the reset plug into the port C connector. Turn on the Sensor, leave the plug in the connector at least three seconds (LED will flash green quickly), then remove plug. Turn the Sensor off, then back on. You have now reset the internal memory.

   Reset Using INI Command—With the Sensor off, connect a PC to port A using the supplied serial data cable. Turn on the Sensor. On the PC, type in all uppercase the command $PASHS,INI,5,5,3,0 and press ENTER. This command will reset both internal and external memory and power cycle the receiver. Refer to Chapter 4, **Command Response Formats** for more information about this command.

Communication with the Sensor

Most standard commercial communications software packages are suitable for this purpose, such as **TERMINAL** in Windows, **PROCOMM**, etc. The program **REMOTE.EXE** provided by Ashtech is a DOS PC communication program similar to **PROCOMM**.

3. Two kinds of commands are used to control the Sensor: SET and QUERY. The SET commands **change** the receiver operating parameters, and begin with the header $PASHS. The QUERY commands **display** receiver operating parameters, operating status, solutions, and raw data, and begin with the header $PASHQ. These commands are presented to the Sensor through a cable from an external device such as a PC.

   After setting up the serial interface as described above, you are ready to send commands to the Sensor. The letters in your command must be typed in **ALL UPPER CASE** and completed with **<Enter> (**or **<CR>(Hex 0D)<LF>(Hex 0A)** as applicable for the external device).

4. For example, type in **$PASHQ,PRT**. If you have typed in and sent the command correctly, you should get an immediate response on the display of the external device

   The response message typically might be:

   $PASHR,PRT,A,5

   This message indicates that the Sensor port A is using its default communications setup 5 (9600 baud, eight data bits, no parity, and one stop bit).

   For a set command, which always begins with the header $PASHS, the default acknowledge indication is **hex 06** for a recognized command, and the default not-acknowledge indication is **hex 15** for an unrecognized command.

5. To change the response to a complete message, send **$PASHS,CACK,0**.

   For information about the Sensor response, refer to “$PASHS,CACK” on page 55.

Monitoring Satellite Tracking

For the following operations, the Sensor must be connected to a GPS antenna, and at least four satellites must be tracked.

6. After connecting the Sensor to an antenna which has a clear view of the sky, the Sensor should track satellites. When the Sensor is tracking satellites, the LED on the front panel flashes green for each satellite. For example, if the LED flashes green five times between red flashes, five satellites are being tracked.

7. Type **$PASHQ,STA** and press <**Enter**> or <**CR**><**LF**>. This command queries which satellites are locked and their signal strength at the time the command is sent.

   The response message typically might be:

```
TIME: 20:09:36 UTC
LOCKED:  01 31 03 21 26 17 23 09 28
C/A S/N: 54 27 92 99 12 51 75 16 88
P1  S/N: 38 15 99 99 03 41 86 05 51
P2  S/N: 37 15 99 99 03 39 85 05 40
```

Monitoring Position

8. If interfacing through port A, type in capital letters:

   $PASHS,OUT,A,NMEA
   $PASHS,NME,PER,1.0
   $PASHS,NME,GGA,A,ON

Ensure you enter these commands. The first command enables NMEA output port A while the third one tells the Sensor to return GGA information through port A. The second one tells the NMEA output rate every 1.0 sec. For more information about these commands, refer to Chapter 4, Command Response Formats.

The response message is in NMEA 083 format with the structure:

```
$GPGGA,hhmmss.ss,ddmm.mmmmmm,s,dddmm.mmmmmm,s,n,
qq,pp.p,±hhhhh.hhh,M,,M,dd.ll,ssss
```

where the fields are as defined in Table 2.5.

Table 2.5: GGA Response Message Structure

Field	Significance
hhmmss.ss	Current UTC time of position computation in hours, minutes and seconds.
ddmm.mmmmmm	Latitude component of position, in degrees, minutes and fraction of minutes.
s	GPS latitude N = North, S = South.
dddmm.mmmmmm	GPS longitude in degrees, minutes and fraction of minutes.
s	Longitude direction: E = east W = west
n	GPS position quality indicator n = 0 - GPS solution is not available n = 1 - GPS autonomous position is available n = 2 - RTCM differential or CPD differential available, solution accuracy at submeter level n = 3 - CPD differential available, solution accuracy at centimeter level
qq	Number of SVs used in position computation 1 through 12
pp.p	HDOP - horizontal dilution of precision 00.0 through 99.9
±hhhhh.hhh	Antenna height above WGS84 ellipsoid -1000 through +18000
M	Meters
dd	(Differential only) Data link age of differential GPS data 0 through 99 seconds
.lll	(CPD Differential only) If in carrier phase differential (CPD) rover mode, the decimal is the solution latency in seconds. The field stays at 0.999 if the latency is greater than 0.999. 0.0 through 0.999 milliseconds.
ssss	Differential reference station ID (STID), 4-character string

To change the output rate, issue the command $PASHS,NME,PER,*x* where *x* is the output rate in seconds.

Example: GGA message, Autonomous Position

```
$GPGGA,015454.00,3723.285136,N,12202.238517,W,1,08,01.0,+00012.
384,M,,M,,0000
```

Example: GGA message, RTCM differential

```
$GPGGA,015454.00,3723.285136,N,12202.238517,W,2,08,01.0,+00012.
384,M,,M,002,0000
```

Example: GGA message, CPD differential (RTCM-RTK or DBEN)

```
$GPGGA,015454.00,3723.285136,N,12202.238517,W,3,08,01.0,+00012.
384,M,,M,00.123,0000
```

9. To stop GGA output, issue the command **$PASHS,OUT,A.**
10. To obtain additional setup information type **$PASHQ,PAR** and **$PASHQ,RAW**.

Operation

Differential Setup

Differential operation is the major application of the Sensor. The Z-12 Real-time Sensor provides the capability of real-time carrier phase differential (CPD), also known as Real-Time Kinematic (RTK), in addition to the conventional RTCM pseudo-range differential. This feature makes the Sensor ideal for navigation and machine control, precision surveying, and extremely accurate positioning. The Sensor produces the ultimate real-time precision: sub-centimeter accuracy under ideal conditions. Coupled with the quick position update option, the Sensor can output solutions at 1Hz, 2Hz, or 5Hz. All of these high-speed position updates are new, independent solutions with extremely low latency, typically 100 to 125 milliseconds.

This section provides a step-by-step guide for the following three different differential operations:

- Carrier phase differential (CPD)—Ashtech proprietary DBEN message
- Carrier phase differential (CPD)—RTCM-RTK type 18/19 message
- RTCM pseudo-range differential—RTCM type 1 message

Hard-wired data link

Differential operation requires a base station and a remote (rover) station. A radio is normally used for the data link between base and remote stations. However, for this instruction, the simplest and most reliable method for getting started is to use a hard-wired RS-232 data link consisting of a null modem cable. This supplied serial data cable serves this purpose.

Hardware Setup

In the following setup, port B for both base Sensor and rover Sensor will be used for differential data link, while port A will be used for connecting to a PC and Sensor serial control.

1. Connect all the cables for the base Sensor and the rover Sensor as described in "Hardware Setup" on page 14.
2. Connect the port B of both base Sensor and the rover Sensor with provided serial cable.

   A typical differential system is depicted in Figure 2.6.

In this manual, the word "remote" or "rover" share the same meaning. They are often used interchangeably.

Entering Base Station Coordinates

This is a common procedure for any base station setup. The coordinates can be entered at any mode, even if the Sensor is not configured in the RTCM base or CPD base mode.

When operating the system in RTCM message format, the base station coordinates must be entered as the antenna phase center position. While operating the system in CPD DBEN message format, the base station coordinates can be entered either as the antenna phase center position and zeros out all the antenna offset parameters, or one can enter the base station coordinates of the ground mark and enter proper antenna offset parameters.

Entering Known Coordinates

If you know the WGS-84 coordinates where the base station antenna is located, enter the latitude, longitude, and the ellipsoidal height via the following commands.

$PASHS,POS,3722.3882335,N,12159.8353120,W,-5.1238.

To verify the entered coordinates, type $PASHQ,POS, the Sensor will response

$PASHR,POS,3722.3882335,N,12159.8353120,W,-5.1238*33

Or you can set each latitude, longitude, or ellipsoidal height via $PASHS,LAT, $PASHS,LON, $PASHS,ALT, respectively. Refer to Chapter 4, Command Response Formats for more detail.

What if the Base Coordinates are Unknown?

If you do not know the base station coordinates, you can use the current autonomous position as the base station coordinates.

1. Verify the base Sensor tracks at least five satellites (use $PASHQ,STA).
2. Verify the base Sensor's autonomous position via $PASHQ,PBN or GGA message as described in "Monitoring Position" on page 17. Ensure also the DOP is less than 5.
3. Send $PASHS,CPD,ENT command to the base Sensor. The autonomous position at the time the $PASHS,CPD,ENT command received will be used as the base station coordinates.
4. Send $PASHQ,POS command to verify the coordinates.

If you enter the base station coordinates this way, any rover using differential data from the base station can still compute very accurate positions up to centimeter level, relative to the base station. But the absolute accuracy will only be as accurate as the accuracy of the autonomous position in the base station.

CPD with DBEN message

Examine the following items prior to conducting a software setup.

1. The hardware setup is complete and correct
2. All parameters are assumed to be at the factory default settings. Refer to "Receiver Memory Reset" on page 16 on how to reset the parameters to the factory defaults.
3. Check both Sensor have the real-time Z (J) option installed. For information on how to verify this option, refer to "Optional Features" on page 5.

   Refer to Chapter 4, **Command Response Formats** for a detailed explanation of the serial commands.

Base Setup

1. Power on the base Sensor.
2. Monitor the satellite tracking and the autonomous position as described in "Getting Started" on page 14.
3. Enter and verify the base coordinates as described in "Entering Base Station Coordinates" on page 20.

4. If applicable, measure and enter the antenna offset parameters: slant, radius, vertical offset, and horizontal offsets in distance and azimuth. For example, to set antenna slant to 5 meters,

   $PASHS,ANH,5.0

   A typical command to set antenna offset parameters could be

   $PASHS,ANT,1.678,0.1737,0.5,0000.00,0.0

   To query current antenna parameters:

   $PASHQ,ANT

   The response would be

   $PASHR,ANT,1.67880,0.1737,00.5000,00000.00,00.0000*12

5. Enter the base station site ID. For example:

   $PASHS,SIT,BASE

6. Send the following commands to the base Sensor

   a. $PASHS,CPD,MOD,BAS

      Sets the Sensor into CPD base mode

If the Sensor begins to emit an audible beep, the position has not been entered yet.

   b. $PASHS,CPD,PRT,B (optional)

      Sets the DBEN output on port B.

   c. $PASHS,CPD,PED,s, (optional) where s is the interval in seconds

      Sets the DBEN output interval other than default every one second

7. To verify the setup, send $PASHQ,CPD command to the Sensor. A typical response message would be

```
STATUS:
    MSMOD:01 Hz           MODE: BASE               BASE STAT: 00000
    PRN: 01 03 09 17 21 23 28 31
    AGE: 0000 ms          RCVD CORD:01.0 SEC  CORD USED: RECEIVED
    AMBIGUITY:            RCV INTVL:01.0 SEC
    Dlf:00000 ms          Tf: 00000 ms  DLc:00000    ms Tc:00000 ms
SETUP:
    DBEN PER: 001.0 SEC   DBEN PORT:B              EOT:CRLF
    AMBIGUITY FIX MODE: 04
    DYNAMICS: WALKING DYNAMIC                  POS OUTPUT: CPD
    MULTIPATH: MEDIUM MULTIPATH                BAS POS USED:XMITED
    FAST CPD: ON          CPD PER: 01 SEC
```

8. To save the above setup so it can be automatically recovered after power loss, issue the command $PASHS,SAV.

9. The base Sensor is now operational. To verify it, connect port B to a PC at 9600 BAUD which is running a communication program, such as Ashtech's REMOTE.EXE, one should see message starts with a header $PASHR,RPC would output on a one second interval.

Rover/Remote Setup

1. Power on the rover Sensor.
2. Monitor the satellite tracking and the autonomous position as described in "Getting Started" on page 14.
3. Make sure the base Sensor and the rover Sensor is connected as shown in Figure 2.6.
4. Send the following commands to the base Sensor

   $PASHS,CPD,MOD,ROV - to set the Sensor into CPD rover mode
5. To verify the setup, send $PASHQ,CPD command to the Sensor. A typical response message would be

```
STATUS:
    MSMOD:01 Hz            MODE: ROVER              BASE STAT: 00000
    PRN: 01 03 09 17 21 23 28 31
    AGE: 394 ms            RCVD CORD:008 SEC  CORD USED: RECEIVED
    AMBIGUITY:FIXED        RCV INTVL:01.0 SEC
    Dlf:00086 ms           Tf: 00029 ms  DLc:00513    ms Tc:00400 ms
SETUP:
    DBEN PER: 001.0 SEC    DBEN PORT:B              EOT:CRLF
    AMBIGUITY FIX MODE: 04
    DYNAMICS: WALKING DYNAMIC            POS OUTPUT: CPD
    MULTIPATH: MEDIUM MULTIPATH          BAS POS USED:RECEIVED
    FAST CPD: ON           CPD PER: 01 SEC
```

6. To save the above setup so it can be automatically recovered after power loss, issue the command $PASHS,SAV.
7. The rover Sensor is now operational. Refer to "Monitoring Position" on page 17 for more information on position information.

   A typical GGA message with fixed ambiguities would be

```
$GPGGA,015454.00,3723.285136,N,12202.238517,W,3,08,01.0,+00012.
384,M,,M,00.123,0000
```

RTCM Differential Setup

A Sensor configured as an RTCM base station can generate up to seven RTCM message types, all of which conform to version 2.2 standards as listed in Table 2.6. A Sensor configured as a rover can accept all seven RTCM messages from a Sensor base station, plus the Type 9 message widely used in marine navigation. Additionally, the Sensor can even take advantage of RTCM-compliant messages from receivers manufactured by other companies (such as the Trimble 4000SSi™). This design provides the versatility and performance necessary to complete any job requiring precision solutions.

Table 2.6: RTCM Message Types

Message Type	Contents of Message
1	Differential GPS corrections
2	Delta differential corrections
3	Reference station parameters
6	No parameters, used as transmission fill (null frame)
9	High-rate differential corrections
16	Special message
18	Uncorrected carrier phase
19	Uncorrected pseudo-range

The Sensor allows you to select any of three RTCM differential modes, as listed in Table 2.7. The first mode uses Type 1 RTCM messages and provides solution accuracies of better than one meter. The second mode uses Type 18/19 messages and provides centimeter and sub-centimeter accuracy. A Sensor base and a Sensor rover can easily be configured to operate in these modes. The third mode requires Type 9 messages to be sent to the rover. An Ashtech reference station or other broadcast source is required for this operation. You can expect sub-meter accuracy from a Sensor configured to receive Type 9 messages.

Table 2.7: Differential RTCM Message Types

Mode	Message Type	Send	Receive	Description	Expected Accuracy
1	Type 1	Yes	Yes	Code phase	Less than 1 meter
2	Type 18/19A*	Yes	Yes	Uncorrected carrier phase and pseudo-range measurements	1 cm horizontal, 2 cm vertical†
	Type 18/19B‡	Yes	Yes	Uncorrected carrier phase and pseudo-range measurements	1 cm horizontal, 2 cm vertical†
3	Type 9	No	Yes	Code phase	Less than 1 meter

Table 2.7: Differential RTCM Message Types (continued)

Mode	Message Type	Send	Receive	Description	Expected Accuracy
* Type 18/19A is for Ashtech-to-Ashtech operation. † Choke ring antenna, short baseline, 1 Hz, fast CPD off ‡ Type 18/19B is for Ashtech-to-Trimble operation.					

CAUTION

Be aware that once RTCM base or rover mode is selected on a given port, all set and query command to that port will be ignored. As a general practice, always use one port to set another port as RTCM differential port. For example, use port A to set port B, and vice versa.

CPD with RTCM-RTK type 18/19 message

Perform the following checklist prior to software setup.

1. The hardware setup is complete and correct
2. All parameters are assumed to be at the factory default settings. Refer to "Receiver Memory Reset" on page 16 on how to reset the parameters to the factory defaults.
3. Check the options in the Sensor against the following:
   - Base—'J' Real-time Z and 'D' Differential options
   - Rover—'J' Real-time Z and ('D' Differential or 'U' Differential Remote option)

Refer to "Optional Features" on page 5 for information on how to verify these options. Refer to Chapter 4, **Command Response Formats** for a detailed explanation of the serial commands.

Base Setup

1. Power on the base Sensor.
2. Monitoring the satellite tracking and the autonomous position as previously section
3. Enter and verify the base coordinate as described in section Entering Base Station Coordinates. Note the coordinates should be corrected for any antenna phase center offsets, if applicable.
4. Send the following commands to the base Sensor
   a. $PASHS,RTC,BAS,B

      Configures the Sensor into RTCM base mode and uses port B for output differential message.

b. $PASHS,RTC,SPD,9

   Selects burst mode to output RTCM message.

c. $PASHS,RTC,TYP,1,1

   Selects Type 1 every second

d. $PASHS,RTC,TYP,2,0

   Disables Type 2

e. $PASHS,RTC,TYP,3,1

   Selects Type 3 every minute

f. $PASHS,RTC,TYP,6,OFF

   Disables Type 6

g. $PASHS,RTC,TYP,16,0

   Disables Type 16

h. $PASHS,RTC,TYP,18,1

   Selects Type 18/19 every second

5. To verify the setup, send $PASHQ,RTC command to the Sensor. A typical response message would be

```
STATUS:
       SYNC:          TYPE:18       STID:0000     STHE:0
       AGE:0000       QA:100.00%    OFFSET:00
SETUP:
       MODE:BASE      PORT:B        AUT:OFF
       SPD:0000       STI:0000      STH:00
       MAC:0060       QAF:100       SEQ:N
       TYP:1          2      3      6      16     18/19A  EOT
       FRQ:01         00     01     OFF    00     01    CRLF
MSG:
```

6. To save the above setup so it can be automatically recovered after power loss, issue the command $PASHS,SAV.

7. The base Sensor is now operational.

   To verify it, connect the port B to a PC at 9600 BAUD which is running a communication program, such as Ashtech's REMOTE.EXE, one should see RTCM message output on a one second interval.

Rover/Remote Setup

1. Power on the rover Sensor.

2. Monitor the satellite tracking and the autonomous position as described in "Getting Started" on page 14.

3. Make sure the base Sensor and the rover Sensor is connected.
4. Send the following command:

   $PASHS,RTC,REM,B - to set the Sensor into RTCM remote mode, and using port B to receive RTCM differential message.
5. Send the following command

   $PASHS,CPD,MOD,ROV - to set the Sensor into CPD rover mode
6. To verify the setup, send $PASHQ,RTC and $PASHQ,CPD commands.
7. To save the above setup so it can be automatically recovered after power loss, issue the command $PASHS,SAV.
8. The rover Sensor is now operational. Refer to “Monitoring Position” on page 17 for more information on position information.

   A typical GGA message with fixed ambiguities would be

   ```
   $GPGGA,015454.00,3723.285136,N,12202.238517,W,3,08,01.0,+00012.
   384,M,,M,00.123,0000
   ```

RTCM differential (pseudo-range) with type 1 message

Perform the following checklist prior to software setup.

1. The hardware setup is complete and correct.
2. All parameters are assumed to be at the factory default settings. Refer to “Receiver Memory Reset” on page 16 on how to reset the parameters to the factory defaults.
3. Check the options in the Sensor
   - Base—‘D’ Differential option
   - Rover—‘D’ Differential option or ‘U’ Differential Remote option

   Refer to “Optional Features” on page 5 for information on how to verify these options. Refer to Chapter 4, **Command Response Formats** for a detailed explanation of the serial commands.

Base Setup

1. Power on the base Sensor.
2. Monitoring the satellite tracking and the autonomous position as described in “Getting Started” on page 14.
3. Enter and verify the base coordinate as described in section Entering Base Station Coordinates. Note the coordinates should be corrected for any antenna phase center offsets, if applicable.

4. Send the following commands to the base Sensor

   $PASHS,RTC,BAS,B

   Configures the Sensor into RTCM base mode and use port B for output differential message.

   $PASHS,RTC,SPD,7

   Selects the 300 bit-per-second speed to output RTCM message.

   By default the type 1 message will be output continuously to port B.

5. To verify the setup, send $PASHQ,RTC command to the Sensor. A typical response message would be

```
STATUS:
       SYNC:          TYPE:00        STID:0000      STHE:0
       AGE:0000       QA:100.00%     OFFSET:00
SETUP:
       MODE:BASE      PORT:B         AUT:OFF
       SPD:0300       STI:0000       STH:00
       MAC:0060       QAF:100        SEQ:N
       TYP:1          2       3      6       16     18/19A  EOT
       FRQ:99         00      00     ON      00     00    CRLF
MSG:
```

6. To save the above setup so it can be automatically recovered after power loss, issue the command $PASHS,SAV.

7. The base Sensor is now operational. To verify it, connect the port B to a PC at 9600 BAUD which is running a communication program, such as Ashtech's REMOTE.EXE, one should see RTCM message output continuously

Rover/Remote Setup

1. Power on the rover Sensor.
2. Monitoring the satellite tracking and the autonomous position as described in "Getting Started" on page 14.
3. Make sure the base Sensor and the rover Sensor is connected.
4. Send the following command:

   $PASHS,RTC,REM,B - to set the Sensor into RTCM remote mode, and using port B to receive RTCM differential message.

5. To verify the setup, send $PASHQ,RTC command.
6. To save the above setup so it can be automatically recovered after power loss, issue the command $PASHS,SAV.

7. The rover Sensor is now operational. Refer to “Monitoring Position” on page 17 for more information on position information.

   A typical GGA message with fixed ambiguities would be

   ```
   $GPGGA,015454.00,3723.285136,N,12202.238517,W,2,08,01.0,+00012.
   384,M,,M,002,0000
   ```

Position Update Rate Configuration

In order to configure the Sensor into 1Hz, 2Hz, or 5Hz position update rate, a quick position update (Q) option must in installed in the rover Sensor. To change the position update rate, issue

$PASHS,MSMOD,x.x

where

Table 2.8: MSMOD data description

x.x (second)	Description	Default Data Record/ Real-time output Interval (second)	Default NMEA output interval (second)
1.0	1Hz position update rate	20.0	5.0
0.5	2Hz position update rate	0.5	0.5
0.2	5Hz position update rate	0.2	0.2

Having received this command, the Sensor will automatically cycle power and reset the above parameters. Always clear the receiver memory after this command to ensure proper operation.

CAUTION

When using the Sensor as a base, always set the update rate to 1Hz. Failure to do this will result in a system malfunction.

Understanding CPD

This chapter provides CPD operation in more detail by describing monitoring the CPD solution, solution output and storage, trouble shooting and performance optimization. RTCM reference station setup is also described briefly.

For detailed information on the commands and responses that are mentioned in this chapter, please refer to Chapter 4, **Command Response Formats**.

Monitoring the CPD Rover Solution

When a sensor is set to CPD rover mode, you can monitor the current CPD solution status and positions with the following commands:

- $PASHQ,CPD—shows the CPD setup in a tabulated format
- $PASHQ,CPD,MOD—shows the CPD setup in a $PASHR format
- $PASHQ,CPD,INF—shows the satellite information in CPD operation
- $PASHQ,CPD,STS—shows the current ambiguities fixing status
- $PASHQ,RRE—shows the post-fit carrier phase residual in CPD solution

Positions can be also monitored from GGA message or CBN message.

How to tell if the integer ambiguities are fixed?

The ambiguities fixing status can be determined through the following messages:

- STS
- GGA
- CBN
- CPD

In $PASHR,CPD,STS message. if the second field > 1.0, it means that the ambiguities are fixed. For example,

$PASHR,CPD,STS,0.005,**0124.72***5C

In $GPGGA message, a solution type of “3” in the sixth field indicates that ambiguities are fixed.

$GPGGA,212349.00,3722.378424,N,12159.841801,W,**3**,08,01.0,-00005.078,M,M,00.138

In ASCII $PASHR,CBN message, a “1” in the third digit of the solution type field indicates the ambiguities are fixed.

$PASHR,CBN,212501.00,????,08,001.2,3722.3784261,N,12159.8417992,W,-00005.0847, 00.011,00.011,00.012,-00.000,+00.000,-00.000,**221001**,+000.000,-000.001,+000.001, 00.000,00.000,00.000*6C

In a CBEN message, the solution RMS values represent one-sigma solution accuracy. A fixed ambiguity solution should have all three RMS values < 0.03 meters, with PDOP < 4.0.

You can also look at the $PASHR,CPD message for ambiguities fixing status. Refer to "$PASHQ,CPD" on page 144.

Solution Latency

The GGA message contains a field which shows the solution latency. For example:

$GPGGA,015454.00,3723.285136,N,12202.238517,W,3,08,01.0,+00012.384,M,,M,**00.123**,0000

The latency in this example is about 120 milliseconds.

Data Link Monitor

The Data Link Status can be monitored via $PASHQ,CPD,DLK message. Pay special attention to the SV list and QA. Refer to "$PASHQ,CPD,DLK" on page 134 $PASHR,CPD,DLK in Chapter 3.

CPD Solution Output and Storage

The raw GPS measurements, autonomous position, RTCM positions, or CPD solutions can be outputted to the serial port for monitoring and logging. If a RZ sensor has external memory, this data can be stored into the receiver's memory as well as downloaded to a PC.

Real-time Solution Output

The CPD rover position, velocity and other solution information can be output via the receiver's serial port, in PBEN /CBEN message format or NMEA message format. The PBEN /CBEN message output rate is controlled via the $PASHS,RCI,x.xx command.

