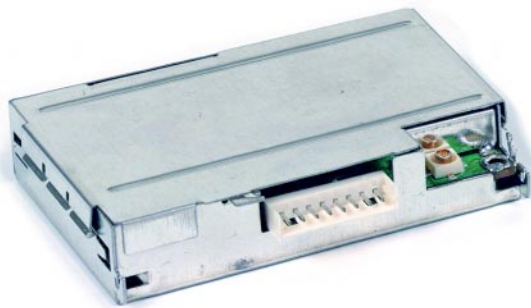


G8™ GPS OEM Board Reference Manual



For support on your G8 product, please contact your distributor.



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Declaration of Conformity

(according to 47 CFR 2.1077)

Ashtech
1170 Kifer Road
Sunnyvale, California 94086
Tel:408-524-1400

declares that the product:

G-8 Evaluator
Model # 990285

complies with part 15 of the FCC Rules. 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.



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November 17, 1997

Declaration of Conformity

(according to ISO/TEC Guide 22 and EN45014)

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Tel:408-524-1400

declares that the product:

G-8 Evaluator
Model # 990285

(This declaration covers all options of the product)

to which this declaration relates, meets the essential health and safety requirements and is in conformity with the relevant EU Directives listed below:

EU EMC Directive 89/336/EEC 1993

using the relevant section of the following EU standards and other normative documents:

EMC:	EN55022 1994 Class A
	ENV50141 (1994)
	EN 61000-4-2 (1995)
	EN 61000-4-3 (1996)
	EN 61000-4-4 (1995)
	EN50082-1 (1992)

Supplementary Information:

The product model listed above complies with the requirements of the Low Voltage Directive 73/23/EEC.



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General Information

Overview

This chapter presents a functional and hardware description of the G8 GPS OEM board, defines the RF interface and the power/input/output signal parameters, and lists power requirements and environmental specifications.

A G8 Evaluation and Development Kit, available separately, lets you rapidly set up and operate the G8 to determine suitability for your application. The kit offers:

- A G8 GPS OEM board enclosed in a housing with RS-232 interfaces,
- Easy-to-use connectors,
- A power switch.

The kit can also be used for software development (experimenting with commands, etc.) and for troubleshooting once the system is deployed. If you have purchased a G8 Evaluation and Development Kit and want to begin working with your kit immediately, go directly to Chapter 4, **Evaluation and Development Kit**, for initial setup instructions.

Functional Description

The G8 OEM board, Figure 1.1, fulfills the need for a low-cost, high-performance GPS sensor, particularly where the requirements are for reliable positioning reporting in difficult environments such as vehicle navigation, fleet management, and personal asset management (tracking of cars, boats, people, etc.). The G8 is designed for system integration, offering autonomous or DGPS positioning, low power, small size, and the standard NMEA protocol. The G8 utilizes 5 VDC power and supports two TTL serial communication ports that are accessible through the I/O connector.

The G8 OEM board processes signals from the Global Positioning System (GPS) satellite constellation to provide real-time position, velocity, and time measurements. The G8 uses eight dedicated separate and parallel channels for Coarse/Acquisition (C/A) code-phase (a.k.a. pseudo-range) on the L1 (1575.42 MHz) band. The G8 receives satellite signals via an L-band antenna with integral low-noise amplifier (an active antenna must be supplied separately). The G8 is designed for outputting position, speed, and time information, either autonomously or differentially corrected using DGPS corrections in RTCM SC-104 Version 2.1 format.



Figure 1.1: G8 OEM Board and Housing

Technical Specifications

Table 1.1 lists the more important technical specifications.

Table 1.1: Technical Specifications

Item	Specification
General	8-channel continuous tracking OEM GPS receiver board
GPS parameters	L1 frequency, C/A code (SPS)
Update rate	1 Hz
Communication interface	NMEA 0183 V2.1 using standard Ashtech command set
RTCM V2.1 message types	Differential remote message types 1, 3, 6, 9, 16
Serial ports	One TTL full duplex for primary I/O One TTL half duplex for RTCM
Baud rate	Software selectable 300 bps to 19200 bps. Maximum recommended character rate is 400 characters per second.
Size	Bare board: 1.54 x 2.36 x 0.41 inches (39 x 60 x 10 mm) With mechanical shield case: 1.58 x 2.41 x 0.52 in (40 x 61 x 13 mm)
Weight	Board: 0.7 oz. (19.8 gr) With mechanical shield case: 1.6 oz. (45.4 gr)
I/O interface	TTL
Input voltage/power	5 VDC \pm 0.25 VDC <700 mW (typical)
Backup power	2.7 to 3.5 VDC (12 μ A) 3.6 to 5.25 VDC (10 μ A)
Receiver noise figure	<7 dB typical without antenna

Performance Specifications

Table 1.2 summarizes the more important performance specifications. Additional details are presented in Table 6.2 on page 99.

Table 1.2: Performance Specifications

Item	Specification
Real-time position accuracy	Horizontal CEP 3.0 m with DGPS correction Horizontal 95% 5.0 m with DGPS correction
Typical acquisition time (Refer to note below)	<10 sec hot start <45 sec warm start <120 sec cold start
Typical reacquisition time	<1 sec from total satellite blockage
Update rate	User-selectable from 1 second to 99 seconds in 1-second increments synchronized with GPS.
1 PPS output	G8 calculates time and outputs a 1 PPS pulse when it has a position and is tracking one (in most cases) or more satellites. 1 PPS pulse output is synchronized to GPS time $\pm 1 \mu\text{sec}$.
Geoid model	Supported internally
Magnetic variation model	Supported internally



If the G8 has a valid Almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the \$PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Hardware Description

Physical Configuration

The G8 is delivered with a mechanical shield case. This mechanical shield case provides protection while handling, a significant degree of ESD protection, and a small degree of EMI protection. We recommended you use the G8 with the mechanical shield case, but this is not absolutely necessary. When the board is used within the mechanical shield case, the most common mounting method utilizes the three mounting holes on the bottom of the mechanical shield case, as shown in Figure 1.2.

CAUTION

When choosing screws for mounting the mechanical shield case, the screw length should be chosen so as to insert no more than 1/8 inch beyond the outer surface of the shield case. A longer screw may damage the OEM board and cause unreliable operation.

