Z18 Reference Station System

Dual-Frequency GPS+GLONASS™ Receiver for Scientific Applications

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

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Introduction

The Z18 Reference Station System™ provides powerful GPS+GLONASS™ technology for high-end reference station applications.

One of the primary advantages of GPS+GLONASS is increased satellite coverage. With a total of 9 healthy GLONASS satellites, there are more than 60% more satellites available for position computation than with GPS alone.

To take advantage of the increased satellite availability, the Z18 has 10 channels for L1 and L2 GPS and 8 Channels for L1 and L2 GLONASS.

Functional Description

The GPS constellation contains 26 usable satellites. As of May 2000, the GLONASS constellation has 9 usable satellites of the planned 24 satellites full constellation. As the Z18 locks onto the signal generated by each satellite, information (ephemeris data) about the position of each satellite is automatically downloaded and stored in receiver memory. Once the ephemeris data is collected, the Z18 can compute its own position.

The Z18 calculates three-dimensional position and velocity when tracking any combination of five satellites (e.g. 3 GPS and 2 GLONASS). By holding the GPS-GLONASS clock offset fixed, the Z18 calculates a 3D position with any combination of 4 satellites (e.g., 2 GPS and 2 GLONASS).

Up to 2 independent measurements are determined per second, with no interpolation or extrapolation from previous solutions. The position and velocity computations are performed using all the satellites in view simultaneously. The Z18 uses a Doppler measurement technique for computing on-the-fly velocity (no dependence on the previous position). All computations are accomplished relative to the World Geodetic System WGS-84 reference ellipsoid when the receiver is used in GPS or MIX mode, and in PZ-90 when in GLO only mode.

Upon application of power, the Z18 runs a self-test of internal memories, and thereafter periodically self-tests various functions during normal operation. Test results are stored for commanded output. After self-test, the Z18 initializes the battery-backed RAM. If the battery-backed RAM fails self-test (due, for example, to a low battery condition), the Z18 clears and reports the loss of stored data, then initializes the 18 channels and begins searching for all satellites within the field of view of the antenna.

Technical Specifications

Table 1.1 lists the technical specifications of the Z18 Reference Station System.

Table 1.1. Technical Specifications

Characteristic	Z18 Reference Station System Specifications
Tracking	• 10 channels L1 and L2 GPS code and carrier • 8 channels L1 and L2 GLONASS code and carrier
Size	17.2 cm wide × 5.8 cm height × 22.5 cm depth
Weight	3.8 lbs
Operating temperature	-30° to +55°C
Storage temperature	-40° to +85°C
Environment • Humidity • Vibration • Shock	 • Resistant to wind-driven rain and dust to MIL-STD-810E • N/A • N/A
Power consumption	11.7 watts
Input Voltage	10 to 30 VDC
Speed (Maximum)	1,000 knots
Altitude (Maximum)	60,000 ft
Interface	• Three bi-directional RS-232 ports via DB 25 connector up to 115,200 bps • One antenna port • External frequency input (5, 10, or 20 MHz)

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Equipment

This chapter includes a functional and hardware description of the Z18, defines the RF interface connector and the power/input/output connector signal parameters, and lists power requirements and environmental specifications.

Hardware Description

The Z18 (Figure 2.1) has three RS-232 input/output (I/O) ports A-C, and a radio-frequency (RF) antenna port. All RS-232 serial ports are capable of two-way communication with external equipment.

Figure 2.1. Z18 Front Panel

Table 2.1 describes the front panel components.

Table 2.1. Z18 Front Panel Description

Nomenclature	Description	Function
EXT RFF	External frequency reference connector	Allows input of external reference clocks Input frequencies 5, 10, or 20 MHz, sinusoidal
GPS ANT	Antenna connector	The RF connector is a standard TNC female wired for connection via 50 Ω coaxial cabling to a GPS+GLONASS antenna with an integral LNA.
OFF/ON	Power switch	Turns the receiver on and off.
PWR/SATS	Power indicator/SV indicator	Flashing red light indicates power is applied to the receiver. Number of green flashes indicates number of satellites the receiver is locked onto. A yellow flash separates the count between the number of GPS and GLONASS satellites the receiver is locked onto.
SERIAL PORTS	Serial power/I/O port	The multi-function 25 pin connector serves as the 3 RS-232 Serial input/output ports (ports A, B, and C) and power input.

Power/Input/Output Connections

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

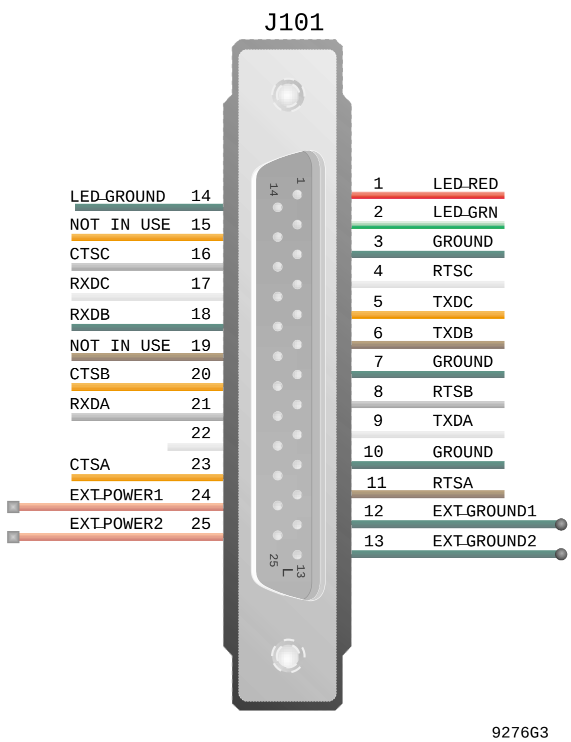

Figure 2.2. DB25 Connector J101

Table 2.2 lists the pin assignments for DB25 connector J101.

CAUTION
Turn off power before connecting or disconnecting cables.

Table 2.2.J101 Connector Pinout

Pin	Code	Pin	Code
1	LED RED - Can be used to drive external LED	14	LED GND
2	LED GRN - Can be used to drive external LED	15	NOT IN USE
3	GND	16	CTSC
4	RTSC	17	RXDC -
5	TXDC	18	RXDB
6	TXDB	19	NOT IN USE
7	GND	20	CTSB
8	RTSB	21	RXDA
9	TXDA	22	No connection
10	GND	23	CTSA
11	RTSA	24	EXT PWR 1
12	EXT GND 1	25	EXT PWR 2
13	EXT GND 2		

Power Requirements

DC voltage: 10 to 30 volts DC, regulated ±5%

Wattage: 11.4 watts (LNA not included)

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

RF Interface Connector

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

The RF circuitry receives satellite data from a GPS+GLONASS antenna and LNA via a coaxial cable, and can supply power to the antenna/LNA by means of that cable. No separate antenna power cable is required. The LNA power consumption is usually below 300 milliwatts .

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

Serial/Power Cable

The serial/power cable, Figure 2.3, connects the Z18 to the power source, the PC and any peripherals.

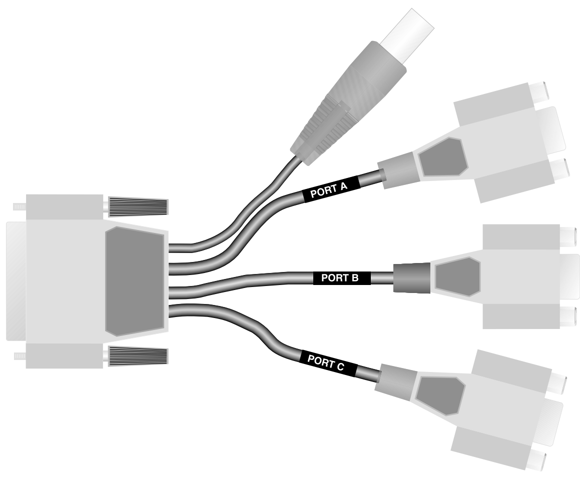

Figure 2.3. Serial/Power Cable

Antenna

The Z18 is designed to work with an antenna-preamplifier that requires five volts and is isolated from DC ground. The gain of the antenna/preamplifier minus the loss of the cable should be between 20 and 30 dB. Connect the antenna cable directly to the antenna connector on the Z18. Antenna cables exceeding 30 meters may require a line amplifier. A Line Amp is available for longer cable length or cable with higher loss.   The Line Amp has N-type connectors to connect to the antenna cable.

Radio Interference

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

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Standard Operation

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

Connection Procedures

Components

The following components comprise a generic reference system configuration:

- Z18 receiver
- GPS+GLONASS choke ring antenna
- Antenna mounting hardware
- Antenna cable
- Serial interface/power cable
- Power supply
- PC with GBSS software

Antenna

Connect the antenna cable from the antenna to the antenna TNC connector on the receiver.

Serial/Power Cable

Connect the 25-pin serial cable to the 25-pin connector on the receiver. Connect the power supply to the power cable.

Power

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

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

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

Communication

After you have the Z18 powered and running, you must send it commands in order to receive data and change parameters. GBSS software which runs on a Windows NT computer is provided with the Z18 to perform data logging and receiver control. The following procedure describes how to send commands to and receive information from the Z18 using GBSS and a personal computer.

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

   The default communication parameters of the Z18 are:

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

   When you first establish communication with the Z18, your communication interface must use this protocol.

Initialization

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

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

If you did not choose to communicate with the Z18 at 9600 baud, you will need to change the above INI command to reflect this. Failure to do this will result in loss of communication.

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Advanced Operation

Receiver Communications

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

Input Messages

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

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

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

All command messages (set or query) must be in uppercase followed by <Enter>. A valid set command, if this command is successfully executed, causes the Z18 to return the $PASHR,ACK*3D, "acknowledged" response message. Valid query commands are acknowledged by return of the requested information. A set command containing a valid $PASHS set command header, followed by character combinations or parameters unrecognized by the Z18 returns the $PASHR,NAK*30 "not-acknowledged" response message. All other invalid commands are ignored.

Output Messages

Output messages are messages the Z18 sends to the data logging device in response to a set or query command. Output messages comprise general status messages, command acknowledged/not acknowledged messages, and GPS data messages. The general status messages are in free-form Ashtech proprietary formats. The command acknowledged/not acknowledged messages and GPS data messages are in ASCII format while the raw data messages output in binary format.

Serial Port Configuration

The Z18 provides RS-232 serial ports with two-way full-duplex communication. The default transmit/receive protocol is 9600 baud, eight data bits, no parity, and one stop bit (8N1). The baud rate of the Z18 ports is adjustable using the $PASHS,SPD speed set command; the data bit, stop bit, and parity protocol is always 8N1.

On initial power-up or after use of the $PASHS,RST (reset to defaults) command, the Z18 defaults to 9600 baud for all RS-232 serial ports.

The baud rates between the Z18 and the interfacing equipment must be the same for the port and the device connected to the port.

To resume communication with the Z18 after changing the baud rate using the $PASHS,SPD set command, change the baud rate of the command device.

Parameter Settings and Status

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

The current settings of receiver parameters can be viewed using the query commands. Many individual parameters have a unique query that can be used to check their status. However, there are 3 main query commands that can be used to check multiple parameters at one time. Each of these query commands relates to a particular area:

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

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

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

```
SPDA:5 SPDB:5 SPDC:5 SPDD:5
GPS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
GLO:YYYYYYYYYYYYYYYYYYYYYYYY
SYS:MIX DTM:W84 GTM:0 GTF:0 DTG:+000000.0000 TDP:40 GTP:Y
PMD:1 FIX:0 ALT:+00000.00 PDP:40 HDP:40 VDP:40
PEM:10 UNH:N ION:N SAV:N
RTC:OFF PRT:-
NMEA: ETR POS GLL GXP GGA VTG GSN GSA SAT GRS RRE GSV ALM DAL UTM RMC ZDA TSH TTT
PRTA: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PRTB: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PRTC: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PRTD: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PER:001.00
```

Figure 4.1. $PASHR,PAR Default Response Message

Figure 4.2 shows a typical response message for the raw data parameters default values of $PASHQ,RAW. See "$PASHQ,RAW,x" for more information.

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

Figure 4.2. $PASHR,RAW Default Response Message

Figure 4.3 shows a typical response message for the RTCM differential parameters and status default values of $PASHQ,RTC.

```
STATUS:
SYNC:    TYPE:00   STID:0000  STHE:0
 AGE:+000   QA:0.0%  OFFSET:00
STATUS:
 MODE:OFF  PORT:?   AUT:N
 SPD:1500  STI:0000 STH:1
 MAX:0060  QAF:100   SEQ:N
TYP: 1  2  3  6   9  16  18  19  22  31  32  6G  34  36
FRQ:01 00 00 00  00  00  00  00  00  01  00  00  00  00
BASE:  LAT:0000.0000,N  LON:00000.00000,W  ALT:+00000.00 WGS
MSG:     first 45 characters of RTCM type 16 message
         next 45 characters of RTCM type 16 message
MSG (GLO):first 45 characters of RTCM GLONASS type 36 message
   next 45 characters of RTCM GLONASS type 36 message
```

Figure 4.3. $PASHR,RTC Default Response Message

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

Default Parameters

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

Table 4.1 lists the default values of all user parameters.

Table 4.1. Default Receiver Parameter

Parameter	Description	Default
SVS	SV tracking selection	Y for all
PMD	Position mode selection	1
FIX	Altitude hold fix mode selection	0
PEM	Position elevation mask	5
PDP	Position dilution of precision mask	40

Table 4.1. Default Receiver Parameter (continued)

Parameter	Description	Default
HPD	Horizontal dilution of precision mask	04
VDP	Vertical dilution of precision mask	04
ION	Enable ionosphere model	N
SAV	Save parameters in battery backup memory	N
LAT	Antenna latitude	00N
LON	Antenna longitude	00W
ALT	Antenna altitude	+00000.000
DTM	Datum selection	W84
UDD	User-defined datum parameters	Semi major axis = 6378137 Inverse flattening = 298.3 Remaining parameters = 0
NMEA messages	NMEA message output status	OFF in all ports
PER	NMEA messages output rate	001.0
RCI	Raw data output rate	005.0
MSV	Minimum number of SV's for data recording	03
ELM	Elevation mask for data recording	5
SIT	Site ID name	????
RAW data	Raw data output status	OFF in all ports
Serial Port Baud Rate	Serial ports baud rate selection	9600 in all ports
RTCM MODE	RTCM differential mode selection	OFF
RTCM PORT	RTCM differential mode port selection	B
AUT	Automatic differential/autonomous switching when RTCM differential mode enabled	N
RTCM SPD	RTCM differential BPS speed setting	1500
STI	RTCM base station ID setting	0000
STH	RTCM base station health setting	0
QAF	RTCM communication quality setting	100

Table 4.1. Default Receiver Parameter (continued)

Parameter	Description	Default
TYPE	RTCM differential messages enabled and output frequency of the enabled messages	1 = 99, 31 = 99, 6 = OFF, 6G = OFF, remaining messages 00
RTCM EOT	End of character selection for RTCM corrections	CRLF

Data Recording

All data recording is done externally using such programs as Magellan's GBSS.

Position Mode/ALT Fix Mode

Because the Z18 mixes two different constellation systems (GPS and GLONASS) to determine position, and the clocks between these two systems are not synchronized, the Z18 initially needs to track a minimum of 5 satellites (any combination of GPS and GLONASS satellites) to compute a 3-D position, or four satellites to compute a 2-D position.

The Z18 has three commands that control the position mode and fix the altitude or time shift between system clocks. These commands enable the Z18 to compute a 3-D position using only four satellites, or a 2-D position using only 3 satellites. The commands are PMD, GTM, and GTP.

The Z18 performs a position computation in four different modes: 0, 1, 2, or 3. These modes determine the number of satellites required to compute a 3-D or 2-D position, and depend upon the priority in which the altitude or time shift are held fixed. The position modes are set with command $PASHS,PMD and depend upon the setting of GTM (whether to compute time shift or hold it fixed), and GTP (set priority to hold fixed time shift over altitude, or vice versa) when the number of used satellites is fewer than 5. See "$PASHS,PMD" for more information.

In **mode 0** with GTM set to 0 (time shift not held fixed), at least 5 satellites with elevation equal to or above the position elevation mask are required to compute a 3D position. With GTM set to 1 (time shift held fixed if number of satellites fewer than 5), or 2 (time shift held fixed), four satellites are required to compute a 3D position; 2D position is not computed in this mode.

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

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

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

Altitude Definition

Two modes define the altitude selected when the Z18 is in altitude hold mode. Use the $PASHS,FIX set command can be used to select between these modes. See "$PASHS,FIX,x" for more information.

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

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

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

Time Shift Hold Definition

Two modes determine what time shift is selected when the Z18 is in time shift hold mode. The $PASHS,GTF command selects the mode, 0 or 1. See "$PASHS,GTF,d" for more information.

In **mode 0**, the Z18 uses the most recent computed time shift.

In **mode 1**, the Z18 uses only the last time shift entered using $PASHS,DTG in the position solution. The Z18 does not compute a position when the time shift entered using the $PASHS,DTG command is not close to the real time shift (varies slightly, current value -1.3 µsec).