If you want the B-file to have autonomous position, use command $PASHS,CPD,OUT command to change it.

The CBEN message can provide more complete information on position, velocity, solution status, position RMS and covariance, number of satellites, and PDOP. The CBEN message output can be in ASCII or binary format. The binary format is bitwise packed and is not IEEE format compatible.

To output the PBEN and/or CBEN message, use the $PASHS,OUT command.

To output the NMEA messages, use the $PASHS,OUT and $PASHS,NME commands.

If for any reason the CPD solution cannot be computed for an epoch, there will be no CPD solution output for that epoch in any real-time or NMEA message.

Other solution messages are also available for query, and not to output periodically like PBEN or CBEN messages. These messages are UBN and OBN. The UBN message gives CPD position, velocity, and statistical information in binary format. The OBN message gives CPD vector and site information in binary format.

Vector Solution Output

This capability allows you to log vector solutions containing the same information as post-processed vector output files (O-file), allowing the position solutions to be imported into an adjustment program. Your Real-time Z solutions may then be included as part of a least-squares network adjustment.

To use this option, a valid site name must be entered (check by using the $PASHQ,RAW command), and the rover's GPS antenna must remain stationary until the site name has been changed to "????." If the GPS antenna is moving with a site name entered, the vector solution will not be valid. If no site name is entered, the vector solution will not be created. Note that a site name must be entered at the base station as well.

Other Ashtech Real-time Z products, such as GPSTopo, with software running on a handheld datalogger automate this process, but it may be performed in the basic Real-Time Sensor system using the following procedure:

1. Check the solution, as described in "Monitoring the CPD Rover Solution" on page 31, to ensure that the current accuracy meets your requirements.
2. Place the antenna over the point to be measured.
3. Issue the following serial commands to the receiver using Ashtech's **REMOTE.EXE** program or a similar serial communication:

   $PASHS,CPD,DYN,0

   $PASHS,CPD,FST,OFF

   $PASHS,SIT,xxxx (where xxxx is the site name you wish to use other than ????)

   These three commands set rover motion dynamics to static, turn Fast CPD off, and set a site name.

4. To improve the vector solution, you may wait for 5-10 epochs of data before issuing the next set of commands:

    $PASHS,SIT,????

    $PASHS,CPD,FST,ON

    $PASHS,CPD,DYN,2

    These three commands reset the unit for dynamic operation. The receiver will beep twice, indicating that the vector solution has been created.
5. Wait for more than two seconds, and then enter the next command to log the solution to the OBEN file:

    $PASHQ,OBN
6. Verify the site name in the vector solution. If it does not match, query again.
7. You can move the GPS antenna to the next site.

Solution Storage

If your sensor has external memory, you can store the raw measurements and the solution information into the receiver's memory. These data can then be downloaded to a PC into B, E, and S file format via Ashtech's **GPPS-HOSE** or **PRISM-TRANSFER** programs at a later time.

- To create/delete files, use $PASHS,FIL command.
- To select file storage type, use $PASHS,RNG command.
- To check the memory usage, use $PASHQ,FCRS or $PASHQ,FLS command.
- To verify the data recording setup, use $PASHQ,RAW and $PASHQ,PAR command.

When setting up a sensor to store solutions, pay special attention to the following items:

- Recording interval
- Minimum number of SV
- Elevation mask
- Ranger mode type
- Recording is set to Yes
- Site name

Since CPD is a differential operation, a solution may not be available if the differential data link is lost. However, the receiver will always store the raw measurements whether the CPD solution is available or not. When the CPD solution is not available, the position computed by the raw pseudo-ranges, or the autonomous position, will be stored instead.

Information in CBEN, OBEN, and UBEN cannot be stored in Sensor memory.

Troubleshooting

The following problems are sometimes encountered by users new to Z-12 Real-Time Sensor. If your system isn't working properly, please refer to this list. If you need further assistance, please call an Ashtech customer service representative.

Table 3.1: Troubleshooting Tips

Symptom	Action
LED displays constant amber	Indicates the system is not operating. Try to clear internal/external memory with $PASH,INI. Should symptom persist, contact Customer Support
PC cannot communicate with Sensor	• Verify cable connections. • Verify communication BAUD rate and communication software setting. • If symptom persists, clear internal memory with $PASHS,INI. • If symptom persists, cycle power.
Sensor not in CPD Rover mode	• Verify the Sensor is capable of Real-Time Z operation (refer to "Specifications and Options" on page 5 for J option). • Verify the Sensor is in Rover mode with $PASHQ,CPD.
$PASHQ,CPD,DLK has no information	• Verify that the receiver is in CPD base mode or in CPD rover mode. • Verify that the antenna connection is connected to the GPS antenna. The GPS antenna must be mounted outdoors, with a clear view of the sky. Nearby buildings and vegetation can block the GPS signals or introduce multipath by reflecting the GPS signals. • Verify the sensor is computing autonomous position properly. • In the base sensor Verify the entered base station coordinates as well, as described in next trouble shooting • In the rover sensor, verify the data link between the base and rover/remote. In case of hardwired data link between receivers from different vendors, check the hardware handshaking in the RS-232 connection.
Base beeps	• The entered coordinates differ from the computed coordinates by more than 500 meters. • Verify the sensor is computing autonomous position properly. • Verify and re-enter the coordinates or enter the raw position as the base coordinates as described in "Base Position Coordinates Selection: $PASHS,CPD,UBS" on page 40.

Table 3.1: Troubleshooting Tips

Symptom	Action
No CPD solution	• Verify that there are at least four common satellites between the base and the rover, using $PASHQ,CPD,INF command. • Verify that base station coordinates have been received in the rover side, using $PASHQ,CPD,POS command. If the coordinates are not being received, make sure the base is sending them periodically, using $PASHQ,CPD,MOD command or $PASHQ,RTC command. Or you can entered the base station coordinates in the rover side, using $PASHS,CPD,POS command.
CPD solution is intermittent and the Rover beeps	• Monitor the data link quality, using the $PASHQ,CPD,DLK command. The QA number should be 90% or higher. • Verify that fast CPD is turned on, using $PASHQ,CPD or $PASHQ,CPD,MOD command. • Verify the rover antenna has clear view to the sky and is tracking satellite properly.
Cannot get fixed CPD solution	• Verify using $PASHQ,CPD,INF command that at least 5 SVs are being tracked for P1 and P2. • Verify that the number of satellites common between the base and rover is 5 or more. Even if 5 or more satellites are tracked, you still may not get a fixed solution at locations with severe multipath. • Move away from the obstruction if possible. Issue $PASHS,CPD,RST command to reinitialize the CPD operation.
CPD solutions are not being stored in the Rover	• Verify that RAM board is installed. • Verify that $PASHQ,CPD,OUT is selected to output CPD solution. • Verify that RECORD is set to Y in $PASHR,RAW message. • Verify there are still memory avaialable.Verify the record interval.
Cannot get the CPD solution output in real-time	• Make sure the communication BAUD rate is correct. In RTCM operation, the sensor port is not being set to RTCM base or REMOTE. • Verify the output selection, using $PASHQ,RAW and $PASHQ,PAR commands.

CPD Solution Parameters

Table 3.2 lists the commands which are provided for optimizing the CPD operations.

Table 3.2: CPD optimization commands

Command	Description
$PASHS,CPD,AFP	Selects the ambiguity fixing parameters
$PASHS,CPD,DYN	Changes the Rover dynamics
$PASHS,CPD,FST	Turns on/off fast CPD operation
$PASHS,CPD,MTP	Changes the expected multipath in the system
$PASHS,CPD,PED	Changes the DBEN output interval
$PASHS,CPD,PER	Changes the CPD update interval
$PASHS,CPD,RST	Reinitializes the CPD operation
$PASHS,CPD,UBS	Selects which base station coordinates to use.

Ambiguity Fix: $PASHS,CPD,AFP

The ambiguity fixing parameter can be set to different confidence levels between 95.0 and 99.9. Higher confidence levels result in longer search times but increase the reliability of the ambiguity fixed solution.

The ambiguity fix mode can be set from 1 to 5. The default setting of 4 is recommended for most static and kinematic surveying applications. Setting the mode to 5 results in the highest reliability that the ambiguities are fixed correctly, but also results in a longer time to resolve the ambiguities and give the fixed solution. Setting the mode to 2 or 3 decreases the time to solve the ambiguities and give the fixed solution, but also increases the chances that the ambiguities are fixed incorrectly. Setting the mode to 1 results in the shortest time to resolve the ambiguities; however, mode 1 also has the highest chance (typically 2.4%) that the ambiguities are fixed incorrectly.

shows the test results for over 12,000 ambiguity fix test performed by Ashtech at various baseline lengths up to nine kilometers. These test results indicate that at the default setting (mode 4), the typical time to resolve the ambiguities is 60 seconds, with a reliability of 99.9% At the fastest setting (mode 1) the results indicate that the typical time to resolve the ambiguities is five seconds, with a reliability of 97.6%.

If the ambiguities are fixed incorrectly, the satellite geometry must change appreciably before the ambiguities will again fix correctly. For a static rover, this will happen within approximately 10 minutes, or when a new satellite is acquired.

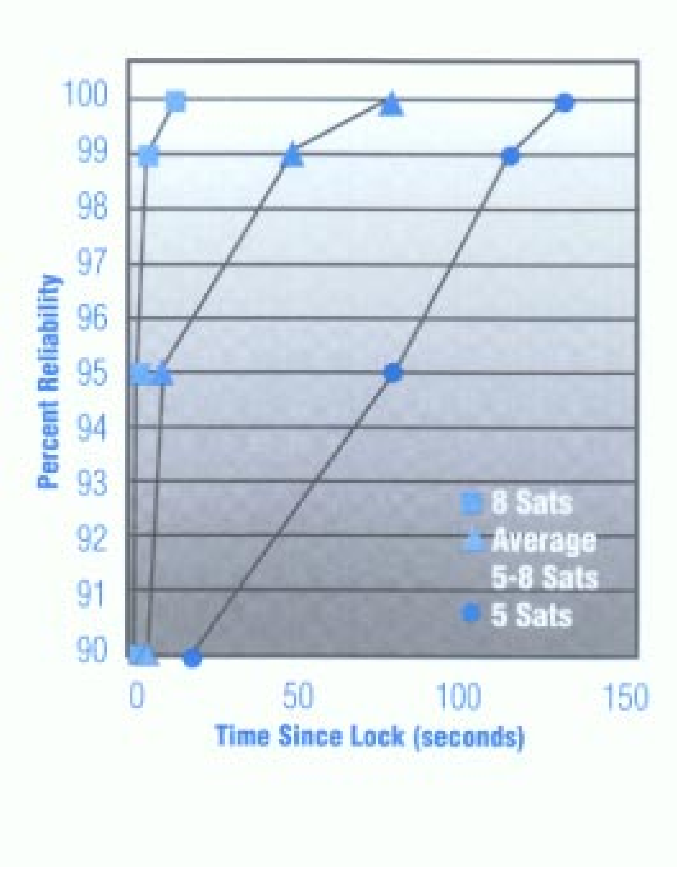

Figure 3.1: Ambiguity Fix Test Results

Dynamics: $PASHS,CPD,DYN

Select the dynamics for the fastest acceleration you expect to be moving. If the dynamics are not set properly, the CPD solution will be less accurate. Use the STATIC dynamics mode only if the antenna will remain on a solid setup such as a tripod. If the antenna is on a pole that may have some slight movement, select Q-STATIC. If you are doing stop-and-go kinematic or rapid static surveys, the WALKING (default) or AUTOMOBILE dynamic should be selected. SHIP dynamics assume limited vertical movement. AIRCRAFT dynamics assume higher speeds and accelerations.

Fast CPD: $PASHS,CPD,FST

Fast CPD off achieves the ultimate in GPS accuracy. With Fast CPD off, sub-centimeter position solution accuracy can be obtained with fixed integer ambiguities. However, it suffers from solution delay. This delay is caused by measurement and radio link delays. The measurement delay is about 1 second. Typical radio data link delays are about 1 second also. DLf and Tf are not shown in $PASHR,CPD message when Fast CPD is off.

For surveying application where accuracy has higher concern over the latency, fast CPD should be turned off, especially when collecting data for static points.

Turning Fast CPD on (default) reduces the solution delay to about 100 millisecond. Because Fast CPD cpmputes the position as soon as Rover measurement has been collected, it does not suffer from radio link delays. However, the position accuracy is only 2-3 centimeters.

Turning FAST CPD on also allows the solution to be available when there is a temporary data drop-out from the base station.

Multipath: $PASHS,CPD,MTP

Set this parameter to the expected GPS signal multipath environment according to the list below:

SEVERE	Forest, urban canyon
HIGH	Water surface, nearby buildings
MEDIUM(default)	Cropland, occasional tree or building
LOW	Flat terrain, no nearby objects
NONE	No multipath, for testing purpose only

DBEN Message Interval: $PASHS,CPD, PED and CPD Update Rate: $PASHS,CPD,PER

In some application where the data link bandwidth is not wider enough to transmit the DBEN or RTCM message at 1Hz rate, you can slow down the DBEN or RTCM output rate in the base side and slow down the CPD update rate in the rover side.

To change the DBEN message interval at the base, use $PASHS,CPD,PED command.

To change the CPD update rate between 1 and 5 seconds, using $PASHS,CPD,PER command. This will affect the CPD solution update rate when fast CPD is off, but not with the fast CPD on. The fast CPD update rate is controlled by $PASHS,MSMOD command.

It is important to set the rover's update rate to match the base's DBEN message output interval.

Initialization: $PASHS,CPD,RST

If you wish to reset the carrier phase cycle ambiguities that have been found, send $PASHS,CPD,RST command. Note that your position accuracy will temporarily degrade and you should wait until the ambiguities are fixed again before expecting centimeter accuracy.

Base Position Coordinates Selection: $PASHS,CPD,UBS

If the transmitted base position were entered incorrectly at the base, you may change this field at the rover to USE ENTERED BASE POS (with $PASHS,CPD,UBS) and then enter the correct base coordinates via $PASHS,CPD,POS command. The CPD data link status on response of $PASHQ,CPD or $PASHR,CPD,DLK message will display the RCVD CORD age as "999 SEC" when the entered page position is used.

If you are using the transmitted coordinates, which is the recommended method, you can verify the transmitted position by sending $PASHQ,CPD,POS command.

Base Station Elevation Mask: $PASHS,ELM

In the base station, set the elevation mask angle to 5 degrees to ensure the maximum coverage. In the rover, you can set a different elevation mask angle for position computation, using $PASHS,PEM command.

Universal RTCM Base Station

With the addition of RTCM type 18/19 message, a single sensor RTCM base station can

- generate type 1 or type 2 message for code differential operation for receivers with RTCM differential options, such as Z-12, RZ Sensor, G-12, GG-24, SCA-12, etc.
- generate type 18/19 message for CPD (RTK) operation in RZ Sensor or Real-Time Z-12.

This makes Z-12 Real-Time Sensor a universal RTCM reference station. All type of messages can be mixed to meet the system accuracy requirements and the radio bandwidth requirements.

Table 3.3 lists the recommended message schedules.

Table 3.3: Default RTCM message schedules

Message Type	Interval (seconds)
1	1
2	0 (off)
3	60 (1 minute)
6	0
16	Off
18/19	1

For CPD (RTK) application only, you can turn on type 3 and type 18/19 only.

For RTCM code differential only, you can turn on type 1 to be continuous and turn off all other message.

Command Response Formats

Overview

This section discusses the format and structure of the commands to and the responses from the sensor. As noted previously, an external device such as a personal computer (PC) or a handheld controller must be used to input commands to the sensor, and to monitor responses from the sensor. All commands must be terminated with <CR><LF> or <Enter>, as appropriate for the external device.

The commands and responses have the following headers:

Set commands:	$PASHS
Query commands:	$PASHQ
Response messages:	$PASHR

The commands and responses fall into the following functional categories:

General Sensor commands

Raw data

NMEA

RTCM

CPD

Table 4.1 summarizes the commands and responses. The pages following Table 4.1 describe each command/response in detail.

Table 4.1: Command Summary

Command	Description	Page
SENSOR COMMANDS		
$PASHQ,ALH	Query satellites with received almanac	52
$PASHS,ANH	Set antenna height	53
$PASHQ,ANH	Query antenna height	53
$PASHS,ANT	Set altitude of antenna, altitude hold fix	53
$PASHQ,ANT	Query antenna altitude	54
$PASHR,ANT	Response message, antenna parameters	54
$PASHS,CACK	Select character or string response to set command	55
$PASHS,CFG	Set sensor hardware configuration	55
$PASHQ,CFG	Query sensor hardware configuration	55
$PASHR,CFG	Response message, sensor hardware configuration	55
$PASHQ,CRS	Query sensor current number of files	56
$PASHR,CRS	Response message, sensor current number of files	56
$PASHS,DSC	Save string to D-file	56
$PASHS,DSY	Set up daisy-chain mode	57
$PASHS,ELM	Set elevation mask	58
$PASHS,EPG	Set static site occupation counter	58
$PASHS,FIL	Close or delete file	58
$PASHS,FIX	Set altitude-fixed mode	59
$PASHQ,FLS	Query file information	59
$PASHR,FLS	Response message, file information	60
$PASHS,HDP	Set HDOP	61
$PASHS,INI	Reset sensor memory and communication parameters	61
$PASHS,ION	Select ionospheric model	62
$PASHQ,ION	Query ionospheric information	62
$PASHR,ION	Response message, ionospheric information	62
$PASHS,LAT	Set latitude of antenna position	62
$PASHQ,LAT	Query antenna latitude	62
$PASHS,LON	Set longitude of antenna position	63
$PASHQ,LON	Query antenna longitude	63
$PASHS,MSMOD	Select CPD processing cycle time	65
$PASHS,MSV	Set minimum number of satellites	65
$PASHQ,PAR	Query NMEA message status	63
$PASHS,PDP	Set PDOP Mask	66
$PASHS,PEM	Set position elevation mask	66

Table 4.1: Command Summary (continued)

Command	Description	Page
$PASHS,PHE	Set photogrammetry edge	65
$PASHQ,PHE	Query photogrammetry edge setting	65
$PASHR,PHE	Response message, photogrammetry	65
$PASHS,PHO	Delete photogrammetry file	66
$PASHS,PJT	Log project data	66
$PASHS,PMD	Select position computation mode, RTCM or autonomous	67
$PASHS,POS	Set position of the antenna	67
$PASHQ,POS	Query position of antenna	68
$PASHR,POS	Response message, antenna position	68
$PASHQ,PRT	Query port and baud rate	69
$PASHR,PRT	Response message, port and baud rate	69
$PASHS,PWR,OFF	Set sensor to sleep (low-power) mode	69
$PASHS,RBT	Reboot sensor	70
$PASHS,RCI	Set recording interval	70
$PASHS,RDP	Set radio parameters	70
$PASHR,RDP	Response message, current radio parameters	71
$PASHS,REC	Turn data recording on/off	71
$PASHQ,RID	Query sensor (receiver) identification	71
$PASHS,RNG	Set sensor data type	72
$PASHS,RST	Reset sensor to factory defaults	72
$PASHS,RTE	Upload route information	77
$PASHS,SAV	Save current parameter settings in external RAM	77
$PASHQ,SCRN,8	Query sensor configuration	77
$PASHS,SIT	Enter site ID	78
$PASHS,SPD	Set communication baud rate	78
$PASHQ,SRD	Query elapsed time for tracked SVs since positioning began	79
$PASHR,SRD	Response message, tracked SVs elapsed time	79
$PASHQ,STA	Query status of currently locked satellites	80
$PASHS,SVM	Query SV mode selection	80
$PASHR,SVM	Response message, mode selection	80
$PASHS,UNH	Use unhealthy SVs	80
$PASHS,USE	Designate satellites to use	81
$PASHS,VDP	Set VDOP mask	81
$PASHQ,WKN	Query week number	81
$PASHR,WKN	Response message, week number	81
$PASHS,WPL	Upload waypoint to sensor	81
$PASHS,ZMD	Set sensor to Z mode	82

Table 4.1: Command Summary (continued)

Command	Description	Page
RAW DATA COMMANDS		
$PASHS,BEN	Select BEN output format	83
$PASHQ,CBN	Query CBEN message	84
$PASHR,CBN	Response message, CBEN	84
$PASHS,DSM	Enable/disable real-time output	85
$PASHQ,OBN	Query vector solution	85
$PASHR,OBN	Response message, vector solution	86
$PASHS, OUT	Enable/disable real-time data output	85
$PASHQ,PBN	Query PBEN data	88
$PASHR,PBN	Response message, PBEN ASCII data for one epoch	88
$PASHQ,RAW	Query raw data parameters	91
$PASHR,UBN	Response message, UBN	91
NMEA MESSAGE COMMANDS		
$PASHS, NME,ALL,X,OFF	Disable all NMEA messages	95
$PASHS, NME,ALM	Enable/disable NMEA almanac message	95
$GPALM	Response message, NMEA almanac	95
$PASHS, NME,APA	Enable/disable NMEA autopilot message	96
$GPAPA	Response message, NMEA autopilot	96
$PASHS, NME,BWC	Enable/disable NMEA bearing and distance	97
$GPBWC	Response message, NMEA bearing and distance	97
$PASHS, NME,DAL	Enable/disable NMEA decimal almanac message	98
$GPDAL	Response message, NMEA decimal almanac	98
$PASHS, NME,GGA	Enable/disable GGA (GPS position) message	99
$GPGGA	Response message, GGA	99
$PASHS, NME,GLL	Enable/disable NMEA latitude/longitude message	101
$GPGLL,	NMEA latitude/longitude message	101
$PASHS, NME,GRS	Enable/disable NMEA GRS (satellite range residual) message	102
$GPGRS	Response message, NMEA GRS message	103
$PASHS, NME,GSA	Enable/disable NMEA DOP and active satellite message	104
$GPGSA	Response message, NMEA DOP and active satellite	104
$PASHS, NME,GSN	Enable/disable NMEA GSN signal strength/satellite number	105
$GPGSN	Response message, NMEA GSN signal strength/satellite number	105
$PASHS, NME,GSV	Enable/disable NMEA GSV (satellites-in-view) message	106
$GPGSV	NMEA GSV (satellites-in-view) message	107
$PASHS, NME,GXP	Enable/disable NMEA GXP (position horizontal) message	108

Table 4.1: Command Summary (continued)

Command	Description	Page
$GPGXP	Response message, NMEA GXP	108
$PASHS, NME,MSG	Enable/disable NMEA MSG (RTCM) message	109
$GPMSG	Response message, NMEA MSG (RTCM)	110
$PASHS, NME,PER	Set NMEA send interval	114
$PASHS, NME,RRE	Enable/disable NMEA RRE (satellite residual and position error) message	114
$PASHQ,RRE	Query RRE (satellite residual and position error) message	114
$GPRRE	RRE (satellite residual and position error) message	114
$PASHS, NME,SAT	Enable/disable NMEA SAT (satellite status) message	116
$PASHQ,SAT	Query NMEA SAT (satellite status) message	116
$PASHR,SAT	NMEA SAT (satellite status) message	116
$PASHS, NME,TTT	Enable/disable NMEA TTT (event marker) message	117
$PASHR, NME	Response message, TTT (event marker)	118
$PASHS, NME,UTM	Enable/disable NMEA UTM (event marker) message	118
$PASHR,UTM	Response message, UTM (event marker)	119
$PASHS, NME,VTG	Enable/disable NMEA VTG (velocity/course) message	119
$GPVTG	NMEA VTG (velocity/course) message	119
$PASHS, NME,XTE	Enable/disable NMEA cross-track error message	121
$GPXTE	NMEA cross-track error message	121
RTCM COMMANDS		
$PASHS, RTC,AUT	Turn auto differential mode on/off	122
$PASHS, RTC,BAS	Set sensor as differential base station	123
$PASHQ,MSG	Query base station	123
$PASHR,MSG	Response message, last 5 messages received	123
$PASHS, RTC,COD	Select pseudo-range for RTCM differential	123
$PASHS, RTC,EOT	Select type of EOT character for RTCM message	124
$PASHS, RTC,F18	Select Ashtech- or Trimble-compatible RTCM message 18/19 format	124
$PASHS, RTC,INI	Initialize RTCM setup	124
$PASHS, RTC,MAX	Set maximum age of RTCM differential corrections	124
$PASHS, RTC,MSG	Define RTCM message	125
$PASHS, RTC,OFF	Disable differential mode	125
$PASHS, RTC,QAF	Set quality threshold	125
$PASHS, RTC,REM	Set sensor as RTCM differential remote	125
$PASHS, RTC,SEQ	Check sequence number	126
$PASHS, RTC,SPD	Set RTCM bit rate	126
$PASHS, RTC,STI	Set station identification	126

Table 4.1: Command Summary (continued)

Command	Description	Page
$PASHS, RTC,STH	Set health of reference station	127
$PASHS, RTC,TYP	Enable type of message	127
$PASHQ, RTC,	Query differential mode parameters and status	128
$PASHQ,DFO	Query RTCM remote station status	130
$PASHR,DFO	Response message, remote station status	130
CPD COMMANDS		
$PASHS, CPD,AFP	Set integer ambiguity parameter	132
$PASHS, CPD,ANT or $PASHS, BPS,POS	Set antenna parameters of other sensor	132
$PASHQ, BPS,ANT	Query antenna parameters of other sensor	132
$PASHR, CPD,ANT	Message, antenna parameters of other sensor	133
$PASHQ, CPD,DLK	Query data link status	133
$PASHR, CPD,DLK	Response message, data link status	134
$PASHS, CPD,DYN	Set rover dynamics	134
$PASHS, CPD,ENT	Set current raw position	135
$PASHS, CPD,EOT	Select type of EOT character, DBEN message	135
$PASHS, CPD,FST	Enable/disable fast CPD mode	136
$PASHR, CPD,INF	Response message, CPD SV information	136
$PASHS, CPD,MOD	CPD mode select	137
$PASHQ, CPD,MOD	Query CPD status	138
$PASHR, CPD,MOD	CPD status message	138
$PASHS, CPD,MTP	Set multipath parameters	139
$PASHS, CPD,OUT	Select solution to output	139
$PASHS, CPD,PEB or $PASHS, BPS,PER	Set BPS transmission period	140
$PASHS, CPD,PER	Set CPD update interval	140
$PASHS, CPD,PED or $PASHS, DBN,PER	Set DBEN transmission period	141
$PASHS, CPD,PRT	Select output port for DBEN and BPS messages	143
$PASHS, CPD,POS	Set reference position of other receiver	141
$PASHQ, CPD,POS	Query reference position of other receiver	142
$PASHR, CPD,POS	Response message, reference position of other receiver	142
$PASHQ, BPS,POS	Response message, reference position of other receiver	142
$PASHS, CPD,RST	Reset CPD processing	142
$PASHQ,CPD	Query CPD status	143
$PASHQ,CPD,STS	Query CPD solution status	145
$PASHR,CPD,STS	Response message, CPD solution status	145
$PASHS,CPD,UBP	Select base position - rover	145

Table 4.1: Command Summary (continued)

Command	Description	Page
$PASHR,BPS	Response message, station coordinates	146
$PASHS,IDR	Set DBEN message and sender/destination ID	148
$PASHQ,IDR	Query DBEN message and sender/destination ID	149
$PASHR,RPC	Response message, packed DBEN	149
$PASHR,RTR	Response message, real-time error	151

General Sensor Commands

The sensor commands are used to control various operations of the sensor, such as port selection, baud rate, type of output message, processing mode, etc.Table 4.2 summarizes the sensor commands.