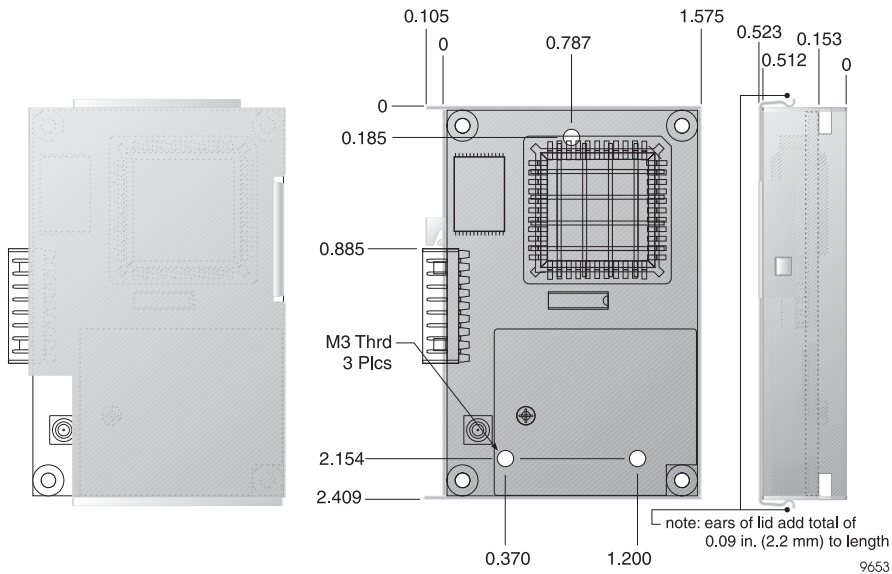


Figure 1.2: Mechanical Shield Case Configuration

Table 1.3: Dimensions

Characteristic	Without Mechanical Shield Case		With Mechanical Shield Case	
	Inches	Millimeters	Inches	Millimeters
Length	2.362	60.0	2.410	61.2
Width	1.535	39.0	1.575	40
Thickness	0.41	10.4	0.523	13.3
Weight	0.7 oz.	19.8 gr	1.6 oz.	45.4 gr
Mounting Method	One hole in each corner of board	One hole in each corner of board	Three holes on bottom of shield case	Three holes on bottom of shield case
Mounting hole diameter	Figure 1.3	Figure 1.3	Figure 1.2	Figure 1.2
Mounting hole location	Figure 1.3	Figure 1.3	Figure 1.2	Figure 1.2

Power/Input/Output Connections

Table 1.4 lists the power/input/output connections for the Molex 8-pin I/O connector. Connector types are defined in Chapter 2.

Table 1.4: Power/Input/Output Connections

Pin	Signal Designation	Function
1	VCC	Primary board power connection
2	V_ANT	Antenna power connection
3	V_BACK	Battery backup power connection
4	GND	Ground
5	RTCM	Receive Port B: Receive data at G8 from external device
6	RXD	Receive Port A: Receive data at G8 from external device
7	TXD	Transmit Port A: Transmit data from G8 to external device
8	1 PPS	1 PPS output

Interfaces to External Equipment

All Ashtech GPS receivers use a combination of standard NMEA commands and Ashtech NMEA style commands (“PASH” commands).

The G8 returns responses in standard NMEA format or Ashtech NMEA style format, depending upon the command given the receiver. The standard NMEA responses are \$GPALM, \$GPGGA, \$GPGLL, \$GPGSA, \$GPGSV, \$GPRMC, \$GPVTG, and \$GPZDA per NMEA Specification NMEA0183 V2.2. Ashtech implements one non-standard NMEA response, the \$GPMMSG response. In addition, Ashtech has implemented a set of NMEA style messages that are maintained for compatibility with the Ashtech OEM product line. These responses are prefixed with the string \$PASHR. All responses include a checksum.

NMEA responses and \$PASH commands and responses are described in detail in Chapter 5.

Power Requirements

The G8 board requires the following operating power (typical):

Main power: 5 VDC \pm 0.25 VDC, maximum ripple 50 mv P-P

Nominal current: <140 mA @ 5 VDC

Nominal power: <700 mW @ 5 VDC

Backup power: 12 μ A at 2.7 to 3.5 VDC; 10 μ A at 3.6 to 5.25 VDC

Sleep mode power: <450 mW

Antenna power (V_ANT): up to 25 VDC, 300 mA max (active antenna must be supplied separately)

Environmental Limitations

The G8 board operates within the environmental limitations listed in Table 1.5.

Table 1.5: Environmental Limitations

Condition	Specification
Operating temperature	-30°C to +80°C
Standby temperature	-30°C to +80°C
Storage temperature	-40°C to +85°C

Table 1.5: Environmental Limitations (continued)

Condition	Specification
Humidity	95% RH non-condensing
Vibration	1.7 g ² /Hz 20 Hz -6 dB/octave 20 to 500 Hz 0.003g ² /Hz 500 to 2000 Hz
Speed limitations	1000 knots (514 m/sec)*
Altitude limitations	60,000 feet (18,288 m)*
* The G8 produces no valid position information beyond these limits.	

Antenna

For optimum performance, G8 requires a reliable, low-power antenna with a built-in low-noise amplifier (LNA). Many antenna manufacturers provide low-cost antennas optimized for a mobile environment, with many choices of design, filtering options, LNA gain level, packaging, connector style, cable length, and mounting options. Given the wide variety of choices in the marketplace, we recommend you obtain your antenna directly from the manufacturer. Table 1.6 lists the required antenna electrical performance specifications. Contact your local G8 distributor for a list of recommended antenna sources.

Table 1.6: Antenna Specifications

Parameter	Specification
Center frequency	1575.42 MHz
Output impedance	50 ohms
Polarization:	RHCP
Gain	Recommended 0 dBic at zenith, minimum -5 dBic at 5° elevation above horizon
LNA gain	26 dB ± 2.5 dB. Excess gain at board input must exceed 10 dB (LNA gain - cable loss >10dB)
Filter	30 dB attenuation 100 MHz above or below center frequency
Noise figure	< 2.5 dB
Power input	Antenna is powered via V_ANT at pin 2. User supplies power for antenna. Voltage input should be limited to 25 VDC or less.
FCC	Per user specification.

The G8 contains an antenna supply circuit that utilizes a 20-ohm series resistor and L/C filter to isolate the DC power from the GPS RF energy. This circuit supplies power to the antenna via the center pin of the RF connector, using the 20-ohm resistor to protect the DC output from short circuits.

The 20-ohm resistor can dissipate up to 1.5 W. The maximum V_ANT voltage which can be safely short-circuit protected is 5.5 volts. The maximum current allowance through the V_ANT pin is 300 mA.

For the nominal case of V_ANT = 5 VDC, a 4.5 VDC (approximate) signal will appear on the center pin of the G8 RF connector. You need to account for the voltage drop across the 20-ohm current-limiting resistor in your choice of antenna and power allocation for your application. A diagram of the antenna supply circuit is shown in Figure 1.4.

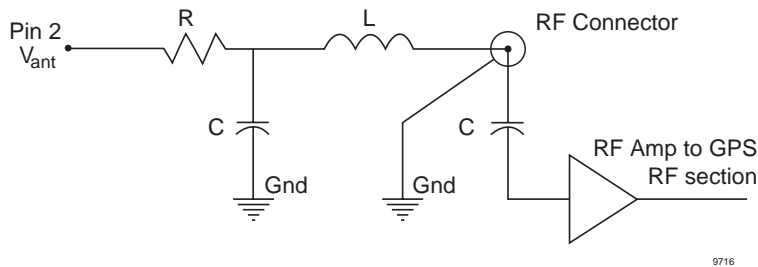


Figure 1.4: Antenna Supply Circuit



There is no impedance requirement at pin 2 (V_ANT). Pin 2 is usually driven by a low-impedance power supply. RF decoupling is done on the G8 board.

Radio Interference

Some radio transmitters, cellular phones, or other mobile communications equipment can interfere with the operation of GPS receivers. Ashtech recommends that you verify that nearby hand-held or mobile communications devices do not interfere with GPS receivers before setting up your project.

The G8 is equipped with an RF shield over the RF section of the receiver. This protects the sensitive components in this area of the board, and also eliminates emissions from this section. The RF shield is soldered to the board and must remain in place at all times. The mechanical shield case does provide a small degree of additional RF isolation. It is recommended that the mechanical shield case be used, but the G8 operates reliably without the mechanical shield case.

Getting Started

General

This section outlines the following procedures to get your G8 GPS OEM board operating as quickly as possible:

- Procedure for connecting the G8 to power, the antenna, and your equipment or system electronics
- Important communication parameters
- Instructions for establishing communications with the G8 using typical communications software with an IBM-compatible PC
- Procedure for sending common commands to the G8

Quick Start

If you have the G8 Evaluation and Development Kit, use it for quick setup and evaluation. Go directly to Chapter 4 for instructions. If you do not have the G8 Evaluation and Development Kit, proceed with the following instructions.