Daisy Chain Mode

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

Data Output

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

- **NMEA**

  NMEA is a standard data transfer format developed to permit ready and satisfactory data communication between electronic marine instruments, navigation equipment and communications equipment when interconnected via an appropriate system. This is data in printable ASCII format and may include information such as position, speed, frequency allocation, etc. Typical messages might be 20 to a maximum of 79 characters in length and generally require transmission no more often than once per second.

- **PROPRIETARY**

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

- **RAW**

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

The receiver has two options which affect the rate at which data is output: position update rate and raw measurement update rate. The highest output rate supported under different conditions is 2 Hz.

NMEA Outputs

As an option, the Z18 allows you to output NMEA message format and other miscellaneous messages through the serial ports. The following standard NMEA messages are available: GLL, GXP, GGA, VTG, GSN, MSG, GSA, GRS, RMC and ZDA. Additional non-standard messages are available: POS, SAT, RRE, and TTT. All standard NMEA messages are a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards Version 2.1. All non-standard messages are a string of ASCII characters delimited by commas, in the Magellan proprietary response format. Any combination of these messages can be output through any of the serial ports, and the same messages can be output through different ports at the same time. The output rate is determined by the $PASHS,NME,PER command, and can be set to any value between 0.5 and 999 seconds . See “NMEA Data Message Commands” for more information.

Raw Data Outputs

As an option, the Z18 allows you to output raw data through the serial ports. Table 4.2 outlines the different types of messages available.

Table 4.2. Raw Data Messages

Message	Description
MPC	measurement data output
PBN	position data
SNV	GPS ephemeris data
SNG	GLONASS ephemeris data
SAL	GPS almanac data
SAG	GLONASS almanac data

All outputs are in binary format. Any combination of messages can be output through any of the serial ports, and the same messages can be output through different ports at the same time. The output rate is determined by the $PASHS,RCI setting, and can be set to any rate between 0.5 and 999 seconds. See “Raw Data Outputs” for more information.

Signal-to-Noise Ratio

The Z18 calculates the signal-to-noise ratio using one of two methods: DBH or AMP. Select the method using the **$PASHS,SNR** command. The default method is DBH.

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

$$SNR = \frac{10}{2T}\log\frac{mean(I)^2}{mean(I^2) - mean(I)^2}$$

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

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

Satellite Search Algorithm

When the Z18 operates for the first time after receipt from Magellen, no almanac or ephemeris data are loaded. The Z18 always assigns the first 10 elements of a 32-element table of satellite PRN numbers to its first 10 channels and the first 8 elements of a 24-element table of the GLONASS frequency numbers to its last 8 channels. If no ephemeris data is available in the memory, or if the data is older than ten hours, 30 to 60 seconds will be needed to collect data. After locking onto four or five satellites and collecting ephemeris data, the Z18 computes its first position. The Z18 continuously collects in its on-board battery-backed-up memory (no external battery is required for memory) almanac and ephemeris data as well as the most recent position. The time to the first position computation, if no almanac/ ephemeris data are available, is typically two minutes (this is called a cold start).

At the next power- up, if the almanac/ephemeris data from battery-backed-up memory are available, the Z18 uses the almanac data, the last computed position, and the time from the on-board real-time clock to search only the visible satellites; under these conditions, the Z18 recomputes a position in 10 to 20 seconds (this is called a warm start).

Projected cold and warm start periods are independent of the 20-60 seconds which the Z18 requires for initialization.

Ionospheric and Tropospheric Models

The Z18 can be set to use an ionospheric and tropospheric model in its position computation using the $PASHS,ION,Y/N command. The ionospheric and tropospheric models are based on the models defined in ICD-GPS-200, Revision B. Typically this function is used to improve the accuracy of stand-alone position by minimizing the influence of ionosphere and troposphere on the code phase. In differential mode, however, the model should not be applied since differential corrections already contain the errors induced by ionosphere and troposphere. Both models are simultaneously turned on or off with the $PASHS,ION command. See “$PASHS,ION,x” for more information.

External Frequency

This feature lets you input an external frequency so that you can synchronize the receiver clock to a more stable external reference.

The procedure for external frequency input is the following:

1. Connect the external frequency output to the corresponding connector on the receiver box (this is the BNC connector next to the antenna input, labeled EXT REF.
2. Issue the command **$PASHS,EXT,x,y** where

   x is the frequency in MHz (5, 10, or 20)

   y is M or A (manual or automatic mode) - in automatic mode the receiver switches to the external frequency only if the receiver senses the external frequency; in manual mode the receiver unconditionally switches to external frequency

The external frequency specifications are summarized in Table 4.3.

Table 4.3. External Frequency Specifications

Item	Specifications
Input impedance	50 ohms
Frequency range	5 MHz, 10 MHZ, or 20 MHz
Lock range	± 5 ppm

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

Datums

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

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

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

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

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

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

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

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

Example: Define local datum as the WGS-72 datum

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

$PASHS,DTM,USR

This implements the transformations listed in Table 4.4 and below.

Table 4.4. Ellipsoid Parameters for WGS-72 and WGS-84

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

$\Delta x = \Delta y = 0 \Delta z = 4.5$ metersm= 0.23×10^{-6}

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

in the following equation:

$$_{GS84} = \begin{bmatrix} 0 \\ 0 \\ 4.5 \end{bmatrix} + (1 + 0.23 \times 10^{-6}) \begin{bmatrix} 1 & -2.686 \times 10^{-6} & 0 \\ 2.686 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{1W}$$

Internally, the receiver implements the transformation *from* WGS-84 *to* WGS-72. Figure 4.4 demonstrates the change in the coordinate systems.

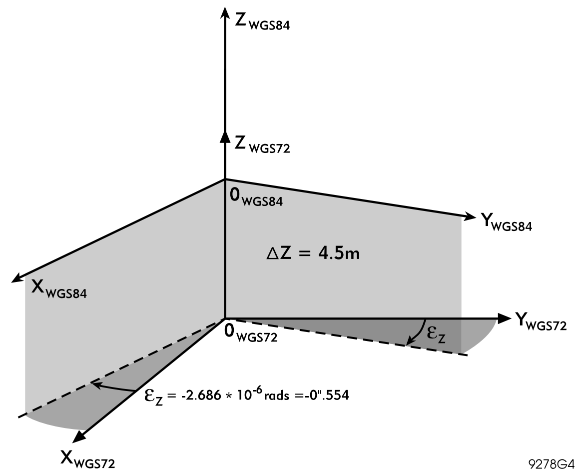

Figure 4.4. Rotation and Translation Between Coordinate Systems

5

Differential and RTK Operations

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

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

As stand-alone, the Z18 can compute a position to around 15 meters. Differential GPS achieves sub-meter precision at a remote receiver, and RTK positioning achieves centimeter accuracy at a remote receiver.

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

Base Stations

Setting Up a Differential Base Station

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

Table 5.1. Differential Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,PEM,4	Set the Base differential mask to four degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna
$PASHS,RTC,BAS,x	Turn on RTCM corrections on port x When this command is sent, a base station automatically sends RTCM message types 1 and 31 once per second.
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode.
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver.
$PASHS,SAV,Y	Save settings

Do not try to transmit corrections on the same Z18 serial port you are using to set up the receiver from your PC.

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

Setting Up an RTK Base Station

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

Table 5.2. RTK Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,ELM,9	Set the RTK Base mask to nine degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna

Table 5.2. RTK Base Station Commands (continued)

Command	Description
$PASHS,RTC,BAS,X	Turn on RTCM corrections on port x When this command is sent, a base station automatically sends RTCM message types 1 and 31 once per second.
$PASHS,RTC,TYP,1,0	Turn off RTCM messasge type 1.
$PASHS,RTC,TYP,31,0	Turn off RTCM messasge type 31.
$PASHS,RTC,TYP,3,1	Turn on RTCM messasge type 3.
$PASHS,RTC,TYP,18,1	Turn on RTCM messasge type 18.
$PASHS,RTC,TYP,19,1	Turn on RTCM messasge type 19.
$PASHS,RTC,TYP,22,1	Turn on RTCM messasge type 22.
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode.
$PASHS,CPD,MOD,BAS	Set receiver as RTK base station with default settings: Type 18 and 19 messages generated one per second. Type 3 and 22 messages generate once per minute. RTCM data output on port B in burst mode.
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver
$PASHS,SAV,Y	Save settings

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

Setting Up a Combined Differential and RTK Base Station

Send the commands listed in Table 5.3 to the receiver.

Table 5.3. Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,PEM,4	Set the Base differential mask to four degrees
$PASHS,ELM,9	Set the RTK base elevation mask to nine degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna
$PASHS,RTC,BAS,x	Turn on RTCM corrections on port x
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode
$PASHS,RTC,TYP,3,1 $PASHS,RTC,TYP,22,1	Turn on base station position messages, once per minute
$PASHS,RTC,TYP,18,1 $PASHS,RTC,TYP,19,1	Turn on Code and Carrier phase messages, once per second
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver
$PASHS,SAV,Y	Save settings

Type 1 and 31 messages are ON by Default.

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

RTCM Messages

The Z18 broadcasts RTCM 104 version 2.2 differential formats. The Z18 is set to differential mode in any of the serial ports with the set command $PASHS,RTC,BAS,c where c is the port. Of RTCM message types 1 through 64, the Z18 processes only: types 3, 16, 22, 32, and 36 for station location and special information; types 1, 2, 9, 31, and 34 for RTCM differential corrections, null frame type 6 and 34, and RTK data message types, 18 and 19. The differential corrections are automatically processed by the Z18. RTCM message types 3, 16, 22, 32, and 36 provide user information from the reference (base) station via the $PASHS,NME,MSG set command and the $PASHQ,MSG query command. RTCM message types 1, 9, 18, 19, 31, and 34 provide differential correction information via the $PASHS,NME,MSG set command and $PASHQ,MSG query command.

On initial power-up or after use of the $PASHS,RST reset to defaults command, the Z18 default automatic differential mode is OFF.

RTCM 104 Format, Version 2.2

When the Z18 is used as a reference station and the RTCM base option is enabled, the Z18 computes differential corrections for up to 18 satellites (10 GPS + 8 GLO), converts those corrections to RTCM format, and transmits the converted messages via its serial ports. It can generate message types 1, 2, 3, 6, 9, 16, 18, 19, 22, 31, 32, 34 null frame, 34, and 36 as detailed in Table 5.4.

Table 5.4. RTCM Message Types

GPS Message Type	Contents of Message	GLONASS Message Type	Contents of Message
1	Differential GPS corrections	31	Differential GLONASS correction
2	Delta differential corrections		
3	Reference station parameters in WGS 84	32	Reference station parameters in PZ-90
6	Null frame	34 with no parameters	Null frame
9	GPS partial correction set	34	GLONASS partial correction set
16	Special GPS text message	36	Special GLONASS text message

Table 5.4. RTCM Message Types (continued)

GPS Message Type	Contents of Message	GLONASS Message Type	Contents of Message
18, 19	RTK carrier phase (both GPS and GLONASS)	18, 19	RTK pseudo-ranges (both GPS and GLONASS)
22	Extended reference station parameter		

The Z18 uses the six-of-eight format (data bits a1 through a6 of an eight-bit byte) for communication between the reference station and user equipment.

6

Command/Response Formats

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

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

Within each section, the commands are listed alphabetically and described in detail. Information about the command including the syntax, a description, the range and default, and an example of how it is used are presented for each command. The syntax includes the number and type of parameters that are used or required by the command. These parameters may be characters or numbers depending upon the particular command. The parameter type is indicated by the symbol that is a part of the syntax, as defined in Table 6.1.

Table 6.1. Command Parameter Symbols

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

For example, for the receiver command

$PASHS,RCI,f<Enter>

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

Receiver Commands

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

Set Commands

The general structure of the set commands is:

$PASHS,str,x,<Enter>

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

$PASHS,RCI,5<Enter>

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

$PASHR,ACK*3D

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

Query Commands

The general structure of the query command is:

$PASHQ,str,x <Enter>

where str is a 3-character string identifier and x is the serial port where the response message will be sent. The serial port field is optional; if the serial port is not included in a query command, the response will be sent to the current port. For example, if you are communicating with the receiver on Port A and send the query command

$PASHQ,PRT <Enter>

the response will be sent to port A. However, if from the same port, you send the query command

$PASHQ,PRT,B <Enter>

then the response will be sent to port B.

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

$PASHQ,PAR <Enter>

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

Table 6.2. Receiver Set/Query Commands

Function	Command	Description	Page
Antenna Position	$PASHS,ALT	Set ellipsoid height of antenna	38
	$PASHS,POS	Set antenna position	50
	$PASHS,POS,CUR	Set antenna position to current computed position	51
Dilution of Precision (DOP)	$PASHS,HDP	Set HDOP mask for position computation	43
	$PASHS,PDP	Set PDOP mask for position computation	49
	$PASHS,TDP	Set GLONASS system time shift DOP mask	57
	$PASHS,VDP	Set VDOP mask for position computation	61

Table 6.2. Receiver Set/Query Commands (continued)

Function	Command	Description	Page
Ionosphere	$PASHS,ION	Include/exclude ionospheric model	44
	$PASHQ,ION	Display ionosphere data information	44
Memory	$PASHS,INI	Clear receiver memory and data	44
	$PASHS,RST	Reset User Parameters	54
	$PASHS,SAV	Save parameters in battery-backed-up memory	54
Miscellaneous Commands	$PASHS,LTZ	Set local time zone	47
	$PASHS,RCI	Set output interval	52
	$PASHS,SIT	Set site name for output	54
	$PASHS,SNR	Set algorithm for SNR computation	55
	$PASHQ,SNR	Display SNR setting	55
External Frequency	$PASHS,EXT	Set external frequency	41
	$PASHQ,EXT	Query external frequency setting	42
Position Computation	$PASHS,DTG	Set GLONASS system time shift relative to GPS system time	39
	$PASHS,ELM	Set elevation mask from data output	41
	$PASHS,FIX	Set altitude hold position fix mode	42
	$PASHS,GTF	Set GLONASS system time shift hold position fixed mode	42
	$PASHS,GTM	Compute/hold GLONASS system time shift	43
	$PASHS,GTP	Set priority of GLONASS system time shift if SVs = 4	43
	$PASHS, MSV	Set minimum # of SV's	47
	$PASHS,PEM	Set elevation mask for position computation	49
	$PASHS,PMD	Set position computation mode	50

Table 6.2. Receiver Set/Query Commands (continued)

Function	Command	Description	Page
Receiver Configuration	$PASHS,CTS	Port protocol	38
	$PASHQ,CTS	Query port protocol settings	38
	$PASHS,DSY	Configures receiver serial ports in daisy-chain mode	38
	$PASHS,DTM	Set datum for position computation	39
	$PASHS,LPS	Set loop tracking parameters	46
	$PASHQ,LPS	Display loop tracking parameter setting	46
	$PASHQ,PAR	Query receiver parameters	47
	$PASHQ,PRT	Request port baud rate	51
	$PASHQ,RID	Request receiver identification	53
	$PASHQ,RIO	Request for receiver ID	53
	$PASHS,SPD	Set speed (baud rate) of serial port	55
	$PASHS,SYS	Set system (GLONASS/GPS/Mixed)	57
	$PASHS,TSC	Set type of time scale used	57
	$PASHQ,TSC	Display time scale setting	58
	$PASHS,UDD	Set user-defined datum	58
	$PASHQ,UDD	Display user-defined datum	60
	$PASHS,UTS	Synchronize with GPS time	61
	$PASHQ,UTS	Query synchronization with GPS time	61
Satellites	$PASHQ,STA	Request status of satellites currently locked	56
	$PASHQ,SVS	Display satellites enabled to acquire	56
	$PASHS,SVS	Designate satellites to acquire	56
	$PASHS,USE	Designate satellites to use	60

ALT: Set Ellipsoid Height

$PASHS,ALT,f

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

Examples: Set antenna height to +100.25 meters

$PASHS,ALT,+100.25<Enter>

Set antenna height to - 30.1 meters

$PASHS,ALT,-30.1<Enter>

CTS: Port Protocol

$PASHS,CTS,c,s

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

Example: Disable the handshaking protocol for port A.

$PASHS,CTS,A,OFF<Enter>

$PASHQ,CTS

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

$PASHR,CTS

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

DSY: Daisy Chain

$PASHS,DSY,x,y

Redirects all characters from one serial port to the other without interpreting them, where x is the source port and y is the destination port. Any combination may be chosen. When a port is in daisy chain mode, it can only interpret the OFF command; all other characters are redirected. The OFF command discontinues the daisy chain mode. Redirection can also be bi-directional (i.e. A to B and B to A at the same time). Table 6.3 lists the daisy chain commands and their effects.

Table 6.3. Daisy Chain Commands

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

The DSY command also works with Ports A and C, or Ports B and C in the manner described in Table 6.3.

DTG: GLONASS Time Shift

$PASHS,DTG,f

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

Example: Set GLONASS system time shift to -1.3 microseconds

$PASHS,DTG,-1.3

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

DTM: Datum Selection

$PASHS,DTM,str

This command selects the geodetic datum used for position computation.

where str can be W84 (WGS-84), E90 (PZ-90), USR (user-defined datum), or other predefined datum as listed in Appendix B. The default is WGS-84. Parameters for a user-defined datum are entered with the $PASHS,UDD command on page 58.