Table 4.2: General Sensor Commands

Command	Description	Page
$PASHQ,ALH	Query satellites with received almanac	52
$PASHS,ANH	Set antenna height	53
$PASHQ,ANH	Query antenna height	53
$PASHS,ANT	Set altitude of antenna, altitude hold fix	53
$PASHQ,ANT	Query antenna altitude	54
$PASHS,CACK	Select character or string response to set command	55
$PASHS,CFG	Set sensor hardware configuration	55
$PASHQ,CFG	Query sensor hardware configuration	55
$PASHR,CFG	Response message, sensor hardware configuration	55
$PASHQ,CRS	Query sensor current segment number	56
$PASHR,CRS	Response message, sensor current segment number	56
$PASHS,DSC	Save string to D-file	56
$PASHS,DSY	Set up daisy-chain mode	57
$PASHS,ELM	Set elevation mask	58
$PASHS,EPG	Set static site occupation counter	58
$PASHS,FIL	Close or delete file	58
$PASHS,FIX	Set altitude-fixed mode	59
$PASHQ,FLS	Query file information	59
$PASHR,FLS	Response message, file information	60
$PASHS,HDP	Set HDOP	61
$PASHS,INI	Reset sensor memory and communication parameters	61
$PASHS,ION	Select ionospheric model	62
$PASHQ,ION	Query ionospheric information	62
$PASHR,ION	Response message, ionospheric information	62
$PASHS,LAT	Set latitude of antenna position	62
$PASHQ,LAT	Query antenna latitude	62
$PASHS,LON	Set longitude of antenna position	63
$PASHQ,LON	Query antenna longitude	63
$PASHS,MSMOD	Select CPD processing cycle time	65

Table 4.2: General Sensor Commands (continued)

Command	Description	Page
$PASHS,MSV	Set minimum number of satellites	65
$PASHQ,PAR	Query NMEA message status	63
$PASHS,PDP	Set PDOP Mask	66
$PASHS,PEM	Set position elevation mask	66
$PASHS,PHE	Set photogrammetry edge	65
$PASHQ,PHE	Query photogrammetry edge setting	65
$PASHS,PHO	Delete photogrammetry file	66
$PASHS,PJT	Log project data	66
$PASHS,PMD	Select position computation mode, RTCM or autonomous	67
$PASHS,POS	Set position of the antenna	67
$PASHQ,POS	Query position of antenna	68
$PASHQ,PRT	Query port and baud rate	69
$PASHR,PRT	Response message, port and baud rate	69
$PASHS,PWR,OFF	Set sensor to sleep (low-power) mode	69
$PASHS,RBT	Reboot sensor	70
$PASHS,RCI	Set recording interval	70
$PASHS,RDP	Set radio parameters	70
$PASHR,RDP	Response message, current radio parameters	71
$PASHS,REC	Turn data recording on/off	71
$PASHS,RID	Sensor identification	71
$PASHS,RNG	Set sensor data type	72
$PASHS,RST	Reset sensor to factory defaults	72
$PASHS,RTE	Upload route information	77
$PASHS,SAV	Save current parameter settings in external RAM	77
$PASHQ,SCRN,8	Sensor configuration	77
$PASHS,SIT	Enter site ID	78
$PASHS,SPD	Set communication baud rate	78
$PASHQ,SRD	Query elapsed time for each tracked SV since positioning began	79
$PASHR,SRD	Response message, tracked SVs elapsed time	79
$PASHQ,STA	Query status of currently locked satellites	80
$PASHS,SVM	Query SV mode selection	80
$PASHR,SVM	Response message, mode selection	80
$PASHS,UNH	Use unhealthy SVs	80
$PASHS,USE	Designate satellites to use	81

Table 4.2: General Sensor Commands (continued)

Command	Description	Page
$PASHS,VDP	Set VDOP mask	81
$PASHQ,WKN	Query week number	81
$PASHR,WKN	Response message, week number	81
$PASHS,WPL	Upload waypoint to sensor	81
$PASHS,ZMD	Set sensor to Z mode	82

Query Satellites with Received Almanac

$PASHQ,ALH

This command asks for ALH message. This message contains the number of satellites with received almanac since the receiver was turned on. The port for the message output may be specified. If the port is not specified, the message is output to the port from which the command was received. The command structure is $PASHQ,ALH,x where x is port, A or B.

$PASHR,ALH

The response message is in the form $PASHR,ALH,n,a where the fields are as described in Table 4.3.

Table 4.3: ALH Structure

Field	Description
n	Number of satellites with received almanac 0 through 32
a	Almanac status NO = receiver collected not almanacs of if TOA of almanacs are different or if WNA not received OK = receiver collected all almanacs. In this case the n field shows the number of satellites in the constellation

Set Altitude of Antenna, Altitude Hold Fix

$PASHS,ALT

This command sets the ellipsoidal height of the antenna The command structure is $PASHS,ALT,sxxxxx.xx where s = + or -, and x = 0 to 99999.99. The sensor uses this data in the position calculation for 2-D position computation, and when in differential base mode.

Examples:$PASHS,ALT,+100.25

$PASHS,ALT,-30.1

Set Antenna Height

$PASHS,ANH

This command sets the antenna height. The command structure is

$PASHSANH,x.xxxx

where x.xxxx is the height in meters. Maximum value is 6.4000.

Example: Set antenna height to 2.0000 meters

$PASHS,ANH,2.0000

Set Antenna Offsets

$PASHS,ANT

This command sets the antenna offsets from a reference point to the antenna phase center. Slant is measured from the reference point to the antenna edge. Radius is the distance from the antenna phase center to the antenna edge. Vertical offset is the offset set from the antenna phase center to the antenna ground plane. Horizontal azimuth is measured from reference point to antenna phase center, with respect to WGS84 north. Horizontal distance is measured from the reference point to a point below or above antenna phase center.

The command structure is **$PASHS,ANT,f1,f2,f3,d4f4,f5*crc** where each field is as defined in Table 4.4.

Table 4.4: ANT Structure

Field	Description
f1	Antenna slant 0 to 6.4000 meters
f2	Antenna radius 0 to 6.4000 meters
f3	Antenna phase center height 0 - 99.9999 meter
d4	Degree part of horizontal azimuth 0 – 359 degree
f4	Minute part of horizontal azimuth (always has 2 integer digits) 00.0 - 59.99 minutes
f5	Horizontal distance 0 - 99.9999 meter
*crc	Checksum

Example: Set antenna height, radius, phase center, horizontal azimuth,and distance:

$PASHS,ANT,1.678,0.1737,0.0,0000.00,0.0

Command

where each item is as described in Table 4.5.

Table 4.5: Typical ANT Command

Item	Description
$PASHS,ANT	Message header
1.678	Specify antenna height as 1.678 meters
0.1737	Specify antenna radius as 0.1737 meters
0.0	Specify antenna phase center height as 0.0 meters
0000.00	Specify antenna horizontal azimuth as 0000.00 degrees
0.0	Specify antenna horizontal distance as 0.0 meters

Query Antenna Parameters

$PASHQ,ANT

This command asks for the current antenna parameters. The port for the message output may be specified; if the port is not specified, the message is output to the port from which the command was received. The command structure is

$PASHQ,ANT,x*crc where x is the port, A or B.

$PASHR,ANT

The response message displays the antenna parameters of the sensor. The message is in the form

$PASHR,ANT,f1,f2,f3,d4d5,f5*crc

where the fields are as defined in Table 4.6

Table 4.6: Antenna Parameters

Field	Description
f1	Antenna slant 0 - 6.4000 meter
f2	Antenna radius 0 - 6.4000 meter
f3	Antenna phase center height 0 - 99.9999 meter
d4d5	Degree part of azimuth 0 – 359 degree
f4	Minute part of azimuth (always have 2 integer digits) 00.0 - 59.99 minute
f5	Horizontal distance 0 - 99.9999 meter

Select Character or String Response to Set Command

$PASHS,CACK

The $PASHS,CACK,[1/0] command switches between single-character acknowledge/notacknowledge (ACK/NAK) response messages and string ACK/NAK response messages. Table 4.7 lists the command structure and corresponding ACK/NAK response message.

Table 4.7: ACK/NAK Response Messages

Command	Acknowledge (ACK) Response	Not-Acknowledge (NAK) Response
$PASHS,CACK,0	$PASHR,ACK*3D	$PASHR,NAK*30
$PASHS,CACK,1	♠ or X* (HEX value 0X06)	§ (HEX value 0X15)

*Note: The program REMOTE.EXE returns the letter “X” instead of a spade symbol.

Example: Send single character for acknowledge:

$PASHS,CACK,1

Response message:

♠ or X for acknowledge or

§ for not-acknowledge

Example: Send string ACK/NACK for acknowledge:

$PASHS,CACK,0

Response message:

$PASHR,ACK*3D for acknowledge or

$PASHR,NAK,30 for not-acknowledge

The default setting is single-character ACK/NAK response message.

Query Sensor Configuration

$PASHQ,CFG

This command queries the current sensor configuration. The structure is

$PASHQ,CFG.

$PASHR,CFG,s

The response is a message in the form $PASHR,CFG where s is Z, LZ, D, or DL:

s = Z: Z-12 or RZ

s = LZ: Z-12 or RZ low power

s = D: DMA

s = DL: DMA low power

Example:

$PASHR,CFG,LZ   Low-power Z-12 receiver

Query Receiver Current Segment Number

$PASHQ,CRS

This command requests the receiver current segment number. The structure is $PASHQ,CRS.   The response is output from the port that received the request.

$PASHR,CRS

The response is in the form $PASHR,CRS,i where i is the current file index in the receiver external memory. Range of i is 0 through 99.

Example: $PASHR,CRS,8

This indicates nine files in the sensor, because the first file is numbered 0, not 1.

Store String

$PASHS,DSC

This command stores a string as an event data to the current open file in receiver. The command structure is $PASHS,DSC,s where s is an ASCII string, maximum 80 characters. The file is output as a D-file during data downloading.

Example: Store string “This is a test”

$PASHS,DSC This is a test

Query File Directory

$PASHQ,DIR,x

This command requests sensor file directory information. The command structure is

$PASHQ,DIR,x

where x is port A, B, or C.

Example: Request file directory on port B

$PASHQ,DIR,B

The associated response message is:

$PASHR,DIR,d1,d2,d3,d4,d5,d6,d7,d8,d9*CK where the items in the response message are as defined in Table 4.8.

Table 4.8: DIR Response Structure

Item	Description
d1	total number of files, range 1 to 10
d2	file name, 4 characters
d3	file size in Kwords, 4 digits
d4	weeknumber(3 char), day (1 char), hours (2 char), min (2char)
d5-d7	for second file (if any)
d8	free memory in external RAM in Kwords, 4 digits
d9	percent of external RAM free in%

Configure Receiver in Daisy Chain Mode

$PASHS,DSY

This command sets the sensor in the daisy chain mode. The command structure is

$PASHS,DSY,s1,s2*crc

where the fields are as defined in Table 4.9.

Table 4.9: Daisy Chain (DSY) Structure

Field	Description
s1,s2	A,A: If the receiver gets an unrecognizable command from port A, it shunts the command directly to port A A,B: If the receiver gets an unrecognizable command from port A, it shunts the command directly to port B A,OFF: Disable daisy chain mode for port A. B,OFF: Disable daisy chain mode for port B B,A: If the receiver gets an unrecognizable command from port B, it shunts the command directly to port A B,B: If the receiver gets an unrecognizable command from port B, it shunts the command directly to port B
*crc	Chesksum

Example: Shunt unrecognizable command to port B:

$PASHS,DSY,A,B

The command $PASHS,DSY,OFF disables the daisy chain mode for all ports.

For bi-directional daisy chain mode you must send two commands. For example, for A<->B mode:
$PASHS,DSY,A,B $PASHS,DSY,B,A

Set Elevation Mask

$PASHS,ELM

This command sets the value of the SV elevation mask for data collection. The command structure is

$PASHS,ELM,x

where x is a number between 0 and 90 (default = 5 degrees).

Example: Set elevation mask to 10 degrees

$PASHS,ELM,10

Set Static Site Occupation Counter

$PASHS,EPG

Set epochs to go (for kinematic use). Epochs to go is a counter used during kinematic surveys that specifies the number of data epochs to be collected at the current site. When the counter reaches 0, the site name automatically changes to ????, indicating that the antenna is about to move. The command structure is

$PASHS,EPG,x

where x (number of epochs to go) is a number between 0 and 999.

Example: Set epochs to 27

$PASHS,EPG,27

Close or Delete File

$PASHS,FIL

Closes the current file or deletes a designated file. The command structure is

$PASHS,FIL,x,y

where x is C for close or D for delete, and y is the file number. The sensor can store up to 10 files in mode 0 or 2.

The first file is numbered 0, not 1.

Example: Close the last file and open a new one

$PASHS,FIL,C

Example: Delete file y

$PASHS,FIL,D,y

Example: Delete all files from the sensor

Command: $PASHS,FIL,D,999

Refer to Table 4.10.

Table 4.10: FIL Structure

Setting	Description
999	Delete all image files in the receiver
d	Index of the file to be deleted
*	Delimiter between data and checksum
h	Byte wise XOR checksum in hex checksum beginning with PASHS (exclude '$' sign)

Return message: 'C' Operation completed successfully

If the file to be deleted is not the last file in the sensor, the sensor moves all the following files up and waits until the operation is complete. After deletion, the file allocation table (FAT) is updated.

Example: $PASHS,FIL,D,5*47 (Delete 5th file in sensor)

Set Altitude-Fixed Mode

$PASHS,FIX

This command sets the altitude-fixed mode for position computation. Two modes define what altitude is selected when the sensor is in altitude hold mode.

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

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

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

The command structure is $PASHS,FIX,x where x is 0 or 1 as defined above. Default is 0.

Example: Use most recently entered altitude:

$PASHS,ALT,FIX,1

Request File Information

$PASHQ,FLS,D,C

This command requests file information within a specified range. The structure is $PASHQ,FLS,d,c where d is the port that received the request and c is the port to

Command

receive the response. If the destination port is not specified, the response message goes to the port that received the request.

$PASHR,FLS

The response is a message in the form

$PASHR,FLS,eeee,ttt,nn,ffff,dd.hh.mm,ffff

where the fields are as described in Table 4.11.

Table 4.11: FLS Structure

Field	Descriiption
eeee	Free memory in sensor external memory 0 through 6200 kilobytes
ttt	Total number of files currently in sensor 1 through 100
nn	Number of files matching query criteria 1 through 10
ffff	Site name of ith file 4-byte character string
dd.hh.mm	GPS week number of the file open time dd = day of week 0 through 6 hh = hour of day 0 through 23 mm = minutes 0 through 59
ffff	Size of file in kilobytes
*	data delimiter
h	Bytewise XOR checksum beginning with "P" (hexadecimal)

Example: Check files 18 and 19

$PASHQ,FLS,18

Response:

$PASHR,FLS,0001,020,02,????,74560647,2051,????,74631651,0003**35

where the items in the response message are as described in Table 4.12.

Table 4.12: Typical FLS Message

Item	Description
0001	1000 kilobytes in sensor external memory
020	20 files currently in sensor
02	20-18 (specified file) = 2 Two files are presented, beginning with 18, ending with 19.
????	Site name of 18th file

Table 4.12: Typical FLS Message (continued)

Item	Description
74560647	745th GPS week 6th day 06 th hour 47th minute
2051	size of file = 2051 kilobytes
????	Site name of 19th file
74631651	746th GPS week 3rd day 16th hour 51st minute
0003	size of file = 3 kilobytes
*35	Checksum

Set HDOP Mask

$PASHS,HDP,x

This command sets the value of the HDOP mask. The command structure is **$PASHS,HDP,x** where x is a number between 0 and 99. The HDOP default is 4.

Example:Set HDOP mask to 6

$PASHS,HDP,6

Reset Receiver Memory and Communication Parameters.

$PASHS,INI

This command resets the receiver memory and serial baud rate. The command structure is **$PASHS,INI,x,y,z,m,c** where the fields are as described in Table 4.13.

Table 4.13: Memory Reset Codes

Field	Description
x	Baud rate setting for port A: 0=300 6=19200 1=600 7=38400 2=1200 8=57600 3=2400 9=115200 4=4800 5=9600
y	Port B same as above
z	Port C same as above

Command

Table 4.13: Memory Reset Codes (continued)

Field	Description
m	Reset memory code: 0 = No memory reset 1 = Reset internal memory (ext RAM) 2 = Reset external memory (BBU- battery-backed-up) 3 = Reset internal and external memory
c	Modem initialization code (the comm. port the init string will be sent to) 0 = None) A or D

Return message**:** None

Select Ionospheric Model

$PASHS,ION,x

This command selects the ionospheric or tropospheric model for the position computation. The command structure is $PASHS,ION,x where x = N (no) or Y (yes). If YES, the ionospheric model is used. If NO, the tropospheric model is used. Default is N (tropospheric model).

Example: Use ionospheric model

$PASHS,ION,Y

Query Ionospheric Data

$PASHQ,ION

The $PASHQ,ION command asks for ionospheric data.

$PASHR,ION

The response is a message in the form $PASHR,ION,struct, where struct is a 74-byte binary structure.

Set Latitude of Antenna Position

$PASHS,LAT

This command sets the latitude of the antenna used in differential base mode. The command structure is **$PASHS,LAT,ddmm.mmmmmmm,x** where ddmm.mmmm is latitude in degrees (dd) and decimal minutes (mm.mmmmmmm), and x is N (North) or S (South). The default is 0.

Example: Set antenna latitude to 3722.3819219° north

$PASHS,LAT,3722.3819219,N

Set Longitude of Antenna Position

$PASHS,LON

Sets the longitude of the antenna used in differential base mode. The command structure is **$PASHS,LON,dddmm.mmmmmmm,x** where dddmm.mmmm is longitude in degrees (ddd) and decimal minutes (mm.mmmmmmm), and x is E (East) or W (West). The default is 0.

Example: Set antenna longitude to 12159.8291219° west

$PASHS,LON,12159.8291219,W

$PASHQ,PAR

The response message for the default values of query command $PASHQ,PAR is typically as shown below.

```
SVS: YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
PMD: 0      FIX:0       PDP: 40     HDOP: 04    VDOp: 04
PEM:10      UNH:N       ION:N       SAV:N
DIF_RTCM    MOD: BASE     PRT:A
LAT:37: 22.38823N  LON:121: 059.8353W  ALT:-00005.12
NMEA:GLL GXP GGA VTG GSN APA ALM MSG XTE BWC DAL GSA GSV GSN TTT RRE GRS UTM SAT
PRTA:OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB:OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PER: 005.0 second(s)
```

where the items are as described in Table 4.14.

Table 4.14: Typical PAR Response Message

Item	Description
SVS	Y indicates satellites (SVs) the sensor will attempt to acquire (total of 32 SVs) . Default is Y (yes).
PMD	Position mode for the minimum number of satellites required to compute a position fix. 0:With default value of 0, a minimum of 4 SVs is needed to compute a position. Altitude is not held fixed. 1:When 3 SVs are locked, sensor holds altitude fixed. When more than 3 are locked, sensor computes altitude. 2:Altitude is always held fixed regardless of number of locked satellites. 3:When 3 SVs are locked, sensor holds altitude fixed. When more than 3 are locked, and HDOP is less than the specified HDOP mask, the sensor computes altitude. When more than 3 SVs are locked, and HDOP is equal to or greater than HDOP mask, the sensor holds altitude fixed. Be aware that when the sensor is first turned on, the altitude is 0. If position mode is set to 1, 2, or 3, enter a value for altitide in the POS field.
FIX	Altitude hold fix mode to be used when computing a 2-D position. With default value of 0, the most recent altitude computation is used.
PDP	Position Dilution of Precision. Default is 40.

Command

Table 4.14: Typical PAR Response Message (continued)

Item	Description
HDOP	Horizontal Dilution of Precision. Default is 4.
VDOP	Vertical Dilution of Precision. Default is 4.
PEM	Position Elevation Mask. Elevation below which the SV will not be used to compute a position. Default is 05 degrees.
UNH	Use unhealthy SVs for position computation. Values are Y (yes), N (no). Default is N.
IONe	Include or exclude ionosphere and tropospheric model in position computation. Values are Y (yes) and N (no). Default is N.
SAV	Save parameters in battery-backed-up memory. With default value N, at the next power cycle, the default parameters are used.
DIF_RTCM MOD:BASE	RTCM differential mode, OFF, BASE or REMOTE
PRT:A	Port sending or receiving differential corrections, A, B, or C.
LAT	Latitude of antenna position in degrees and decimal minutes. Default is 0.
LON	Longitude of antenna position in degrees and decimal minutes. Default is 0.
ALT	Height of antenna in meters. Default is 0.
NMEA	NMEA message type for output. GLL Latitude/longitude message GXP Horizontal position message GGA GPS position message VTG Velocity/course message GSN Signal strength/satellite number APA Auto pilot message ALM Almanac message MSG RTCM message XTE Cross-track error message BWC Bearing and distance message DAL Almanac DAL format message GSA DOP and active satellites message GSV Satellites in view message TTT Event marker message RRE Satellite residual and position error message GRS Satellite range residual message UTM Position using UTM coordinates message SAT Satellite status message
PRT:A	Output to port A. Default is all OFF.
PRT:B	Output to port B. Default is all OFF.
PER	NMEA message send interval. If 1 HZ, the default is 20 seconds. If Q option is installed, and sensor runs at 2 or 5 Hz, the default is 0.2/0.5 second.

Set Photogrammetry Edge

$PASHS,PHE

This command selects the rising or falling edge of the photogrammetry edge. The structure is

$PASHS,PHE,x

where x is R for rising edge, F for falling edge.

Example: Select falling edge:

$PASHS,PHE,F

This command requires that the P (Photogrammetry/Event Marker) option be installed in the sensor.

$PASHQ,PHE

The corresponding query command is $PASHQ,PHE,x where x is the port, A, B, or C, to output the message.

$PASHR,PHE

The response message is in the form $PASHR,PHE,x where x is R for rising edge, or F for falling edge.

$PASHR,PHE,R

Select CPD processing cycle

$PASHS,MSMOD

This command sets the repetition rate for CPD processing. The structure is

$PASHS,MSMOD,*f*

where *f* is 0.2, 0.5, or 1 second. This command requires that the Q option be installed in the sensor. Be aware that this command initiates a power cycle and will require you to reinitialize differential parameters.

Example: Set CPD repetition rate to 1 second

$PASHS,MSMOD,1

Example: $PASHS,MSMOD,0.2

Return message**: N**one

Set Minimum Satellites

$PASHS,MSV

This command sets the minimum number of satellites for data collection. The command structure is

$PASHS,MSV,x

where x is a number between 1 and 9. Default is 3.

Example: Set minimum satellites to 4

$PASHS,MSV,4

Set PDOP Mask

$PASHS,PDP,x

This command sets the value of the PDOP mask. The command structure is **$PASHS,PDP,x** where x is a number between 0 and 99. Position is not computed if the PDOP exceeds the PDOP mask. The PDP default is 40.

Example: Set PDOP to 30

$PASHS,PDP,30

Set Position Elevation Mask

$PASHS,PEM

This command sets the elevation mask for position computation.

The command structure is **$PASHS,PEM,d** where d is 0 to 90 degrees. Default is 5 degrees.

Example: Set position elevation position mask to 15 degrees

$PASHS,PEM,15

Photogrammetry (Event Marker) and 1 PPS Commands

$PASHS,PHO,D

This command allows you to delete the photogrammetry file from the receiver memory.