Connection Procedures

Board

Figure 2.1 shows the power and I/O connections to the 8-pin I/O connector on the board.

CAUTION

To avoid damage to the G8, always turn off the power supply before connecting or disconnecting to the 8-pin I/O connector.

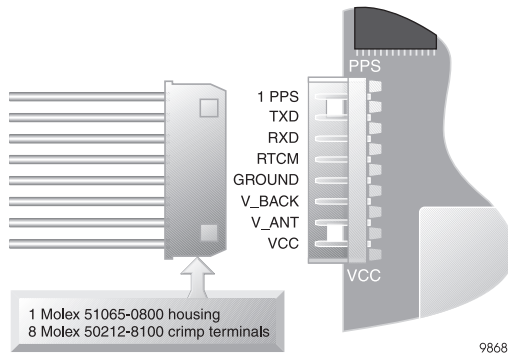


Figure 2.1: Power and I/O Connections for Bare OEM Board

1. To interface to the board, you will need to connect to two different interface connectors:
 - **I/O connector** - the I/O connector on the G8 OEM board is a Molex socket P/N 53254-0810. To mate with this socket, you will need to provide a board-based connector or construct a power-I/O cable. A cable requires a Molex terminal crimp housing P/N 51065-0800 and eight crimp pins P/N 50212-8100. Assemble a power-I/O cable using these parts, as shown in Figure 2.1.



There may be other mating connector options that are more appropriate for your application. Contact your supplier for additional mating connector information.

- **RF connector** - The RF connector is a Hirose S.FL2-R-SMT. This is a small upward-facing connector designed for minimal number of connections. Its mating connector is a right-angle plug, Hirose P/N S.FL2-LP-0.7DW. This connector also requires a center pin insert, P/N S.FL2-LP female terminal. Ashtech strongly recommends that you have an antenna cable assembled by a Hirose authorized value-added reseller. Contact Ashtech customer support for a reseller in your area.
2. Once you have constructed a board-based connector or a power-I/O cable, connect the female plug on the cable to the 8-pin Molex I/O connector on the G8.

- Connect the wires of the power-I/O cable as specified in Table 2.1. Do not turn on power at this time; proceed with other connections as specified below.

Table 2.1: Power/Input/Output Parameters

Pin	Signal Designation	Function
1	VCC	Primary board power connection
2	V_ANT	Antenna power connection
3	V_BACK	Battery backup power connection
4	GND	Ground
5	RTCM	Receive Port B: Receive data at G8 from external device
6	RXD	Receive Port A: Receive data at G8 from external device
7	TXD	Transmit Port A: Transmit data from G8 to external device
8	1 PPS	1 PPS event marker output TTL

- Once you have constructed the antenna interface cable, connect the antenna cable to the Hirose antenna connector on the G8 and connect your antenna.



For maximum reliability, connection and disconnection of the Hirose antenna connector should be minimized.

The G8 is designed to work with an antenna that includes an LNA. The antenna is powered via V_ANT and is isolated from DC ground. The gain of the antenna-preamplifier minus the loss of the cable should be between 10 and 35 dB.



Best results are obtained if the antenna has an unobstructed view of the entire sky. A ground plane is desirable but not necessary. Should you want the antenna stationary, try to locate it as high as possible and away from metallic objects such as towers, and large structures such as buildings. These objects may reflect the incoming GPS signals, causing multipath reflections that can reduce accuracy.

5. With all connections made as described above, apply 5 VDC power to the G8 at pin 1 (VCC). Remember also to be sure power is applied to the antenna via pin 2 (V_ANT). Antenna power restrictions are defined in Chapter 1.

CAUTION

The G8 uses 5 VDC power, not 12 VDC. Connect the appropriate power input line (VCC) to a stable 5-volt source ONLY. The voltage can fluctuate no more than $\pm 5\%$.

When the G8 is connected to power, it automatically begins its startup and acquisition routines, attempting to acquire satellites (SVs or Space Vehicles) within the field of view of the antenna. G8 firmware versions HD00 or newer automatically output NMEA messages \$GPGGA and \$GPVTG. Once enough SVs have been acquired for a valid position report, accurate position and velocity information will be included in these messages. You may change the reporting rate of the output or disable them completely as described in Chapter 5, **Command/Response Formats**.

To ensure the fastest possible restart times, you should also connect the G8 to a power backup source at pin 3 (V_BACK). Your backup source should be in the range of 2.7 to 5.25 VDC. Backup draws 10 to 12 μA , depending upon the backup voltage.

Serial Data Communication

Communication Port Setup

After performing the steps above, you are ready to command the G8 and receive data. The G8 serial port A must be connected to a PC, microprocessor, or other intelligent processing device, before you can issue commands. The G8 OEM board utilizes TTL signal levels (+ 5 VDC, 0 VDC) for communication, not RS-232 levels (± 12 VDC). If you plan to communicate directly with the G8 OEM board from a PC, you must first convert the PC RS-232 interface levels to TTL levels. Specific I/O interface levels are provided in Table 2.2.

CAUTION

Attempting to communicate to the G8 OEM board using RS-232 voltage levels will result in poor operation or failure in communication. Applying a negative voltage to the I/O pins could cause excessive current draw or damage to the G8.

Table 2.2: TTL I/O Interface Levels

Voltage	Minimum	Maximum
V_{il}	-0.5V	0.8V
V_{ih}	2.2 V	$V_{cc} + 0.5V$
V_{ol}	---	0.4V
V_{oh}	2.4V	---

Table 2.3 lists the default communication parameters of the G8 at first power-up.

Table 2.3: Default G8 Communication Parameters

Baud	Data Bits	Parity	Stop Bits	Port
4800	8	None	One	A



When first establishing communication with the G8, the communications interface must use these parameters, otherwise the G8 will not recognize any serial input. Once communication is established at 4800 baud, the G8 can be reconfigured to operate at a different baud rate by issuing \$PASH commands to the serial port from the attached PC or other processing device.

RTS/CTS Considerations

Once you convert the G8 GPS OEM board TTL outputs to RS-232 levels, there is one other important consideration.

The RS-232 specification is very general, intended to cover a wide variety of computer-to-computer communication situations. As such, it contains a lot of controls that are not necessary in most situations. For the G8 OEM board, merely connecting GND to GND, TX1 to RX2, and TX2 to RX1 is all that is required. However, some computer software uses RTS (Request To Send) and CTS (Clear To Send); this is known as flow control. The purpose of these signals is to allow the intended receiver to hold off transmission until it is able to take care of the data. The transmitter will assert RTS and then wait until it sees CTS before beginning transmission. This avoids loss of data that could occur if the transmitter started before the receiver was ready. The G8 OEM board does not utilize flow control and therefore ignores RTS/CTS signals on the RS-232 line.

Most system integrators simply connect RTS to CTS at both ends of the communication channel. In this case, as soon as the transmitter asserts RTS, it sees CTS and begins transmission. Because the G8 OEM board does not utilize flow control, you may need to connect RTS to CTS at the computer or processor that is communicating with the G8. This is an individual judgement call which depends

upon both the hardware configuration of the host and on the design of the software in the host. It may or may not be necessary, but should be considered in your interface design. The G8 Evaluator (see Chapter 4) connects the RTS and CTS lines; the G8 OEM board does not.