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

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

Example: Set the datum to International 1924.

$PASHS,DTM,AST<Enter>

DUG: UTC-GPS Time Difference

$PASHQ,DUG

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

$PASHR,DUG,struct

where struct is in binary format as listed in Table 6.4

Table 6.4. GPS-UTC Time Codes

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

ELM: Raw Data Elevation Mask

$PASHS,ELM,x

Sets the value of elevation under which the measurement data (MPC) for that satellite will not be output, where x is the elevation mask in degree. The default is 10°.

Example: Set elevation mask to 5 degrees

$PASHS,ELM,5

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

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

EXT: Set Frequency Input

$PASHS,EXT,x,y

This command sets internal/external reference frequency input, where x is the frequency in MHz (0, 5, 10, or 20) and y is the mode (automatic or manual).

Table 6.5 outlines the structure:

Table 6.5. EXT Structure

Field	Description
x	Frequency in 0 MHz, 5 MHz, 10 MHz, or 20 MHz. 0-back to internal clock.
y	M or A (manual or automatic mode) - in automatic mode the receiver switches to the external frequency only if the receiver senses the external frequency; in manual mode the receiver unconditionally switches to external frequency.

User settings are saved in battery-backed-up memory through power cycles, and are used until a new frequency is selected, or the memory is cleared.

Example: Enable the external frequency at 20 mHz.

$PASHS,EXT,20,A<Enter>

$PASHQ,EXT,c

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

Example: Query the external frequency status to port A.

$PASHQ,EXT,A<Enter>

$PASHR,EXT

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

Table 6.6. EXT Response Structure

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

FIX: Altitude Fix Mode

$PASHS,FIX,x

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

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

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

Example: Fix using most recent altitude

$PASHS,FIX,0

GTF: Set GLONASS Time Shift

$PASHS,GTF,d

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

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

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

Default is 0.

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

GTM: GLONASS Time Shift Relative or Fixed

$PASHS,GTM,d

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

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

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

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

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

GTP: Set Priority of GLONASS Time Shift

$PASHS,GTP,c

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

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

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

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

$PASHS,GTP,Y<Enter>

HDP: Horizontal Dilution of Precision

$PASHS,HDP,d

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

Example: Set HDOP mask to 6

$PASHS,HDP,6<Enter>

INI: Receiver Initialization

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

Reset receiver internal memory and serial port baud rates, where x1 through x4 are the codes for baud rate settings for ports A through D respectively (see $PASHS,SPD command for code), and z is the memory reset code defined in Table 6.7.

Table 6.7. Reset Memory Codes

Reset Memory Code z	Action
0	No memory reset
3	Reset internal memory

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

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

ION: Set Ionospheric Models

$PASHS,ION,x

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

Example: Include ionospheric and tropospheric models

$PASHS,ION,Y

$PASHQ,ION,x

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

$PASHR,ION

The response message has the format:

$PASHR,ION,struct

where Table 6.8 outlines *struct*.

Table 6.8. Ionosphere Data Format

Type	Size	Content
float	4	a_0 ionospheric parameter (seconds).
float	4	a_1 ionospheric parameter (sec. per semicircle).
float	4	a_2 ionospheric parameter (sec. per semicircle^2).
float	4	a_3 ionospheric parameter (sec. per semicircle^3).
float	4	b_0 ionospheric parameter (seconds).
float	4	b_1 ionospheric parameter (sec. per semicircle).
float	4	b_2 ionospheric parameter (sec. per semicircle^2).
float	4	b_3 ionospheric parameter (sec. per semicircle^3)
double	8	A_0 constant (zero-order terms of GPS/UTC polynomial) (sec)
double	8	A_1 constant (first-order terms of GPS/UTC polynomial) (sec/sec)
unsigned long	4	t_{ot} reference time for UTC data (seconds)
short	2	W_{nt} UTC reference week number
short	2	Δ_{tLS} delta time due to leap-second (seconds)
short	2	WN_{LSF} Week of leap second correction
short	2	DN day of leap second correction
short	2	DtLSF Delta time between GPS and UTC (seconds)
short	2	WN Current GPS week number
unsigned long	4	TOW current time of week in seconds
short	2	bulwn current GPS week number when message was read (usually same as WN)
unsigned long	4	bultow time of week when message was read (usually same as TOW) (seconds)
short	2	Checksum computed by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	76 bytes	

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

LPS: Loop Tracking

$PASHS,LPS,x,y,z

Set user-selectable third-order loop tracking parameters, where x is the ratio of the carrier loop, y is the carrier loop parameter, and z is the code loop parameter (see $PASHQ,LPS below for more information). Loop setting allows you to select the tracking loop parameters based on application. The carrier and code loop parameters are set independently. Firmware uses default values until you select another setting. The user settings are saved in battery-backed memory and are used until a new setting is selected, or the memory is cleared. The default is 1, 2, 1.

Example: Change loop parameters

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

$PASHQ,LPS,x

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

$PASHR,LPS

The response is in the form

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

where

x = 0-10 (ratio)

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

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

Loop setting values:

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

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

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

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

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

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

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

LTZ: Set Local Time Zone

$PASHS,LTZ,d1,d2

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

Example: Set local time zone to +7 hours, 0 minutes

$PASHS,LTZ,+7,0

MSV: Set Minimum Satellites

$PASHS,MSV,x

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

Example: Set minimum satellites to 4

$PASHS,MSV,4

PAR: Query Receiver Parameters

$PASHQ,PAR,c

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

Example: $PASHQ,PAR

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

```
SPDA:5 SPDB:5 SPDC:5 SPDD:5
GPS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
GLO:YYYYYYYYYYYYYYYYYYYYYYYY
SYS:MIX DTM:W84 GTM:0 GTF:0 DTG:+000000.0000 TDP:40 GTP:Y
PMD:1 FIX:0 ALT:+00000.00 PDP:40 HDP:40 VDP:40
PEM:10 UNH:N ION:N SAV:N
RTC:OFF PRT:-
NMEA: ETR POS GLL GXP GGA VTG GSN GSA SAT GRS RRE GSV ALM DAL UTM RMC ZDA TSH TTT
PRTA: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PRTB: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PRTC: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PRTD: --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---
PER:001.00
```

Figure 6.1. Typical $PASHR,PAR Response Message

where Table 6.9 outlines the information in the response message.

Table 6.9. $PASHR,PAR Response Message Parameters

Parameter	Description
SPDA:5	Serial port A baud rate. Default is 5 (9600).
SPDB:5	Serial port B baud rate. Default is 5 (9600).
GPS:Y	GPS satellites attempted to acquire. Default is all Y.
GLO:Y	GLONASS satellites attempted to acquire. Default is Y.
SYS:MIX	Type of navigational system used (GPS, GLONASS, or mixed). Default is MIX.
DTM:W84	Geodetic datum being used. Default is WGS-84.
GTM:0	Time shift mode for the minimum number of satellites required to compute a position. Default is 0.
GTF:0	Time shift mode for position computation. Default is 0.
DTG:0	Time shift in microseconds. Default is 0.
TDP:40	Time dilution of precision. Mask default is 40.
GTP:Y	Time shift priority over altitude fixed for position computation. Default is Y.
PMD:1	Position mode for the minimum number of satellites required to compute a position.
FIX:0	Altitude hold position fix mode for the altitude used when computing a 2-D position. With the default value (0), the most recent antenna altitude is used.
ALT:+00000.00	Height of the antenna position in meters. Default is 0.

Table 6.9. $PASHR,PAR Response Message Parameters (continued)

Parameter	Description
PDP:40	Position Dilution Of Precision. Mask default is 40.
HDP:40	Horizontal Dilution Of Precision. Mask default is 40.
VDP:40	Vertical Dilution Of Precision mask. Default is 40.
PEM:05	Position elevation mask. Elevation below which the satellite will not be used to compute a position. Default is 05 degrees.
UNH:N	Use unhealthy satellites for position computation. The default is N.
ION:N	Do not include ionospheric and tropospheric models in position computation. Default is N.
SAV:N	Save parameters in the battery-backed memory. With default value (N), at the next power cycle, the default parameters are used.
RTC:OFF	RTCM differential mode setting. OFF for disabled, BAS for base station setting, REM for remote station setting. Default is OFF.
PRT:A	Port assigned to send or receive differential corrections.
PER:001.00	Send interval of the NMEA response messages, with the exception of TTT. Default is 1 second.

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

PDP: Position Dilution of Precision

$PASHS,PDP,d

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

Example: Set PDOP mask to 20

$PASHS,PDP,20<Enter>

PEM: Position Elevation Mask

$PASHS,PEM,d

This command sets the elevation mask for position computation. The structure is $PASHS,PEM,d where d is 0 to 90 degrees. Default is 10 degrees. Satellites with elevation less than the elevation mask are not used for position computation.

Example: Set position elevation mask to 15 degrees

$PASHS,PEM,15<Enter>

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

PMD: Position Mode

$PASHS,PMD

This command sets the position mode for minimum number of satellites required to compute a position. The structure is $PASHS,PMD,d where d = 0, 1, 2, or 3.

Table 6.10. Position Mode Settings

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

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

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

$PASHS,PMD,0<Enter>

POS: Set Antenna Position

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

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

Table 6.11. POS Structure

Field	Description	Range
m1	Latitude in degrees, decimal minutes (ddmm.mmmmmm)	0 - 90.0
c1	North (N) or South (S)	N, S
m2	Longitude in degrees, decimal minutes (dddmm.mmmmmm)	0 - 180.0

Table 6.11. POS Structure (continued)

Field	Description	Range
c2	East (E) or West (W)	E, W
f1	the ellipsoidal height in meters (+ or -) and xxxxx.xxx	± 0 - 99999.999

Example: Set antenna position

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

POS CUR: Set Antenna to Current Computed Position

$PASHS,POS,CUR

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

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

PRT: Port Setting

$PASHQ,PRT,c

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

Example:

$PASHQ,PRT<Enter>

$PASHR,PRT

The response is a message in the form:

$PASHR,PRT,x,d where

x = communication port

d = communication speed outlined in Table 6.12

Table 6.12. Serial Port Baud Rate Codes

Code	Baud Rate
0	300
1	600
2	1200

Table 6.12. Serial Port Baud Rate Codes (continued)

Code	Baud Rate
3	2400
4	4800
5	9600 (default)
6	19200
7	38400
8	56800
9	115200

RCI: Recording Interval

$PASHS,RCI,f

Sets the value of the interval at which raw data messages will be output, where f is any number between 0.5 and 999 in seconds, depending upon the raw data update rate option installed (Table 6.13). Default is 20.0.

Table 6.13. Raw Data Update Rate Options

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

To receive data at high baud rates (e.g., 115,000), you must ensure that your computer has a suitable serial I/O capability. Most computers with 486 or Pentium processors and 16550 UART serial ports can support high data rates.

Example: Set recording interval to 5 seconds

$PASHS,RCI,5<Enter>

RID:Receiver ID

$PASHQ,RID,c

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

Example: Query the receiver in to the current port.

$PASHQ,RID<Enter>

$PASHR,RID

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

$PASHR,RID,18,s1,s2,s3,*cc

where:

18 = Z18 Reference Station System

s1 = firmware version

s2 = installed option

s3 = channel version

Response:

$PASHR,RID,18,0064,BUEX-FT--S3,ZT15*33

RIO: Request for Receiver ID

$PASHQ,RIO

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

$PASHR,RIO

The response message is in the form:

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

where Table 6.14 outlines the response parameters:

Table 6.14. RIO Structure

Field	Description	Range
s1	Product name or receiver type	Maximum 10 characters
s2	Main processor firmware version	Maximum of 10 characters
s3	Channel firmware version	Maximum of 10 characters

Table 6.14. RIO Structure (continued)

Field	Description	Range
s4	Option settings	Maximum of 12 characters
cc	Byte-wise checksum (XOR of all characters between but excluding $ and *)	2 hex characters

Example: Query the receiver ID.

$PASHQ,RIO

Typical Response:

$PASHR,RIO,Z18,0064,ZT15,BUEX-FT--S3,*51

RST: Reset Receiver to Default Parameters

$PASHS,RST

Reset the receiver parameters to their default values.

Example: Reset user parameters to default values.

$PASHS,RST<Enter>

SAV: Save User Parameters

$PASHS,SAV,x

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

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

Example: Save user parameters to internal battery memory

$PASHS,SAV,Y<Enter>

SIT: Set Site Name

$PASHS,SIT,s

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

Example: Set site name to 0001

$PASHS,SIT,0001<Enter>

SNR: Set Signal-to-Noise Ratio

$PASHS,SNR,s

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

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

Example: Compute SNR using DBH algorithm

$PASHS,SNR,DBH<Enter>

$PASHQ,SNR,x

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

$PASHR,SNR

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

SPD: Serial Port Baud Rate

$PASHS,SPD,x,d

Set the baud rate of the Z18 Reference Station System serial port x, where d is the output port, and d is a number between 0 and 9 specifying the baud rate as shown in Table 6.15 Default is 9600 baud.

Table 6.15. Baud Rate Codes

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

To resume communication with the Z18 Reference Station System after changing the baud rate using this command, change the baud rate of the command device.

Example: Set port A to 19200 baud

$PASHS,SPD,A,6<Enter>

STA: Show Status of Satellites

$PASHQ,STA,c

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

Example: Query STA to the current port.

$PASHQ,STA<Enter>

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

Example:

```
TIME:   18:38:31 UTC
LOCKED: 03 23 16 39 54
CA:     54 26 17 31 35
P1:     52 24 15 29 33
P2:     51 22 14 27 32
```

SVS: Satellite Selection

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

Select satellites that the Z18 Reference Station System attempts to acquire, where:

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

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

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

$PASHS,SVS,YYYYYYYYYNNYYNNNNNNNNNNNNNNNNNN NNYYYY NNYYNNNNYYYYYYYYYYYY

SYS: Set Navigational System

$PASHS,SYS,s

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

GPS - Only GPS is used

GLO - Only GLONASS is used

MIX - Both systems are used (default)

Example: Set the receiver to use GPS only

$PASHS,SYS,GPS<Enter>

TDP: Time Shift Dilution of Precision

$PASHS,TDP,d

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

Example: Set GLONASS system time shift DOP mask to 30

$PASHS,TDP,30

TSC: Set Type of Time Scale

$PASHS,TSC,s

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

GPS - use GPS system time scale (default)

GLO - use GLONASS system time scale

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

NMEA messages (always output UTC time),

Raw data (time tag dependent upon TSC setting).

$PASHQ,TSC,x

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

$PASHR,TSC,s

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

UDD: Set User-Defined Datum

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

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

Table 6.16. UDD Structure

Field	Description	Range	Units	Default
d1	Geodetic datum id. Always 0 for WGS 84	0	n/a	0
d2	Semi-major axis	6300000-6400000	meters	6378137
f1	Flattening in meters	290.00000000-300.00000000	meters	298.25722356
f2	Translation in x direction	±1000.000	meters	0.0
f3	Translation in y direction	±1000.000	meters	0.0
f4	Translation in z direction	±1000.000	meters	0.0
f5	Rotation in x axis + rotation is counter clockwise, and rotation is clockwise rotation.		radians	0.0
f6	Rotation in y axis		radians	0.0
f7	Rotation in Z axis		radians	0.0
f8	Scale factor. Range -10.00 to +10.00	±10	n/a	0.0

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

Example: Define local datum as the WGS-72 datum

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

$PASHS,DTM,USR

This implements the transformations listed in Table 6.17 and below.

Table 6.17. Ellipsoid Parameters for WGS-72 and WGS-84

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

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

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

in the following equation:

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

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

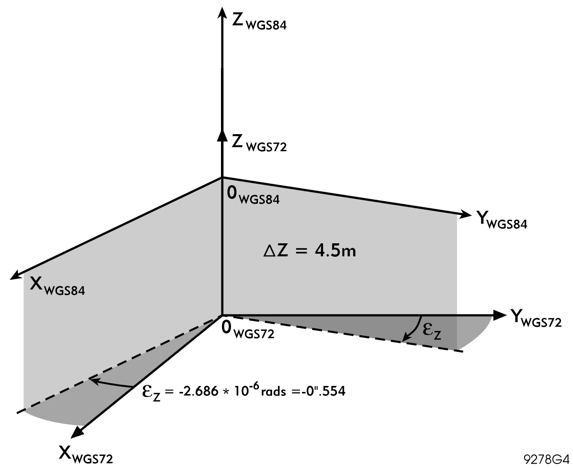

Figure 6.2. Rotation and Translation Between Coordinate Systems

$PASHQ,UDD,c

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

Example: Query datum parameters to port C.

$PASHS,UDD,c<Enter>

$PASHR,UDD

The response is in the format:

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

where the fields are as defined in Table 6.16.