Example: Delete the photogrammetry file

$PASHS,PHO,D

Log Project Data

$PASHS,PJT

This command lets you log project data. The structure is

$PASHS,PJT,s,rr,aa,mmdd,ii,<text>

where the fields are as described in

Table 4.15: PJT Structure

Field	Description
s	Session, one character
rr	Receiver number 0 through 99

Table 4.15: PJT Structure (continued)

Field	Description
aa	Antenna number 0 through 99
mmdd	Month and day
ii	Operator ID 2 characters
<text>	Comment, up to 13 characters

Set Position Mode

$PASHS,PMD

This command sets the position mode for minimum number of SVs required to compute a position in RTCM or autonomous operating mode. The command structure is $PASHS,PMD,x where x = 0, 1, 2, or 3 as detailed below.

x = 0 minimum of 4 SVs needed (e.g., for 3-D)

x = 1 default, minimum of 3 SVs needed; with 3 SVs, altitude is held (2-D); with 4 or more, altitude is not held (3-D)

x = 2 minimum of 3 SVs needed; altitude always held (always 2-D) x = 3 minimum of 3 SVs needed; with 3 SVs, altitude is always held; with 4 SVs, altitude is held only if HDOP is greater than HDOP mask (2-D), otherwise 3-D

x = 3 for 3 SVs locked, altitude is held fixed;

for SVs >3 and HDOP < HDOP mask, altitude is computed;

for SVs > 3 and HDOP equal to or greater than HDOP mask, altitude is held fixed

Example: Set minimum SVs for 3-D computation

$PASHS,PMD,3

Set Position of the Antenna

$PASHS,POS

This command sets the position of the antenna used in differential base mode. The structure is

$PASHS,POS,ddmm.mmmmmmm,x,dddmm.mmmmmmm,y,sxxxxx.xx

where the fields are as defined in Table 4.16.

Table 4.16: POS Command Structure

Field	Description
ddmm.mmmmmmm	Latitude in degrees (dd) and decimal minutes

Command

Table 4.16: POS Command Structure (continued)

Field	Description
x	North (N) or South (S
dddmm.mmmmmmm	longitude in degrees (ddd) and decimal minutes (mm.mmmmmmm)
y	East (E) or West (W)
sxxxxx.xx	ellipsoidal height in meters where s is the sign (+ or -) and xxxxx ranges from 0 to ±99999.99.

Example:

$PASHS,POS,3722.2912129,N,12159.7998265,W,+15.25

$PASHQ,POS

The associated query command is $PASHQ,POS,x,*crc where x is the port A, B, or C. The port for message output may be specified in this command; if the port is not specified, the message is output to the port from which this command was received

$PASHR,POS

The response is a message in the form $PASHR,POS. This message returns the reference point position of the receiver. The message structure is

$PASHR,POS,d1f1,c2,d3f3,c4,f5*crc

where the fields are as defined in Table 4.17.

Table 4.17: POS Message Structure

Field	Description
d1	Degree part of reference point latitude: 0 to 90 degrees
f1	Minute part of reference point latitude (always 2 integer digits)
c2	Direction of latitude: S = south, N = north
d3	Degree part of reference point longitude, 0 to180 degrees
d3	Degree part of reference point longitude, 0 to180 degrees
f3	Minute part of reference point longitude (always 2 integer digits) 00.0 to 59.99 minute
c4	Direction of longitude: E = east W = west
f5	Reference point altitude (always + or - zign) -9999.9999 to +9999.9999 meters

Query Port and Baud Rate

$PASHQ,PRT

This command asks for the sensor port and baud rate. The structure is

$PASHQ,PRT

$PASHR,PRT

The response is a message in the form:

$PASHR,PRT,x,d

where x is the specified port, and d is the baud rate index, as listed in Table 4.18.

Table 4.18: Baud Rate Indexes

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

Example: Query baud rate

$PASHQ,PRT

Response:

$PASHR,PRT,B,6 port B is being used, and baud rate is 19200 bps

Set Receiver To Sleep Mode

$PASHS,PWR,OFF

This command puts the sensor into the sleep (low-power) mode. The structure is

$PASHS,PWR,OFF

To turn the sensor back on, wait at least one minute, then send any character through serial port A.

Reboot

$PASHS,RBT

Clear (reboot) internal RAM and reset sensor. Resets baud rate to 9600 baud.

The structure is $PASHS,RBT.

Set Recording Interval

$PASHS,RCI

This command sets the value of the interval during which raw data will be output or recorded. The command structure is

$PASHS,RCI,x

where x is an integer number between 1 and 999 seconds. Default is 20.0. With the Q option installed, the RCI values are as listed in .

Table 4.19: RCI Structure

Field	Description
x	Output port A or B
mmm	Modem mode TRS
cc	Channel 0-15
llll	RF link speed 4800 or 9600
r	RF sensitivity (squelch) 0,1,1

Example: Set recording interval to 5.0 seconds

$PASHS,RCI,5.0

Be aware that if the 0.2 and 0.5-second modulations are used, the data cannot be post-processed; data can be post-processed only if the integer intervals are used. For example, 1,3,5 seconds can be used for post-processing, while 0.2, 0.5, 1.5, etc. cannot be used for post-processing. Refer to "Query Radio Mode Parameters" on page 70.

Query Radio Mode Parameters

$PASHQ,RDP

This command asks for the RDP message, which contains information about current radio mode parameters. The port for message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received. The command structure is

$PASHQ,RDP,x where x is the port for message output, port A or B

$PASHR,RDP

The response message is in the form

$PASHR,RDP,x,m,c,l,r

where the fields are as described in Table 4.20.

Table 4.20: RDP Structure

Field	Description
x	Output port A or B
mmm	Modem mode TRS
cc	Channel 0 through 15
llll	RF link speed 4800 or 9600
r	RF sensitivity (squelch) 0, 1, 2

Example:

$PASHR,RDP,A,TRS,7,9600,2

Example: Set port A, TRS, channel 2, 4800 baud, squelch 2

Turn Data Recording On/Off

$PASHS,REC

This command turns data recording on or off. The command structure is

$PASHS,REC,x

where x is Y (yes) or N (no).

Example: Turn data recording on

$PASHS,REC,Y

Query Sensor (Receiver) ID

$PASHQ,RID

ThE $PASHQ,RID command queries the sensor ID (serial number and firmware time stamp). The response is output through the port that received the request.

$PASHR,RID

The response message is in the form $PASHR,RID..... , showing the configuration and options. A typical response message might be:

$PASHR,RID,ZM,30,3J16,C05,1C63

See $PASHQ,SCRN,8 for full details.

Command

Set Type of Data

$PASHS,RNG

This command sets the data type mode. The command structure is

$PASHS,RNG,x where x is 0 or 2:

0 = geodetic data (B-file)

2 = position data (C-file).

Reset Parameters To Factory Defaults.

$PASHS,RST

This command resets the sensor to the factory defaults and clears all memory. The structure is $PASHS,RST. Be aware that not all parameters are reset by this command, only the parameters listed in Table 4.21. . For a complete reset, use the

Table 4.21: Parameters Reset by RST Command

Parameter	Description	Default Value
SETUP		
INTVL	Recording interval	20.0 Hz 0.5 Hz 0.2 Hz
MIN SV	Minimum SVs to record	3
ELV MASK	Elevation Mask	10 degrees
RNGR	Recording data type (0-2)	0-without DNS 1-with DNS
POSITION COMPUTATION PARAMETERS		
UNHEALTHY	Use unhealthy SVs to compute position	No
ELV MASK	Elevation mask	10 degrees
PDOP MASK	Position dilution of precision	40
HDOP MASK	Horizontal dilution of precision	04
VDOP MASK	Vertical dilution of precision	04
POS COMP	Compute position?	Yes
ION MODEL	Ionospheric model to use in computation: ionospheric or tropospheric	Y=ionospheric N=tropospheric Default is N
UTM COORD	Use UTM coordinates instead of geodetic coordinates	No
CPD PHASE DIFFERENTIAL MODE SELECTION		
MODE	Differential mode setting: Disabled/Base/Rover	RZ: keep last set value
USE PORT	Port to output CPD correction	Port B
SOLUTION/ USE?BAS POS	Use transmitted or entered base position	Transmitted
SOLUTION/ OUTPUT? POS	Output CPD, raw, or RVP (reverse vector processing) position	CPD position
SOLUTION/ DYNAMICS	Dynamics for fastest expected velocity	Walking
SOLUTTION/ MULTIPATH	Expected multipath environment	Medium
SOLUTION/ FAST CPD	Fast CPD solution	On
DATA SELECTION/ INTERVAL	DBEN output interval (base station only)	1 second

Table 4.21: Parameters Reset by RST Command (continued)

Parameter	Description	Default Value
THIS COORDINATES' XMIT INTVL	Broadcast interval for BPS message. BPS message contains base station ground mark coordinates (if relevant) and antenna offset from reference point. This command is relevant only for base or RBP rover mode.	30 seconds
ADVANCED PARAMS/ AMBIGUITY FIX MODE	Confidence level for reliability of ambiguity fixed solution. (See $PASHS,CPD,AFP for details)	4
RTCM DIFFERENTIAL MODE SELECTION		
MODE	Differential mode setting (Disabled/Base/Remote	Disabled
AUTO DIFF	If automatic, switch position computation from differntial to stand-alone	Auto Diff Off
OUTPUT PORT	Port to output differential data	Port A
CODE	C?A code/L1 P-code/RTCM differential	C/A code
QAFREQ	Communication quality between base station and user equipment. Not used in base mode. This number is a percent of the parity passed messages.	
SPD	Output message speed (not used in REMOTE)	0050
FREQ (TYPE 1)	Frequency message type 1: 0=no message 1-98=number of seconds between messages 99=send message continuously	99
FREQ (TYPE 2)	Frequency message type 2 0=no message 1-98=number of minutes between messages 99=send message continuously	00
FREQ (TYPE 3)	Same as type 1	00
FREQ (TYPE 16)	Same as type 1	00
TYPE 6	Enable/disable message type 6	Enable
FREQ (TYPE 18/19)	Compatibility: A=Ashtech B=Trimble	A
MAX AGE	Remote mode, maximum age of messages in seconds	60
SEQ	Check sequence number in a message (remote only): Y=yes N=No	N
MESSAGE	Text message sent from base to user equipment	None
PORT SETUP - SERIAL PORT SETTING AND MESSAGE SENT THROUGH IT		
NMEA	Enable/disable NMEA message	Disable
INTERVAL	NMEA message send interval	
REAL TIME	Enable/disable real-time output	Disable

Table 4.21: Parameters Reset by RST Command (continued)

Parameter	Description	Default Value
CBEN	Epoch-by-epoch solution	Off
MBEN	Measurement data	Off
PBEN	Position data	Off
SNAV	Ephemeris data, binary only	Off
SALM	Proprietary, binary only	Off
FORMAT	Output format, ASCII/binary	ASCII
BAUD RATE	Real-time message baud rate	9600
PULSE GENERATION PARAMETERS		
PERIOD	Time span between 2 pulses 0.5 to 60 seconds	1 second
OFFSET	The range that PPS may be advanced or delayed from GPS time (± 500 ms)	000.000
EXTERNAL FREQUENCY SETUP - SKIP FOR RZ		
EXTERNAL FREQUENCY	External frequency to synchronize sensor data (1-21 MHz in units of 10 Hz)	00.00
SAVE THROUGH POWER CYCLE	Save settings through power cycle	No
MODEM SETUP		
PORT	Output port connected to modem (Port A or B)	RZ: Port B Others: Port A
TYPE	Modem type selection (Pre-defined Telebit Modems): Worldblazer, Trailblazer, Cellblazer, User-defined)	
SENSOR CONTROL		
Z MODE	Z mode status (Y/N/A)	A
CHAR ACK	Single character or string	Single character RZ only)

Command

Table 4.21: Parameters Reset by RST Command (continued)

Parameter	Description	Default Value
CYCLE TIME	Fast CPD update rate:	**1 sec** - no Q option **0.5 sec** - Q option and internal memory cleared **1 or 0.2** second - Q option and internal memory not cleared (RZ only)
	SATELLITE SELECTION	
AUTO SELECTION	Track all satellites flagged Y or locked satellites only N	Y
INDIVIDUAL SATELLITES	Select or track this satellite (max 12 SVs at one time)	Y
	SITE AND SESSION CONTROL	
SITE	Name of measured site (4 alphanumeric characters)	????
SESS	ID of session (alphanumeric character)	-
RCV#	Receiver ID number (3 alphanumeric characters)	-
ANT#	Antenna ID number (3 alphanumeric characters)	
MMDD	Month and day of session	-
OPR	ID of operator (3 alphanumeric characters)	-
CODE	User comments (up to 13 alphanumeric characters)	-
	OTHER PARAMETERS	
USE GROUP DELAY	Subtract navigation group delay from satellite clock offset	Yes
KEEP SAVED USER SETUP		No
Keep daisy chain setup of serial port		No
Photogrammetry event signal		Active rising

initialization command $PASHS,INI.

Upload Route Information

$PASHS,RTE

This command uploads a number of route information. The structure is

$PASHS,RTE,d1,d2,d3......

where the fields are as described in Table 4.22.

Table 4.22: RTE Structure

Field	Description
d1, d2, d3......	Waypoint number 1 through 20

Example**:** $PASHS,RTE,3,7,12,13

Return message**:** None

Save Parameters

$PASHS,SAV

This command enables or disables the command to save user parameters in memory. The command structure is **$PASHS,SAV,x** where x is Y (yes) or N (no). Parameters are saved until the sensor is reset.

Example: Enable the save parameter command

$PASHS,SAV,Y

Query Sensor Configuration

$PASHQ,SCRN,8

The $PASHQ,SCRN,8 command queries the configuration and options of the sensor. A typical response message might be:

XXXXXXXXX¬XX¿=XXXXX¶¶XX**ZM,30,3J16,C05,1C63DP12M-Q-LJ**

In the example above the first portion of the message (typically 20-24 characters) is in binary and is reporting information other than sensor configuration. The bold part of the example, delimited by commas, shows the configuration and the installed options, as listed in Table 4.23.

Table 4.23: Configuration and Options

Field	Description
ZM	Type of sensor
30	3 = channel option, 0 = codeless option

Table 4.23: Configuration and Options (continued)

Field	Description
3J16	Firmware version, 4 characters
C05	C = coprocessor, 05 = sensor option
1C63	Channel version, 4 characters
DP	Options: D = differential, base or remote U = differential, rover only P = photogrammetry
12	Code option: 1 = P code L1 2 = P code L2
M	Remote monitor
Q	1/4-second ("quick") update rate
L	Low-power (sleep) mode
J	Real-time Z option

Enter Site ID

$PASHS,SIT,x

This command sets the site name. The comand structure is

$PASHS,SIT,x

where x is a user-defined string of four characters.

Example: Set site name to 0001

$PASHS,SIT,0001

Set Communication Baud Rate

$PASHS,SPD

This command sets the baud rate of sensor serial port x. The command structure is

$PASHS,SPD,x,s

where x is A, B, or C, and s is a code number between 0 and 7 specifying the baud rate as shown in Table 4.24. Default is 9600 baud..

Table 4.24: Communication Baud Rate

Code	Baud Rate	Code	Baud Rate
0	300	5	9600
1	600	6	19200

Table 4.24: Communication Baud Rate (continued)

Code	Baud Rate	Code	Baud Rate
2	1200	7	38400
3	2400	8	57600
4	4800	9	115200

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

Example: Set port A to 19200 baud

$PASHS,SPD,A,6

Query Elapsed Time for Each Tracked SV Since Positioning Began

$PASHQ,SRD

This command asks for the elapsed time for each tracked satellite since positioning began. The structure is $PASHQ,SRD.

$PASHR,SRD

The response message is in the form $PASHR,SRD,ss,ttt where the fields are as described in Table 4.25.

Table 4.25: SRD Structure

Field	Description
ss	PRN number of satellite currently being measured 0 through 12
ttt	Elapsed time that the satellite has been locked 0 through 999 minutes
NOTE: ss and ttt fields may be concatenated and delimited with comma.	

Example: SVs 29, 18, 2, 19, 28, 27, 31, and 16 all locked for at least 999 minutes

$PASHR,SRD,29,999,18,999,02,999,19,999,28,999,27,999,31,999,16,999

Command

Query Status of Currently Locked Satellites

$PASHQ,STA

This command asks for the status of currently locked satellites. The structure is

$PASHQ,STA or

$PASHQ,STA,x

where x is the port to output the response. If no port is specified, the response is output from the port that received the request.

A typical response is shown below

TIME	17:16:59	UTC
LOCKED	29 18 02 19 07 28 27 31 16	
CA S/N	25 60 79 85 20 21 92 55 46	
P1 S/N	99 61 70 34 38 99 25 41 29	
P2 S/N	99 61 70 34 38 99 25 41 29	

Query SV Mode Selection

$PASHQ,SVM

This command asks for the current SV mode selection. The structure is $PASHQ,SVM.

$PASHR,SVM

The response message is in the form

$PASHR,SVM,ss,m where the fields are as described in Table 4.26.

Table 4.26: SVM Structure

Field	Description
ss	PRN number of SV 1 through 32
m	Mode N = normal mode. Satellite is included for tracking with auto selection on F = forced mode. Satellite is included for tracking without auto selection on D = disabled mode. Satellite in not included for tracking

Use Unheathy SVs

$PASHS,UNH

This command lets you use unhealthy SVs for position computation.

The structure is **$PASHS,UNH**,x where x is Y (yes) or N (no).

Example: Include unhealthy SVs

$PASHS,UNH,Y

Designate Satellites to Use

$PASHS,USE

This command selects satellites to track or not track. The structure is

$PASHS,USE,d,c where d = PRN number of the satellite (range from 1 to 32), and c = Y to use or N to not use.

Example: Use (track) satellite 15

$PASHS,USE,15,Y

Set VDOP Mask

$PASHS,VDP

This command sets the value of the VDOP mask.

The structure is **$PASHS,VDP,x** where x is 0 to 99. The VDOP default is 4. VDP is not used in CPD.

Example: Set VDOP to 6

$PASHS,VDP,6

Query Week Number

$PASHQ,WKN

This command asks for the WKN message, which contains the current GPS week number. The port for the message output may be specified. If the port is not specified, the message is output to the port from which this command was received. The command structure is

$PASHQ,WKN,x

where x is the port for message output, port A or B

$PASHR,WKN

The response message is in the form $PASHR,WKN,n where n is the current GPS week number.

Example: $PASHR,WKN,795

Upload Waypoint to Sensor

$PASHS,WPL

This command uploads a waypoint to the sensor. The command structure is

$PASHS,WPL,ddmm.mmmm,y,ddmm.mmmm,x,ww,nnnnnnn where the fields are as described in Table 4.27.

Table 4.27: WPL Structure

Field	Description
ddmm.mmmm	dd = degree part of latitude 0 through 90 mm.mmmm = decimal minutes 0 through 59.9999
y	Direction of latitude S = south N = north
ddmm.mmmm	dd = degrees of longitude 0 through 180 mm.mmmm = decimal minutes 0 through 59.9999
x	direction of longitude E = east W = west
ww	Waypoint number 0 through 99
nnnnnnn	Waypoint name up to 7-character string

Example:

$PASHS,WPL,3722.3871,N,12159.8269,W,1,ASHTECH

Return message: None

Set Sensor to Z Mode

$PASHS,ZMD

This command sets the sensor to Z mode. The structure is $PASHS,ZMD,c where c is:

A = auto Z mode   Y = Z mode only   N = P-code tracking

Example: Set sensor to P-code tracking:

$PASHS,ZMD,N

The senosr automatically switches to Z mode when P code is not available.

Raw Data Commands

Table 4.28 summarizes the raw data commands.

Table 4.28: Raw Data Commands

Command	Description	Page
$PASHS,BEN	Select BEN output format	83
$PASHQ,CBN	Query CBEN message	84
$PASHR,CBN	Response message, CBEN	84
$PASHS,DSM	Enable/disable real-time output	85
$PASHQ,OBN	Query vector solution	85
$PASHR,OBN	Response message, vector solution	86
$PASHS, OUT	Enable/disable real-time data output	85
$PASHQ,PBN	Query PBEN data	88
$PASHR,PBN	Response message, PBEN ASCII data for one epoch	88
$PASHQ,RAW	Query raw data parameters	91
$PASHR,UBN	Response message, UBN	91

Select BEN Output Format

$PASHS,BEN

This command selects the BEN output file format, ASCII or binary. The command structure is

$PASHS,BEN,s1,c1,crc

where the field parameters are as defined in Table 4.29.

Table 4.29: BEN Command Structure

Field	Description
s1	BEN output format: ASC = ASCII BIN = binary
c1	Serial port of Z-12 Real-time receiver A = port A B = port B If this field is empty, the specified port is the current port.
*crc	Checksum

Example: Set BEN output file format to binary on port B:

$PASHS,BEN,BIN,B

Command

Query CBEN Message

$PASHQ,CBN

This command asks for the CBN message. This command queries only the current epoch. For query about bufferized message, use the $PASHQ,UBN command. The command strtucture is

$PASHQ,CBN,c1*crc

$PASHR,CBN

The response message is in the form

$PASHR,CBN,...

This response message displays ASCII information on epoch-by-epoch solutions. The structure is

$PASHR,CBN,xx,xx,xx.xx,ssss,xx,xxx.x,xx,xx.xxxxxxx,s,xxx,s,±xxx.xxx,xx.xxxx,xx.xxxx,xx.xxxx,±xx.xxx,±xx.xxx,±xx.xxx,ABCDEF,±xxx.xxx,±xxx.xxx,±xxx.xxx,xx.xxx,xx.xxx,xx.xxx,*crc

where the fields are as defined in Table 4.30.

Table 4.30: Epoch Information Structure

Field	Description
xx	Receiver time GMT hour 0 to 23
xx	Receiver time GMT minute 0 to 59
xx.xx	Receiver time GMT second 0 to 59.99
ssss	Receiver 4-char string site ID
xx	Number of satellites used in CPD position computation 0 to 12
xxx.x	PDOP 0 to 204.8
xx	Latitude degrees 0 to 90
xx.xxxxxxx	Latitude decimal minutes 0 to 59.9999999
s	Latitude direction N = north, S = south
xxx	Longitude degrees 0 to 180
s	Longitude direction E = east, W = west
±xxxxx.xxx	Ellipsoid height -1000 to +100000 meters
xx.xxxx	Standard deviation of latitude component 0 to 99.9999 meters
xx.xxxx	Standard deviation of longitude component 0 to 99.9999 meters
xx.xxxx	Standard deviation of ellipsoid height 0 to 99.9999 meters
±xx.xxx	Cross correlation of XY ±30 meters
±xx.xxx	Cross correlation of XZ ±30 meters

Table 4.30: Epoch Information Structure (continued)

Field	Description
±xx.xxx	Cross correlation of YZ ±30 meters
ABCDEF	Solution type flag containing 6 fields, 8 bytes.
±xxx.xxx	East velocity - 1000 to +1000 meters\sec
±xxx.xxx	North velocity - 1000 to +1000 meters\sec
±xxx.xxx	Up velocity ± 1000 meters\sec
xx.xxx	Standard deviation of east velocity 0 to 16.0 meters/sec
xx.xxx	Standard deviation of north velocity 0 to 16.0 meters/sec
xx.xxx	Standard deviation of up velocity 0 to 16.0 meters/sec

Enable/Disable Real-Time Output

$PASHS,DSM

This command enables/disables real-time output transition. The structure is $PASHS,DSM,c,s where the fields are as defined in Table 4.31.

Table 4.31: DSM Structure

Field	Description
c	Communication port, A or B
ss	Switch ON = stop all real-time outputs temporarily and start recording data in external memory OFF = stop recording data and output all existing data from external memory to serial port using XMODEM protocol. Upon completion, resume real-time output.

Example: Stop real-time outputs on port A and record data to external memory:

$PASHS,DSM,A,ON

Example: Stop recording data and dump data to port A, then resume real-time.

$PASHS,DSM,A,OFF

Query Vector Solution

$PASHQ,OBN

This command asks for the OBN message. This message contains information on vector solution, accumulated from beginning of static site occupation. This information includes vector solution (coordinates between base and rover reference points) and supplemental information. The port for message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received. This query is relevant only if the receiver is in CPD mode and the dynamic parameter is set to static (antenna on tripod, not on manual pole). The command structure is

$PASHQ,OBN,x   where x is the serial port for message output, A or B

$PASHR,OBN

The response message displays information about vector solutions accumulated from the beginning of a static site occupation. The message structure is

$PASHR,OBN,<binary data length><binary data><checksum>

where the field structure is as defined in Table 4.32.

Table 4.32: OBN (Binary Data) Structure.

Field	Type	Description
Number of channels	Integer	Number of channels in receiver: 12
Base site information	Integer	Site ID, 4 characters
	Float	Slant height, meters
	Float	Antenna radius, meters
	Float	Additional vertical offset, usually height of phase center above point when slant measured, meters
	Float	North offset, meters
	Float	East offset, meters
	Float	Temperature, °C
	Float	Humidity, percent
	Float	Air pressure, millibars
	Double	WGS84 X component of position, meters
	Double	WGS84 X component of position, meters
	Double	WGS84 X component of position, meters

Table 4.32: OBN (Binary Data) Structure. (continued)

Field	Type	Description
Baseline information	Integer	Number of epochs available
	Integer	Number of epochs used for solution
	Integer	Number of satellites used for solution
	Integer	Reference satellite PRN
	Integer	PRNs of used satellites
	Long	L1 ambiguitiy, 0.01 cycle
	Integer	Number of epochs for each satellite
	Float	Standard deviation of L1 ambiguity, cycles
	Long	L2 ambiguity, 0.01 cycle
	Float	Standard deviation of L2 ambiguity, cycles
	Float	Sigma X, standard deviation of baseline vector X component, meters
	Float	Sigma Y, standard deviation of baseline vector Y component, meters
	Float	Sigma Z, standard deviation of baseline vector Z component, meters
	Float	Cross correlation of XY, meters
	Float	Cross correlation of XZ, meters
	Float	Cross correlation of YZ, meters
	Double	Delta X, baseline vector X component, meters
	Double	Delta Y, baseline vector Y component, meters
	Double	Delta X, baseline vector Z component, meters
	Float	Lowest contrast ration for fixing ambiguities
	Integer	Number of fixed ambiguities
	Float	RMS residual, averaged post-fit phase residuals, meters
	Float	CHI2, averaged post-fit chi2
Time tag	Integer	Week number of static site occupation beginning
	Integer	Week number of last epoch accumulated
	Long	Week millisecond of static site occupation beginning, milliseconds
	Long	Week millisecond of last epoch accumulated, milliseconds
		Total number of bytes in OBEN: 446, including checksum

Enable/Disable Real-Time Data Output

$PASHS,OUT

This command enables or disables real-time data output. The structure is

$PASHS,OUT,c

where c is port A or B. Alternatively,

$PASHS,OUT,c,d1,d2,d3....... where data types d1, d2, d3......can be specified; data types listed in Table 4.33 can be concatenated, must be delimited by comma [,].