Default Data Output

For G8 firmware version HC00 and earlier versions all the default data output commands are set to NO (i.e., no output). Even though the G8 may be calculating positions, it does not output any data until you send a message commanding it to do so. For firmware versions HD00 and later, the G8 will automatically output the \$GPPGA and &GPVTG message on startup.

Data Rate Limitations

The maximum recommended data I/O rate for the G8 is 400 characters per second. This equates to approximately six standard NMEA responses. Choose data output carefully so as not to overrun this maximum. If the maximum rate is exceeded the G8 may perform unreliably.

Initial Operating Instructions

After the G8 is powered and running, you may send it command messages in order to change the output or modify operating parameters. The following procedure describes briefly how to send commands to and receive information from the G8 using an IBM-compatible PC. Many standard communications software packages allow you to interface with the G8. Be sure to send commands to Port A of the G8 receiver.

Your command can be typed in upper or lower case, and must be completed by pressing the <enter> key. If you have typed and sent the command correctly, you should get an ACK response for a correct command, and a NAK response for an illegal or incorrect command. To become familiar with the G8 messages, send a few common commands to the G8 and observe the responses.

1. Type: \$PASHQ,PRT and press <enter>. This command queries the communication setup of the port.



Pressing <enter> is equivalent to <CR><LF>.

2. The response message is:
\$PASHR,PRT,A,4

This message indicates port A of the G8 is using its default communications setup 4, which is 4800 baud, eight data bits, no parity, and one stop bit. For

details of this command, refer to \$PASHS,SPD and \$PASHQ,PRT in Chapter 5.

3. Type \$PASHS,NME,GSA,A,ON and press <enter>. This command enables the NMEA GSA message which provides a list of locked satellites at a set rate.

The response message to this command is structured as shown below and explained in Table 2.4:

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

Table 2.4: GSA Message Structure

Parameters	Description	Range
c1	Mode: M: manual, A: automatic	'M' / 'A'
d1	Mode: 1: fix not available, 2: 2D, 3: 3D	1 -3
d2 - d13	Satellites used in solution (null for unused channel)	1 -32
f1	PDOP	0 - 9.9
f2	HDOP	0 - 9.9
f3	VDOP	0 - 9.9
*cc	Checksum	

A typical response message might look like the display shown below and described in Table 2.5:

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

Table 2.5: Typical GSA Message

Item	Significance
\$GPGSA	Header
M	Manual mode
3	3D mode
empty field	Satellite in channel 1
02	Satellite in channel 2
empty field	Satellite in channel 3
04	Satellite in channel 4
27	Satellite in channel 5
26	Satellite in channel 6

Table 2.5: Typical GSA Message (continued)

Item	Significance
07	Satellite in channel 7
empty field	Satellite in channel 8
empty field	Satellite in channel 9
empty field	Satellite in channel 10
empty field	Satellite in channel 11
empty field	Satellite in channel 12
3.2	PDOP
1.4	HDOP
2.9	VDOP
*38	checksum

4. Type \$PASHS,NME,GGA,A,ON and press <enter>. (For firmware version HD00 or later, this message is automatically turned on at power-up). This command tells the G8 to return antenna position information through port A at a set rate. The default rate for NME commands is once per second.

The response message to this command displays once per second in the form shown below and defined in Table 2.6:

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

Table 2.6: GGA Message Structure

Parameters	Description	Range
m1	Current UTC time of position fix in hours, minutes, and seconds (ddmmss.ss)	00-235959.50
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmmm)	0-90
c1	Direction of latitude N= North, S= South	'N' / 'S'
m3	Longitudinal component of position in degrees and decimal minutes (dddmm.mmmmmm)	0-180
c2	Direction of longitude E = East, W= West	'E' / 'W'
d1	Position type 1. Autonomous position 2. RTCM differential corrected position or CPD float position 9. Position computed using almanac information	1, 2, 9

Table 2.6: GGA Message Structure (continued)

Parameters	Description	Range
d2	Number of GPS satellites being used in the position computation	0-8
f1	Horizontal dilution of precision (HDOP)	0 - 99.9
f2	Altitude in meters above the geoid (i.e., mean-sea level). For 2-D position computation, this item may contain the user entered altitude used to compute the position computation. Note that user-entered altitude would have been entered using the \$PASHS,ALT command which uses altitude above the ellipsoid, not altitude above geoid).	-30000.00 to 30000.00
M	Altitude units M = meters	'M'
f3	Geoidal separation in meters	±999.99
M	Geoidal separation units M = meters	'M'
d3	Age of differential corrections (seconds)	0-999 (RTCM mode)
d4	Base station ID (RTCM only)	0-1023
cc	checksum	

A typical response might be as shown below and described in Table 2.7:

```
$GPGGA,015454.00,3723.285132,N,12202.238512,W,2,4,03.8,00012.123,
M,-032.121,M,014,0000*75
```

Table 2.7: Typical GGA Message

Item	Significance
\$GPGGA	Header
015454.00	UTC time
3723.285132	Latitude (ddmm.mmmmmm)
N	North Latitude
12202.238512	Longitude (dddmm.mmmmmm)
W	West longitude
2	RTCM differential position
4	Number of satellites used in position
3.8	HDOP
00012.123	Altitude
M	Units of altitude (M = meters)

Table 2.7: Typical GGA Message (continued)

Item	Significance
-032.121	Geoidal separation
M	Units of geoidal separation (M=meters)
14	Age of correction (seconds)
0000	Base station ID
*75	checksum

5. Type **\$PASHS,NME,SAT,A,ON** and press <enter>. This command tells the G8 to return locked satellite information through port A at a set rate. The response message displays once per second:
\$PASHR,SAT,“.....”
where the “.....” is the number of SVs locked, and the elevation, azimuth, and signal strength for each locked SV.
6. For details on these commands and responses, as well as the rest of the G8 command and response repertoire, refer to Chapter 5.

Operation

This section summarizes system setup, G8 operation at power-up, input and output messages, serial port configuration, parameter settings and status, the satellite search algorithm, modes of operation, antenna position setting, NMEA outputs, and differential operation.

System Setup

Verify that the G8 is set up as described in Chapter 2.

Message Format

The G8 command/response firmware allocates the two RS-232 ports (A and B) to receive command messages from an external control device (such as a PC), and receive differential corrections from a reference station. Commands can be input to either port A or B, but only port A provides responses to commands.

Input Messages to the G8

The input messages comprise **set** command messages, and **query** command messages. The **set** commands instruct the G8 to perform a specified and often continuous activity; the **query** commands instruct the G8 to report its present status one time only. The general command messages comply with the NMEA 0183 standard to the following extent:

- NMEA 0183 ASCII strings following \$ character
- Headers are Ashtech NMEA style, registered with NMEA (i.e., PASH)
- Message IDs are Ashtech NMEA style
- Data items are separated by commas
- Checksum character delimiter and NMEA checksum bytes are recognized by the G8 but are optional. The hexadecimal checksum is computed by exclusive OR-ing all of the bytes in the message between, but not including, the \$ and the *.
- Message is ended with the standard NMEA message terminator characters, <CR> and <LF> (same as <enter>).ll command messages (set, query or general) recognize upper or lower case letters. They are accepted by <enter>. A valid set command causes the G8 to return the **\$PASHR,ACK*3D, “acknowledged”** response message. A set command containing a valid \$PASHS set command header followed by character combinations unrecognized by the G8 causes return of the **\$PASHR,NAK*30, “not-acknowledged”** response message. All other invalid set commands are ignored. Valid query and general command messages

are acknowledged by return of the requested information, and all invalid query and general commands cause the G8 to return the **\$PASHR,NAK*30** “not acknowledged” response message.