USE: Use Satellites

$PASHS,USE,d,c

Selects satellites to track or not track, where

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

ALL = all satellites

GPS = GPS satellites only

GLO = GLONASS satellites only

c = Y to use, N to not use

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

Example: Use (track) satellite 15

$PASHS,USE,15,Y<Enter>

UTS: Synchronize with GPS Time

$PASHS,UTS,s

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

$PASHQ,UTS,x

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

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

$PASHR,UTS,x

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

$PASHR,UTS,x*cc

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

VDP: Vertical Dilution of Precision

$PASHS,VDP,d

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

Example: Set VDOP mask to 6

$PASHS,VDP,6

Raw Data Output Commands

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

Set Commands

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

$PASHS,RAW,str,c,x,f

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

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

will output MPC messages to serial port A. IF the $PASHS,RAW command is sent correctly, the receiver will respond with $PASHR,ACK acknowledgment. The message will be output to the indicated serial port at the recording interval defined by the $PASHS,RCI command. The default output frequency is every 5 seconds.

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

For example the command:

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

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

In general, the parameters that affect raw data output are the same as those that control data recording including: recording interval, elevation mask, and minimum number of satellites. See Table 6.18, Raw Data Commands for more details about the commands that control these parameters.

Query Commands

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

$PASHQ,str,x

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

$PASHQ,PBN<Enter>

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

$PASHQ,MPC,C<Enter>

will output a single MPC message to port C.

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

Table 6.18 lists all the available raw data commands.

Table 6.18. Raw Data Commands

Function	Command	Description	Page
Almanac Data	$PASHS,RAW,SAL	Enable/disable GPS raw almanac data.	70
	$PASHQ,SAL	Query GPS raw almanac data.	71
	$PASHS,RAW,SAG	Enable/disable GLONASS raw almanac data.	69
	$PASHQ,SAG	Query GLONASS raw almanac data.	69
Disable Message	$PASHS,RAW,ALL	Disable raw date message	68
Ephemeris Data	$PASHS,RAW,SNG	Enable/disable GLONASS raw ephemeris data.	72
	$PASHQ,SNG	Query GLONASS raw ephemeris data	72
	$PASHS,RAW,SNV	Enable/disable GPS raw ephemeris data	74
	$PASHQ,SNV	Query GPS raw ephemeris data	74
Measurement Data	$PASHS,RAW,MPC	Enable/disable raw measurement data (MPC)	64
	$PASHQ,MPC	Query raw measurement data (MPC)	64

Table 6.18. Raw Data Commands (continued)

Function	Command	Description	Page
Position Data	$PASHS,RAW,PBN	Enable/disable raw position data (PBEN)	67
	$PASHQ,PBN	Query raw position data (PBEN)	67
Raw Data Parameters	$PASHS,ELM	Set raw data output elevation mask	41
	$PASHS,MSV	Set minimum number of satellites	47
	$PASHS,RCI	Set recording interval	52
	$PASHQ,RAW	Show current settings of raw data parameters	68
	$PASHS,SIT	Set site name	54

MPC: Enable/Disable MPC Message

$PASHS,RAW,MPC,x,s

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

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

Example: Enable MPC message on port A

$PASHS,RAW,MPC,A,ON

$PASHQ,MPC,x

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

$PASHR,MPC

The response is a binary message in the format:

$PASHR,MPC,(measurement structure)

where Table 6.19 defines the measurement structure.

Table 6.19. MPC Structure

Field	Bytes	Content
unsigned short	2	Sequence ID number in units of 50 ms, modulo 30 minutes
unsigned char	1	Number of remaining structures to be sent for current epoch
unsigned char	1	Satellite PRN number (1-56). The broadcast ephemeris from a GLONASS satellite does not contain the satellite slot number. This information is derived from the almanac. When the Z18 Reference Station System has ephemeris data for a satellite but no almanac data (after memory reset with the INI command) the satellite number is set to zero. Once the almanac has been received, the satellite number is updated.
unsigned char	1	Satellite elevation angle (degrees)
unsigned char	1	Satellite azimuth (units of 2 degrees)
unsigned char	1	Channel ID (1-18)
		C/A CODE DATA BLOCK 29 bytes
unsigned char	1	Warning flag Bit 1 Bit 2 0 0 Code and/or carrier phase measured 0 1 Code and/or carrier phase measured, navigation message obtained, measurement not used to compute position 1 0 Code and/or carrier phase measured, navigation message obtained, measurement used to compute position 3 Carrier phase questionable 4 Code phase questionable 5 Code phase integration not stable 6 Not used 7 Possible loss of lock 8 Loss-of-lock counter reset NOTE: More than one bit can be set at the same time.
unsigned char	1	Goodbad flag indicates quality of position measurement: 0 = measurement not available and no additional data will be sent 22 = code and/or carrier phase measured 23 = code and/or carrier phase measured and navigation measurement obtained, but measurement not used to compute position 24 = code and/or carrier phase measured and navigation measurement obtained, measurement used to compute position

Table 6.19. MPC Structure (continued)

Field	Bytes	Content
char	1	Polarity_know. This number is either 0 or 5 0 means the satellite is just locked 5 means the preamble was found and the polarity of phase tracking is known and taken into account (i.e., phase measurements can be used for ambiguity fixing).
unsigned char	1	Signal-to-noise ratio of satellite observation
unsigned char	1	Always 0 (not used)
double	8	Full carrier phase measurement in cycles.
double	8	Raw_range. Raw range to satellite in seconds. Computed by formula: receiver time - transmitted time. NOTE: If TSC is set to GPS, in GLONASS pseudoranges, due to 13-sec (currently) difference between GLONASS system time and GPS system time, raw range will have 13-sec integer part. If TSC is set to GLO, in GPS pseudoranges, due to 13-sec (currently) difference between GPS system time and GLONASS system time, raw range will have –13 sec integer part.
long	4	Doppler (10^{-4} Hz)
long	4	Smoothing. Bits 0-23-smooth correction 0-22 - magnitude of correction (centimeters) 23 (MSB) - sign Bits 24-31 - Smooth count, unsigned, as follows: 0 - unsmoothed 1 - least smoothed 100 - most smoothed
	(29)	**Pcode on L1 block**, same format as C/A code data block
	(29)	**Pcode on L2 block**, same format as C/A code data block
unsigned char	1	Computed by XORing all the bytes of the structure. (MCA only)
total bytes	95	

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

PBN: Enable/Disable PBN Message

$PASHS,RAW,PBN,x,s

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

Example: Enable PBN on port B

$PASHS,RAW,PBN,B,ON

$PASHQ,PBN,x

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

$PASHR,PBN

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

$PASHR,PBN,(position structure)

where Table 6.20 defines the measurement structure.

Table 6.20. PBN Structure

Field	Bytes	Content
long rcvtime	4	Signal received time in milliseconds of week of GPS system time or in milliseconds of week/day of GLONASS system time (see commands $PASHS,TSC and $PASHS,SYS for more information). If GLONASS system time scale is chosen, operation (rcvtime % day) produces GLONASS system time (a time within a day) in all cases. This is the time tag for all measurements and position data.
char sitename	4	Set to user-entered string or four question marks ???? if empty
double navx	8	Antenna position ECEF x coordinate in meters.
double navy	8	Antenna position ECEF y coordinate in meters.
double navz	8	Antenna position ECEF z coordinate in meters.
float navt	4	Receiver clock offset in meters.
float navxdot	4	The antenna x velocity in meters per second.
float navydot	4	The antenna y velocity in meters per second.
float navzdot	4	The antenna z velocity in meters per second.
float navtdot	4	Receiver clock drift in meters per second.

Table 6.20. PBN Structure (continued)

Field	Bytes	Content
unsigned short PDOP	2	PDOP multiplied by 100.
unsigned short checksum	2	The checksum is computed by breaking the structure into 27 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	56	

RAW,ALL:Turn Off All RAW

$PASHS.RAW,ALL,c,OFF

Turns off all raw binary messages output to a given port, where c is the port.

The return message is $PASHR,ACK*3d if the message is received OK, or $PASHR,NAK*30 if the received command is invalid.

RAW: Setting Query Command

$PASHQ,RAW,x

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

Example:

$PASHQ,RAW

Typical Response Message

```
RCU:020.00 MSV:3 ELM:05 REC:Y
ANJ:0.0000 SIT:???? EPG:000 RNG:0
RAW:  MBN MCA MFG PBN SNV SNG SAL SAG
PRTA: --- --- --- --- --- --- --- ---
PRTB: --- --- --- --- --- --- --- ---
PRTC: --- --- --- --- --- --- --- ---
PRTD: --- --- --- --- --- --- --- ---
```

where Table 6.21 outlines the response parameters:

Table 6.21. $PASHQ,RAW Response Parameters

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

SAG: Enable/Disable GLONASS Satellite Almanac Message

$PASHS,RAW,SAG,x,s

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

Example: Disable SAG message on port A

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

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

$PASHQ,SAG,x

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

$PASHR,SAG

The response is a binary message in the form:

$PASHR,SAG,(structure)

where Table 6.22 defines the measurement structure.

Table 6.22. SAG (GLONASS Almanac) Structure

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

SAL: Enable/Disable GPS Satellite Almanac Message

$PASHS,RAW,SAL,x,s

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

Example: Disable SAL message on port A

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

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

$PASHQ,SAL,x,

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

$PASHR,SAL

The response is a binary message in the form:

$PASHR,SAL,(almanac structure)

where Table 6.23 defines the measurement structure.

Table 6.23. SAL (Almanac) Structure

Field	Bytes	Content
short prn	2	Satellite PRN number [0,...,31]
short health	2	Satellite health.
float	4	e eccentricity
long	4	toa reference time for orbit (sec).
float	4	i0 inclination angle (semicircles)
float	4	omegadot rate of right ascension (semicircles/sec)
double	8	roota Square root of semi-major axis (meters 1/2)
double	8	omega0 longitude of ascending node (semicircles)
double	8	omega augment of perigee (semicircles)
double	8	m0 mean anomaly at reference time (semicircles)
float	4	af0 clock correction (sec)
float	4	af1 clock correction (sec/sec)
short	2	wna almanac week number
short	2	wn week number
long	4	tow seconds of GPS week (sec) [0,...,604799]
unsigned short	2	Checksum computed by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	70	

SNG: Enable/Disable GLONASS Ephemeris Data

$PASHS,RAW,SNG,x,s

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

Example: Output GLONASS ephemeris data on port A

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

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

$PASHQ,SNG,x

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

$PASHR,SNG

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

$PASHR,SNG,(ephemeris structure)

where Table 6.24 defines the measurement structure.

Table 6.24. SNG GLONASS Ephemeris Data Structure

Type	Size in Bytes	Content
long	4	Start time of the 30-second frame in satellite time scale t_k from which the ephemeris data is derived; time modulo one day (seconds)
short	2	Day number of 30-second frame; modulo four-year period counting from beginning of last leap year, which corresponds to parameter t_b (t_b is set within this day number). This parameter varies within the range 1 to 1461. If day number = 0, the day number is unknown (absent in navigation frame).
long	4	Ephemeris data reference time within the day expressed in GLONASS system time scale = UTC + 3 hours (seconds)
float	4	Frequency offset γ_η of the on-board frequency standard at t_b (dimensionless)
float	4	Bias t_n between satellite time scale and GLONASS system time scale at t_b (seconds)
double	3*8	Satellite ECEF (PZ-90) X, Y, Z coordinates (km)
float	3*4	Satellite ECEF (PZ-90) velocity X', Y', Z'(km/sec)

Table 6.24. SNG GLONASS Ephemeris Data Structure (continued)

Type	Size in Bytes	Content
float	3*4	Satellite perturbation acceleration X”, Y”, Z” due to moon and sun (km/sec/sec)
double	8	Bias between GLONASS system time scale and UTC + 3 hours time scale τ_c (seconds)
char	1	Age of ephemeris parameter E_n (interval from moment when ephemeris data was last uploaded to t_b)
char	1	Combined 3-bit flag (contains Ï1, Ï2, Ï3, see GLONASS ICD)
char	1	Satellite health status flag (0 = good, 1 = bad)
char	1	Satellite frequency channel number [-7,...,24]
short	2	Satellite system number (satellite number [1,...,24])
unsigned short	2	Word checksum computed by breaking the structure into 40 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total	82 bytes	(95 for structure plus header and <CR><LF>)

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

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

The broadcast ephemeris from a GLONASS satellite does not contain the satellite slot number. This information is derived from the almanac. When the Z18 Reference Station System has ephemeris data for a satellite but no almanac data (this occurs at startup, before the almanac has been fully transmitted), the satellite number is set to zero. Once the almanac has been received, the satellite number is updated.

SNV: Enable/Disable GPS Ephemeris Data

$PASHS,RAW,SNV,x,s

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

Example: Enable SNV on port A

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

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

$PASHQ,SNV,x

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

$PASHR,SNV

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

$PASHR,SNV,(ephemeris structure)

where Table 6.25 defines the measurement structure.

Table 6.25. SNV (Ephemeris) Structure

Field	Bytes	Content
short wn	2	GPS week number [0,...,1023]
long tow	4	Seconds of GPS week [0,...604799]
float tgd	4	Group delay ($\pm 127*2^{-31}$) (seconds)
long aodc	4	Clock data issue
long toc	4	Clock data reference time [0,...,604784] (LSB = 2^4 seconds)
float af2	4	Clock correction (sec/sec^2).
float af1	4	Clock correction (sec/sec).
float af0	4	Clock correction (sec).
long aode	4	Orbit data issue.
float deltan	4	Mean anomaly correction (semicircles/sec).
double m0	8	Mean anomaly at reference time (semicircles).
double e	8	Eccentricity.
double roota	8	Square root of semi-major axis (meters $^{1/2}$).

Table 6.25. SNV (Ephemeris) Structure (continued)

Field	Bytes	Content
long toe	4	Reference time for orbit (sec).
float cic	4	Harmonic correction term (radians).
float crc	4	Harmonic correction term (meters).
float cis	4	Harmonic correction term (radians).
float crs	4	Harmonic correction term (meters).
float cuc	4	Harmonic correction term (radians).
float cus	4	Harmonic correction term (radians).
double omega0	8	Longitude of ascending node (semicircles).
double omega	8	Argument of perigee (semicircles).
double i0	8	Inclination angle (semicircles).
float omegadot	4	Rate of right ascension (semicircles/sec).
float idot	4	Rate of inclination (semicircles/sec).
short accuracy	2	User range accuracy (URA), coded 0-15. 0 = 2 m 6 = 16 m 12 = 1024 m 1 = 2.8 m 7 = 32 m 13 = 2048 m 2 = 4 m 8 = 64 m 14 = 4096 m 3 = 5.7 m 9 = 128 m 15 = no prediction possible 4 = 8 m 10 = 256 m 5 = 11.3 m 11 = 512 m
short health	2	Satellite health.
short fit	2	Curve fit interval (0 or 1) 0=>interval = 4 hours 1=>interval = 6 hours
char prnnum	1	Satellite PRN number minus 1 (0 to 31)
char res	1	Reserved character.
checksum	2	The checksum is computed by breaking the structure into 65 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	132	

NMEA Data Message Commands

The NMEA message commands control all query and set commands related to NMEA format messages and miscellaneous messages in a NMEA style format. All standard NMEA message are a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards version 2.1. All non-standard messages are a string of ASCII characters delimited by commas in the Ashtech proprietary format. Any combination of these messages can be output through different ports at the same time. The output rate is determined by the $PASHS,NME,PER command and can be set to any value between 0.5 and 999 seconds.

Maximum NMEA update rate is dependent on receiver options.

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

Set Commands

The general structure of the NMEA set commands is:

$PASHS,NME,str,x,s,f

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

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

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

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

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

Example: Enable GGA message on port A

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

Output enabled NMEA messages every 5 seconds

$PASHS,NME,PER,5 <Enter>

Query Commands

While the set commands will continuously output response messages at a set interval, the query command will output a single response message. The general structure of the NMEA query commands is:

$PASHQ,str,x, <Enter>

where str is one of the 3 character NMEA strings and x is the optional output serial port. The serial port field is optional. If a port is not specified, the receiver sends the response to the current port.

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

$PASHQ,POS,D <Enter>

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

$PASHQ,GSA <Enter>

Response message

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

The generic NMEA response message format is:

$<header><data items> *cc

where Table 6.26 outlines the response format:

Table 6.26. NMEA Response Structure

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

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

The following is an example of an NMEA sentence.

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

where Table 6.27 outlines the response format:

Table 6.27. GLL Structure

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

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

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

$PASHR,str,<data items>*cc

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

Table 6.28 lists the NMEA data message commands. Only the set command for each NMEA message type is listed, as the description for the set, query and response message to each NMEA message are grouped together.

Table 6.28. NMEA Data Message Commands

	Command	Description	Page
Disable NMEA Messages	$PASHS,NME,ALL	Disable all messages	79
Almanac Information	$PASHS,NME,ALM	Enable/disable Almanac message	79
Differential Information	$PASHS,NME,MSG	Enable/disable base station message	93
Output Rate Parameter	$PASHS,NME,PER	Set send interval of NMEA response message	105

Table 6.28. NMEA Data Message Commands (continued)

	Command	Description	Page
Position Information	$PASHS,NME,GGA	Enable/disable GPS position response message	80
	$PASHS,NME,GLL	Enable/disable lat/lon message	82
	$PASHS,NME,GXP	Enable/disable position computation with time of fix information	91
	$PASHS,NME,POS	Enable/disable position message	106
	$PASHS,NME,RMC	Enable/disable declination message	108
Residual Information	$PASHS,NME,RRE	Enable/disable satellite residual and position error	109
	$PASHS,NME,GRS	Enable/disable satellite range residual	84
Satellite Information	$PASHS,NME,GSA	Enable/disable satellites used message	80
	$PASHS,NME,GSN	Enable/disable signal strength/satellite number	89
	$PASHS,NME,SAT	Enable/disable satellite status message	112
Time and Date	$PASHS,NME,ZDA	Enable/disable time and date message	115
Track, Speed	$PASHS,NME,VTG	Enable/disable velocity/course message	114

ALL: Disable All NMEA Messages

$PASHS,NME,ALL,x,OFF

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

Examples: Turn off all NMEA messages for Port A.