Table 4.33: Real-Time Data Output Data Types

Data Type	Description	Format	RZ
ASC	Set output data format to ASCII		x
BIN	Set output data format to binary		x
CBN	CBN data	ASCII/binary	x
EPB	Unsolicited broadcast raw ephemeris data	Binary only	
DBN	DBEN data set by IDR command	Binary only	
SAL	Almanac data in Ashtech format	Binary only	x
SNV	Ephemeris data	Binary only	x
NMEA	Selected NMEA messages	ASCII only	x
MBN	Measurement data	ASCII/binary	x
PBN	Position data	ASCII/binary	x
VTS3	Vehicle tracking with 3-digit resolution	ASCII only	x
VTS4	Vehicle tracking with 4-digit resolution	ASCII only	x

Example: Output MBN, SNV data in binary format from port C.

$PASHS,OUT,C,MBN,SNV,BIN

1. See data format discussion for data structure.

2. For binary data type, except for EPB, the sensor outputs only the header (without data) while in ASCII output mode. There is no impact on NMEA data while in binary output mode; the NMEA message is always in ASCII format.

3. Data can be concatenated in any order.

Query PBEN Data for One Epoch

$PASHQ,PBN

The $PASHQ,PBN command requests PBEN data for one epoch.

$PASHR,PBN

The response message is in ASCII format with the following structure

$PASHR,PBN,f1,f2,f3,f4,d1:f5,d2:f6,f7,f8,f9,f10,d3,s,d4,d5,d6,d7 where the fields are as defined in

Table 4.34: PBEN Data structure

Field	Description
f1	Receiver time in seconds of week when code is received 0 through 604800.00
f2	Station position ECEF-X ±9999999.9 meters
f3	Station position ECEF-Y ±9999999.9 meters
f4	Station position ECEF-Z ±9999999.9 meters
d1	Latitude degrees 0 through 90 - at beginning signifies south
f5	Latitude minutes 0 through 59.9999
d2	Longitude degrees 0 through 180 - at beginning signifies west
f6	Longitude minutes 0 through 59.9999
f7	Altitude ± 99999.9 meters
f8	Velocity in ECEF-X ± 999.99 meters
f9	Velocity in ECEF-Y- ± 999.99 meters
f10	Velocity in ECEF-Z ± 999.99 meters
d3	Number of satellites used for position computation 3 through 12
d4	PDOP 0 through 99
d5	HDOP 0 through 99
d6	VDOP 0 through 99
d7	TDOP 0 through 99

Command

Query Raw Data Parameters

$PASHQ,RAW

The $PASHQ,RAW query command is available only if Raw Data Output (option O) is installed. The response message for the default values of the command is:

```
RCI:020,0     MSV:3        ELM:10      REC:Y
ANH:0.0000   SIT:????     EPG:000     RNG:0
RAW:    MBN     PBN     SNV     SAL     CBN
PRTA:   OFF     OFF     OFF     OFF     OFF
PRTB:   OFF     OFF     OFF     OFF     OFF
```

where the items in the message are as described in Table 4.35.

Table 4.35: RAW Message Structure

Item	Description
RCI:020.0	Send or record interval of the data in seconds. Default is once every 20 seconds for 1 HZ NAV cycle. The default is 0.2 or 0.5 second for 5 Hz or 2 Hz NAV cycle, respectively.
MSV:3	Minimum number of SVs for the data to be sent or recorded
ELM:05	Data elevation mask. The elevation below which data from that satellite will not be recorded. Default is 10 degrees.
REC:Y	Record data to internal memory. Y = yes, N = no.
ANH:0.0000	Antenna height in meters.
SIT:????	Site ID.
EPG:000	Epoch counter. 0 through 999.
RNGR	Controls how data and positions are stored. 0 indicates geodetic mode. Stores phase data in B-files that can be post-processed differentially using carrier phase or code phase. 1 stores phase data in B-files that can be post-processed differentially using ccode phase only. Mode 1 can store more than twice the number of positions as mode 0. 2 stores smoothed positions in C-files only. These positions can be differentially corrected only in real time; they can not be post-processed differentially.

Query UBN Message

$PASHQ,UBN

This command asks for the UBN message, which contains position solutions, buffered in the sensor. The message has two mandatory parameters. The first parameter is full GPS time. The UBN message should contain only solutions made for epochs after this time. The second parameter is signed integer. The message should contain no more solutions than the absolute value of this parameter. If the second parameter is positive, the message should contain the oldest solutions made after the GPS time specified in the first parameter. If the second parameter is negative, the message should contain the latest solutions made after the GPS time specified in the first parameter. The port for message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received. The command structure is

$PASHQ,UBN,g,n,t,x

where the fields are as defined in Table 4.36.

Table 4.36: UBN Structure

Field	Description
g	GPS time since 1/5/80 in seconds
n	Number of solutions and head/tail selector
t	Time interval between output solutions constant 1 second
x	Port for message output, A or B

Example:

$PASHQ,UBN,0.0,+1,1.0

$PASHR,UBN

The response is a message in the form

$PASHR,UBN,<binary data length><binary data>

where the structure is as defined in Table 4.37.

Table 4.37: UBN Response Structure

Field	Description
<binary data length>	Number of bytes in <binary data>
<binary data>	Integer array as follows:
	Solution GPS time (inside week)
	Solution type: bits 7 and 6 display solution dimension: bit 7 bit 6 0 0 no solution 0 1 2D solution (RTCM and autonomous modes) 1 0 3D solution bits 1 and 0 display solution method 0 0 autonomous mode 0 1 RTCM mode 1 0 usual CPD mode 1 1 fast CPD mode
	CPD flag bit 3 - if cycle slips detected bit 3 - if ambiguities are floating bit 1 - if solution is projected bit 0 - if there were Kalman filter reset
	Number of satellites used/available for position solution
	Rover site ID
	Latitude of position -pi/2(S) through +pi/2 (N) radians

Command

Table 4.37: UBN Response Structure (continued)

Field	Description
	Longitude of position -pi (W) through +pi/2 (E) radians
	Position altitude (ellipsoidal height) in meters
	Speed over ground (SOG) meters/sec
	Course over ground (COG) 0 through 360 degrees
	Vertical speed meters/sec
	HDOP
	VDOP
	Standard deviation of latitude meters
	Standard deviation of latitude meters
	Standard deviation of latitude meters
	Cross correlation of latitude and longitude
	Cross correlation of latitude and longitude
	Cross correlation of longitude and altitude
	Standard deviation of north velocity
	Standard deviation of east velocity
	Standard deviation of up velocity
	Chi square of position solution
	Averaged postfit residual

NMEA Data Message Commands

NMEA data message commands can be sent to the sensor through serial port A, B, or C, and can also be directed so the message is output through port A, B, or C.

The general format for the NMEA message set commands is:

$PASHS,NME,str,x,y

The command enables or disables NMEA message type str on port x, where x is A, B, or C, str is one of the following three-character strings

```
GLL   GXP   GGA   VTG   GSN   MSG  APA   ALM   MSG   XTE
BWC  DAL   GSA   GSV   TTT   RRE   GRS   UTM   SAT
```

and y is ON or OFF.

To display the NMEA message, two commands are required: first, the NMEA message type command, followed by the output enabling command $PASHS,OUT,x,NMEA.

Example: Enable NMEA GLL (latitude/longitude) message on port A

$PASHS,NME,GLL,A,ON followed by

$PASHS,OUT,x,NMEA where x is the output port.

After one of the NMEA set commands enables the corresponding NMEA response message, the sensor outputs the message at the frequency selected by the $PASHS,NME,PER set command. Default is once every 20 seconds without the Q option, or once every half-second if the Q option is installed. Refer to Table 4.38.

Table 4.38: NMEA Periods

Setting	NMEA Period
Without Q option (MSMOD=1)	1, 2, 3, 4....999 seconds
With Q option (MSMOD=1)	0.5, 1, 1.5, , 2, 2.5....999 seconds
Without Q option (MSMOD=0.5)	1, 2, 3, 4....999.5 seconds
With Q option (MSMOD=0.2)	0.2, 0.4, 0.6, 0.8, 1, 1.2, 1.4....999.8 seconds

To turn off the NMEA message, issue the appropriate disabling command.

Example: Disable NMEA GLL message on port A

$PASHS,NME,GLL,A,OFF

The $PASHR,PAR command lets you see the status of all the NMEA messages.

Table 4.39 summarizes the NMEA commands.

Table 4.39: NMEA Data Message Commands

Command	Description	Page
$PASHS, NME,ALL,X,OFF	Disable all NMEA messages	95
$PASHS, NME,ALM	Enable/disable NMEA almanac message	95
$GPALM	Response message, NMEA almanac	95
$PASHS, NME,APA	Enable/disable NMEA autopilot message	96
$GPAPA	Response message, NMEA autopilot	96
$PASHS, NME,BWC	Enable/disable NMEA bearing and distance	97
$GPBWC	Response message, NMEA bearing and distance	97
$PASHS, NME,DAL	Enable/disable NMEA decimal almanac message	98
$GPDAL	Response message, NMEA decimal almanac	98
$PASHS, NME,GGA	Enable/disable GGA (GPS position) message	99
$GPGGA	Response message, GGA	99
$PASHS, NME,GLL	Enable/disable NMEA latitude/longitude message	101
$GPGLL,	NMEA latitude/longitude message	101
$PASHS, NME,GRS	Enable/disable NMEA GRS (satellite range residual) message	102
$GPGRS	Response message, NMEA GRS message	103
$PASHS, NME,GSA	Enable/disable NMEA DOP and active satellite message	104
$GPGSA	Response message, NMEA DOP and active satellite	104
$PASHS, NME,GSN	Enable/disable NMEA GSN signal strength/satellite number	105
$GPGSN	Response message, NMEA GSN signal strength/ satellite number	105
$PASHS, NME,GSV	Enable/disable NMEA GSV (satellites-in-view) message	106
$GPGSV	NMEA GSV (satellites-in-view) message	107
$PASHS, NME,GXP	Enable/disable NMEA GXP (position horizontal) message	108
$GPGXP	Response message, NMEA GXP	108
$PASHS, NME,MSG	Enable/disable NMEA MSG (RTCM) message	109
$GPMSG	Response message, NMEA MSG (RTCM)	110
$PASHS, NME,PER	Set NMEA send interval	114
$PASHS, NME,RRE	Enable/disable NMEA RRE (satellite residual and position error) message	114

Table 4.39: NMEA Data Message Commands (continued)

Command	Description	Page
$PASHQ,RRE	Query RRE (satellite residual and position error) message	114
$GPRRE	RRE (satellite residual and position error) message	114
$PASHS, NME,SAT	Enable/disable NMEA SAT (satellite status) message	116
$PASHQ,SAT	Query NMEA SAT (satellite status) message	116
$PASHR,SAT	NMEA SAT (satellite status) message	116
$PASHS, NME,TTT	Enable/disable NMEA TTT (event marker) message	117
$PASHS, NME,UTM	Enable/disable NMEA UTM (event marker) message	118
$PASHR,UTM	Response message, UTM (event marker)	119
$PASHS, NME,VTG	Enable/disable NMEA VTG (velocity/course) message	119
$GPVTG	NMEA VTG (velocity/course) message	119
$PASHS, NME,XTE	Enable/disable NMEA cross-track error message	121
$GPXTE	NMEA cross-track error message	121

Disable All NMEA Messages

$PASHS,NME,ALL,x,OFF

The command $PASHS,MNME,ALL,x,OFF disables all NMEA message types on port x, where x is port A or B; port C is not supported.

Example: Disable all NMEA messages on port A

$PASHS,NME,ALL,A,OFF

NMEA Almanac

$PASHS,NME,ALM

This command outputs almanac information. The structure is

$PASHS,NME,ALM,x

where x is the port to output the message.

$GPALM

The response message displays an almanac for each satellite in the GPS constellation. The structure is:

$GPALM,tt,nn,ss,www,h,e,t,i,a,r,p,l,m,c,a where each field is as described in Table 4.40.

Table 4.40: ALM Structure

Field	Description
tt	Total number of messages 01 through 12
nn	Number of this message 01 through 12
ss	Satellite PRN number 01 through 32
www	GPS week 3 digits
h	SV health 1 ASCII hex byte
e	Eccentricity 4 ASCII hex bytes
t	Almanac reference time in seconds 2 ASCII hex bytes
i	Inclination angle in semicircles 4 ASCII hex bytes
a	Rate of ascension in semicircles 4 ASCII hex bytes
r	Root of semi-major axis 6 ASCII hex bytes
p	Argument of perigee semicircle 6 ASCII hex bytes
l	Longitude of ascension mode in semicircles 6 ASCII hex bytes
m	Mean anomoly semicircle 6 ASCII hex bytes
c	Clock parameter in seconds 3 ASCII hex bytes
a	Clock parameter in seconds/sec 3 ASCII hex bytes

Example:
$GPALM,20,01,28,674,00,1D,09BC,FD30,A10D27,BBD4EB,8CB47B,E35E03,FFA,000

Autopilot Message

$PASHS,NME,APA

This command asks for the NMEA autopilot infomation. The structure is

$PASHS,NME,APA,x where x is the port to output the message.

$GPAPA

The response message displays autopilot navigation information in the form:

$GPAPA,c,l,eee.eee,s,N,c,A,bbb,c,sss

where each field is as described in Table 4.41

Table 4.41: Autopilot APA Structure

Field	Description
c	Suspect or ambiguous A = valid V = invalid
l	Cycle lock A = valid V = invalid

Table 4.41: Autopilot APA Structure (continued)

Field	Description (continued)
eee.eee	Cross-track error 0 through 999.999
s	Sense L = left R = right
N	Nautical miles
c	Arrival circle A = valid V = invalid
A	A for arrival perpendicular (crossing the line which is perpendicular to the course line and which passes through the destination waypoint)
bbb	Bearing to destination from origin 0 through 999
c	Bearing M = magnetic T = true north
sss	Destination waypoint identifier 3-character string

Example: $GPAPA,A,A,9.999,R,N,A,A,069,M,001

NMEA Bearing and Distance

$PASHS,NME,BWC

This command asks for the bearing and distance information. The structure is

$PASHS,NME,BWC,x

where x is the port to output the message.

$GPBWC

The response message displays bearing and distance. The structure is

$GPBWC,hh,mm,ss.ss,dd,mm.mmmm,d,dd,mm.mm,d,bbb.bb,ddd.ddd,ppp

where the fields are as described in Table 4.42.

Table 4.42: BWC Structure

Field	Description
hh	UTC of bearing hours 0 through 23
mm	UTC of bearing minutes 0 through 59
ss.ss	UTC of bearing seconds 0 through 59.99
dd	Latitude of waypoint degrees 0 through 90
mm.mmmm	Latitude of waypoint minutes 0 through 59.9999
d	Direction of latitude N= north S = south
dd	Longitude of waypoint degrees 0 through 180
mm.mm	Longitude of waypoint minutes 0 through 59.99
d	Direction of longitude E = east W = West
bbb.bb	True bearing (T for true) 0 through 999.99

Table 4.42: BWC Structure (continued)

Field	Description
ddd.ddd	Distance (N for nautical miles) 0 through 999.999
ppp	Waypoint identifier 3-character string

Example:

$GPBWC.015454.00,0000.000,N,00000.0000,E,069.00,T,84,73,M,999.999,N,001

NMEA Decimal Almanac Message

$PASHS,NME,DAL

This message displays the NMEA almanac message in DAL format. The structure is:

$PASHS,NME,DAL,ss,hhh,e.eeeeeeeE±99,ttttttt,i.iiiiiiiE±99,±a.aaaaaaaE±99,
±m.mmmmmmmE±99,±c,cccccccE±99, c.cccccccE±99, www

where the fields are as defined in Table 4.43.

Table 4.43: NMEA DAL Structure

Field	Description
ss	Satellite PRN number 1 through 32
hhh	Satellite health 0 through 255
e.eeeeeeeE±99	Eccentricity 9.9999999E±99
ttttttt	Reference time for orbit 0 through 9999999 seconds
i.iiiiiiiE±99	Inclination angle 0 through 9.9999999E±99 semicircles
±a.aaaaaaaE±99	Omegadot, rate of right ascension ±9.9999999E±99 semicircles/sec
r.rrrrrrrE±99	Roota, square root of semi-major axis 0 through 9.9999999E±99 meters 1/2
±l.lllllllE±99	Omega0, longitude of right ascension node ±9.9999999±99
±a.aaaaaaaE±99	Omega, argument of perigee ±9.9999999±99 semicircles
±m.mmmmmmmE±99	M_0 mean anomaly at reference time ±9.9999999E±99
±c,cccccccE±99	af_0 clock parameter ±9.9999999E±99 seconds
c.cccccccE±99	af_1 clock parameter 0 through 9.9999999E±99 seconds/second
www	GPS week number wn 3 digits

$GPDAL

A typical response message is shown in the following example.

Example:

$GPDAL,14,00,5.2795410E-03,032768,3.065721E-01,-2.4811015E-09,5.1536948E03,5.8827317E-01,8.8243234E-01,-8.8568139E-01,8.201599E-05,7.2759576E-12,571

GGA (GPS Position) Message

$PASHS,NME,GGA,x,Y

This command enables/disables the NMEA GPS position response message on port x, where x is either A, B, or C, and Y is ON or OFF. This message is not output unless position is computed.

Example: Enable GGA on port A

$PASHS,NME,GGA,A,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPGGA

The response message is in the form:

$GPGGA,hhmmss.ss,ddmm.mmmmm,s,dddmm.mmmmm,s,n,

qq,pp.p, saaaaa.aa,u,±xxxx.x, M,sss,aaaa *cc

where the structure is as defined in Table 4.44.

Table 4.44: GGA Structure

Field	Description
1	Current UTC time, hhmmss, of position fix in hours, minutes and seconds.
2	Latitude component of position, ddmm.mmmmm, in degrees, minutes and fraction of minutes.
3	atitude sector, s = N - North, s = S - South.
4	Longitude component of position, dddmm.mmmmm, in degrees, minutes and fraction of minutes.
5	Longitude sector, s = E - East, s = W - West.
6	Raw/differential position, n n = 1 - Raw; position is not differentially corrected n = 2 - position is differentially corrected.
7	qq = number of SVs used in position computation.
8	HDOP - horizontal dilution of precision, pp.p = 00.0 to 99.9.
9	GPS Sensor-computed altitude, saaaaa s = "+" or "-" aaaaa = Altitude 00000 to 30000 meters above WGS-84 reference ellipsoid. For 2-D position computation this item contains the altitude used to compute the position computation.
10	Altitude units, u = M - meters.
11	Geoidal separation (value output only if Geoidal Height option (G) is installed in the receiver).
12	Geoidal separation units, u = M - meters.
13	Age of the differential corrections, sss, in seconds.
14	Base STID, aaaa.

Example:

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

Typical Response:

$GPGGA,183805.50,3722.36223,N,12159.82741,W,2,03,02.8,
+00016.12,M,31,M,005,0001*6F

Table 4.45 describes each item in the response message.

Table 4.45: Typical GGA Response Message

Item	Description
$GPGGA	Header
183805.50	Time of position computation
3722.36223	Latitude
N	N North
12159.82741	Longitude
W	West
2	Differential mode
03	Number of SVs used in position computation
02.8	HDOP
+00016.12	Altitude
M	Meters. Units of altitude.
31	Geoidal separation
M	Meters. Units of geoidal separation
005	Age of differential corrections
0001	Base station ID
6F	Message checksum in hexadecimal

GLL (Latitude,Longitude)

$PASHS,NME,GLL

This command enables/disables the NMEA latitude/longitude response message. The command structure is **$PASHS,NME,GLL,x,y** where x is either port A, B, or C, and y is ON or OFF. This message is not output unless position is computed.

Example: Enable GLL message on port A

$PASHS,NME,GLL,A,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPGLL

The response message is in the form

$GPGLL,ddmm.mmmmm,s,dddmm.mmmmm,s,hhmmss.ss,s*cc

Command

where each field is as described in Table 4.46.

Table 4.46: GLL Structure

Field	Description
ddmm.mmmmm	Latitude component of position, ddmm.mmmmm, in degrees, minutes and decimal fraction of minutes
s	Latitude sector, s = N - North, s = S - South
dddmm.mmmmmm	Longitude component of position, dddmm.mmmmm, in degrees, minutes and decimal fraction of minutes.
s	Longitude sector, s = E - East, s = W - West
hhmmss.ss	UTC of position (hours, minutes, seconds)
s	Status, A= valid, V=invalid
*cc	Checksum

Example:

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

Typical Response:

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

where each item in the response message is as defined in Table 4.47.

Table 4.47: Typical GLL Message

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

NMEA GRS (Satellite Range Residual)

$PASHS,NME,GRS,x,

This command enables/disables the NMEA satellite range residual response message to port x, where x is A, B, or C, and y is ON or OFF. This message is not output unless a position is computed.

Example: Enable GRS message on port C

$PASHS,NME,GRS,C,ON   followed by output command

$PASHS,OUT,x,NMEA   where x is the output port.

$GPGRS

The response message is in the form

$GPGRS,hhmmss.ss,m,sxx.x,sxx.x,sxx.x,....*cc

Range residuals are recomputed after the GGA position is computed. Therefore the mode m is always 1.

There will be a range residual sxx.x for each satellite used in position computation, and the order of the residuals matches the order of the satellites in the GSS message. Table 4.48 shows the structure of the GRS response message. .

Table 4.48: GRS Structure

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

Example:

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

Typical Response:

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

Table 4.49 describes a typical GRS response message.

Table 4.49: Typical GRS Response Message

Item	Description
$GPGRS	Header
180257.50	Time of position computation
1	Mode
+00.3	Range residual for first SV in GSS message

Command

Table 4.49: Typical GRS Response Message (continued)

Item	Description
-00.4	Range residual for second SV in GSS message
+00.2	Range residual for third SV in GSS message
+00.5	Range residual for fourth SV in GSS message
+00.7	Range residual for fifth SV in GSS message
-00.8	Range residual for sixth SV in GSS message
64	Message checksum in hexadecimal

NMEA DOP and Active Satellite Message

$PASHS,NME,GSA

This command enables/disables the DOP and active satellite message to be sent out to the serial port. The structure is $PASHS,NME,GSA,x,y , where x is port A, B or C and y is ON or OFF.

Example: Enable GSA message on port B

$PASHS,NME,GSA,B,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPGSA

The response is a message in the form

$GPGSA,c1,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,f1,f2, f3*CC where each item is as described in Table 4.50.

Table 4.50: GPGSA Structure

Item	Description
c1	Mode M: manual A:automatic
d1	Mode 2:2D 3:3D
d2-d13	Satellites used in position computation (range 1 to 32)
f1	PDOP (range 0 - 9.9)
f2	HDOP (range 0 - 9.9)
f3	VDOP (range 0 - 9.9)
cc	Checksum

Example:

$GPGSA,A,2,1,4,6,7,9,11,3,2,5

NMEA GSN (Signal Strength/Satellite Number)

$PASHS,NME,GSN,x,y

This command enables/disables the signal strength/satellite number response message on port x, where x is either A, B, or C, and y is ON or OFF.

Example: Enable GSN message on port C

$PASHS,NME,GSN,C,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPGSN

The response is a message in the form:

$GPGSN,qq,pp,ss,ss,.....ttt*cc

For each SV locked, a PRN number item and a signal strength item follow; qq indicates the number of SVs displayed in the message.

Table 4.51 defines the field structure.

Table 4.51: GSN Structure

Field	Description
qq	Number of SVs locked, number of SVs in message
pp	SV PRN number, pp = 1 to 32
ss	SV signal strength/signal-to-noise ratio, ss = 00 to 99
ttt	999 ends the message if no RTCM age is reported or age of differential corrections in seconds if in RTCM mode

Example:

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

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

Table 4.52 presents a typical GSN response message.

Table 4.52: Typical GSN Message

Item	Description
$GPGSN	Header
03	Number of SVs locked
03	PRN number of the first SV
060	Signal strength of the first SV
23	PRN number of the second SV

Table 4.52: Typical GSN Message (continued)

Item	Description
039	Signal strength of the second SV
16	PRN number of the third SV
021	Signal strength of the third SV
999	Termination when no RTCM information
7d	Message checksum in hexadecimal

NMEA GSV (Satellites-In-View)

$PASHS,NME,GSV,x,y

This command enables/disables the satellites-in-view message to send out of serial port, where x is port A, B or C, and y is ON or OFF.

Example: Output GSV message on port A

$PASHS,NME,GSV,A,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPGSV

The response message is in the form:

$GPGSV,d1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,d14,d15,
d16,d17,d18,d19*CC

where the fields are as defined in Table 4.53.