Output Messages From the G8

Output messages are messages the G8 sends to the PC or system electronics in response to a command message. These messages comprise G8 general status messages, command acknowledged/not acknowledged messages, and GPS data messages. The G8 general status messages have free-form Ashtech NMEA style formats. The command acknowledged/not acknowledged messages and GPS data messages comply with NMEA 0183 as follows:

- NMEA ASCII strings following \$-character
- Headers are standard NMEA or Ashtech NMEA style
- Message IDs are standard NMEA or Ashtech NMEA style
- Standard NMEA format messages contain hexadecimal checksum bytes
- Data items are separated by commas; successive commas indicate invalid or missing data (null fields)
- Message is ended with <CR><LF>, the standard NMEA message terminator characters

Serial Port Configuration

Port A provides two-way full duplex RS-232 communication. Be aware that the signals are, however, at TTL levels. The default transmit/receive protocol is 4800 baud, eight data bits, no parity, and one stop bit (8N1). The baud rate is adjustable using the **\$PASHS,SPD** speed set command; the data bit, stop bit and parity protocol are always 8N1.

On initial power-up or after issuing the **\$PASHS,RST** (reset to defaults) command, the G8 default is 4800 baud for both RS-232 serial ports A and B.

The baud rates between the G8 and the interfacing equipment must be the same for both the port and the device connected to that port.

To maintain communication with the G8 while changing the baud rate, issue the **\$PASHS,SPD** (set command) to change the G8 baud rate, then change the baud rate of the command device to match the new G8 rate.

Antenna Connection

The G8 requires that a compatible active antenna be connected to the antenna port for reliable operation. Antenna specifications are provided in Chapter 1. The antenna

must have a clear view of the entire sky in order for the G8 to meet the specifications defined in this manual.

Satellite Search Algorithm

When the G8 is operated for the first time after receipt from Ashtech, or after the power and back-up battery have been disconnected, no almanac or ephemeris data are available. The G8 always assigns the first eight elements of a 32-element table of SV PRN numbers to its eight channels. Within 35 to 40 seconds after locking the first SV, the G8 time is set. The G8 computes its first position after three (for 2D) or four (for 3D) SVs are locked, provided that the satellite geometry is adequate. The G8 continuously stores the most recent almanac, ephemeris, and position data into its battery-backed memory, which allows for faster position computation when next turned on.

The G8 performs a cold start if there are no valid almanac or ephemeris data in the battery-backed memory, or if it has no previously known position; this is generally true if the G8 has been off for more than six months. With no SV information to help narrow the search, cold start typically requires about two minutes to compute the initial position. If the G8 has been off for less than six months but more than four to six hours, then the stored almanac and position data allow it to narrow the SV search and perform a warm start. In warm start the initial position is typically computed in about 30 seconds. The G8 will turn on with a hot start if its battery-backed memory contains valid almanac, ephemeris, and position data; this is generally true if the G8 has been off for no more than four to six hours. This data allows the G8 to search only for visible SVs in known locations, and the first position is typically computed in about 10 seconds.



If the G8 has a valid Almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the \$PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Parameter Settings and Status

The G8 has the default operational parameters listed in Table 3.1. These parameters can be changed using the indicated set commands; detailed explanations of the set commands are presented in chapter 5.

Table 3.1: Default Parameters

Item	Default Value	Set Command	Page
Latitude	None	\$PASHS,POS	58
Longitude	None	\$PASHS,POS	58
Altitude	None	\$PASHS,POS	58
Navigation Position Mode	4	\$PASHS,PMD	57
2D Altitude	0	\$PASHS,ALT	51
HDOP Mask	4	\$PASHS,HDP	52
PDOP Mask	6	\$PASHS,PDP	57
Elevation Mask	5 degrees above horizon	\$PASHS,PEM	56
Datum	WGS-84	\$PASHS,DTM	51
Satellites inhibited	none	\$PASHS,USE	65
DGPS positioning	OFF	\$PASHS,RTC	94
Auto Differential Mode	Enabled	\$PASHS,RTC,AUT	94
Differential Data Age Selection	15 seconds	\$PASHS,RTC,MAX	94
Serial port A speed	4 (corresponds to 4800 bps)	\$PASHS,SPD	63
Serial port B speed	4 (corresponds to 4800 bps)	\$PASHS,SPD	63
Altitude Position Fix Mode	0	\$PASHS,FIX	52
Kalman filter dynamics mode	3	\$PASHS,KFP,DYN	54
Timezone offset	00:00	\$PASHS,LTZ	54
Enable ALM msg to port	A, OFF	\$PASHS,NME,ALM	70
Enable GGA msg to port	A, ON (HD00 or later)	\$PASHS,NME,GGA	72
Enable GLL msg to port	A, OFF	\$PASHS,NME,GLL	74
Enable GSA msg to port	A, OFF	\$PASHS,NME,GSA	76
Enable GSV msg to port	A, OFF	\$PASHS,NME,GSV	77
Enable RMC message to port	A, OFF	\$PASHS,NME,RMC	85
Enable VTG msg to port	A, ON (HD00 or later)	\$PASHS,NME,VTG	89
Enable ZDA msg to port	A, OFF	\$PASHS,NME,ZDA	90
Enable MSG msg to port	A, OFF	\$PASHS,NME,MSG	79
Enable POS msg to port	A, OFF	\$PASHS,NME,POS	82
Enable UKO msg to port	A, OFF	N/A	N/A

Table 3.1: Default Parameters (continued)

Item	Default Value	Set Command	Page
Enable SAT msg to port	A, OFF	\$PASHS,NME,SAT	87
Enable XMG msg to port	A, OFF	N/A	N/A
Receiver update interval	1 second	\$PASHS,NME,PER	82

On initial power-up or after use of the **\$PASHS,RST** (reset to default command), the G8 reverts to its default parameter settings. To list the current status of these settings, there is one query command available:

\$PASHQ,PAR (general parameters)

The response message for the default values of the query command **\$PASHQ,PAR** (general parameters) is:

```
PMD:4          FIX:0          PEM:05 PDP:06 HDP:04
DTM:W84      LTZ:+00,00      SAV:N
USE:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
CDS:  AUTO
LAT:0000.000000,N LON:00000.000000,E  ALT:+00000.00
NMEA:  ALM GGA GLL GSA GSV MSG POS RMC SAT UKO VTG ZDA XMG
PRTA:  ... ..
PER:  001.0
```

CAUTION

The **\$PASHQ,PAR** response message is free-form and subject to change in future firmware versions. These messages are not intended to be computer-readable.

Saving New Parameter Settings

If you want to save any parameters changed by a set command, parameter values can be saved by the **\$PASHS,SAV,Y** set command. Once this command has been used, The G8 will use the saved parameters instead of the defaults as long as there is the appropriate battery backup voltage on pin 3 (V-back). Without battery backup, the parameters will **NOT** be saved. **\$PASHS,RST** always reinstates the defaults.

Position Modes

The G8 operates in two position modes, 3D and 2D. These modes are explained in detail in “Position Modes” on page 96.

Altitude Hold Definition

Two modes are available to determine what altitude is selected when the G8 is in altitude-hold mode. The **\$PASHS,FIX** set command can be used to select between these modes.