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

ALM: Almanac Message

$PASHS,NME,ALM,x,s

This command enables or disables the almanac message, where x is the receiver serial port and s is ON or OFF.

Example: Enable almanac message on port C:

$PASHS,NME,ALM,C,ON<Enter>

$PASHQ,ALM,x

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

Example: Query almanac data message to receiver port D:

$PASHQ,ALM,D<Enter>

GGA: GPS Position Message

$PASHS,NME,GGA,x,s

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

Example: Enable GGA on port A

$PASHS,NME,GGA,A,ON

$PASHQ,GGA,x

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

Example: Output GGA message on port B

$PASHQ,GGA,B

$GPGGA

The response message is in the form:

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

Table 6.29 outlines the GGA structure.

Table 6.29. GGA Structure

Field	Description	Range
m1	Current UTC time of position fix in hours, minutes and seconds (hhmmss.ss).	00 to 235959.50
m2	Latitude component of position in degrees, minutes and fraction of minutes (ddmm.mmmmmm).	0 to 90°
c1	Latitude sector, N = North, S = South.	‘N’ or ‘S’
m3	Longitude component of position in degrees, minutes and fraction of minutes (dddmm.mmmmmm).	0 to 180°
c2	Longitude sector, E = East, W = West.	‘E’ or ‘W’

Table 6.29. GGA Structure (continued)

Field	Description	Range
d1	Position Type, n 1 = Autonomous position 2 = position differentially corrected 3 = RTK float 4 = RTK fixed	1, 2, 3, 4
d2	number of GPS satellites used in position computation.	3 to 24
f1	HDOP - horizontal dilution of precision	0 to 99.9
f2	Altitude in meters above the geoid. For 2-D position computation this item contains the altitude held fixed.	0 to 30000.000
M	Altitude units, M = meters.	‘M’
f3	Geoidal separation (value output only if Geoidal Height option (G) is installed in the receiver).	±999.999
M	Geoidal separation units, M = meters.	‘M’
f4	Age of the differential corrections, sss, in seconds.	±999.999
d3	Base station ID (RTCM only)	0 to 1023
*cc	checksum	

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

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

Example:

Query: $PASHQ,GGA,C or

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

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

Typical Response:

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

Table 6.30 outlines the GGA response message structure.

Table 6.30. Typical GGA Response Message

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

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

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

GLL: Latitude, Longitude Message

$PASHS,NME,GLL,x,s

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

Example: Enable GLL message on port A

$PASHS,NME,GLL,A,ON

$PASHQ,GLL,x

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

Example: Output GLL message on port B

$PASHQ,GLL,B

$GPGLL

The response message is in the form:

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

Table 6.31 outlines the GLL structure.

Table 6.31. GLL Structure

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

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

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

Example:

Query: $PASHQ,GLL,B [or]

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

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

Table 6.32 outlines a typical GLL response message.

Table 6.32. Typical GLL Response Message

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

GRS: Satellite Range Residual Message

$PASHS,NME,GRS,x,s

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

Example: Enable GRS message on port B

$PASHS,NME,GRS,B,ON

$PASHQ,GRS,x

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

Example: Output GRS message on port B

$PASHQ,GRS,B

$GPGRS/$GLGRS

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

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

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

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

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

Command/Response

Table 6.33 outlines the GRS message structure.

Table 6.33. GRS Structure

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

Example:

Query: $PASHQ,GRS,A or

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

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

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

Table 6.34 outlines a typical GPGRS response message. Table 6.35 outlines a typical GLGRS response message.

Table 6.34. Typical GPGRS Response Message

Field	Significance
$GPGRS	Header
180257.50	Time of position fix
1	Mode
+00.3	Range residual for first GPS satellite
-00.4	Range residual for second GPS satellite
+00.2	Range residual for third GPS satellite
+00.5	Range residual for fourth GPS satellite
+00.7	Range residual for fifth GPS satellite
-00.8	Range residual for sixth GPS satellite
*36	Message checksum in hexadecimal

Table 6.35. Typical GLGRS Response Message

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

GSA: DOP and Active Satellites Message

$PASHS,NME,GSA,x,s

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

Example: Enable GSA message on port B

$PASHS,NME,GSA,B,ON

$PASHQ,GSA,x

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

Example: Output GSA message on port B

$PASHQ,GSA,B

$GPGSA/$GLGSA

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

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

The second message contains GLONASS satellite information in the form:

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

The satellite PRN displayed in each of the ss fields of the GPGSA message is associated with one of the 10 GPS channels in the receiver, where the first ss field corresponds to the satellite locked to channel 1 and the last corresponds to the satellite locked to channel 10. The satellite PRN displayed in each of the ss fields of the GLGSA message is associated with one of the 8 GLONASS channels in the receiver, where the first ss field corresponds to the satellite locked to channel 11, and the last corresponds to the satellite locked to channel 18.

Table 6.36 outlines the GSA response message structure.

Table 6.36. GSA Structure

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

Examples:

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

Table 6.37 outlines the GPGSA response message.

Table 6.37. Typical GPGSA Response Message

Item	Significance
$GPGSA	Header
M	Manual mode
3	3D mode
15	Satellite 15 used for position computation
empty field	No locked satellite in this channel or locked satellite not used in position solution
20	Satellite 20 used
01	Satellite 1 used
22	Satellite 22 used

Table 6.37. Typical GPGSA Response Message (continued)

Item	Significance
14	Satellite 14 used
21	Satellite 21 used
25	Satellite 25 used
empty field	No locked satellite in this channel or locked satellite not used in position solution
empty field	No locked satellite in this channel or locked satellite not used in position solution
empty field	No locked satellite in this channel or locked satellite not used in position solution
29	Satellite 29 used
01.8	PDOP = 1.8
01.0	HDOP = 1.0
01.5	VDOP = 1.5
0F	Message checksum in hexadecimal

Example:

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

Table 6.38 outlines the GLGSA response message.

Table 6.38. Typical GLGSA Response Message

Item	Significance
$GLGSA	Header
M	Manual mode
3	3D mode
33	Satellite 33 used for position computation
54	Satellite 54 used for position computation
empty field	No locked satellite in this channel or locked satellite not used
empty field	No locked satellite in this channel or locked satellite not used
41	Satellite 41 used
38	Satellite 38 used
empty field	No locked satellite in this channel or locked satellite not used in position solution

Table 6.38. Typical GLGSA Response Message (continued)

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

GSN: Signal Strength/Satellite Number Message

$PASHS,NME,GSN,x,s

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

Example: Enable GSN message on port B

$PASHS,NME,GSN,B,ON

$PASHQ,GSN,x

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

Example: Output GSN message on port B

$PASHQ,GSN,B

$GPGSN/$GLGSN

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

The first message contains GPS satellite information in the form:

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

The second message contains GLONASS satellite information in the form:

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

when n is equal to the number of locked satellites.

Table 6.39 outlines the GPGSN message response structure.

Table 6.39. GSN Structure

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

Example:

Query: $PASHQ,GSN,A or

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

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

Table 6.40 outlines the GPGSN response message.

Table 6.40. Typical GPGSN Response Message

Field	Significance
$GPGSN	Header
03	Number of satellites locked
03	PRN number of the first GPS satellite
060	Signal strength of the first GPS satellite
23	PRN number of the second GPS satellite
039	Signal strength of the second GPS satellite
16	PRN number of the third GPS satellite
021	Signal strength of the third GPS satellite
999	Termination with no RTCM information
7D	Message checksum in hexadecimal

Example:

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

Table 6.41 outlines the GLGSN response message.

Table 6.41. Typical GLGSN Response Message

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

GXP: Position Horizontal Message

$PASHS,NME,GXP,x,s

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

Example: Output GXP message on port B

$PASHS,NME,GXP,B,ON

$PASHQ,GXP

The associated query command is

$PASHQ,GXP,x

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

$GPGXP

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

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

Table 6.42 outlines the GXP response message structure.

Table 6.42. GXP Structure

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

Example:

Query: $PASHQ,GXP,B or

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

Typical Response:

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

Table 6.43 outlines the GXP response message.

Table 6.43. Typical GXP Response Message

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

MSG: RTCM Message

$PASHS,NME,MSG,x,s

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

Unless the Z18 Reference Station System **is sending or receiving differential corrections, this command is ignored.**

Example: Enable MSG on port A

$PASHS,NME,MSG,A,ON

$PASHQ,MSG,x

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

$GPMSG

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

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

$GPMSG,d1,d2,f1,d3,d4,d5,m1,d5,d7,f2,f3,d8*cc

Message types 1 and 9 output correction information for GPS satellites, while message types 31 and 34 output correction information for GLONASS satellites.

Differential GPS Corrections (Type1) and GPS Partial Correction Set (Type 9)

Table 6.44 outlines the $GPMSG response structure.

Table 6.44. $GPMSG Structure for RTCM Message Types 1 and 9

Field	Description
d1	RTCM type, 01, 09, 31, or 34
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999

Table 6.44. $GPMSG Structure for RTCM Message Types 1 and 9 (continued)

Field	Description
m1	Current UTC time of position computation in hours, minutes, and seconds
d6	User differential range error (UDRE)
d7	Satellite PRN number. GPS satellites for message types 1 and 31 and GLONASS satellites for message types 9 and 34.
f2	Pseudo-range correction (PRC) in meters
f3	Range rate correction (RRC) in meters/sec
d8	Issue of data (IODE) for message types 1 and 9, and reference time of GLONASS ephemerides (TB) for message types 31 and 34.
*cc	Message checksum in hexadecimal

Message types 1/31 and 9/34 are identical except for the fact that message type 1/31 has correction information (fields 9, 10, 11, 12, 13) for all GPS+GLONASS satellites, and each message type 9/34 has correction information for up to 3 GPS+GLONASS satellites per transmission. Note that for message types 01 and 09, GPS PRN numbers are between 1 and 32, and for message types 31 and 34, GLONASS ID numbers are between 1 and 24 (GLONASS slot numbers).

Example:

$GPMSG,01,0000,2220.0,1,0,127,003702:00,2,12, -
0081.30,+0.026,235,2,13,+0022.86,+0.006,106,2,26,-0053.42,-
0.070,155,2,02,+0003.56,+0.040,120, 2,27,+0047.42,-0.005, 145*7A

where Table 6.45 outlines the $GPMSG response format.

Table 6.45. $GPMSG Response for RTCM Messages 1, 31, and 9, 34

Item	Description
$GPMSG	Header
01	RTCM message
0000	Station ID
2220.0	Z count in seconds and tenths
1	Sequence number
0	Station health
127	Total number of characters of the time item
003702.00	Current time in hours, minutes, and seconds
2	UDRE for SV 12

Table 6.45. $GPMSG Response for RTCM Messages 1, 31, and 9, 34 (continued)

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

The format for RTCM message type 3 and 32 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,f1,f2,f3,*cc

Format and contents of message types 3 and 32 are identical except for the fact that message type 32 displays the base coordinates in the PZ-90 coordinate system, while message type 3 uses the WGS-84 coordinate system.

GPS Reference Station Parameters (Type 3) and GLONASS Reference Station Parameters (Type 32):

Table 6.46 outlines the $GPMSG structure.

Table 6.46. $GPMSG Structure for RTCM Message Types 3 and 32

Field	Description
d1	RTCM type, 03 or 32
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	current GPS system time of position computation in hours, minutes and seconds
f1	metric x - distance from geocenter (x component of station) using WGS-84 in message type 3, and SGS-90 in message type 32
f2	metric y - distance from geocenter (y component of station) using WGS-84 in message type 3, and SGS-90 in message type 32
f3	metric z - distance from geocenter (z component of station) using WGS-84 in message type 3, and SGS-90 in message type 32
*cc	Message checksum in hexadecimal

Example:

$GPMSG,03,0000,1200.0,7,0,038,231958.00,-2691561. 37,-4301271.02,+3851650.89*6C

Table 6.46 outlines the $GPMSG response structure.

Table 6.47. $GPMSG Response for RTCM Message Type 3

Item	Description
03	RTCM type
0000	Station ID
1200.0	Z count in seconds and tenths
7	Sequence number

Table 6.47. $GPMSG Response for RTCM Message Type 3 (continued)

Item	Description
0	Station health
038	Total number of characters after the time item
231958.00	Current time in hours, minutes and seconds
-2691561.37	Station X component using WGS-84
-4301271.02	Station Y component using WGS-84
+3851650.89	Station Z component using WGS-84
*6C	Message checksum in hexadecimal

The format for RTCM message types 16 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,s1*cc

GPS Special Text Message (Type 16).

Table 6.48 outlines $GPMSG structure for message types 16.

Table 6.48. $GPMSG Structure for RTCM Message Types 16

Field	Description
d1	RTCM type 16
d2	station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	sequence number, 0 to 7
d4	station health, 0 to 7
d5	total number of characters after the time item, 000 to 999
m1	current GPS system time of position computation in hours, minutes and seconds
s1	text message
*cc	Message checksum in hexadecimal

Example:

$GPMSG,16,0000,1209.6,5,0,038,232008.00,THIS IS A MESSAGE SENT FROM BASE*5C

Table 6.49 outlines the $GPMSG response message for message type 16.

Table 6.49. $GPMSG Response, RTCM Message Type 16

Item	Description
$GPMSG	Header
16	RTCM type
0000	Station ID
1209.6	Z count in seconds and tenths
5	Sequence number
0	Station health
038	Total number of characters after the time item
232008.00	Current time in hours, minutes and seconds
THIS IS A....	Message content
5C	Message checksum in hexadecimal

RTCM type 18 is the uncorrected carrier phase message used to transmit data to the rover for RTK processing. The format for RTCM type 18 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,s1,d6,d7,n(d8,d9,d10,d11,f2)*cc

Table 6.50 outlines the $GPMSG response message structure for RTK Uncorrected Carrier Phases (Type 18)

Table 6.50. $GPMSG Structure for RTCM Message Type 18

Field	Description
d1	RTCM type, 18
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	Current UTC time of position computation in hours, minutes, and seconds
s1	GPS / GLONASS Constellation Indicator
d6	Frequency Indicator: "00": L1 message, "01": L2 message, "10","11" :Reserved

Table 6.50. $GPMSG Structure for RTCM Message Type 18 (continued)

Field	Description
d7	GNSS Time of measurement (GPS or GLONASS time) (added to Z-Count)
	The following data is displayed for each Satellite in the message:
d8	Multiple message indicator (1 = more messages will follow with same time tag, 0 = last message)
d9	GPS (PRN Range 0-31) or GLONASS (Slot number 1-24) Satellite ID
d10	Data Quality Indicator (See RTCM Paper 88-97/SC104-156 Version 2.2)
d11	Cumulative loss of continuity indicator (unfixed cycle slips or loss of lock)
f2	Uncorrected Carrier Phase (Cycles)
*cc	Message checksum in hexadecimal

Typical Example 4:

$GPMSG,18,0000,1747.8,4,0,170,202908.50,GLO,0,200000,0,0,20,4,01,-8259701.2187,0,0,04,4,01,+5708064.4921,0,0,16,4,05,-1803924.6250,0,0,14,4,01,-0383075.2578,0,0,15,4,01,-7205926.2500,0,0,06,4,01,-0607101.0039*33

Table 6.51 outlines the $GPMSG structure for message type 18.