Table 4.53: GSV Structure

Field	Description
d1	Total number of messages (1 to 3)
d2	Message number (1 to 3)
d3	Total number of satellites in view (1 to 12)
d4	Satellite PRN (1 to 32)
d5	Elevation (degrees from 0 to 90)
d6	Azimuth (degrees from 0 to 359)
d7	SNR (0 to 99 dB)
d8-d11	Same as d4-d7 but for second satellite
d12-d15	Same as d4-d7 but for third satellite
d16-d19	Same as d4-d7 but for fourth satellite

Example: Query: $PASHQ,GSV,c or
Set:$PASHS,NME,GSV,c,ON
Typical response:

$GPGSV,2,1,08,16,23,293,29,19,63,050,59,28,11,038,21,29,14, 145,16*78

where each item is as described in Table 4.54.

Table 4.54: Typical GSV Message

Field	Description
$GPGSV	Header
2	Total number of messages
1	message number
8	number of SVs in view
16	PRN of first satellite
23	elevation of first satellite
293	azimuth of first satellite

Table 4.54: Typical GSV Message (continued)

Field	Description
29	signal-to-noise of first satellite
19	PRN of second satellite
63	elevation of second satellite
050	azimuth of second satellite
59	signal-to-noise of second satellite
28	PRN of third satellite
11	elevation of third satellite
038	azimuth of third satellite
21	signal-to-noise of third satellite
29	PRN of fourth satellite
14	elevation of fourth satellite
145	azimuth of fourth satellite
16	signal-to-noise of fourth satellite
78	message checksum in hexadecimal

NMEA GXP (Position Horizontal)

$PASHS,NME,GXP,x,y

This command enables/disables the position horizontal message on port x, where x is either A, B, or C, and y is ON or OFF. This message is not output unless position is computed.

Example: Output GXP message on port C

$PASHS,NME,GXP,C,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPGXP

The response message is in the following form:

$GPGXP,hhmmss:ss,ddmm.mmmmm,s,dddmm.mmmmm,s*cc

where the fields are as defined in Table 4.55.

Table 4.55: Typical GXP Response Message

Field	Description
hhmmss:ss	Current UTC time, hhmmss:ss,of position fix in hours, minutes and seconds

Table 4.55: Typical GXP Response Message (continued)

Field	Description
ddmm.mmmmm	Latitude component of position, ddmm.mmmmm, in degrees, minutes and fraction of minutes
s	Latitude sector N = North S = South
dddmm.mmmmm	Longitude component of position, dddmm.mmmmm, in degrees, minutes and fraction of minutes
s	Longitude sector E = East W = West

Example:

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

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

where each item in the response is as described in Table 4.56.

Table 4.56: GXP Structure

Field	Description
$GPGXP	Header
183805.00	Time of position fix
3722.36221	Latitude
N	North
12159.82742	Longitude
W	West
5C	Message checksum in hexadecimal

NMEA MSG (RTCM) Message

$PASHS,NME,MSG

This command enables/disables the message containing RTCM reference (base) station message types 01, 03, 06, 09, and 16. The structure is

$PASHS,NME,MSG,x,y

where x is the output port, A, B, or C, and y is ON or OFF.

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

Example: Enable MSG on port A

$PASHS,NME,MSG,A,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

Command

$GPMSG

The response message format depends upon the RTCM message type enabled: type 1 is enabled by default; types 3, 6, 9, and 16 must be enabled by the $PASHS,RTC,TYP command.

The format for RTCM message types 1 and 9 is:

$GPMSG,rr,ssss,zzzz.z,s,h,ccc,hhmmss:ss,e,vv,spppp.pp,sr.rrr,iii*cc

where the fields are as defined in Table 4.57.

Table 4.57: Structure for RTCM Message Types 1 and 9

Field	Description
rr	2 rr = RTCM type, 01 or 09
ssss	station identifier, 0000 to 1023
zzzz.z	Z count in seconds and tenths, 0000.0 to 3600.0
s	sequence number, 0 to 7
h	Station health, 0 to 7
ccc	total number of characters after the time item, 000 to 999
hhmmss:ss	current UTC time of position computation in hours, minutes and seconds
e	user differential range error (UDRE)
vv	satellite PRN number
spppp.pp	pseudo-range correction (PRC) in meters
sr.rrr	range rate correction (RRC) in meters/sec
iii	issue of data (IODE
*cc	checksum in hexadecima

Message types 1 and 9 are identical except for the fact that message type 1 has correction information (fields 9, 10, 11, 12, 13) for all satellites, and each message type 9 has correction information for up to 3 satellites per transmission.

Example 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

where each item is as described in Table 4.58.

Table 4.58: Typical RTCM Message Types 1 and 9

Item	Description
$GPMSG	Header
01	RTCM message
0000	Station ID
2220.0	Z count in seconds and tenths
1	Sequence number
0	Station health
127	Total number of characters of the time item
003702:00	Current time in hours, minutes, and seconds
2	UDRE for SV 12
12	Satellite PRN number
-0081.30	PRC for SV 12
+0.026	RRC for SV 12
235	IODE for SV 12
2	UDRE for SV 13
13	Satellite PRN number
+0022.86	PRC for SV 13
+0.006	RRC for SV 13
106	IODE for SV 13
2	UDRE for SV 26
26	Satellite PRN number
-0053.42	PRC for SV 26
-0.070	RRC for SV 26
155	IODE for SV 26
2	UDRE for SV 26
02	Satellite PRN number
+0003.56	PRC for SV 02
+0.040	RRC for SV 02
120	IODE for SV 02
2	UDRE for SV 02
27	Satellite PRN number
+0047.42	PRC for SV 27
-0.005	RRC for SV 27

Table 4.58: Typical RTCM Message Types 1 and 9 (continued)

Item	Description
145	IODE for SV 27
7A	Message checksum in hexadecimal

The structure for RTCM message type 3 is:

$GPMSG,rr,sss,zzz.z,s,h,ccc,hhmmss:ss,sxxxxxxx.xx,syyyyyyy.yy, szzzzzzz.zz

where the fields are as defined in Table 4.59.

Table 4.59: Structure for RTCM Message Type 3

Field	Description
rr	RTCM type
sss	station identifier, 0000 to 1023
zzz.z	Z count in seconds and tenths, 0000.0 to 3600.0
s	sequence number, 0 to 7
h	station health, 0 to 7
ccc	total number of characters after the time item, 000 to 999
hhmmss:ss	current GPS time of position computation in hours, minutes, seconds
sxxxxxxx.xx	metric x - distance from geocenter (x component of station)
syyyyyyy.yy	metric y - distance from geocenter (y component of station)
szzzzzzz.zz	metric z - distance from geocenter (z component of station)
*cc	checksum

Example 2:

Typical Response: $GPMSG,03,0000,1200.0,7,0,038,231958:00,
-2691561.37,-4301271.02,+3851650.89*6C

where each item is as described in Table 4.60.

Table 4.60: Typical RTCM Message Type 03

Item	Description
$GPMSG	Header
03	RTCM type
0000	Station ID
1200.0	Z count in seconds and tenths
7	Sequence number
0	Station health

Table 4.60: Typical RTCM Message Type 03 (continued)

Item	Description
038	Total number of characters after the time item
231958:00	Current time in hours, minutes and seconds
-2691561.37	Station X component
-4301271.02	Station Y component
+3851650.89	Station Z component
6C	6C message checksum in hexadecimal

The structure for RTCM message types 6 and 16 is shown below, except that type 6 does not contain text:

$GPMSG,rr,sss,zzz,z,s,h,ccc,hhmmss:ss,text*cc

where each item is as described in Table 4.61.

Table 4.61: Structure for RTCM Message Types 6 and 16

Field	Description
rr	RTCM type 6 or 16
sss	station identifier, 0000 to 1023
zzz.z	Z count in seconds and tenths, 0000.0 to 3600.0
s	sequence number, 0 to 7
h	station health, 0 to 7
ccc	total number of characters after the time item, 000 to 999
hhmmss:ss	current GPS time of position computation in hours, minutes, seconds
text	text message, type 16 only
8*cc	checksum, type 6 only
9*cc	checksum, type 16 only

Example 3:

$GPMSG,16,0000,1209.6,5,0,038,232008:00,THIS IS A MESSAGE SENT FROM BASE*5C

where each item is as described in Table 4.62.

Table 4.62: Typical RTCM Message Types 6 and 16

Item	Description
16	RTCM type
0000	Station ID

Command

Table 4.62: Typical RTCM Message Types 6 and 16 (continued)

Item	Description
1209.6	Z count in seconds and tenths
5	Sequence number
0	Station health
038	Total number of characters after the time item
232008:00	Current time in hours, minutes and seconds
TEXT	Message content
5C	Message checksum in hexadecimal

Set NMEA Send Interval

$PASHS,NME,PER,x

Set the send interval of the NMEA response messages in seconds. The structure is $PASHS,NME,PER,x where x is a any half-second or full-second value between 0.5 and 999.5 (default once per half-second if the 2HZ option is installed, once per second if not installed).

RRE (Satellite Residual and Position Error) Message

The structure is $PASHS,NME,PER,x where x is any half-second or full-second value between 0.5 and 999. Default once per half-second if the Q option is installed, once per second if it is not installed.

$PASHS,NME,RRE,x,y

This command enables/disables the satellite residual and position error message to port x, where x is A, B, or C and y is ON or OFF. This message is not output unless a position is computed.

Example: Enable RRE message on port A

$PASHS,NME,RRE,A,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$PASHQ,RRE,x

The associated query command is $PASHQ,RRE,x where x is port A, B, or C.

Example: Query RRE on port C

$PASHQ,RRE,C

$GPRRE

The response is a message in the form

$GPRRE,qq,ss,sxxx.x,...hhhh.h,vvvv.v*cc

A range residual (xxx.x) is computed for each satellite (ss) used in position computation. Residuals and position errors not computed unless at least 5 satellites are used in position computation. The fields in the RRE message are as defined in Table 4.63.

Table 4.63: RRE Structure

Field	Description
qq	Number of satellites used to compute position
ss	PRN number for each of the satellites used in position computation
s,xxx.x.....	+ or - and xxx.x = range residuals magnitude in meters for each satellite used in position computation
hhhh.h vvvv.v	Last 2 fields: hhhh.h = horizontal RMS position error in meters vvvv.v = vertical RMS position error in meters

Example: Query: $PASHQ,RRE,A or

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

Typical Response:

$GPRRE,05,18,+000.2,29,+000.2,22,-000.1,19,-000.1,28,

+000.5,0002.0,0001.3*76

where each item is as described in Table 4.64.

Table 4.64: Typical RRE Response

Item	Description
$GPRRE	Header
05	Number of SVs used to compute position
18	PRN of first SV
+000.2	Range residual for first SV in meters
29	PRN of second SV
+000.2	Range residual for second SV in meters
22	PRN of third SV
-000.1	Range residual for third SV in meters
19	PRN of fourth SV
-000.1	Range residual for fourth SV in meters
28	PRN of fifth SV
+000.5	Range residual for fifth SV in meters
0002.0	Horizontal position error in meters

Table 4.64: Typical RRE Response (continued)

Item	Description
0001.3	Vertical position error in meters
76	Message checksum in hexadecimal

NMEA SAT (Satellite Status) Message

$PASHS,NME,SAT

This command enables/disables the satellite status message. The srructure is

$PASHS,NME,SAT,x,y

where x is the output port A, B, or C, and y is ON or OFF.

Example: Enable SAT message on port B

$PASHS,NME,SAT,B,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$PASHQ,SAT

The associated query command is $PASHQ,SAT.

$PASHR,SAT

The response is a satellite status response message in the form:

$PASHR,SAT,qq,pp,aaa,ee,ss,h*cc

The SV-locked item is followed by as many groups of the following items as there are SVs currently being tracked: PRN number, azimuth, elevation, signal strength, and whether SV is used in position fix solution; qq indicates the total number of SVs in the message. Table 4.65 defines each field of the message.

Table 4.65: SAT Structure

Field	Description
qq	Number of SVS locked, number of SVs in message, range 0-12
pp	SV PRN number, range 1 to 32
aaa	SV azimuth angle, 000 to 359 degrees
ee	SV elevation angle, 00 to 90 degrees
ss	SV signal strength/signal-to-noise ratio, 00 to 99
h	SV used/not used if position computation U = SV used in position computation - = SV not used in position computation

Example 1:

Query: $PASHQ,SAT,B or

Set: $PASHS,NME,SAT,B,ON

Typical Response:

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

where each item is as described in Table 4.66.

Table 4.66: Typical SAT Message

Item	Description
$PASHR,SAT	Header
03	Number of SVs locked
03	PRN number of the first SV
103	Azimuth of the first SV in degrees
56	Elevation of the first SV in degrees
60	Signal strength of the first SV
U	SV used in position computation
23	PRN number of the second SV
225	Azimuth of the second SV in degrees
61	Elevation of the second SV in degrees
39	Signal strength of the second SV
U	SV used in position computation
16	PRN number of the third SV
045	Azimuth of the third SV in degrees
02	Elevation of the third SV in degrees
21	Signal strength of the third SV
U	SV used in position computation
6E	Message checksum in hexadecimal

NMEA TTT (Event Marker) Message

$PASHS,NME,TTT

This command enables/disables the event marker message. The structure is

$PASHS,NME,TTT,x,y

where x is the output port A, B, or C, and y is ON or OFF. This message is not output unless an event pulse is being input through the serial port and the event marker option (E) is available in the receiver.

Example: Enable TTT message on port A

$PASHS,NME,TTT,A,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

There is no query command for TTT.

$PASHR,TTT

The response is a message in the form:

$PASHR,TTT,x,hh:mm:ss.sssssss*cc

where each field is as defined in Table 4.67.

Table 4.67: TTT Structure

Field	Description
x	Day of GPS week, 1 to 7, where Sunday = 1
hh:mm:ss.sssssss	Time in hours, minutes, seconds

Example: Enable TTT event marker on port A

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

Typical Response: $PASHR,TTT,6,20:41:02.0000000*OD

where each item is as described in Table 4.68.

Table 4.68: Typical TTT Message

Item	Description
$PASHR	Header
6	Day of week (Friday)
20:41:02.0000000	Time
OD	Message checksum in hexadecimal

NMEA TTT (Event Marker) Message

$PASHS,NME,UTM

This message displays position using UTM coordinates. The structure is;

$PASHS,NME,UTM........

where the fields are as defined in Table 4.69.

Table 4.69: NMEA UTM Structure

Field	Description
hh.mm.ss.ssss	UTC of position in hours, minutes, decimal seconds
zzz	Zone for coordinates 0 through 999

Table 4.69: NMEA UTM Structure (continued)

Field	Description
eeeeeee.ee	East UTM coordinate 0 through 9999999.99 meters
nnnnnnn.nn	North UTM coordinate 0 through 9999999.99 meters
q	GPS quality indicator 1 = GPS available 2 = RTCM differential available 3 = Carrier phase differential (CPD) available
ss	Number of satellites being used 3 through 12
hh.h	HDOP 0 through 99.9
aaaaa	Antenna height in meters -1000 through 18000
ggg.g	Geoidal height in meters -999.9 through 999.9
aa	Age of data link differential data 0 through 99 seconds
l.lll	RZ only - solution latency in CPD rover mode. 0.0 through 0.999 milliseconds. Stays at 0.999 if latency is greater than 0.999.
ssss	Differential reference station ID 4-character string

$PASHR,UTM

The response message is in the form $PASHR,UTM,.... as shown below.

Example:

For RTCM Differential:

$PASHR,UTM,015454.00,10S,588757.62,4136720.05,2,04,03.8,+00012,M,,M14,1010

For CPD Differential (RZ Only):

$PASHR,UTM,015454.00,10S,588757.62,4136720.05,2,04,03.8,+00012,M,,M14.123,1010

NMEA VTG (Velocity/Course) Message

$PASHS,NME,VTG

This command enables/disables the velocity/course message. The structure is

$PASHS,NME,VTG,x,y

where x is the output port A, B, or C and y is ON or OFF. This message is not output unless position is computed.

Example: Enable VTG message or port B

$PASHS,NME,VTG,B,ON followed by output command

$PASHS,OUT,x,NMEA where x is the output port.

$GPVTG

The response is a message in the form:

$GPVTG,ttt,c,ttt,c,ggg.gg,u,ggg.gg,u*cc

where each field is as defined in Table 4.70.

Table 4.70: VTG Structure

Field	Description
ttt	True track/true course over ground, ttt = 000 to 359 degrees
c	True course over ground marker, c = always T (true course)
ttt	Magnetic track/magnetic course over ground, ttt = 000 to 359 degrees (output only if magnetic variation option (M) is installed in receiver)
c	Magnetic course over ground marker, c = always M (magnetic course)
ggg.gg	Speed over ground, ggg.gg = 000 to 999.99 knots
u	Speed over ground units, u = N (nautical miles per hour)
ggg.gg	Speed over ground, ggg.gg = 000 to 999.99 kilometers per hour
u	Speed over ground units, u = K (kilometers per hour)

Example:

Query: $PASHQ,VTG,B or

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

Typical Response:

$GPVTG,179,T,193,M,000.11,N,000.20,K*3E

where each item is as described in Table 4.71.

Table 4.71: Typical VTG Message

Item	Description
$GPVTG	Header
178	Course over ground in degrees
t	True course over ground marker
193	Magnetic course over ground
M	Magnetic course over ground marker
000.11	Speed over ground in knots
N	Knots
000.20	Speed over ground in kilometers/hour
K	Kilometers/hour
3E	Message checksum in hexadecimal

NMEA Message VTG (COG/SOG)

$GPVTG

This message displays the vehicle course over ground (COG) and speed over ground (SOG). The structure is

$GPVTG,ccc,T,ccc,M,sss.ss,N,,sss.ss,K

where the fields are as described in Table 4.72.

Table 4.72: VTG Structure

Field	Description
ccc,T	COG (Course Over Ground) and T for true north 0 through 359 degrees
ccc,M	COG and M for magnetic variation north 0 through 359 degrees
sss.ss,N	SOG (Speed Over Ground) and N for knots 0 through 999.99 knots/hour
sss.ss,K	SOG (Speed Over Ground) and K for km r 0 through 999.99 km/hour

Example:

$GPVTG,329.01,T,346.31,M,000.07,N,000.13,K

NMEA Cross-Track Error

$PASHS,NME,XTE

This command asks for the cross-track error. The structure is

$PASHS,NME,XTE,x

where x is the port to output the message.

$GPXTE

This response message displays the cross-track error (XTE). The structure is

$GPXTE,v,v,eee.eee,s,n

where the fields are as defined in Table 4.73.

Table 4.73: XTE Structure

Field	Description
v	Validation of SNR A = valid V = invalid
v	Validation of cycle lock A = valid V = inavlid
eee.eee	Cross-track error 0 through 999.999
v	Steer left or right L = left R = right
N	Nautical miles constant

Example:

$GPXTE,A,A,019.999,R,N

RTCM Commands

Table 4.74 summarizes the RTCM commands.

Table 4.74: RTCM Commands

Command	Description	Page
$PASHS, RTC,AUT	Turn auto differential mode on/off	122
$PASHS, RTC,BAS	Set sensor as differential base station	123
$PASHQ,MSG	Query base station	123
$PASHR,MSG	Response message, last 5 messages received	123
$PASHS, RTC,COD	Select pseudo-range for RTCM differential	123
$PASHS, RTC,EOT	Select type of EOT character for RTCM message	124
$PASHS, RTC,F18	Select Ashtech- or Trimble-compatible RTCM message 18/19 format	124
$PASHS, RTC,INI	Initialize RTCM setup	124
$PASHS, RTC,MAX	Set maximum age of RTCM differential corrections	124
$PASHS, RTC,MSG	Define RTCM message	125
$PASHS, RTC,OFF	Disable differential mode	125
$PASHS, RTC,QAF	Set quality threshold	125
$PASHS, RTC,REM	Set sensor as RTCM differential remote	125
$PASHS, RTC,SEQ	Check sequence number	126
$PASHS, RTC,SPD	Set RTCM bit rate	126
$PASHS, RTC,STI	Set station identification	126
$PASHS, RTC,STH	Set health of reference station	127
$PASHS, RTC,TYP	Enable type of message	127
$PASHQ, RTC,	Query differential mode parameters and status	128
$PASHQ,DFO	Query RTCM remote station status	130
$PASHR,DFO	Response message, remote station status	130

Turn Auto Differential Mode On/Off

$PASHS,RTC,AUT

Turns auto differential mode on or off. The command structure is **$PASHS,RTC,AUT,x** where x is Y (on) or N (off). When in auto-diff mode the sensor generates raw positions automatically if differential corrections are older than the maximum age, or are not available. Used only in REMOTE mode. .

Example: Turn auto differential mode on

$PASHS,RTC,AUT,Y

Set Receiver as Differential Base Station

$PASHS,RTC,BAS

Set the sensor to operate as a differential base station using RTCM format. The command structure is **$PASHS,RTC,BAS,x** where x is the differential port and can be set to A, B, or C.

Example: Set to RTCM differential base mode using port B

$PASHS,RTC,BAS,B

$PASHQ,MSG

The associated query command is $PASHQ,MSG,x where x is port A, B, or C.

$PASHR,MSG

The response message displays the last 5 messages from the mailbox. The message structure is

$PASHR,MSG,s0,s1,s2,s3,s4,s5,s6,s7,s8,s9*crc

where the fields are as defined in Table 4.75.

Table 4.75: MSG Message Structure

Field	Description
s0	Last received message
s1	Time of last received message: hour, minute
s2	Message received before last
s3	Time of this message: hhmm hour, minute and so on up to 5

Select Pseudo-Range for RTCM Differential

$PASHS,RTC,COD

This command selects the type of pseudo-range code to be used for RTCM differential mode. The structure is $PASHS,RTC,COD,s where s is

CA = Use C/A code for differential correction

‘ L1P = Use L1P code for differential correction

Example: Set sensor to use L1P code for differential corrections

$PASHS,RTC,COD,L1P

There is no response message. This command requires that the RTCM Differential or RTCM Remote Only options (D or U, respectively) be installed in the sensor.

Select Type Of EOT Character for RTCM Message

$PASHS,RTC,EOT

Selects the type of EOT characters to be transmitted at the end of an RTCM message. The structure is **$PASHS,RTC,EOT,s** where s is:

blank = no characters

CR = carriage return

CRLF = carriage return and linefeed (default)

This command requires that the RTCM Differential option D or RTCM Remote Only option U be installed in the sensor.

Compatible RTCM Message 18/19 Format

$PASHS,RTC,F18

This command lets you configure the sensor to generate two types of RTCM 18/19 messages. The structure is $PASHS,RTC,F18,x where x is A or B:

A = generate Ashtech RTCM 18/19

B = generate Trimble RTCM 18/19

There is no industry standard at this time, pending a decision by the RTCM Committee. The sensor will remain in the configured mode after power cycle, until the internal memory is cleared, or the $PASHS,RST command is issued. This command requires that the RTCM Differential or RTCM Remote Only options (D or U, respectively) be installed in the sensor. There is no response message.

Initialize RTCM Setup

$PASHS,RTC,INI

This command initializes the RTCM setup. The command $PASHS,RTC,INI must be issued to the RTCM remote station if the communication link between the base and remote is disrupted for less than 30 seconds. Further, this command can be issued at any time to reset the RTCM setup back to the default values. This command requires that the RTCM Differential or RTCM Remote Only options (D or U, respectively) be installed in the sensor. There is no response message.

Set Maximum Age of RTCM Differential Corrections

$PASHS,RTC,MAX

This command sets the maximum age in seconds of an RTCM differential correction. If the age is greater than this seeting, the age will not be used. The command structure is **$PASHS,RTC,MAX,x** where x is any number between 1 and 1199. Default is 60. Used only in REMOTE mode.

Define RTCM Message

$PASHS,RTC,MSG

Define RTCM message up to 90 characters long that will be sent from the base to the remote. The command structure is **$PASHS,RTC,MSG,x** where x is the tex messaget. Used only if message type 16 is enabled.

Example: Define RTCM message "This is a test message"

$PASHS,RTC,MSG,This is a test message

Disable Differential Mode

$PASHS,RTC,OFF

This command disables differential mode.

Example:

$PASHS,RTC,OFF

Set Quality Threshold

$PASHS,RTC,QAF

This command sets the number of received differential correction frames in RTCM differential mode above which the quality factor is reset to 100%. The command structure is **$PASHS,RTC,QAF,x** where x is any number between 0 and 999. This QAF number is used to compute the QA value where:

QA = good messages/QAF

The QA parameter allows you to evaluate the communication quality between the base and remote stations. The QA value can be seen using the $PASHQ,RTC query command. Default is 100. Used only in REMOTE mode.

Example: Set quality factor to 200

$PASHS,RTC,QAF,200

Set Sensor as Differential Remote

$PASHS,RTC,REM

This command sets the sensor to operate as a differential remote station using RTCM format. The command structure is **$PASHS,RTC,REM,x** where x is differential port A, B, or C.

Example: Set receiver as differential remote using port C

$PASHS,RTC,REM,C

Check Sequence Number

$PASHS,RTC,SEQ

Checks sequence number of received messages7 and, if sequential, accept corrections; if not, don't use correction. The command structure is **$PASHS,RTC,SEQ,x** where x is Y (check) or N (do not check). Default is N. Used only in REMOTE mode. Valid only at beginning of differential operation. After two sequential RTCM corrections have been received, differential operation begins.

Example: Check sequence number

$PASHS,RTC,SEQ,Y

Set RTCM Bit Rate

$PASHS,RTC,SPD

This command sets the number of bits per second that are being sent to the serial port of the base station. The command structure is **$PASHS,RTC,SPD,x** where x is the code for the output rate in bits per second. The available speeds are 25, 50, 100, 110, 150, 200, 250, 300, and 1500 as listed in Table 4.76. . Default is 300 bits per second.