- In **mode 0**, the most recent altitude is used. This is either the one entered by using the **\$PASHS,ALT** or **\$PASHS,POS** set command or the one computed as part of a 3D position, whichever is most recent.
- In **mode 1**, only the last altitude entered by using the **\$PASHS,ALT** set command is used in the position fix solution.

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

Antenna Position Setting

Two commands are available to enter the known antenna position:

\$PASHS,POS (position setting including latitude, longitude, altitude)

\$PASHS,ALT (altitude for fixed 2D operation)

NMEA Outputs

The G8 allows you to output messages in NMEA format, and other messages through serial port A, as listed in Table 3.2.

Table 3.2: NMEA and Miscellaneous Output Messages

Message	Type	Description	Page
\$GPALM	NMEA	GPS almanac	70
\$GPGGA	NMEA	Position fix	72
\$GPGLL	NMEA	Geographic latitude/longitude	74
\$GPGSA	NMEA	GPS DOP and active satellites	76
\$GPGSV	NMEA	GPS satellites in view	78
\$GPRMC	NMEA	Recommended minimum specific GPS Data	85
\$GPVTG	NMEA	Course over ground and ground speed	89
\$GPZDA	NMEA	Time and date	91
\$GPMSG	Non-standard NMEA	Differential message RTCM-SC104 types 1, 3, 9, 16	80
\$PASHR,POS	Ashtech NMEA Style	Position	83
\$PASHR,SAT	Ashtech NMEA Style	Satellite status	87

Any combination of these messages can be output through serial port A. The output rate is determined by the **\$PASHS,NME,PER** command, and can be set to any value between 1 and 999 seconds. Additional details are presented in the discussion of NMEA message commands in Chapter 5, **Command/Response Formats**.



G8 message outputs should be chosen so as not to overrun the maximum recommended character rate of 400 characters per second. This equates to approximately six standard NMEA responses. Overrunning this output rate may cause unreliable G8 operation.

All standard NMEA messages are a string of ASCII characters delimited by commas and that comply with the NMEA 0183 standard, Version 2.1. All non-standard messages are a string of ASCII characters delimited by commas using the Ashtech NMEA style response format.

Differential Operation

This section discusses differential operation in general, sources of error, the G8 messages for differential operation, and RTCM 104 format as it applies to a remote station.

General

Real-time “Broadcast” differential GPS positioning (DGPS) involves a reference (base) station computing the SV range corrections and transmitting them to a remote (rover) unit. The G8 is designed to operate as a remote unit. When a reference station transmits these corrections in real time to the G8 via a communications link, the G8 applies the corrections to its measured ranges and uses the corrected ranges to compute its position.

Real time “inverse” differential positioning uses DGPS corrections applied at the base instead of at the remote unit. The G8 can be set to output the **\$PASHR,ITA** response, which outputs pseudorange and doppler information for each SV that can be used to apply corrections back at the base station. As with broadcast DGPS, this approach requires an efficient communication link since the **\$PASHR, ITA** output must be sent to the base for processing.

The base receiver determines range corrections by subtracting the measured range from the true range, computed by using an accurate position entered in the receiver. This accurate position must have been previously surveyed using GPS or some other technique.

As a stand-alone receiver, and with SA (Selective Availability) on, the G8 typically computes a position within about 30 meters of truth but always within 100 meters. In differential mode, the G8 can achieve better than 3m (CEP) precision. For both

broadcast and inverse DGPS operation, 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.

Sources of Error

The major sources of error affecting the accuracy of GPS range measurements are SA (Selective Availability), SV orbit estimation, SV clock estimation, ionosphere, troposphere, and receiver noise in measuring range. The first five sources of error are almost totally removed using differential GPS.

Receiver noise is not correlated between the base and the remote receiver and is not cancelled by differential GPS.

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

RTCM Messages

For broadcast DGPS mode the G8 accepts RTCM SC-104 Version 2.2 differential formats. The G8 is set to receive RTCM corrections in either of the two ports by issuing the set command **\$PASHS,RTC,REM,c** where c is the port. Of RTCM message types 1 through 64, the G8 processes types 3 and 16 for station location and special information; types 1 and 9 for RTCM differential corrections; and null frame type 6. The differential corrections are automatically processed by the G8.



It is recommended, but not required, that RTCM information be input on port B.

RTCM message types 3 and 16 provide user information from the reference (base) station, while RTCM message types 1 and 9 provide differential correction information. The reference station sends types 1 and 9 continuously and may send either type 3 or type 16 individually. The **\$PASHS,NME,MSG** set command and **\$PASHQ,MSG** query command cause the most recent RTCM input data to be reported, via the **\$GPMSG** message.

On initial power-up or after use of the **\$PASHS,RST** (reset to defaults command) the G8 default automatic differential mode is OFF, and the default is 15 seconds for the maximum age of an RTCM differential correction, above which it is not be used. If the automatic mode is not enabled by the **\$PASHS,RTC,AUT** set command and the differential correction data is older than the maximum age specified by the **\$PASHS,RTC,MAX** set command, the G8 does not return antenna position data.

In automatic mode, if no differential correction data is received or the age of data is older than the specified maximum age, the G8 returns the uncorrected position.

RTCM 104 Format, Version 2.2

The G8 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.

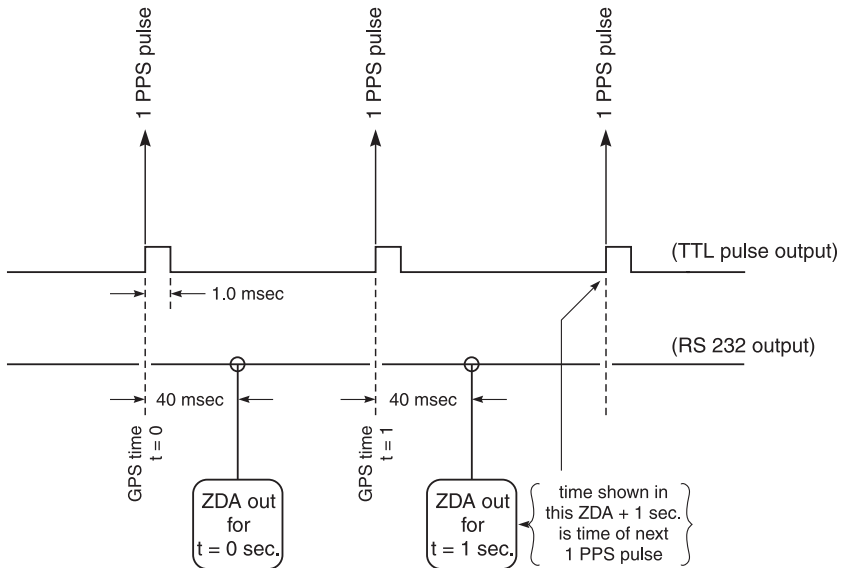
The G8 can accept any type of RTCM message, however it decodes types 1, 3, 6, 9, and 16, as detailed in Table 3.3, and uses only types 1 and 9 for differential corrections.

Table 3.3: RTCM Format

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

Pulse Generation (1 PPS)

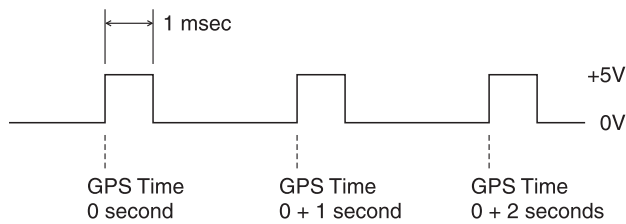
The G8 calculates time and outputs a 1 PPS pulse when it has a position and is tracking one (in most cases) or more satellites. Figure 3.1 shows the timing relationships. The 1 PPS output is accurate to $\pm 1 \mu\text{sec}$ if the receiver is within 300 meters of the last valid position. Time is reported in the NMEA message ZDA. The 1 PPS output is available on pin 8 of the G8 8-pin I/O connector.