Table 6.51. $GPMSG Response for RTCM Message 18

Item	Description
$GPMSG	Header
18	RTCM message
0000	Station ID
1747.8	Z count in seconds and tenths
4	Sequence number
0	Station health
170	Total number of characters of the time item
202908.50	Current time in hours, minutes, and seconds
GLO	GLONASS Constellation

Table 6.51. $GPMSG Response for RTCM Message 18 (continued)

Item	Description
0	L1 Frequency indicator
200000	GPS system time of measurement basis
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
20	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-8259701.2187	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
04	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
+5708064.4921	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
16	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
05	Cumulative loss of continuity error (cycle slips)
-1803924.6250	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
14	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-0383075.2578	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
15	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤0.03933 cycle)

Table 6.51. $GPMSG Response for RTCM Message 18 (continued)

Item	Description
01	Cumulative loss of continuity error (cycle slips)
-7205926.2500	Carrier phase (cycles)
0	Last message for this SV and Time Tag
0	Code indicator 0=C/A Code
06	GLONASS slot number (ID)
4	Data quality indicator (phase error ≤ 0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-0607101.0039	Carrier phase (cycles)
*33	Message checksum in hexadecimal

RTCM type 19 is the uncorrected code phase message used to transmit data to the rover for RTK processing. The format for RTCM type 19 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,s1,d6,d7,d8,n(d9,d10,d11,d12,f2)*cc

Table 6.52 outlines the $GPMSG response message format for RTK Uncorrected Pseudoranges (Type 19):

Table 6.52. $GPMSG Structure for RTCM Message Type 19

Field	Description
d1	RTCM type, 19
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	Current UTC time of position computation in hours, minutes, and seconds
s1	GPS / GLONASS Constellation Indicator
d6	Frequency Indicator: “00”: L1 message, “01”: L2 message, “10”,”11” :Reserved
d7	Smoothing Interval (0=1 min, 1 = 1..5 min, 2=5..15 min, 3=undefined)

Table 6.52. $GPMSG Structure for RTCM Message Type 19 (continued)

Field	Description
d8	GNSS Time of measurement (GPS or GLONASS time) (added to Z-Count)
	The following data is displayed for each Satellite in the message:
d9	Multiple message indicator (1 = more messages will follow with same time tag, 0 = last message)
d10	GPS (PRN Range 0-31) or GLONASS (Slot number 1-24) Satellite ID
d11	Data Quality Indicator (See RTCM Paper 88-97/ SC104-156 Version 2.2)
d12	Pseudorange multipath error indicator quantization (See RTCM Ver 2.2)
f2	Uncorrected Pseudorange (meters)
*cc	Message checksum in hexadecimal

Typical Example 5:

$GPMSG,19,0000,1747.8,6,0,148,202908.50,GLO,0,3,200000,0,20,14,15,21322294.20,0,04,14,15,23304544.46,0,16,14,15,22933427.40,0,14,14,15,22844988.16,0,15,14,15,21307216.00,0,06,14,15,21096086.06*2B

Table 6.53 outlines the $GPMSG response structure:

Table 6.53. $GPMSG Response for RTCM Message 19

Item	Description
$GPMSG	Header
19	RTCM message
0000	Station ID
1747.8	Z count in seconds and tenths
6	Sequence number
0	Station health
148	Total number of characters of the time item
202908.50	Current time in hours, minutes, and seconds
GLO	GLONASS Constellation
0	L1 Frequency indicator

Table 6.53. $GPMSG Response for RTCM Message 19 (continued)

Item	Description
3	Smoothing Interval (3=undefined)
200000	GPS system time of measurement basis
0	Last message for this SV and Time Tag
04	GLONASS slot number (ID)
14	Data quality indicator (≤5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
21322294.20	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
20	GLONASS slot number (ID)
14	Data quality indicator (≤5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
23304544.46	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
16	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
22933427.40	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
14	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
22844988.16	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
15	GLONASS slot number (ID)
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
21307216.00	Uncorrected Pseudorange (meters)
0	Last message for this SV and Time Tag
06	GLONASS slot number (ID)

Table 6.53. $GPMSG Response for RTCM Message 19 (continued)

Item	Description
14	Data quality indicator (?5.409 meters)
15	Pseudorange multipath error indicator quantization not determined
21096086.06	Uncorrected Pseudorange (meters)
*2B	Message checksum in hexadecimal

RTCM type 22 provides additional station position information and antenna height information. The format for RTCM type 22 is:

$GPMSG,d1,d2,f1,d3,d4,d5,m1,f1,f2,f3,f4*cc

Table 6.54 outlines the response structure for Extended Reference Station Parameters (Type 22):

Table 6.54. $GPMSG Structure for RTCM Message Type 22

Field	Description
d1	RTCM type, 22
d2	Station identifier, 0000 to 1023
f1	Z count in seconds and tenths, 0000.0 to 3600.0
d3	Sequence number, 0 to 7
d4	Station health, 0 to 7
d5	Total number of characters after the time item, 000 to 999
m1	current GPS system time of position computation in hours, minutes and seconds
f1	L1 ECEF DELTA-X (meters)
f2	L1 ECEF DELTA-Y (meters)
f3	L1 ECEF DELTA-Z (meters)
f4	Antenna L1 phase center height (meters)
*cc	Message checksum in hexadecimal

Example:

$GPMSG,22,0000,1717.2,2,0,045,202908.50,+0.000664,+0.004180,-0.002461,+0.000000*69

Table 6.55 defines the response format for a typical RTCM type 22 message.

Table 6.55. $GPMSG Response for RTCM Message Type 22

Item	Description
22	RTCM type
0000	Station ID
1717.2	Z count in seconds and tenths
2	Sequence number
0	Station health
045	Total number of characters after the time item
202908.50	Current UTC time of position calculation in hours, minutes, and seconds
+0.000664	L1 ECEF DELTA-X (meters)
+0.004180	L1 ECEF DELTA-Y (meters)
-0.002461	L1 ECEF DELTA-Z (meters)
+0.000000	Antenna L1 phase center height (meters)
69	Message checksum in hexadecimal

PER: Set NMEA Send Interval

$PASHS,NME,PER,x

Set send interval of the NMEA response messages in seconds, where x is a value between 0.5 and 999, depending upon position update rate option installed (2, or 1 Hz).

Example: Set send interval to 10.0 seconds

$PASHS,NME,PER,10.0

Table 6.56 outlines the PER (NMEA output rate) range options.

Table 6.56. PER (NMEA Output Rate) Range Options

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

POS: Position Message

$PASHS,NME,POS,x,c

Enable/disable NMEA position response message on output port x, and c is ON or OFF. If no position is computed, an empty message outputs.

Example: Enable position message on port B

$PASHS,NME,POS,B,ON

$PASHQ,POS,x

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

$PASHR,POS

The response is a message containing information on the most recently computed position. This response message is in the form:

$PASHR,POS,d1,d2,m1,m2,c1,m3,c2,f1,f2,f3,f4,f5,f6,f7,f8,f9,s*cc

Table 6.57 defines the POS response structure.

Table 6.57. POS Response Structure

Field	Description	Range
d1	position type: 0 = autonomous 1 = position differentially corrected with RTCM code 2 = position differentially corrected with CPD float solution 3 = position is CPD fixed solution	0 to 3
d2	Number of satellites used in position computation	3 to 12
m1	Current UTC time, (hhmmss), of position computation in hours, minutes and seconds	00 to 235959.50
m2	Latitude component of position in degrees, minutes, and fraction of minutes (ddmm.mmmm)	0 to 90°
c1	Latitude sector: N = North, S = South	‘N’ or ‘S’
m3	Longitude component of position in degrees, minutes, and fraction of minutes	0 to 180°
c2	Longitude sector: E = East, W = West	W or E
f1	Altitude in meters above WGS-84 reference ellipsoid. For 2-D position computation this item contains the altitude held fixed.	± 30000.00
f2	Reserved	

Table 6.57. POS Response Structure (continued)

Field	Description	Range
f3	True track/true course over ground in degrees (000.00 to 359.99 degrees)	0 to 359.9
f4	Speed over ground in knots	0 to 999.9
f5	Vertical velocity in meters per second	± 999.9
f6	PDOP - position dilution of precision	0 to 99.9
f7	HDOP - horizontal dilution of precision	0 to 99.9
f8	VDOP - vertical dilution of precision	0 to 99.9
f9	TDOP - time dilution of precision	0 to 99.9
s1	Firmware version ID	4 character string

If there is no valid position, POS provides: number of satellites, time, DOPs, firmware version ID. All other fields are null.

If there are not enough satellites to compute DOP, then the DOP field is null.

Example 1:

Query: $PASHQ,POS,A or

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

Typical Response:

$PASHR,POS,0,06,183805:00,3722.36221,N, 12159.82742, W,+00016.06,,179.22,021.21,+003.96+34,06.1,04.2,03.2,01.4,GA00*cc

Table 6.58 outlines a typical POS response message.

Table 6.58. Typical POS Response Message

Item	Description
$PASHR,POS	Header
0	Position is autonomous
06	Number of satellites used in position computation
183805.00	Time of position computation
3722.36221	Latitude
N	North
12159.82742	Longitude
W	West
+00016.06	Altitude in meters

Table 6.58. Typical POS Response Message (continued)

Item	Description
empty field	Reserved
179.22	Course over ground in degrees (True)
021.21	Speed over ground in knots
+003.96	Vertical velocity in meters per second
06.1	PDOP
04.2	HDOP
03.3	VDOP
01.4	TDOP
GA00	Version number
cc	Message checksum in hexadecimal

RMC: Recommended Minimum Course

$PASHS,NME,RMC,x,c

Enables/disables the magnetic declination message where x is the serial port, and c is ON or OFF.

Example: Enable RMC message on port C

$PASHS,NME,RMC,C,ON

$PASHQ,RMC,x

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

$GPRMC

The return message is in the form:

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

Table 6.59 outlines the response structure.

Table 6.59. RMC Response Structure

Parameters	Description	Range
m1	UTC time of the GGA fix associated with this sentence (hhmmss.ss)	000000.00-23559.95
c2	Status	A => Data Valid V => Navigation Receiver Warning
m3	Latitude (ddmm.mmmm)	0000.0000-8959.9999
c4	Latitude direction	N => North S => South
m5	Longitude (dddmm.mmmm)	00000.0000-17959.9999
c6	Longitude direction	E => East W => West
f7	Speed over ground, knots	000.00-999.99
f8	Course Over Ground, degrees True	000.00-359.99
d9	date, mmddyy	010100-123199
f10	Magnetic Variation, degrees	0.00-99.99
c11	Direction of Variation Easterly variation (E) subtracts from True course. Westerly variation (W) adds to True course	E => East W =>West
*cc	The hexadecimal checksum	

RRE: Satellite Residual and Position Error Message

$PASHS,NME,RRE,x,c

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

Example: Enable RRE message on port A

$PASHS,NME,RRE,A,ON

$PASHQ,RRE,x

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

Example:

$PASHQ,RRE,A

$GPRRE/$GLRRE

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

$GPRRE,d1,n(d2,f1)f2,f3

The second message contains GLONASS satellite information in the form:

$GLRRE,d1,n(d2,f1)f2,f3

where n is equal to the number of satellites used to compute a position.

Table 6.60 outlines the RRE response structure.

Table 6.60. RRE Response Structure

Field	Description
d1	Number of satellites used to compute position
d2	PRN number for each of the satellites used in position computation. GPS satellite ranging from 1 to 32 in the $GPRRE message and GLONASS satellite ranging from 33 to 56 in the $GLRRE message
f1	Range residuals magnitude in meters for each satellite used in position computation: GPS satellites in message.
f2	Horizontal RMS position error for mixed constellation in meters
f3	Vertical RMS position error for mixed constellation in meters

Example:

Query: $PASHQ,RRE,A or

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

Typical Responses:

$GPRRE,05,18,+000.2,29,+000.2,22,-000.1,19,- 000.1,28,
+000.5,0002.0,0001.3*76

$GLRRE,03,45,+000.4,36,+000.2,52,-000.2,0002.0,0001.3*A1

Table 6.61 outlines the typical $GPRRE response message.

Table 6.61. $GPRRE Response Message

Item	Description
$GPRRE	Header
05	Number of satellites used to compute position
18	PRN of first satellite
+000.2	Range residual for first satellite in meters
29	PRN of second satellite
+000.2	Range residual for second satellite in meters
22	PRN of third satellite
-000.1	Range residual for third satellite in meters
19	PRN of fourth satellite
-000.1	Range residual for fourth satellite in meters
28	PRN of fifth satellite
+000.5	Range residual for fifth satellite in meters
0002.0	Horizontal position error in meters
0001.3	Vertical position error in meters
76	Message checksum in hexadecimal

Table 6.62 outlines the $GLRRE response message.

Table 6.62. $GLRRE Response Message

Item	Description
$GLRRE	Header
03	Number of satellites used to compute position
45	PRN of first GLONASS satellite
+000.4	Range residual for first GLONASS satellite in meters
36	PRN of second GLONASS satellite
+000.2	Range residual for second GLONASS satellite in meters
52	PRN of third GLONASS satellite
-000.2	Range residual for third GLONASS satellite in meters

Table 6.62. $GLRRE Response Message (continued)

Item	Description
0002.0	Horizontal position error in meters
0001.3	Vertical position error in meters
A1	Message checksum in hexadecimal

SAT: Satellite Status Message

$PASHS,NME,SAT,x,y

Enable/disable satellite status message on port x, where x is the output port, and y is ON or OFF. This message is output even if no position is computed.

Example: Enable SAT message on port B

$PASHS,NME,SAT,B,ON

$PASHQ,SAT,x

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

Example:

$PASHQ,SAT,B

$PASHR,SAT

The response is a message in the form:

$PASHR,SAT,d1,n(d2,d3,d4,d5,c1)*cc

where n is equal to the number of satellites locked.

Table 6.63 outlines the SAT field structure.

Table 6.63. SAT Structure

Field	Description
d1	Number of satellites locked, number of satellites in message, range 0-24
d2	Satellite PRN number, range 1 to 56 (1 to 32 for GPS, 33 to 56 for GLONASS)
d3	Satellite azimuth angle, 000 to 359 degrees
d4	Satellite elevation angle, 00 to 90 degrees
d5	Satellite signal strength/signal-to-noise ratio, 00 to 99
c1	Satellite used/not used in position computation U = Satellite used in position computation - = Satellite not used in position computation

Example 1:

Query: $PASHQ,SAT,B or

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

Typical Response:

$PASHR,SAT,04,03,103,56,60,U,23,225,61,39,U,16,045,02,21,U,40,160,46,50,U*6E

Table 6.64 outlines the response format.

Table 6.64. Typical SAT Response Message

Item	Description
$PASHR,SAT	Header
04	Number of satellites locked
03	PRN number of the first satellite
103	Azimuth of the first satellite in degrees
56	Elevation of the first satellite in degrees
60	Signal strength of the first satellite
U	Satellite used in position computation
23	PRN number of the second satellite
225	Azimuth of the second satellite in degrees
61	Elevation of the second satellite in degrees
39	Signal strength of the second satellite
U	Satellite used in position computation
16	PRN number of the third satellite
045	Azimuth of the third satellite in degrees
02	Elevation of the third satellite in degrees
21	Signal strength of the third satellite
U	Satellite used in position computation
40	PRN number of fourth satellite
160	Azimuth of fourth satellite in degrees
46	Elevation of fourth satellite in degrees
50	Signal strength of fourth satellite
U	Satellite used in position computation
6E	Message checksum in hexadecimal

VTG: Velocity/Course Message

$PASHS,NME,VTG,x,c

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

Example: Enable VTG message or port B

$PASHS,NME,VTG,B,ON

$PASHQ,VTG,x

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

$GPVTG

The response message is in the form:

$GPVTG,f1,T,f2,M,f3,N,f4,K

Table 6.65 outlines the VTG structure.

Table 6.65. VTG Structure

Field	Description
f1	True track/true course over ground, ttt.tt = 000.00 to 359.99 degrees
T	T = true course
f2	Magnetic track/magnetic course over ground, (000.00 to 359.99) degrees. (Output only if magnetic variation option (M) is installed in receiver)
M	Magnetic course over ground marker, M = magnetic course
f3	Speed over ground, 000 to 999.99 knots
N	Speed over ground units, N = nautical miles per hour
f4	Speed over ground, = 000 to 999.99 kilometers per hour
K	Speed over ground units, = K (kilometers per hour)

Example:

Query: $PASHQ,VTG,B or

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

Typical Response:$GPVTG,179.21,T,1934.4,M,000.11,N,000.20,K*3E

Table 6.66 outlines the example VTG response message.

Table 6.66. Typical VTG Response Message

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

ZDA: Time and Date Message

$PASHS,NME,ZDA,x,c

Enable/disable the time and date message or port x, where x is the output port, and c is ON or OFF. This message is output even if a position is not computed.

Example: Disable ZDA message on port A

$PASHS,NME,ZDA,A,OFF

$PASHQ,ZDA,x

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

$GPZDA

The response message is in the form:

$GPZDA,m1,d1,d2,d4,d5

Table 6.67 outlines the ZDA structure.

Table 6.67. ZDA Structure

Field	Description
m1	UTC time (hhmmss.ss) (hours, minutes, seconds)
d1	Current day 01 - 31
d2	Current month 01 - 12
d3	Current year 0000-9999

Table 6.67. ZDA Structure (continued)

Field	Description
d4	Local zone offset from UTC time where s = sign and hh = hours Range 00 - ±13
d5	Local zone offset from UTC time where mm = minutes with same sign as shh

Example:

Query: $PASHQ,ZDA,A or

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

Typical Response: $GPZDA,132123.00,10,03,1996,+07,00*ss

Table 6.68 outlines the example ZDA response message.

Table 6.68. Typical ZDA Response Message

Item	Description
$GPZDA	Message header
123123.00	UTC time
10	Current day
03	Current month
1996	Current year
+07	Local zone
*22	Checksum in hexadecimal

RTCM Response Message Commands

The RTCM commands allow you to control and monitor RTCM real-time differential operations. Only the base RTCM commands are available. For a discussion of RTCM differential, refer to Chapter 5, **Differential and RTK Operations**.

Set Commands

All RTCM commands but one are set commands. Through the set commands you can modify and enable a variety of differential parameters. If the set command is sent correctly, the receiver will respond with the $PASHS,ACK acknowledgement. If a parameter is out of range or the syntax is incorrect, then the receiver will respond with a $PASHS,NAK to indicate that the command was not accepted.