Table 4.76: Codes for Output Bit Rate

Code	0	1	2	3	4	5	6	7	8	9
Rate	25	50	100	110	150	200	250	300	1500	Burst mode

Used only in BASE mode.

Example: Set bit rate to 110 bits/sec

$PASHS,RTC,SPD,3

If burst mode is selected, the message is sent at the configured serial port rate.

Set Station Identification

$PASHS,RTC,STI

This command sets the user station identification (user STID) to any value between 0000 and 1023. The command structure is **$PASHS,RTC,STI,xxxx** where xxxx is the station identification. In RTCM differential mode, corrections will not be applied if the station ID of the base and rover are different, unless the rover is set to zero. If the user STID of the rover station is set to zero, the sensor will attempt to use the differential corrections it receives, regardless of STID of base station. Default is 0000.

Example: Set site identification to 0001

$PASHS,RTC,STI,0001

Set Health of Reference Station

$PASHS,RTC,STH

This command sets the health of the reference station. The command structure is **$PASHS,RTC,STH,x** where x is any value between 0 and 7. Used only in BASE mode. Default is 0. The codes for the station health are definedby RTCM as listed in Table 4.77.

Table 4.77: Station Health Codes

Code	Health Indication
7	Reference station not working.
6	Reference station transmission not monitored.
5	Specified by service provider.
4	Specified by service provider.
3	Specified by service provider.
2	Specified by service provider.
1	Specified by service provider.
0	Specified by service provider.

Example: Set health to "Reference station not working"

$PASHS,RTC,STH,7

Enable Type of Message

$PASHS,RTC,TYP

This command enables the type of message to be sent by the base station, and the period that it will be sent. The command structure is **$PASHS,RTC,TYP,x,y** where x is the type and y is the period. Used only in BASE mode. Table 4.78 indicates the

Table 4.78: Types of RTCM Messages

Type	Range
1	0 to 99 seconds, where 0 is disabled and 99 is generated continuously
3	0-99 minutes, where 0 is disabled and 99 is generated continuously
6	1 = ON, 0 = OFF Default = OFF
9	Same as type 1. Sensor can not output type 9.
16	Same as type 3
18	
19	

types of messages available and the period range setting.

Note that although all messages can be enabled simultaneously, only one can be set to 99. Default is type 6 OFF, type 1 set to 99, and all others set to 00 (disabled).

Example: Enable type 1, sent out every second

$PASHS,RTC,TYP,1,1

Query Differential Mode Parameters and Status

$PASHQ,RTC

This query command is available only if one of the differential options - differential base and remote (option D) or differential remote only (option U) - is installed in the sensor. The response message for the default values of the command is as shown below.

```
STATUS:
    SYNC:   TYPE:00    STID:0000   STHE:0
    AGE:    QA:100.00%  OFFSET:00
SETUP
    MODE:OFF    PORT: A     AUT:OFF
    SPD:0050    STI:0000    STH:00
    MAX:0060    QAF:100     SEQ:N
    TYP:1   2   3   6   16   18/19   EOT
    FRQ:99  00  00  0N  00   00      CRLF
    MSG:
```

Command

Table 4.79 describes each item of the message.

Table 4.79: RTC Message Structure

Item	Description
STATUS	Asterisk (*) denotes sync to last received RTCM message between base and remote stations (remote only).
TYPE	RTCM message type being sent (base) or received (remote). Types 1,2,3,6,16,18/19
STID	Station identification received from the base station. 4 characters, 0 through 1023
STHE	Station health received from the base station. See $PASHS,STH for details.
AGE	In base mode, displays the elapsed time between the beginning of transmission of message types 1, 9, 18/19. In remote mode, displays the age of the received messages in seconds.
QA	Displays the communication quality factor betwee base and remote. Defined as 100 x number of good measurements, divided by total number of messages. Remote only.
OFFSET	The number of bits from the beginning of the RTCM byte, in case of bit slippage.
MODE	RTCM mode. BAS (base), REM (remote) or OFF (default).
PORT	Communication port, A or B (default is A).
AUT	Automatic differential mode, ON or OFF (default).
SPD	RTCM bit rate. Burst mode transmits RTCM messages at the current configured serial port baud rate. Rates are 0 (burst mode), 25, 50, 100, 110, 150, 200, 250, 300, 1500.
STI	User-assigned station ID. 4 characters, 0 through 1023
STH	Station health. See STHE.
MAX	Specifies the maximum age, in seconds, required for a message to be used (remote only). Range is 0 through 999, 60 is default.
QAF	Sets the criteria to be applied when evaluating the quality of communication between base and remote. Remote only. Range is 0 through 999, default is 100.
SEQ	Check for sequential received message number for the message to be accepted (base only. N = no (default), Y = yes.
TYP	RTCM message type that the sensor can generate (base only. Type 1, 2, 3, 6, 16, 18/19.
EOT	End of transmission data. CRLF (default), CR, or NONE
FRQ	RTCM message send frequency. The period is in seconds for types 1 and 18/19, and minutes for all other types. 99 = continuous, 00 = disabled. Default is 1 for type 1, OFF for type 6, and 1 for 18/19.
MSG	For base mode, contains the message, up to 90 characters, that is sent from base to remote when message type 16 is enabled. In remote mode, displays the message, up to 90 characters, that is received from base.

If any of these parameters is changed by the corresponding set command, send the corresponding query command to obtain the current status. If changed, use the $PASHS,SAV,Y set command to save the values. After the next power-up, the message displayed in response to the corresponding query command will display the saved values instead of the defaults. The set command $PASHS,RST always resets the parameters to the default values.

Query RTCM Remote Station Status

$PASHQ,DFO

This command queries the status of the remote station. The structure is

$PASHQ,DFO,x

where x is the port for message output. If the port is not specified, the message is output to the port on which this command was received.

$PASHR,DFO

The response message is in the form $PASHR,DFO,............ where the fields are as defined in Table 4.80.

Table 4.80: DFO Structure

Field	Description
	RTCM differential mode status 0 = sensor not in remote mode, do not send remaining messages 2 = sensor in remote mode
	Message status 0 = no message has been received, do not send remaining messages 1 = message is not synchronized (message is older than maximum age) 2 = message is synchronized with last received message
	Reference station ID 4-character string 0 through 1023
	Reference station health 0 through 7
	Age of received message in seconds 0 through maximum age
	Quality factor 3 bytes 0 through 999
	Number of SVs for which PRC and RRC are transmitted
	PRN number 0 through 32
	Pseudo-range correction in meters
	Range rate correction in centimeters per second
	Delimiter at end of data
	Bytewise XOR checksum

Command

CPD Commands

Table 4.81 summarizes the CPD commands.

Table 4.81: CPD Commands

Command	Description	Page
$PASHS, CPD,AFP	Set integer ambiguity parameter	132
$PASHS, CPD,ANT or $PASHS, BPS,POS	Set antenna parameters of other receiver	132
$PASHR, CPD,ANT	Message, antenna parameters of other receiver	133
$PASHQ, CPD,DLK	Query data link status	133
$PASHR, CPD,DLK	Response message, data link status	134
$PASHS, CPD,DYN	Set rover dynamics	134
$PASHS, CPD,ENT	Set current raw position	135
$PASHS, CPD,EOT	Select type of EOT character, DBEN message	135
$PASHS, CPD,FST	Enable/disable fast CPD mode	136
$PASHR, CPD,INF	Response message, CPD SV information	136
$PASHS, CPD,MOD	CPD mode select	137
$PASHQ, CPD,MOD	Query CPD status	138
$PASHR, CPD,MOD	CPD status message	138
$PASHS, CPD,OUT	Select solution to output	139
$PASHS, CPD,PEB or $PASHS, BPS,PER	Set BPS transmission period	140
$PASHS, CPD,PER	Set CPD update interval	140
$PASHS, CPD,PED or $PASHS, DBN,PER	Set DBEN transmission period	141
$PASHS, CPD,PRT	Select output port for DBEN and BPS messages	143
$PASHS, CPD,POS	Set reference position of other receiver	141
$PASHS, CPD,RST	Reset CPD processing	142
$PASHQ, CPD	Query CPD status	143
$PASHQ, CPD,STS	Query CPD solution status	145
$PASHR, CPD,STS	Response message, CPD solution status	145
$PASHR,BPS	Response message, station coordinates	146
$PASHS,IDR	Set DBEN message and sender/destination ID	148
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$PASHR,RPC	Response message, packed DBEN	149
$PASHR,RTR	Response message, real-time error	151

Set Integer Ambiguity Parameter

$PASHS,CPD,AFP

This command sets the integer ambiguity fixing parameter. The command structure is

$PASHS,CPD,AFP,f1,*crc where field f1 is as defined in Table 4.82**.**

Table 4.82: AFP Structure

Field	Description
f1	Ambiguity fixing parameter. Range 1 through 5.
*crc	

Example: Set ambiguity fixing parameter to 4:

$PASHS,CPD,AFP,4

Set Antenna Parameters Of Other Receiver

$PASHS,CPD,ANT OR $PASHS,BPS,ANT

This command sets the antenna parameters of the OTHER receiver. Slant is measured from the reference point to the antenna edge. Radius is the distance from the antenna phase center to the antenna edge. Vertical offset is the offset set from the antenna phase center to the antenna ground plane. Horizontal azimuth is measured from reference point to antenna phase center, with respect to WGS-84 north. Horizontal distance is measured from reference point to point below (above) antenna phase center.

The structure is

$PASHS,CPD,ANT,f1,f2,f3,d4f4,f5*crc

where each field is as defined in Table 4.83.

Table 4.83: CPD ANT Structure

Field	Description
f1	Antenna slant 0 - 6.4000 meter
f2	Antenna radius 0 - 6.4000 meter
f3	f3 Antenna phase center height 0 - 99.9999 meter
d4	Degree part of horizontal azimuth 0 – 359 degree
f4	Horizontal distance 0 - 99.9999 meter
f5	Minute part of horizontal azimuth (always have 2 integer digits) 00.0 - 59.99 minute
*crc	

Command

Example:

$PASHS,CPD,ANT,1.790,0.1737,0.0,0000.00,0.0

$PASHQ,CPD,ANT OR $PASHQ,BPS,ANT

The accompanying query commands are $PASHQ,CPD,ANT and $PASHQ,BPS,ANT. These commands ask for information about the OTHER sensor's antenna parameters. The port for the message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received

The command structure is **$PASHQ,CPD,ANT,c1*crc** where c1 is the port for message output, port A, C, or C.

$PASHR,CPD,ANT

The response is a message in the form

$PASHR,CPD,ANT,f1,f2,f3,d4d5,f5*crc

where the fields are as described in Table 4.84.

Table 4.84: CPD,ANT Structure

Field	Description
f1	Antenna slant 0 through 6.4000 meters
f2	Antenna radius 0 through 6.4000 meters
f3	Antenna phase center height 0 through 99.9999 meter
d4	Degree part of azimuth 0 through 359 degree
f4	Minute part of azimuth (always 2 integer digits) 00.0 through 59.99 minute
f5	Horizontal distance 0 through 99.9999 meter

Query Data Link Status

$PASHQ,CPD,DLK

This command asks for the DLK (data link) message. The port for message output may be specified in this command. If the port is not specified, the message is output to the port from which the command was received. The command structure is

$PASHQ,CPD,DLK,x

where x is the port for message output, port A or B.

$PASHR,CPD,DLK

The response is a message in the form $PASHR,CPD,DLK,mmm,b,n,......where the fields are as defined in Table 4.85.

Table 4.85: DLK Message Structure

Field	Description
mmm	Receiver mode: BAS = base ROV = rover RBB = RBR = OFF = off
Following message available only when sensor is not in OFF mode.	
b	BPS message warning flag (see $PASHR,BPS for coding method)
n	Number of satellites in current DBEN message
s	SV PRN number in DBEN message
w	SV PRN warnings
m	Warrning message + = no warnings C = warning in L1 measurements P = warning in L2 measurements - = warning in both measurements
h	DBEN message header (send/receive ID, PASH)
a	BPS message age in seconds
p	Percentage of good DBEN message reception
l	DBEN message latency in milliseconds
	Communication port status: + = data in communication port - = no data in communication port

Set Rover Dynamics

$PASHS,CPD,DYN

This command enters the rover's dynamic information; relevant only for ROVER or RBP BASE receiver. The command structure is

$PASHS,CPD,DYN,d1*crc

Command

where the field parameters are as defined in Table 4.86.

Table 4.86: CPD DYN Structure

Field	Description
d1	Dynamic - one of the following values: 0 = static (antenna on tripod) 1 = quasistatic (antenna on hand-carried pole) 2 = walking 3 = automobile 4 = aircraft 5 = ship
*crc	Checksum

Example: Set dynamic for automobile:

$PASHS,CPD,DYN,3

Set Current Raw Position

$PASHS,CPD,ENT

Set current raw position as BASE position. The command structure is

$PASHS,CPD,ENT*crc

where *crc is the checksum.

Example:

$PASHS,CPD,ENT

Select Type Of EOT Character, DBEN Message

$PASHS,CPD,EOT

Selects the type of EOT characters to be transmitted at end of DBEN message. The command structure is $PASHS,CPD,EOT,s1

where the field is as defined in Table 4.87..

Table 4.87: CPD EOT Structure

Field	Description
s1	NONE=no characters to be sent CR=0x0D CRLF=0x0D 0x0A (default)

Example: Send CRLF

$PASHS,CPD,EOT,CR

Enable/Disable Fast CPD Mode

$PASHS,CPD,FST

This command enables/disables fast CPD mode. If this mode turned on, the rover receiver performs a fast CPD position solution. This command is relevant for ROVER mode only. The command structure is

$PASHS,CPD,FST,s1*crc

where the field parameters are as defined in Table 4.88.

Table 4.88: Fast CPD Structure

Field	Description
s1	Fast mode, 'ON or OFF'
*crc	Checksum

Example: Turn fast CPD mode ON;

$PASHS,CPD,FST,ON

Display CPD SV Information

$PASHR,CPD,INF

This command asks for the INF message containing CPD SV status information. The port for message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received. The command structure is

$PASHR,CPD,INF,s1,d1,d2c2,...,d10,d11c11,...,l1,l2,d20*crc

where the fields are as defined in Table 4.89.

Table 4.89: CPD INF Structure

Field	Description
s1	CPD mode: OFF = odd BAS = base ROV = rover RBR = RBB =
d1	Number of Svs in base station. This determines the number of fields to follow 0 - 12

Command

Table 4.89: CPD INF Structure (continued)

Field	Description
d2	SV PRN for the Svs in base sensor 1-32
c2	Warning field description: + - no warnings C - warning in L1 measurements P - warning in L2 measurements - - warning in both measurements '+' '-' 'C' 'P'
....	repeats d2c2 for other SV PRNs in base station
d10	Number of Svs in the rover station. This determines the number of fields to follow. 0-12
d11	SV PRN for the Svs in the rover receiver 1-32
c11	Warning field description: + - no warnings C - warning in L1 measurements P - warning in L2 measurements - - warning in both measurements '+' '-' 'C' 'P'
....	... repeats for other SV PRNs in rover station
11	Last BPS message time
12	Last DBEN message time
d20	BPS message warning (see $PASHR,BPS for coding scheme)

Example:
$PASHR,CPD,INF,ROV,09,04+,05+,06+,09+,12+,16+,20+,24+,25+,08,04+,05+,06
+,09+, 12+,16+,20+,24+,11340671,11363510,02*03

CPD Mode Select

$PASHS,CPD,MOD

This command sets the sensor to the CPD operation mode. The command structure is

$PASHS,CPD,MOD,s1*crc

where the field parameters are as defined in Table 4.90.

Table 4.90: CPD MOD Command Structure

Field	Description
s1	BAS=CPD base mode ROV=CPD rover mode RBR=RBP (reverse baseline processing) rover mode; computes DBEN and BPS messages only RBB=RBP base mode; computes RBP rover position OFF=Disable CPD mode
*crc	Checksum

Example: Set mode to CPD, reverse vector processing, rover

$PASHS,CPD,MOD,RBR

$PASHQ,CPD,MOD

The accompanying query command is $PASHQ,CPD,MOD. This command requests information about current CPD mode. The port for the message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received. The command structure is **$PASHQ,CPD,MOD,c1*crc** where C1 is the port, A, B, or C.

$PASHR,CPD,MOD

The response message is in the form

$PASHR,CPD,MOD,s0,s1,c2,f3,d4,d5,s6,s7,f8,s9,d10,s11,s12,f9*crc

where the fields are as described in Table 4.91.

Table 4.91: CPD MOD Message Structure

Field	Description
s0	Mode BAS = base ROV = rover RBB = RBR = OFF = off
s1	CPD mode: FST = fast OFF = off
c2	Port A or B
f3	CPD update period 1 through 5 seconds
d4	A *priori* rover dynamics 0 through 3
d5	A *priori* multipath information 0 through 4
s6	DBEN type: RCA, RP1, RP2, RPC
s7	DBEN smooth: SMS = on NSM = off
f8	DBEN transmission period 0 through 999.0
s9	Base position to use: ETD = XIT =
d10	PBS transmission period 0, 10, 30, 100, 300
s11	Solution to output: CPD, RAW, RBP
s12	CPD autodifferential mode/disabled: AUT = enabled OFF = off
f9	Ambiguity fixing parameter 1 through 5
*crc	Checksum

Command

Example:

$PASHR,CPD,MOD,BAS,FST,A,2,1,RPC,SMS,111,ETD,10,CPD,AUT,2*crc

Select CPD processing cycle

$PASHS,MSMOD

This command sets the repetition rate for CPD processing. The structure is

$PASHS,MSMOD,*f*

where *f* is 0.2, 0.5, or 1 second. This command requires that the Q option be installed in the sensor. Be aware that this command initiates a power cycle and will require you to reinitialize differential parameters.

Example: Set CPD repetition rate to 1 second

$PASHS,MSMOD,1

Set Multipath Parameters

$PASHS,CPD,MTP

This command enters the multipath parameters; relevant for rover mode or RBP BASE mode only. The command structure is

$PASHS,CPD,MTP,d1*crc

where the field parameters are as defined in Table 4.92.

Table 4.92: MTP Stucture

Field	Description
d1	Multipath, one of the following values: 0=no multipath (zero baseline) 1=Low (open field) 2=Medium (default) 3=High (water surface, buildings) 4=Severe (forest, urban canyon)
*crc	Checksum

Example: Set multipath to severe:

$PASHS,CPD,MTP,4

Select Solution to Output

$PASHS,CPD,OUT

This command selects which solution to output to serial port and/or external RAM. This command is relevant for rover mode or RBP BASE mode. The command structure is

$PASHS,CPD, OUT,d1*crc where the field parameters are as defined in Table 4.93**.**

Table 4.93: Solution Selection

Field	Description
d1e	0=raw pseudo range solution (autonomous) 1=CPD solution if available Note: When the receiver is set to ROVER mode and the CPD solution is not available, no solution will be output to the serial port. However, the raw pseudo-range solution will be stored into the external RAM. Note: If the receiver is in RBP BASE mode, CPD solution will be output via serial ports but will not be stored in receiver's external memory (B and C files) because this solution is rover's position. 2= the same as 1 but solution WILL BE stored in receiver's external memory.
*crc	Checksum

Example: Output CPD solution if available:

$PASHS,CPD,OUT,1

Set CPD Update Interval

$PASHS,CPD,PER

This command selects the slow CPD update interval. This command is relevant only for ROVER mode or RBP BASE mode. The command structure is

$PASHS,CPD,PER,f1

where f1 is the Kalman filter update period, 1, 2, 3, 4, or 5 seconds.

Example: Set Kalman update period to 1 second:

$PASHS,CPD,PER,1

Set BPD Transmission Period

$PASHS,CPD,PEB OR $PASHS,BPS,PER

This command sets the BPS message transmission period. The BPS message contains the base station ground mark coordinates (if relevant), and antenna offset from reference point. This command is relevant only for BASE mode or RBP ROVER mode.

The $PASHS,BPS,PER command sets the base station broadcasting interval. The command structure is:

$PASHS,BPS,PER,d1*crc

where d1 is as defined in Table 4.94.

Table 4.94: PEB/PER Structure

Field	Description
d1	Base coordinates broadcast interval in seconds. Only the following values are valid: 0, 10, 30, 60, 120, 300 means no transmision. second
*crc	

Example: $PASHS,BPS,PER,30

Set DBEN Transmission Period

$PASHS,CPD,PED OR $PASHS,DBN,PER

This command sets the DBEN message transmission period; relevant only for BASE mode or RBP ROVER mode. The command structure is **$PASHS,CPD,PED,f1*crc** where f1 is the DBEN message transmission interval, 0 to 999 seconds. The value should have no fraction part, i.e, 1.0, 3.0 are valid, but 2.5 is invalid. A value of 0.0 means no transmission

Example: $PASHS,CPD,PED,1.0

Set Reference Position of Other Receiver

$PASHS,CPD,POS OR $PASHS,BPS,POS

This command sets the reference point position of the OTHER receiver. The command structure is

$PASHS,CPD,POS,d1f1,c2,d3f3,c4,f5*crc

where the field structure is as defined in Table 4.95.

Table 4.95: CPD or BPS POS Structure

Field	Description
d1	Degree part of reference point latitude 0-90 degrees
f1	Minute part of reference point latitude (always 2 integer digits) 0-60 minutes
c2	Direction of latitude S=south, N=north
d3f3	0-180 degrees 00.0-59.99 minutes
c4	Direction of longitude E=east, W=west
f5	Reference point altitude (always has sign, + or -) -9999.9999 to +9999.9999 meters
*crc	Checksum

Example: Set position of other receiver:

$PASHS,CPD,POS,3722.2432438,N,12350.5438423,W,+34.567

$PASHQ,CPD,POS OR $PASHQ,BPS,POS

The accompanying query commands are $PASHQ,CPD,POS and $PASHQ,BPS,POS. These commands request information about the OTHER receiver's position. The port for the message output may be specified in this command. If the port is not specified, the message is output to the port from which this command was received. The command structure is **$PASHQ,CPD,POS,x*crc** where x is the port A, B, or C.

$PASHR,CPD,POS

This message displays the reference point position of ANOTHER receiver. The structure is **$PASHR,CPD,POS,d1f1,c2,d3f3,c4,f5*crc** where the fields are as defined in Table 4.96.

Table 4.96: CPD POS Structure

Field	Description
d1	Degree part of reference point latitude 0-90 degree
f1	Minute part of reference point latitude (always 2 integer digits) 00.0 - 59.99 minute
c2	Direction of latitude S= south, N = north'
d3	Degree part of reference point longitude 0-180 degree
f3	Minute part of reference point longitude (always 2 integer digits) 00.0 - 59.99 minute
c4	Direction of longitude E = east, W = west
f5	Reference point altitude (must have + or -sign) -9999.9999 through +9999.9999 meters

Example: $PASHR,CPD,POS

Reset CPD Processing

$PASHS,CPD,RST

This command resets the CPD processing (Kalman filter reset); relevant for ROVER mode or RBP BASE mode only. The command structure is

$PASHS,CPD,RST*crc

Example: Reset CPD processing

$PASHS,CPD,RST

Command

Select Output Port for DBEN and BPS Messages

$PASHS,CPD,PRT

This command selects the serial port that will output DBEN and BPS messages; relevant only to BASE or RBP ROVER mode. The command structure is:

$PASHS,CPD,PRT,x

where x is port A or B.

Example: Output DBEN and BPS messages on port B:

$PASHS,CPD,PRT,B

CPD Status

$PASHQ,CPD

The $PASHQ,CPD command requests the current CPD status.

The return message is typically:

```
STATUS:   MSMOD:02 Hz        MODE:DISABLED       BASE STAT:00000
PRN:
INTVL:01.0 sec      RCV INTVL:01.0 sec
AGE:0000 ms     RCVD CORD:000 sec           CORD USED:RECEIVED
AMBIGUITY:        RCV INTVL: 01.0 SEC
 Dlf:00000 ms      Tf:00000 ms                          DLc:01214  ms
Tc:00000 ms
SETUP:   DBEN PER:01.0 sec            DBEN PORT:B         EOT:CRLF
AMBIGUITY FIX MODE:04
DYNAMICS:WALKING DYNAMIC    POS. OUTPUT:CPD
MULTIPATH:MEDIUM        MULTIPATH  BAS POS USED:RECEIVED
FAST CPD:ON                        CPD PER:02 sec
```

Table 4.97 describes each item in the response.