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Figure 3.1: Relationship of GPS Time in PRN Record to 1PPS Pulse

Figure 3.2 shows the 1 PPS pulse characteristics. The 1 PPS pulse occurs when the signal goes high. The 1 PPS is generated exactly on the GPS second, and the pulse remains high for 1 millisecond.



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Figure 3.2: PPS Pulse

Evaluation and Development Kit

Overview

The G8 Evaluation and Development Kit, Figure 4.1, lets you rapidly set up and operate the G8 to determine suitability for your application. The G8 Evaluation and Development Kit can also be used for software development (experimenting with commands, etc.) and for troubleshooting once your system is deployed.

The G8 Evaluation and Development Kit provides the following conveniences which would otherwise have to be devised by the user:

- Built-in RS-232 interface does TTL to RS-232 conversion for you
- Standard SMA connector for antenna connection
- Standard serial interface connector connects directly to PC
- Standard BNC connector on back panel for 1 PPS output
- Packaged unit protects OEM board in rugged test and evaluation environments
- Connects to standard 12 VDC power (such as a vehicle battery)
- Built-in battery eliminates need for battery backup connection
- Wide range of input power provides flexibility in test setups
- All interface cabling is provided for you

Configuring Your Kit for Operation

To configure and operate your G8 Evaluation and Development kit, follow the six steps below in sequence. For detailed mounting instructions and detailed cable connection information, refer to the appropriate sections later in this chapter.

Step 1 - Inventory Your Equipment

Check your G8 Evaluation Kit to ensure that all items are available, as shown in Figure 4.1 and listed in Table 4.1. Separate the manuals and Evaluate software disk from the hardware (G8 Evaluator, antenna, cables, etc.)

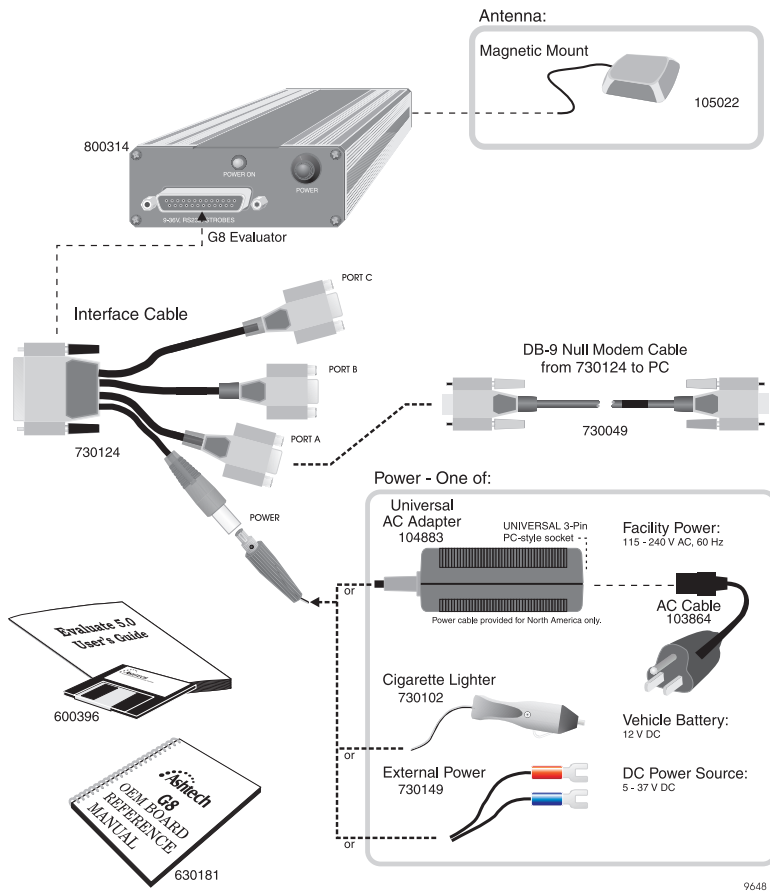


Figure 4.1: G8 Evaluation and Development Kit

Step 2 - Load the Evaluate software into your computer

Refer to the Evaluate User's Guide P/N 630063. Follow the setup and software loading instructions in the guide.

When you load the Evaluate software into the PC, make sure the software version is 4.01 or later, earlier versions will not work with the G8. After your software is loaded, there is no need to launch the Evaluate application. You will be instructed to do this in a later step.

Step 3 - Prepare Your Equipment for Operation

Connect devices as shown in Figure 4.2. It is very important to follow instructions 1 through 6 below.

CAUTION

DO NOT connect power at any time during this step.

1. Connect the multipoint interface cable 730124 to the DB-25 connector on the G8 Evaluator.
2. Connect the DB-9 null modem cable from the port A connector (labelled "Port A-1 PPS Out") on the interface cable to an initialized serial port on your IBM-compatible computer. If the serial port of your computer is not initialized, it will not be recognized by the Evaluate software.



Within the G8 Evaluator, the RTS/CTS lines of the interface cable are connected. This is done to ensure that your computer will always receive an immediate CTS signal when it asserts RTS as part of its communication process. Refer to Table 4.7 on page 41 for specific interconnection details.



Port B of interface cable (730124) is used for inputting RTCM DGPS corrections. Port C is never used for G8 operation and is not connected to anything inside the G8 evaluator.

3. Connect the power connector on the interface cable to the appropriate adapter (AC, vehicle cigarette lighter, or external DC power source) but **DO NOT** connect power at this time.

4. Connect the antenna to the GPS ANT connector on the back of the G8 evaluator. You may connect a different active antenna to the G8 Evaluator, but please refer to Table 1.6 on page 8 for antenna specifications. If it requires a voltage level other than 4.5 VDC, you must supply your own external power and use a DC block at this connector in order to ensure reliable operation of your antenna and G8 Evaluator.

CAUTION

You must provide a DC block if you are providing external power to the antenna.

Also note that a passive antenna is not compatible with the G8 Evaluator, as it does not have enough gain to provide the RF signal strength needed at the input to the OEM board for reliable operation. If you use your own antenna, it must meet the specifications listed in Table 1.6 on page 8.

5. If you are using the 1PPS output, connect the 1 PPS output connector on the back of the G8 Evaluator to the appropriate recording device. Or, you may also use the PPS output available at pin 9 of Port A. The PPS signal appears at both pin 9 and the BNC connector on the back panel of the G8 Evaluator.
6. If using RTCM corrections, connect RTCM source to the DB-9 connector labelled port B of interface cable 730124.

CAUTION

The 9-37 VDC power that you provide to the adapter cable connector also appears on pin 4 of the two DB-9 connectors for ports B and C. Before connecting equipment to port, make sure that this 9-37 VDC power does not damage or interfere with that equipment. Port C is never used for the G8 Evaluator. NEVER connect any cables to Port C.