Query Commands

There is only one query command: $PASHQ,RTC. Use this command to monitor the parameters and status of RTCM differential operations. The query command has an optional port field. If the query is sent with the port field left empty, then the response will be sent to the current port. For example, the query:

$PASHQ,RTC<Enter>

Will output an RTCM status message to the current port. The command:

$PASHQ,RTC,c<Enter>

Will output an RTCM status message to port C.

Table 6.69 lists the RTCM commands.

Table 6.69. RTCM Commands

	Command	Description	Page
Base Parameters	$PASHS,RTC,BAS	Set receiver to operate as differential base station	118
	$PASHS,RTC,MSG	Defines RTCM type 16 message	118
	$PASHS,RTC,SPD	Sets baud rate of base station	121
	$PASHS,RTC,STH	Sets health of reference station	121
	$PASHS,RTC,TYP	Enables type of message	122
	$PASHQ,RTC	Requests base or remote differential mode parameters and status	119
	$PASHS,RTC,OFF	Disable differential mode	118
	$PASHS,RTC,STI	Set station identification	122

BAS: Set Receiver as Differential Base Station

$PASHS,RTC,BAS,x

Set the Z18 Receiver to operate as an RTCM differential base station, where x is the port through which corrections will be sent.

Example: Set to differential base mode using port B:

$PASHS,RTC,BAS,B<Enter>

MSG: RTCM Type 16 Message

$PASHS,RTC,MSG,s

Define RTCM type 16 message, where s is a character string up to 90 characters long that will be sent from the base to the remote. Used only if message type 16 is enabled.

Example: Define RTCM message “This is a test message”:

$PASHS,RTC,MSG,This is a test message<Enter>

OFF: Disable Differential Mode

$PASHS,RTC,OFF

Disables base differential mode.

Example:

$PASHS,RTC,OFF<Enter>

Command/Response

RTC: RTCM Differential Parameters

$PASHQ,RTC,c

Request differential mode parameters, where c is the optional serial port. The response message is a free form response that looks like:

```
STATUS:
        SYNC:    TYPE:00   STID:0000  STHE:0
        AGE:+999   QA:100.0%  OFFSET:00
SETUP:
        MODE:OFF  PORT:A   AUT:N
        SPD:000300  STI:0000 STH:1
        MAX:0060  QAF:100   SEQ:N
        TYP: 1  2  3  6   9  16  18  19  22  31  32  6G  34  36
        FRQ:01 00 00 00  00  00  00  00  00  01  00  00  00  00
BASE:  LAT:0000.0000,N  LON:00000.00000,E  ALT:+00000.00 W84
MSG:
MSG (GLO):
```

where Table 6.70 outlines the response message format:

Table 6.70. RTC Response Message Structure

Field	Description
Status:	
SYNC	Indicates with an * that synchronization between base and remote has been established. Valid only for REMOTE mode.
TYPE	Indicates type of message being sent (base).
STID	Displays the station ID of the base station.
STHE	Displays the station health of the base station.
AGE	In BASE mode, displays the elapsed time in seconds between the beginning of the transmission of Type 1 or 9 messages.
QA	Displays the communication quality factor between base and remote. • Defined as 100 x number of good messages/total number of messages Valid for REMOTE mode only.
OFFSET:	Displays the number of bits from the beginning of the RTCM byte (in case of a bit slippage).
SETUP:	
MODE:OFF	Displays differential mode either base (BAS) or disabled (OFF).

Table 6.70. RTC Response Message Structure (continued)

Field	Description
PORT:A	Displays port used to send RTCM corrections.
AUT:N	Displays auto differential mode. Default is N. Used only in REMOTE mode.
SPD:0300	RTCM bit rate. The number of bits per second sent to the differential serial port. Use only in BASE mode.
STI:0000	User-supplied station ID. Default is 0000.
STH:0	User-set reference station health. Default is 0. Used only in BASE mode.
MAX:0060	Maximum age, in seconds, allowed for a message to be used to compute a differentially corrected position. Default is 60. Used only in REMOTE mode.
QAF:100	The criteria to be applied when evaluating the quality of communication between base and remote. Used in computer QA. Default is 100. Used only in REMOTE mode.
SEQ:N	Indicates if there is a check for sequential received message number for the message to be accepted. Default is N. Used only in REMOTE mode.
TYP	Indicates the RTCM message types the receiver can generate. Messages available are 1, 3, 6, 9, 16, 18, 19, 22, 31, 32, 6G, 34, and 36. Message 2 is not generated. used only in BASE mode.
FRQ	Indications the output period for message types 1, 2, 3, 9, 16, 18, 19, 31, 32, 34, and 36. A 0 indicates message disabled, a 99 indicates continuous output, and any other number specifies the number of seconds between transmissions for message types 1, 9, 18, 19, 31, and 34 and the number of minutes between transmissions for all other messages. Default for message types 1 and 31 is 99, for types 6 and 6G is OFF, and for all other messages is 00.
BASE	For base mode, displays the antenna position of the base station in latitude, longitude, and altitude above reference ellipsoid, and reference coordinates to use when computing corrections. Antenna position is entered with commands POS.
MSG	For base mode, contains the text message, up to 90 characters, that is sent from the base to the remote when message type 16 is enabled.
MSG(GLO)	For base mode, contains the text message, up to 90 characters, that is sent from the base to the remote when message type 36 is enabled.

If changed, parameter values are saved by the $PASHS,SAV,Y set command, after the next power-up, the response to the $PASHQ,RTC query command will display the saved quantities instead of the defaults. $PASHS,RST always reinstates the defaults.

SPD: Set RTCM Bit Rate

$PASHS,RTC,SPD,d

Set the number of bits per second that are being generated to the serial port of the base station, where d is the code for the output rate in bits per second. Default is 300 bits per second. Used only in BASE mode. Table 6.71 lists the bit rate codes.

Table 6.71. Bit Rate Codes

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

Example: Set bit rate to 110 bits/second

$PASHS,RTC,SPD,3<Enter>

STH: Health of Reference Station

$PASHS,RTC,STH,d

Set the health of the reference station, where d is any value between 0 and 7. Used only in BASE mode. Default is 0. Table 6.72 lists the codes for the station health.

Table 6.72. Reference Station Health Codes

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

Example: Set health to “Reference station not working.”

$PASHS,RTC,STH,7<Enter>

STI: Set Station Identification

$PASHS,RTC,STI,d

Set user station identification (user STID) to any value between 0000 and 1023. Default is 0000.

Example: Set site identification to 0001.

$PASHS,RTC,STI,0001<Enter>

TYP: Enable Type of Message

$PASHS,RTC,TYP,x,s

Enables the type of message to be sent by the base station and the period at which it will be sent, where x is the type and s is the period. Table 6.73 lists the type of messages available and the period range setting.

Table 6.73. Base Station Message Types and Period Ranges

Type	Range
1	0-99 seconds, where 0 is disabled and 99 is generated continuously
3	0-99 minutes, where 0 is disabled and 99 is generated continuously
6	ON or OFF. Default = OFF
9	0-99 seconds, where 0 is disabled and 99 is generated continuously
16	0-99 minutes, where 0 is disabled and 99 is generated continuously
18	0-99 seconds, where 0 is disabled and 99 is generated continuously
19	0-99 seconds, where 0 is disabled and 99 is generated continuously
22	0-99 minutes, where 0 is disabled and 99 is generated continuously
31	0-99 seconds, where 0 is disabled and 99 is generated continuously
32	0-99 minutes, where 0 is disabled and 99 is generated continuously
6G	ON or OFF. Default = OFF
34	0-99 seconds, where 0 is disabled and 99 is generated continuously
36	0-99 minutes, where 0 is disabled and 99 is generated continuously

Example: Enable type 1, sent out every second.

$PASHS,RTC,TYP,1,1<Enter>

When the command $PASHS,RTC,BAS is sent, message types 1 and 31 are generated continuously by default.

A

GPS and GLONASS Concepts

When the Global Positioning System (GPS) became operational in 1993, it promised to provide a new utility as pervasive and as useful as the telephone. However, GPS has certain limitations that become apparent in certain applications. These limitations are dramatically reduced by the augmentation of GPS with the Russian GLObal NAvigation Satellite System (GLONASS). The Ashtech Z18 GPS+GLONASS receiver uses the 9 healthy GLONASS satellites in addition to the 26 healthy GPS satellites, providing a system even more reliable and more accurate than either system alone.

Differential Position Accuracy

Because there are more satellites in view, the DOPs (Dilution Of Precision) typically decrease by 20%-50%, and differential accuracy improves by a similar amount. In fact, there is no limit to how much the DOPs can change.

Basic Concepts

GPS and GLONASS both work on the principle of triangulation: if you know your distance from several known points, then you can compute your position. The known points for both systems are the satellites. The distance to a satellite is measured by timing how long the satellite signal takes to reach you; multiply this time by the speed of light and you have the distance.

The GPS satellite clocks are all synchronized. Similarly, the GLONASS satellites are all synchronized with each other, but GPS time is not synchronized with GLONASS time. Thus, the receiver clock has two errors: the error with GPS time, and the error with GLONASS time. These two clock errors, plus latitude, longitude, and altitude, give 5 unknowns, which are solved by having 5 satellites (or more) in view.

The Z18 receiver fixes the altitude, if the altitude of the antenna is known; this removes one unknown, and only four satellites are needed. The receiver also determines the offset between GPS and GLONASS time. You can command the receiver to fix the time offset; this eliminates another unknown, thus only three satellites are needed for a 2-D position, or four for a 3-D position. Any combination of GPS & GLONASS satellites work, the receiver seamlessly integrates the two systems into one 48-satellite constellation.

Signal Structure

GPS and GLONASS have similar signal structures.

- Both transmit on two frequency bands, LI and L2
- Both have PRN codes in the LI frequency band, known as Coarse/ Acquisition (C/A) code for GPS, and standard (S) code for GLONASS
- Both transmit almanac and ephemerides at a data rate of 50 bus. The receiver tracks the LI C/A and S codes from both GPS and GLONASS
- Both have PRN codes that repeat every one millisecond (C/A for PS and S for GLONASS)

Differences in Signal Structure

The difference between GPS and GLONASS signal structures is that GPS uses the same frequencies but different PRN codes for each satellite (CDMA, Code Division Multiple Access). GLONASS uses the same PRN codes for each satellite, but different frequencies within the LI and L2 bands (FDMA, Frequency Division Multiple Access). A PRN code identifies each GPS satellite. GPS PRN codes are numbered from 1 through 32, 24 of which are used for the full constellation. GLONASS satellites are identified by their orbital slot number. There are 24 orbital slots, numbered sequentially 1 through 24. The satellite takes the slot number it occupies.

Differences in Implementation

GPS and GLONASS satellites transmit orbit information about the satellites in almanacs. Each satellite transmits an almanac which tells the receiver which satellites are operating and where they are. This is how the receiver knows which satellites are above the horizon. GPS satellites are identified in their almanac by their PRN numbers, while GLONASS satellites are identified by their orbital slot (ID) numbers. Each slot number has an associated carrier number in the almanac which tells the receiver which frequency the satellite is on.

Each GPS satellite transmits at an L1 frequency of 1575.42 MHz, and at an L2 frequency of 1227.60 MHz. Each GLONASS satellite transmits at an L1 frequency of 1602 + K(9/16 MHz), and at an L2 frequency of 1246 + K(7/16 MHz). K is the carrier number given in the almanac for each satellite. Currently K is in the range 1 through 24.

Changes are planned for the GLONASS frequency plan:

- **Stage 1—**Present to 1998 -The carrier numbers will be assigned in such a way as to avoid the frequencies in the band 1610.6-1613.8 MHz used in Radio Astronomy. This means the carrier number assignments K= 16, 17, 18, 19, 20 will not be used. To compensate for the lost frequencies, identical frequencies will be used for two satellites on opposite sides of the earth.
- **Stage 2**—1998 to 2005 - The next Generation of GLONASS-M satellites will use the carrier number assignments 1 through 12.
- **Stage 3**—beyond 2005 - The GLONASS-M satellites will use the carrier number assignments (-7 through +4). Carriers 5 and 6 will be used for interaction with the ground control segment.

Any or all of these changes in frequency will have no effect on the Z18 receiver, because the capability to handle any of the carrier number assignments is built in, and the satellite almanac always tells the receiver which assignment to use for each satellite.

The satellite ephemerides are like a high-precision almanac, they tell the receiver precisely where the satellite is. Each satellite (both GPS and GLONASS) transmits its own ephemerides. The GPS satellites provide their positions in terms of the WGS- 84 (World Geodetic System, 1984) while the GLONASS satellites provide positions in the PZ-90 reference system (sometimes called PE-90 Parameters of the Earth, 1990 or E90). The Z18 translates the two systems into a single user-selectable reference system. The default is WGS- 84, and by default, the Z18 converts GLONASS satellite positions into WGS-84 coordinates and computes positions in WGS-84 coordinates.

Satellite orbits

The orbits of GPS and GLONASS are similar. GPS satellites orbit in 6 planes, 4 satellites per plane. GLONASS uses 3 planes, 8 satellites per plane. The GLONASS inclination is slightly higher (64.8°) than GPS (55°). The orbits of both systems are circular, and with similar radii.

Geoid Model

The receiver uses the OSU-91 geoid model. Grid size is 5 x 5 degrees, and the interpolation technique is similar to the GPS ICS algorithm. Expected accuracy when the actual position is on a grid point is 0.5 to 0.6 meters, in accordance with the OSU-91 specification. Expected accuracy when the actual position is halfway between grid points is better than 8 meters.

Magnetic Model

The receiver uses the WMM-95 magnetic model. Grid size is 5 x 5 degrees, and the interpolation technique is similar to the GPS ICD algorithm. Expected accuracy depends upon the geomagnetic latitude. The errors are least at the equator, and greatest at the magnetic poles, and equal to 0.5 degrees (RMS) when the actual position is on a grid point. Expected accuracy when the actual position is halfway between grid points is better than 2.5 degrees (RMS). In arctic and antarctic regions, deviations from model values are frequent and persistent.

Comparison of GPS and GLONASS

Table A.1 compares the operating characteristics of GPS and GLONASS.

Table A.1. Comparison of GPS and GLONASS

Parameter	GPS	GLONASS
SIGNAL STRUCTURE		
C/A Code (L1)		
Code rate	1.023 MHz	0.511 MHz
Chip length	293 m	587 m
Selective availability	No	No
P Code		
Code rate	10.23 MHz	5.11 MHz
Chip length	29.3 m	58.7 m
Selective availability	No	No
Encryption (anti-spoofing)	Yes	No

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

Parameter	GPS	GLONASS
Signal separation	CDMA	FDMA
Carrier frequency	• 1575.42 MHz • 1227.60 MHz	• 1602 + Kx9/16 MHZ, where K is within the range -7 to +24 • 1246 + Kx7/16 MHz, where K is within the range -7 to +24
SATELLITES		
Number	24	24
Planes	6	3
Satellites per plane	4, unevenly spaced	8, evenly spaced
Orbital inclination	55°	64.8°
Orbital radius	26560 km	25510 km
Orbital period	11 hours 58 minutes	11 hours 15 minutes
NAVIGATION MESSAGE		
Duration	12.5 minutes	2.5 minutes
Capacity	37500 bits	7500 bits
Time reference	UTC (US Naval Observatory)	UTC (SU, Russia)
Geodetic datum	WGS-84	PZ-90

GPS and GLONASS System Time

GPS system time is equal to UTC time + the number of leap seconds added since 1980 (currently 12 seconds). GLONASS system time is equal to UTC time + 3 hours. There is an additional GLONASS time shift relative to GPS time of approximately -28.6 microseconds. Therefore, when UTC time equals 00:00:00.000000, GPS system time equals 00:00:12.000000, and GLONASS system time equals 00:02:59.9999714. In other words, GLONASS system time leads GPS system time by 3 hours minus the number of leap seconds plus the sub-second time shift value, which is currently equal to 2:59:47.9999714 (as of 30 June 1997).

GPS+GLONASS Standards

Two standards are used widely and successfully for GPS applications. These are

RTCM (Radio Technical Commission for Maritime Services) standard for differential corrections

NMEA (National Marine Electronics Association) standard for reporting position, velocity and satellite data.

Although both these standards were initially for marine use, they have been adopted worldwide for all applications of GPS.

RTCM SC-104

The RTCM Special Committee 104 (SC-104) has defined differential correction messages that are used worldwide for GPS. The messages that carry the GPS corrections are message types l and 9. Similar messages for GLONASS differential corrections are message types 31, GLONASS equivalent to GPS message type 1, and GLONASS type 34, GLONASS equivalent to GPS message type 9.

Other RTCM messages carry information about reference station parameters, satellite health, etc. These have been defined for both GPS and GLONASS.

Other messages are being developed to improve further the operation of GPS+GLONASS systems in differential mode. A GLONASS-GPS time offset message has been proposed, which allows the reference station to report the time offset between the two systems so that the GPS+GLONASS receiver does not have to calculate it. Table 1.2 lists the RTCM SC-104 messages for GPS and GLONASS, which the receiver supports, both as a reference station and a rover.