Table 4.97: CPD Status Message Structure

Parameter	Description
MSMOD	NAV Solution cycle With Q option:1,2,5 Without Q option:1
MODE	CPD differential mode: DISABLED (default) BASE ROVER RVP BASE RVP ROVER

Table 4.97: CPD Status Message Structure (continued)

Parameter	Description
BASE STAT	A -'1' if the receiver has not tracked the L2 observables B - '1' if the entered position and computed position differ by more than 500 metres in any direction C - '1' if the base station has not cimputed position using the raw pseudo-ranges D - '1' if base station antenna parameters are all zeros. E - '1' if the base station coordinates are not entered. Default: 00000
INTVL	See DBEN PER below
RCV INTVL	Interval of DBEN message received (Rover) 0 (default)
PRN	Lists the satellites' PRN ID in the transmitting DBEN message or received DBEN message. 1-32
AGE	Display the DBEN message age (from BPS message) in milliseconds. Always zero at the base 0 (default)..9999
RCVD COORD	Display the age of the received base station coordinates in seconds 0(default)..999
CORD USED	Display which base station coordinates are used in the CPD data processing ENTERED/RECEIVED (default)
AMBIGUITY	Display ambiguity fix status (Rover) FIXED/FLOAT(default)
DIf	Time delay to start Fast CPD task 0 (default)
Tf	Time to execute Fast CPD task (Rover) 0 (default)
Dlc	Time delay to start CPD (Rover) 0 (default)
Tc	Time to execute CPD (Rover) 0 (default)
DBEN PER	DBEN output period (Base) 0..999.0
DBEN PORT	DBEN output port (Base) A/B(default)
EOT DBEN	EOT characters (Base) CR/CRLF/NONE (default)
AMBIGUITY FIX MODE	Ambiguity fix mode (Rover) 1..5 (default at 4)
DYNAMICS	(Rover) WALKING DYNAMIC (default) / STATIC DYNAMIC/Q- STATIC DYNAIMC / AUTOMOBILE DYNAMIC / AIRCRAFT DYNAMIC / SHIP DYNAMIC
POS OUPUT	Type of position for output (Rover) CPD (default) / RAW
MULTIPATH	(Rover) MEDIUM MULTIPATH (default) / NO MULTIPATH / LOW MULTIPATH / HIGH MULTIPATH / SEVERE MULTIPATH
BAS POS USED	Same as CORD USED (Rover) XMITED (default) / ENTERED
FAST CPD	Fast CPD algorithm (Rover) ON (default or OFF

Table 4.97: CPD Status Message Structure (continued)

Parameter	Description
CPD PER	CPD update period (Rover): Fast CPD OFF 1 1Hz and Fast CPD ON 1 1Hz or 2Hz and Fast CPD ON 2

where c1 is the port for message output, port A, B, C, or D.

Query CPD Solution Status

$PASHQ,CPD,STS

This command asks for the CPD solution status message. This message contains information about current CPD processing status. The command structure is

$PASHQ,CPD,STS,x

where x is the port for message output, port A or B.

$PASHR,CPD,STS,...

The response message is in the form

$PASHR,CPD,STS,rr,ccccc.cc

where the fields are as described in Table 4.98.

Table 4.98: CPD STS Structure

Field	Description
rr	RMS phase residual 0.00 through 0.10 meters
ccccc.cc	Ambiguity fixing contrast ratio 0.00 through 99999.99

Example: $PASHR,CPD,STS,0.03,7.77

Select Base Position - Rover

$PASHS,CPD,UBP

This command selects the base position to use in ROVER mode; relevant for ROVER mode only. The command structure is

$PASHS,CPD,UBP,d1*crc

where the field parameters are as defined in Table 4.99.

Table 4.99: Base Position - Rover

Field	Description
d1	Solution output selection: 0 = Use entered base position 1 - Use transmitted base position
*crc	Checksum

Example: Use transmitted base position

$PASHS,CPD,UBP,1

Display Station Coordinates

$PASHR,BPS

This response message displays station's coordinates. The command has a fixed length of 96 bytes, not including <CR><LF>. The structure is

$PASHR,BPS,d1f1,c1,d2f2,c2,f3,f4,f5,f6,d3f7,f8,s1*crc

where the fields are as defined in Table 4.100.

Table 4.100: BPS Structure

Field	Description
d1	Latitude t 0 through 90 degrees
F1	L latitude decimal minutes 0 through 99.9999999
C1	Latitude direction N=north S=south
D2	Longitude degree part o through 360 degrees
F2	Longitude decimal minutes 0 - 59.9999999
C2	Longitude direction E=east W=west
F3	Altitude -99999.9999 - 99999.9999 to meters
F4	Antenna slant 0 - 6.400 meters
F5	Antenna radius in meters
F6	Antenna vertical offset -99.9999 to + 99.9999 meters
D3	Antenna horizontal offse azimuth 0 through 360 degrees
F7	Antenna horizontal offset 0 through 59.99 minutes
F8	Antenna horizontal offset distance 0 - 99.9999 meters
S1	LL status byte in hex

Command

Table 4.100: BPS Structure (continued)

Field	Description
S1	hex coded one byte of status flag

In the above table, s1 is a hex-coded one byte of status flag, as defined inTable 4.101.

Table 4.101: Status Flag

Bit	Description
1 (LSB)	Base station coordinates not entered
2	Base station antenna offset is not entered (This is questionable. In some case, the user will choose to enter the antenna phase center coordinates, then the antenna offsets are all zeros)
3	The base station is not computing position with raw pseudo ranges
4	4 The entered coordinates are more than 500 meters different in each direction from the computed position based on the raw pseudo ranges.
5	5 The base station is not tracking satellites properly (need more careful definition of not tracking satellite properly)
6	Not used
7	Not used
8	Not used

Example: $PASHR,BPS,3722.3767699,N,12159.8358039,W,
- 005.0450,0.0000,0.0000,00.0000,00000.00,00.0000,02*2E

Set DBEN Message and Sender/Destination ID

$PASHS,IDR

This command sets the type of DBEN message and the sender and destination ID. The structure is

$PASHS,IDR,ssdd,ttt

where the fields are as described in Table 4.102.

Table 4.102: IDR Structure

Field	Description
ssdd	Sender ID (ss) concatenated with destination ID (dd)
ttt	DBEN type: RCA RWL RP1 RP2 RPC

Example: $PASHR,IDR,BS??,RPC

Query Sensor ID and DBEN Message Type

$PASHQ,IDR

The associated query command is $PASHQ,IDR, and the response message is in the form:

$ssddR,ttt

Example: Query: $PASHQ,IDR

Response: $BS??R,RPC

Packed DBEN

$PASHR,RPC

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

The response message is in the form

$PASHR,RPC,<data length><packed data>

where the field structure is as defined in Table 4.103.

Table 4.103: RPC Message Structure

Field	Type	Size in Bytes	Description
data length	unsigned short	2	number of bytes in <packed data> part
packed data	unsigned char	data length	See table below
chksum	unsigned short	2	Acumulative unsigned short summation of the <packed data>, after <data length> before <ChkSum>

Table 4.104 details the structure of the <packed data> field.

Table 4.104: Packed Data Field Structure

Data Type	Symbol	Range	Reso-lution	Compress Num. Bits	Description
double	rcvtime	0 to 604800000	1 msec	30	Receiver time in GPS milliseconds of week
char (4)	site ID			32	Receiver 4-character site ID

Table 4.104: Packed Data Field Structure (continued)

Data Type	Symbol	Range	Reso-lution	Compress Num. Bits	Description
long	PRN			32	SVPRN for the satellites which have data in this message. It is a bitwise indication. Starting from the LSB, bit 1 corresponds to SVPRN #1, bit 2 to SVPRN #2, and so on. Bit value of 1 means that SVPRN has data in message; otherwise 0.

Table 4.105 defines the data that will repeat for each satellite whose corresponding bit in PRN is 1.

Table 4.105: PRN Data Structure

Data Type	Symbol	Range	Reso-lution	Compress Num. BIts	Description
double	PL1		1.0e-10 seconds	31	Pseudorange in units of 1.0e-10 seconds (or 01. nanoseconds). Multiply this value by 1.0e-10 to get pseudorange in seconds. A zero value indicates bad pseudorange.
char	WN			1	Warning bit 1=bad carrier phase and possible cycle slip 0=good carrier phase
	Sign		1	2	Carrier phase sign bit 1=negative carrier phase value 0=positive carrier phase value
long	PH_I		1	28	Integer part of carrier phase measurement in cycles
double	PH_F		15.0e-4	11	Fractional part of the carrier phase measuement in units of 5e-4 cycles. Multiply this number by 5e-4 to get fractional carrier phase measurement = PH_I + PF_F*5.0e-4.

Zeros are padded so that all of the <packed data> will be a module of 16 bits. Total number of bits in <packed data>:ceil((94 + 72*2*N_{SVS})/16*16 and

<data length> = ceil ((94 + 72*2*N_{SVS})/16)*2

in which ceil (a) means truncates to +Inf, e.g., ceil (3.1) = 4, ceil (3.5) = 4, ceil (3.95) = 4.

N_{SVS} is number of SVs.

Table 4.106 defines the DBEN message size.

Table 4.106: DBEN Message Size

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

Report Real-Time Error

$PASHR,RTR

This command returns a real-time error message in the form

$PASHR,RTR,d where d is a hex listing as defined in

Table 4.107: Real-Time Error Codes (Hex)

Setting Parameter	Description	Value
d	Barcode GPS time not available	0x01
	Barcode greater that 80 characters	0x02
	Tracking fewer satellites than selected minimum	0x04
	PPS period reset to 00.00 second warning	0x08
	Port A will output differential data at a different baud rate	0x10
	Port can only send out differential RTCM data	0x20
	Baud rate has been reset to 4800 bps	0x40
	Baud rate has been reset to 9600 bps	0x80
	Magnetic variable table checksum error	0x100
	Filed on external memory, delete unwanted files	0x200
	Channel does not send data	0x400
	Channel does not read data	0x800
	Bad channel echo	0x1000
	Autonomous position did not converge	0x2000

Photogrammtery & Event Marker

Photogrammetry (Event Marking) Interfaces

When the event [P] option is installed, the sensor can measure and record event times with high accuracy. In order to store an event time in the sensor's memory, a trigger signal must be applied to the appropriate connector located on the panel of the sensor; in the sensor, this connector is pin 9 of serial port B. The photogrammetry feature allows the event time to be stored in memory and downloaded using the HOSE program, or output by using the $PASHS,NME,TTT command.

At the rising or falling edge (selectable) of the trigger signal, the time is recorded in the sensor's nonvolatile external memory. The recorded time can be read by the downloading (HOSE) program at a later time. The trigger signal can be set to the falling edge using the $PASHS,PHE command.

The measured time is accurate down to 1 microsecond. This is a GPS time (currently UTC + 11 seconds) and is recorded as the number of seconds since the start of the GPS week (00:00 a.m. Sunday). The HOSE program reads the time and converts it to day number, hours, minutes, seconds, and fractional seconds up to 6 digits. With each event time, the sensor also records the site name. One example of the record is:

TEXA 4 21:30:19:430964

The photogrammetry time measures the event time relative to the sensor's GPS time. It measures only the first event during the period between 2 GPS epochs. Refer to Figure A.1. This allows use of mechanical switches without concern for contact bounces.

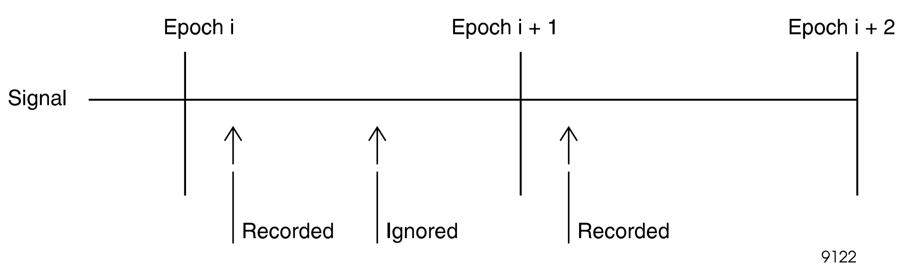

Figure A.1: Photogrammetry Time Measurement

The sensor stores only one event time per data collection period. If more than one event time is measured within a data collection period, the sensor records only the first one.

Therefore, setting the interval parameter to 1 second ($PASHS,RCI,1) yields the highest event time record rate.

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

The trigger pulse may be TTL-compatible or open collector. Minimum pulse duration is 100 nanoseconds when the signal is not terminated at the sensor input. The impedance is approximately 2K ohms.

Use a coaxial cable with BNC connectors to connect the camera trigger output to the photogrammetry input connector of the sensor.

Time Tagging the Shutter Signal

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

If the GPS measurements are recorded at the rate of one per second, the distance that the aircraft moves in ½ second is about 100 meters. Therefore, the distance between the position of the camera at the time the picture was taken and the GPS position fixes can be as much as 50 meters. The motion of the aircraft during this time may be in the meter range.

To minimize the errors discussed above, the closed loop technique is recommended.

Radio Link

Careful consideration must be given to the following situations to get the full performance from the radio data link:

Data Transmission Rate

To provide real-time, accurate rover position solutions at a 1-second rate, the Real-time Z system requires radios which can transmit data at a speed of at least 4800 baud. For best performance, radios capable of a 9600 baud data link speed are strongly recommended, especially for RTCM operation with type 18/19 messages. A high data link speed is required since the base station has to transmit a large amount of data to the rover station in each message it sends (both GPS carrier phase and pseudo-range measurements).

Line-of-Sight Transmission

Because of the high data transmission rate requirement, the Real-time Z system usally uses radios operating in the VHF/UHF frequency range. These frequencies are predominantly line-of-sight. The base station antenna should be placed as high as possible for maximum range. However, this needs to be balanced with reasonably short radio antenna cables, due to the relatively high transmission line loss on a cable when using VHF/UHF frequencies. Foliage, buildings or desert terrain may shorten the transmission distance while improvement may be found in transmissions over water, snow, or ice. The following is a formula for computing the approximate line-of-sight distances that can be achieved between the base and rover stations

$$d = \sqrt{\frac{3 \times K \times h}{2}}$$

where

d—line-of-sight distance in miles

h—base station antenna height in feet

K—surface reflectance coefficient, which is 1.33 for temperate climates (polar climates will have larger K values).

Sensitivity

Sensitivity of the transmitter and the receiver should be properly selected depending on the area and the amount of interference. For the base station, the recommended sensitivity setting is low while for the rover station, it is medium or high.

If you select a channel and you notice that the radio status light is blinking, there is probably someone broadcasting on that frequency and you should select different channel if you have another available.

Differential GPS

This appendix presents a brief overview of real-time differential, including code differential and carrier phase differential, sources of error, differential data messages. Differential remote/rover and base operations are available as receiver options. The RZ sensor is capable of both code-based differential and carrier phase differential.

Fundamentals of Differential GPS

The fundamental concept for any differential GPS system is to utilize the GPS measurement data from a stationary GPS receiver at a known site (base station or reference station) to correct the errors in the measurement data of a GPS receiver at an unknown site (remote station or rover station), thus achieving highly accurate relative position. The GPS differential data transferred from the base station to the rover station can be either pseudo-range measurements, carrier phase measurements, or a combination of both. Differential data can be in either raw data format or in a specific correction format.

The most common real-time differential GPS system uses a standard pseudo-range correction format called RTCM, sometimes referred to as code-based differential. The pseudo-range differential GPS can achieve accuracy ranging from several meters to less than a meter. To achieve centimeter accuracy, the carrier phase data must be used as well. A differential GPS system which uses the pseudo-range and carrier phase measurement data is called Carrier Phase Differential (CPD) GPS or often called real-time kinematic (RTK).

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

Code Based Differential

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

Carrier Phase Differential (CPD)

In CPD mode, the pseudo-range and carrier phase measurement data, which are coded in a DBEN message format, or RTCM Types 18 and 19, are transmitted from the base station to the rover station. This allows the rover station to compute very accurate differentially corrected positions.

The real-time Z system utilizes Ashtech's PNAV data processing engine, which processes the raw measurement data from both base receiver and the rover in double-difference form. Double-difference processing, widely used in post-processing geodetic surveying software, can achieve state-of-the-art differential GPS accuracy: less than a centimeter.

On-the-Fly Ambiguity Resolution

The most important feature of the real-time Z system is its ability to resolve the cycle integer ambiguities of the carrier phase measurements while the rover station is moving, thus the term "on-the-fly". With a PDOP less than two, and five or more common satellites in view of the base and rover stations, real-time Z can achieve centimeter-level accuracy very quickly, typically in less than a minute.

Fast Carrier Phase Differential

Another important feature of real-time Z is the fast CPD algorithm which reduces the position solution latency, or delay.

Whether pseudo-range or carrier phase differential GPS, the most accurate solution is obtained by processing the matched time-tag data from both the base station and the rover station. This is not a problem in post-processing, since all of the raw data is recorded in the files. For real-time applications using carrier phase differential (CPD), the position solution could be delayed up to 2 seconds. This is due to the extra data processing required and the latency of the radio data link. This slight delay is acceptable for most applications such as static point surveying, but may not be acceptable for certain vehicle navigation and kinematic surveying applications.

To reduce the position solution latency, the sensor incorporates a fast CPD algorithm which utilizes differential correction, commonly used in pseudo-range differential GPS, as well as an optimized data processing, reducing the CPD solution delay to about 100 milliseconds. With fast CPD, a real-time rover can produce position solutions up to 5 Hz, and each epoch solution is independent, not extrapolated or interpolated.

Vector and Reverse Vector Processing

The most commonly used real-time differential GPS operation is to place one receiver at a known position to serve as the base station. The base station transmits its raw measurement data over a radio link to multiple rover stations which use the raw measurement data to compute their positions more accurately. This operational mode is widely used in vehicle navigation, land and aerial surveying.

However, real-time Z is not constrained to operate in this mode alone. For applications such as robot monitoring and remote machine control, you may want to know the rover's position at the base station. This is called Reverse Vector Processing (RVP). When the real-time Z system is configured in RVP mode, the raw measurement data from the rover station is transmitted. The base station, at a known site, uses the data from the rover station to compute the rover's position.

Sources of Error

Error source affecting the performance of the real-time differential GPS can be categorized into two groups - those that affect the Z-12 sensor and those that affect the data link.

Sensor Related Errors

The major sources of error affecting the accuracy of DGPS solution are SV orbit estimation, SV clock estimation, ionosphere, troposphere, sensor noise and multipath in the measurements, carrier phase integer ambiguities in carrier phase differential. The first four sources of error are almost totally removed using differential GPS. Their residual error is in the order of one millimeter for every kilometer of separation between base and remote sensors.

Total position error (or error-in-position), is a function of the range or carrier phase errors (or errors-in-range) and by the PDOP (three-coordinate position dilution of precision). The PDOP is a measure of the SV geometry.

GPS Signal Multipath

Multipath is by far the most unpredictable error source affecting differential GPS position accuracy. Multipath is also one of the largest error sources, and because it has strong correlation, it requires a longer time to average out its affect. While most error sources can be canceled out by a differential GPS system, multipath can not because it is a local effect. That is, multipath affects the base station and rover station differently. To avoid large multipath effects, do not place the GPS antenna near any metal objects, vegetation, or water, since the GPS satellite signals reflect off these objects very easily and corrupt the reception of the direct signals from the satellites. Also, try to mount the antenna higher to reduce the effect of ground multipath reflections.

Carrier phase has relative smaller multipath error as compared to the code-phase. Thus for code differential, the carrier phase is used to smooth the pseudo-range measurements and reduce the sensor noise and multipath. After locking to a satellite, the rms noise of the smoothed pseudo-range is reduced with the square root of n where n is the number of measurements.

Satellite Geometry

The recommended satellite geometry is to have the RZ Sensor (both base and rover) track at least 5 common satellites above the elevation mask angle with the PDOP (Position Dilution of Precision) less than 4. Of course, the more satellites the receivers track, the better. The best performance can be obtained with the receivers tracking 8 satellites with a PDOP of 2 or less.

Maintaining Lock to the Satellites

During the operation of the Real-time Z system, it is recommended that continuous lock to the GPS satellites be maintained for best performance. Having uninterrupted data from the satellites provides faster ambiguity resolution and better position accuracy, since more data can be used. Therefore, make sure to place the GPS antennas (for both the base and remote stations) so that they have a good view of the whole sky. Do not mount them near any large obstructions. However, since it is understood that tracking satellites continuously is sometimes not possible due to obstructions such as bridges and trees, the Real-time Z system can still recover from these situations and provide the best accuracy possible.

Carrier Phase Integer Ambiguities

For carrier phase differential, the integer cycle ambiguities are initially estimated as float numbers. At this stage the position accuracy converges from the meter level to submeter level. The integer ambiguity search process is also launched from epoch to epoch. Once the integer ambiguities can be fixed into integer values, centimeter-level position accuracy can be achieved.

Data Link Related Errors

Radio Link Dropout

When the rover does not receive the DBEN or RTCM messages, it will continue to compute its CPD position for about thirty seconds if Fast CPD is on. However, the three-dimensional position error (sigma) will increase during this period. When the DBEN messages are re-acquired, the sigma will immediately drop to the value before the radio link drop out. If Fast CPD is off, CPD position computation will stop within seconds of losing the DBEN messages. For best results in the field, Fast CPD should be left on, and the base radio antenna should be located as high as possible with a line of site to the rover.

Selective Availability

Selective Availability (SA) is the intentional degradation of the GPS satellite signal by the US Department of Defense. Like multipath, SA is strongly correlated; but unlike multipath, it affects the base and rover stations about the same way. Therefore, most of the SA effects can be removed by a differential GPS system. Note that small position errors will still be present due to SA for any real-time differential GPS system. This is because the rover may have to predict the SA effect for the time gap caused by the radio link delay. A rule of thumb to predict the effect of SA is

$$\text{SA Error} = 0.5 * a * t^2 \quad \text{(meters)}$$

Where a is the SA acceleration in meters /second^2, currently it is about 0.01 meters / second^2 and it is subject to change by DoD without notice; t is the delay in the radio link. For example, for a 2 second delay the error due to SA is roughly 0.02 meters.

Differential Message

Table Table C.1 shows the differential message type supported in RZ Sensor.

Table C.1: Differential Messages

Differential Operation	Differential Message Supported
Code Differential	• RTCM type 1 • RTCM type 2 • RTCM type 9 (receiver only)
Carrier Phase Differential (CPD or RTK)	• RTCM type 18/19 • DBEN

Glossary

Almanac
A comprehensive database of all pertinent information for all satellites- orbit, position, health, etc.

Ambiguity fixing
A process to determine carrier phase cycle ambiguities to integers.

Altitude hold
A means of reducing the number of satellites to 3 for a position computation. If altitude is not held (fixed), 4 satellites are required. Altitude hold is seldom required now that a full constellation of satellites is available.

Autonomous
A GPS position determined by a single sensor without reference to a precise known location. The autonomous solution contains errors arising from ionosphere, SA, troposphere, and multipath. Accuracy is in the range of tens of meters.

Carrier Phase Cycle Ambiguities
The constant offset contained in the carrier phase measurements. This constant offset is of integer nature.

CBEN
Ashtech proprietary message format containing position, velocity, solution status, position RMS and covariance, number of satellites, PDOP. ASCII or binary. Binary format is packed and is not compatible with IEEE format.

Clock offset
The difference in time between GPS time and a satellite clock or a sensor clock (less accurate).

Code Phase
See **Pseudo-range**

CPD
Ashtech's proprietary carrier phase differential method for GPS positioning. Pseudo-range and carrier phase measurements in DBEN message format are transmitted from base to rover via a data link (usually a radio), allowing the rover to compute an extremely accurate differentially corrected position, in centimeter ot subcentimeter level.

DBEN
An Ashtech proprietary binary message format which contains a message header, receiver time, receiver site ID, pseudo-range and carrier phase measurements, checksum, and message tail. This message is for CPD operation.

D-file
GPS time-stamped descriptor text file.

Double Difference
The code phase (pseudo-range) measurement or carrier phase measurements can be differenced between two sites and differenced between two satellites. This is called double difference. Double difference removes/reduces most of the common errors between the measurements. It is a way of differential processing. Difference between two sites removes/reduces Ionospheric delay Tropospheric delay Satellite clock error, including S/A effects
Difference between two satellites received from the same receiver removes/reduces the receiver clock error

Ephemeris
A subset of the almanac containing information

for one specific satellite.

Fast CPD
An Ashtech proprietary differential technique to generate position at high output rate and low latency.

Fixed Ambiguities
The Carrier Phase Cycle Ambiguities are of integer natures. When they can be fixed to integers, the position accuracy is in centimeter to sub-centimeter level.

Float Ambiguities
The Carrier Phase Cycle Ambiguities are estimated as float numbers. With float ambiguities, the expected position accuracy is around meter to sub-meter level.

Integer Ambiguities
see **Carrier Phase Cycle Ambiguities**

IODE
Issue of Date Ephemerides

Kalman Filter
An optimal stochastic filtering which combines the recusive least squares and stochastic process in an optimal way. It is a widely used scheme in navigation and other signal processing application.

MBN
Measurement data, ASCII or binary.

Multipath
A reflective signal which contaminates the main path of the signal. GPS multipath is one of the major error source affecting the position accuracy. It cannot be corrected by differential technique, but can be reduced by situating the antenna away from metals, water, and obstructions.

OBN
Output message containing CPD vector and site information. Binary only.

PBEN
CPD rover position, velocity, and other data, ASCII or binary.

PRN
The ID number assigned to a satellite in accordance with *ICD-GPS-200, Navstar GPS Space Segment/Navigation User Interfaces, Revision B.*

Pseudo-range
Distance measurement from satellite to sensor, uncorrected for sync errors between satellite clock and sensor clock.

Raw data
Unformatted data collected by a GPS receiver

RBP
Reverse baseline processing. A mode of operation in which a rover transmits raw data to a base station, which then computes the rover position; that is, the base station knows the rover position.

Real-time Kinematic
A differential GPS operation using the carrier phase measurements with fixed integer ambiguities. It achieves the ultimate GPS accuracy, in the range from centimeters to millimeters.

Receiver clock error
The difference between GPS time and receiver time.

Rover Dynamics
A linearized model of the rover motion/ acceleration. Rover dynamics constitutes the stochastic process parts of the Kalman filter. It propagates/extrapolates the solution from one epoch to the next epoch.

RTK
See **Real-time Kinematic**.

RVP
Reverse Vector Processing, see **RBP**.

SA
Selective Availability. Intentional degrading of GPS signal by US Department of Defense to hamper use by enemy. Can be mostly nullified by differential operation.

SV
space vehicle (satellite)

UBN
Output message containing CPD position, velocity, and statistical information. Binary only.

UDRE
User differential range error

Week number
Sequential GPS week number measured from 1/5/80.

Z mode, Z-tracking™
Ashtech proprietary method for achieving precise position when Anti-Spoofing (AS) is on.

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