Table A.2. RTCM SC-104 Messages for GPS and GLONASS

Parameter	GPS Message Type	GLONASS Message Type
Differential corrections	1	31
Reference station parameters	3	32
Null frame (filler)	6	6
Partial satellite set differential corrections	9	34
Special message	16	36
RTK Uncorrected Carrier Phases	18	18

Table A.2. RTCM SC-104 Messages for GPS and GLONASS

Parameter	GPS Message Type	GLONASS Message Type
RTK Uncorrected Pseudoranges	19	19
Extended reference station parameters	22	22

NMEA 0183

The National Marine Electronics Association Standard NMEA 0183 defines interfacing standards for marine electronic devices. The following messages apply specifically to GPS, and are supported by the receiver:

- GGA—Global positioning system fix data
- GSA—GPS DOP and active satellites
- GRS—GPS range residuals for each satellite

B

Reference Datums and Ellipsoids

The following tables list geodetic datums and reference ellipsoid parameters.

Table B.1. Available Geodetic Datums

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
ADN	Clarke 1880	-162, -12, 206	Adindan (Ethiopia,Mali,Senegal,Sudan)
ARF	Clarke 1866	-143, -90, -294	ARC 1950 (Botswana,Lesotho,Malawi,Swaziland,Zaire,Zambia,Zimbabwe
ARS	Clarke 1866	-160, -8, -300	ARC 1960 (Kenya,Tanzania)
AST	International 1924	-104, -129, 239	Camp Area Astro (Antarctica)
AUA	Australian National	-133, -48, 148	Australian Geodetic Datum 1966(Australia, Tasmania Island)
AUG	Australian National	-134, -48, 149	Australian Geodetic Datum 1984 (Australia, Tasmania Island)
BOO	International 1924	307, 304, -318	Bogota Observatory (Columbia)
BUK	Bessel 1841	-384, 664, -48	Bukit Rimpah (Indonezia)
CAI	International 1924	-148, 136, 90	S. American Campo Inchauspe (Argentina)
CAP	Clarke 1866	-136, -108, -292	Cape (South Africa)
CGE	Clarke 1866	-263, 6, 431	Carthage (Tunisia)
CHI	International 1924	175, -38, 113	Chatham 1971 (Chatham,New Zeland)

Table B.1. Available Geodetic Datums (continued)

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
CHU	International 1924	-134, 229, -29	S. American Chua Astro (Paraguay)
CNA	Clarke 1866	0, 125, 194	N. American Central America
COA	International 1924	-206, 172, -6	S. American Corrego Alegre (Brazil)
CRB	Clarke 1866	-7, 152, 178	N. American Caribbean
DJK	Bessel 1841	-377, 681, -50	Djacarta (Indonesia)
E90 or PZ-90	Earth-90	0, 0, 4	Earth-90 (GLONASS Coordinate system)
EUA	International 1924	-87, -96, -120	European 1950 (Western Europe:Austria,Denmark,France,F.R. of Germany, Netherlands, Switzerland)
EUE	International 1924	-104, -101, -140	European 1950 (Cyprus)
EUF	International 1924	-130, -117, -151	European 1950 (Egypt)
EUH	International 1924	-117, -132, -164	European 1950 (Iran)
EUJ	International 1924	-97, -88, -135	European 1950 (Sicily)
EUM	International 1924	-87, -98, -121	European 1950 mean
EUS	International 1924	-86, -98, -119	European 1979 (Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland)
FAH	Clarke 1880	-346, -1, 224	Oman
GAA	International 1924	-133, -321, 50	Gandajika Base (Rep. of Maldives)
GEO	International 1924	84, -22, 209	Geodetic Datum 1949 (New Zealand)
GUA	Clarke 1866	-100, -248, 259	Guam 1963 (Guam Island)
HAW	International 1924	89, -279, -183	Hawaiian Hawaii (Old)
HJO	International 1924	-73, 46, -86	Hjorsey 195 (Iceland)
HNK	International 1924	-156, -271, -189	Hong Kong 1963
HRN	International 1924	-333, -222, 114	Herat North (Afghanistan)
HTS	International 1924	-634, -549, -201	Hu-Tzu-Shan (Taiwan)

Table B.1. Available Geodetic Datums (continued)

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
INA	Everest	214, 836, 303	Indian (Thailand, Vietnam)
INM	Everest	289, 734, 257	Indian (India,Nepal,Bangladesh)
IRL	Modified Everest	506, -122, 611	Ireland 1965
KAN	Everest	-97, 787, 86	Kandawala (Sri Lanka)
KAU	International 1924	45, -290, -172	Hawaiian Kauai (Old)
KEA	Modified Everest	-11, 851, 5	Kertau 1948 (West Malayzia, Singapore)
KRS	Krasovsky	26, -139, -80	Krassovsky 1942 (Russia)
LIB	Clarke 1880	-90, 40, 88	Liberia 1964
LUZ	Clarke 1880	-133, -77, -51	Luzon (Philippines excluding Mindanoa Is.)
MAS	Bessel 1841	639, 405, 60	Massawa (Eritrea,Ethiopia)
MAU	International 1924	65, -290, -190	Hawaiian Oahu (Old)
MER	Clarke 1880	31, 146, 47	Merchich (Morocco)
MIN	Clarke 1880	-92, -93, 122	Minna (Nigeria)
MND	Clarke 1866	-133, -79, -72	Mindanao Island
MXC	Clarke 1866	-12, 130, 190	N. American Mexico
NAC	Clarke 1880	-8, 160, 176	N. American CONUS 1927 (North America)
NAD	Clarke 1880	-5, 135, 172	N. American Alaska 1927 (Alaska)
NAE	Clarke 1880	-10, 158, 187	N. American Canada 1927 (Canada incl. Newfoundland Island)
NAH	Clarke 1880	-231, -196, 482	Nahrwan (Saudi Arabia)
NAN	Clarke 1880	-6, 127, 192	Central America (Belize,Costa Rica,El Salvador, Guatemala, Honduras, Nicaragua, Mexico)
NAR	GRS1980	0, 0, 0	North American 1983
OAH	International 1924	56, -284, -181	Hawaiian Oahu (Old)
OEG	Helmert 1906	-130, 110, -13	Old Egyptian

Reference Data

Table B.1. Available Geodetic Datums (continued)

Datum ID	Reference Ellipsoid	Offset in meters from local system to WGS-84 (dX,dY,dZ)	Datum Description
OGB	Airy 1830	375, -111, 431	Ordnance Survey of Great Britain 1936 (England,Isle of Man,Scotland,Shetland Islands, Wales)
OHA	Clarke 1866	61, -285, -181	Old Hawaiian
PIT	International 1924	185, 165, 42	Pitcairn Astro 1967 (Pitcairn Island)
PRV	International 1924	-288, 175, -376	S. American (Provisional 1956)
PUE	Clarke 1866	11, 72, -101	Puerto Rica and Virgin Islands
QAT	International 1924	-128, -283, 22	Qatar National (Qatar)
QUO	International 1924	164, 138, -189	Qornoq (South Greenland)
SAN	South American 1969	-57, 1, -41	S. American 1969 (Argentina,Bolivia,Brazil,Chile,Colombia,Ecuador,Guyan,Paraguay,Peru,Venezuela,Trinidad,Tobago)
SCK	Bessel 1841 Namibia	616, 97, -251	Schwarzeck (Namibia)
SEG	International 1924	-403, 684, 41	Gunung Segara (Kalimantan-Indonesia)
SRD	International 1924	-225, -65, 9	Rome 1940 Sardinia Island
TAN	International 1924	-189, -242, -91	Tanarive Observatory 1925 (Madagascar)
TIL	Everest	-689, 691, -46	Timbalai 1948 (Brunei,East Malaysia, Sarawak,Sabah)
TOY	Bessel 1841	-128, 481, 664	Tokyo (Japan,Korea,Okinawa)
TRI	International 1924	-632, 438, -609	Tristan Astro 1968 (Tristan du Cunha)
USR	WGS84	0, 0, 0	User defined
VIT	Clarke 1866	-51, 391, -36	Viti Levu 1916 (Fiji Islands)
W72	WGS72	0, 0, 4.5	World Geodetic System - 72
W84	WGS84	0, 0, 0	World Geodetic System - 84
YAC	International 1924	-155, 171, 37	S. American Yacare (Uruguay)
ZAN	International 1924	-265, 120, -358	Zanderij (Surinam)

PZ-90 is the official designation of the GLONASS Coordinate System, which is sometimes referred to as Earth-90, E90, or PE-90.

Table B.2. Reference Ellipsoids

Ellipsoid	a (meters)	1/f	f
Airy 1830	6377563.396	299.3249647	0.00334085064038
Modified Airy	6377340.189	299.3249647	0.00334085064038
Australian National	6378160.0	298.25	0.00335289186924
Bessel 1841	6377397.155	299.1528128	0.00334277318217
Clarke 1866	6378206.4	294.9786982	0.00339007530409
Clarke 1880	6378249.145	293.465	0.00340756137870
Earth-90	6378136.0	298.257839303	0.00335280374301
Everest (india 1830)	6377276.345	300.8017	0.00332444929666
Everest (W.Malaysia&Singapore)	6377304.063	300.8017	0.00332444929666
Geodetic Reference System 1980	6378137.0	298.257222101	0.00335281068118
Helmert 1906	6378200.0	298.30	0.00335232986926
International 1924	6378388.0	297.00	0.00336700336700
Krasovsky	6378245.0	298.3	0.00335232986925
South American 1969	6378160.0	298.25	0.00335289186924
World Geodetic System 1972 (WGS-72)	6378135.0	298.26	0.00335277945417
World Geodetic System 1984 (WGS-84)	6378137.0	298.257223563	0.00335281066475

C

Floating Point Data Representation

The receiver stores the floating point data types using the IEEE single and double precision format. The formats contain a **sign bit field**, an **exponent field**, and a **fraction field**. The value is represented in these three fields.

Sign Bit Field

The sign bit field of the number being represented is stored in the sign bit field. If the number is positive, the sign bit field contains the value 0. If the number is negative, the sign bit field contains the value 1. The sign bit field is stored in the most significant bit of a floating point value.

Exponent Field

The exponent of a number is multiplied by the fractional value of the number to get a value. The exponent field of the number contains a biased form of the exponent. The bias is subtracted from the exponent field to get the actual exponent. This allows both positive and negative exponents.

Fraction Field

The IEEE floating point format stores the fractional part of a number in a normalized form. This form assumes that all non-zero numbers are of the form:

1.xxxxxx (binary)

The character ‘x’ represents either a 0 or 1 (binary).

Because all floating point binary numbers begin with 1, the 1 becomes the implicit normalized bit and is omitted. It is the most significant bit of the fraction, and the binary point is located immediately to its right. All bits after the binary point represent values less than 1 (binary). For example, the number 1.625 (decimal) can be represented as:

1.101 (binary) which is equal to:

2^0 + 2^-1 + 2^-3 (decimal) which is equal to:

1 + 0.5 + 0.125 (decimal) which is equal to:

1.625 (decimal).

The Represented Value

The value of the number represented is equal to the exponent multiplied by the fractional value, with the sign specified by the sign bit field.

If both the exponent field and the fraction field are equal to zero, the number being represented will also be zero.

Note that in some systems (Intel-based PCs in particular) the order of the bytes will be reversed.

Single-Precision Float

The single precision format uses four consecutive bytes, with the 32 bits containing a sign bit field, an 8-bit biased exponent field, and a 23-bit fraction field. The exponent has a bias of 7F (hexadecimal). The fraction field is precise to 7 decimal digits. The single-precision format can represent values in the range 1.18*10^-38 to 3.4*10^38 (decimal), as presented in Table C.1.

Table C.1. Single-Precision Format

31-28	**27-24**	**23-20**	**19-16**	**15-12**	**11-8**	**7-4**	**3-0**	
S EXPONENT FRACTION								VALUE
0000	0000	0000	0000	0000	0000	0000	0000	0.0
0011	1111	1000	0000	0000	0000	0000	0000	1.0
1111	1111	1111	1111	1111	1111	1111	1111	NAN (not a number)
0011	1111	0100	0000	0000	0000	0000	0000	0.75

In Table C.1, the value 1.0 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 7F (hexadecimal). The exponent is calculated by subtracting the bias value (7F) from the exponent field value. The result is 0.

7F - 7F = 0

The exponent multiplier is equal to 2^0, which is equal to 1 (decimal).

3. The fraction field is equal to .0. After adding the implicit normalized bit, the fraction is equal to 1.0 (binary). The fraction value is equal to 2^0 (decimal), which is equal to 1 (decimal).
4. The value of the number is positive 1*1= 1.0 (decimal).

In Table C.1, the value 0.75 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 7E (hexadecimal). The exponent is calculated by subtracting the bias value (7F) from the exponent field value. The result is -1 (decimal).

7E - 7F = -1

The exponent multiplier is equal to 2^-1, which is equal to 0.5 (decimal).

3. The fraction field is equal to .1 (binary). After adding the implicit normalized bit, the fraction is equal to 1.1 (binary). The fraction value is equal to 2^0 + 2^-1 (decimal), which is equal to 1 + 0.5 (decimal), which is equal to 1.5 (decimal).
4. The value of the number is positive 0.5*1.5 = 0.75 (decimal).

Floating Point Data Rep-

Double-Precision Float

The double-precision format uses eight consecutive bytes, with the 64 bits containing a sign bit field, an 11-bit biased exponent field, and a 52-bit fraction field. The exponent has a bias of 3FF (hexadecimal). The fraction field is precise to 15 decimal digits. The double-precision format can represent values in the range 9.46*10^-308 to 1.79*10^308 (decimal), as presented in Table C.2.

Table C.2. Double-Precision Format

63-60	**59-56**	**55-62**	**51-48**	**47-44**	**43-40**	**...**	**15-12**	**11-8**	**7-4**	**3-0**	
S EXPONENT FRACTION											VALUE
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.0
0011	1111	1111	0000	0000	0000	...	0000	0000	0000	0000	1.0

Table C.2. Double-Precision Format (continued)

63-60	59-56	55-62	51-48	47-44	43-40	...	15-12	11-8	7-4	3-0	
1111	1111	1111	1111	1111	1111	...	1111	1111	1111	1111	NAN (not a number)
0011	1111	1110	1000	0000	0000	...	0000	0000	0000	0000	0.75

In Table C.2, the value 1 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 3FF (hexadecimal). The exponent is calculated by subtracting the bias value (3FF) from the exponent field value. The result is 0 (decimal).

3FF - 3FF = 0

The exponent multiplier is equal to 2^0, which is equal to 1 (decimal).

3. The fraction field is equal to .0 (binary). After adding the implicit normalized bit, the fraction is equal to 1.0 (binary). The fraction value is equal to 2^0 (decimal), which is equal to 1 (decimal).
4. The value of the number is positive 1*1 = 1.0 (decimal).

In Table C.2, the value 0.75 is calculated as shown below.

1. The sign of the value is positive because the sign bit field is equal to 0.
2. The exponent field is equal to 3FE (hexadecimal). The exponent is calculated by subtracting the bias value (3FF) from the exponent field value. The result is -1 (decimal).

3FE - 3FF = -1

3. The fraction field is equal to .1 (binary). After adding the implicit normalized bit, the fraction is equal to 1.1 (binary). The fraction value is equal to 2^0 + 2^-1 (decimal), which is equal to 1 + 0.5 (decimal), which is equal to 1.5 (decimal).
4. The value of the number is positive 0.5*1.5 = 0.75 (decimal).

D

Global Product Support

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

- telephone
- email
- Ashtech BBS system
- Internet

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

Ashtech customer support:

Santa Clara, California, USA

800 Number: 1-800-229-2400

Local Voice Line: (408) 615-1500

Fax Line: (408) 615-5200

Email: support@ashtech.com

Ashtech Europe Ltd. Oxfordshire UK

TEL: 44-118-987-3454

Fax : 44-118-987-3247

Solutions for Common Problems

- Check cables and power supplies. Many hardware problems are related to these simple problems.
- If the problem seems to be with your computer, re-boot it to clear the system's RAM.
- If you are experiencing receiver problems, power cycle the receiver or try a different serial port.
- Verify the batteries are charged.

If none of these suggestions solves the problem, contact Customer Support. To assist the Customer Support, please have the following information available:

Table D.1 GPS Product Information

Information Category	Your actual numbers
Receiver model	
Receiver serial #	
Software version #	
Software key serial #	
Firmware version #	
Options*	
A clear, concise description of the problem.	

* The firmware version # and options can be obtained using the $PASHQ,RID (receiver identification) command.

Corporate Web Page

You can obtain data sheets, GPS information, application notes, and a variety of useful information from Ashtech's Internet web page. The Internet address is:

http://www.ashtech.com

Repair Centers

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

Magellan Corporation
471 El Camino Real
Santa Clara CA 95050-4300
Voice: (408) 524-1680
or (800) 229-2400
fax: (408) 524-1500

Ashtech Europe Ltd.
5 Curfew Yard, Thames St.
Windsor SL4 1SN
Berkshire UK
TEL: 011 44-118-987-3454
FAX: 011 44-118-987-3427

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