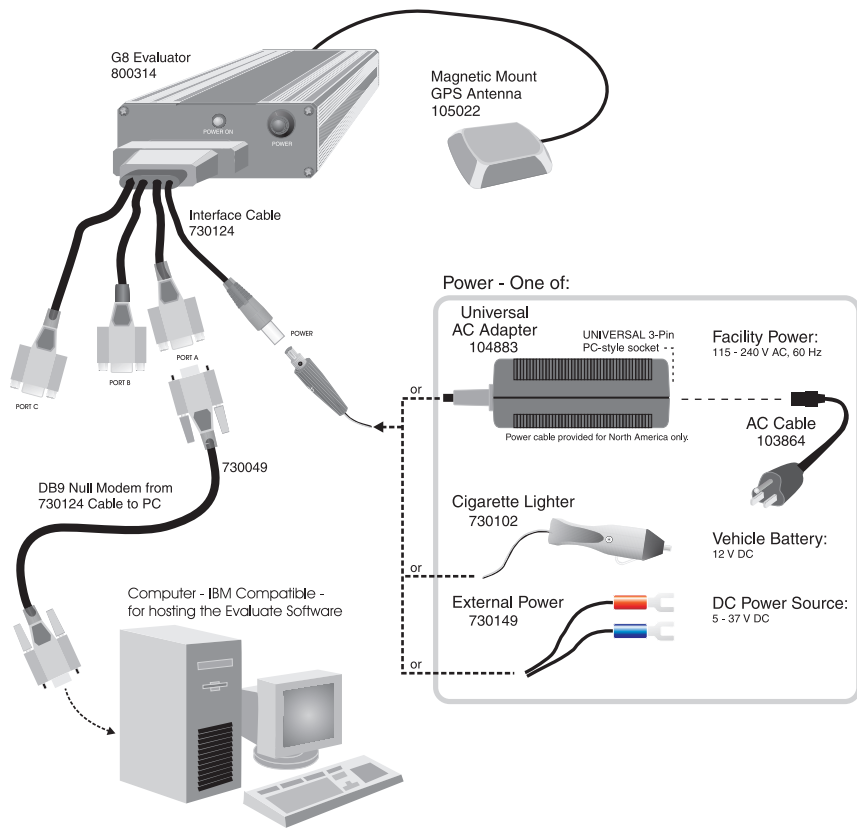
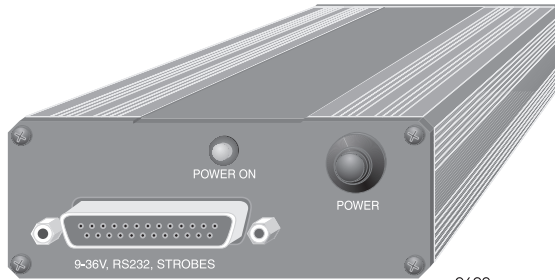


Figure 4.2: Setup Using G8 Evaluation & Development Kit

9604



9602

Front



9603

Rear

Figure 4.3: Connectors on G8 Evaluator Front and Rear Panels

Step 4 - Position the GPS Antenna

Regardless of the antenna you use, it is very important that the antenna have a clear view of the entire sky. Obstructions may cause satellites to be hidden from view, creating a situation where the G8 will be unable to provide a position report.

Be aware that your receiver reports the position of the **GPS antenna**, not the position of the receiver. Please take this into account when making accuracy measurements.

When the G8 Evaluator is connected to power it automatically provides +5VDC power to its internal G8 OEM board and 4.5 VDC power to the GPS antenna connector on the rear of the G8 Evaluator. The 4.5VDC power signal on the antenna connector is designed for the antenna included in the kit. To ensure reliable operation,

simply connect the antenna to the antenna connector and locate the antenna such that it has a clear view of the entire sky.



“Clear view of the entire sky” means exactly that. Locating the antenna on top of your computer monitor inside your office does not provide a clear view of the sky. Moving it to a window may help, but the window provides only a partial view of the sky. Generally, for optimum operation your antenna must be outside, away from any natural or man-made object that obstructs or reflects radio frequency signals. Failure to locate the antenna with a clear view of the sky will impact G8 start time and accuracy.

Step 5 - Power On the Equipment

Once you have completed steps 1 through 4, you are ready to power on your equipment. Ensure that, if you are using your own antenna, it meets the specifications listed in Table 1.6 on page 8, and it operates at 4.5 VDC. If it does not operate at 4.5 VDC, you must provide the correct voltage and must have installed a DC block between the SMA connector on the G8 Evaluator rear panel and your antenna cable.

Connect the power cable to a power source. If the PWR ON light on the front panel of the G8 Evaluator is not lit, push the POWER button. The PWR ON light should now be lit.

When the G8 Evaluator is turned on for the first time, be aware of the following conditions:

1. The first power-on may require that G8 search several minutes to lock on to enough satellites to compute a position, assuming the antenna has a clear view of the entire sky. If the antenna is obstructed, the initial start may take longer to acquire satellites. “Cold starts” will typically take around 2 minutes.

CAUTION

If the G8 has a valid Almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the \$PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

2. The G8 serial interface turns on at 4800 baud. Your external device (e.g., P.C.) must initially communicate with the G8 at this rate. After communication is established, you can use the PC to change the baud rate.
3. Once the G8 is powered on and has completed its initial start process, it immediately begins calculating position. For firmware revision HC00 or earlier, the G8 default power-on configuration is NO OUTPUT MESSAGES. To output position messages, you must turn on the outputs you

want by using the external device to issue the appropriate commands (refer to Chapter 5). For firmware revision HD00 or later, the G8 automatically outputs \$GPGGA and \$GPVTG NMEA messages on power up. These messages will contain valid data once the G8 has completed its cold, warm, or hot start sequence.

The Evaluate software provides simple communication programs designed to interface to G8 Evaluator. Move on to Step 6 to initiate communication with the G8 Evaluator.



Ashtech recommends first time users always operate the G8 Evaluator first with Evaluate software. Once operation is understood, use Evaluate or other terminal program to send any Set or Query commands defined in Chapter 5. For configuring G8 Evaluator for RTCM operation, refer to Chapter 3, Operation and Chapter 5, Command/Response Formats.

Step 6 - Communicate to the G8 Evaluator Using Evaluate Software

With your G8 Evaluator powered on, you are ready to communicate to it using the Evaluate software. Open the Evaluate application on your computer. When the **Evaluate** opening screen, Figure 4.4, appears select the appropriate activity in the **Start From** menu; for the first start-up, this selection will be **Connect to GPS Receiver**. From this point on, follow the instructions in the Evaluate User's Guide.

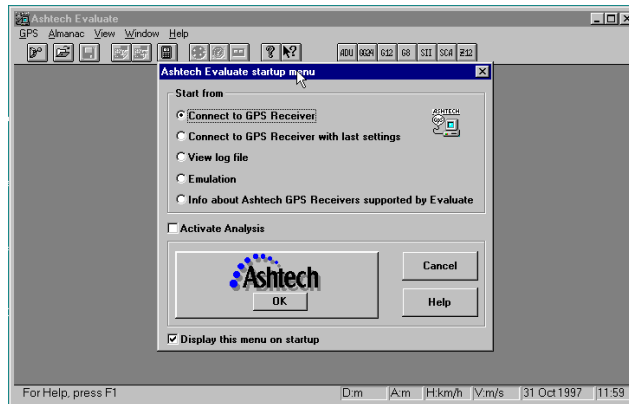


Figure 4.4: Evaluate Opening Screen

Mounting the G8 Evaluator

The G8 Evaluator is shipped in a desktop configuration for desktop use with the rubber pads installed on the bottom of the case. For hard mounting, remove the rubber pads and attach the mounting plate to the bottom of the case using the four supplied screws, then attach the mounting plate to the appropriate surface. Figure 4.5 shows the hole locations and dimensions of the mounting plate.

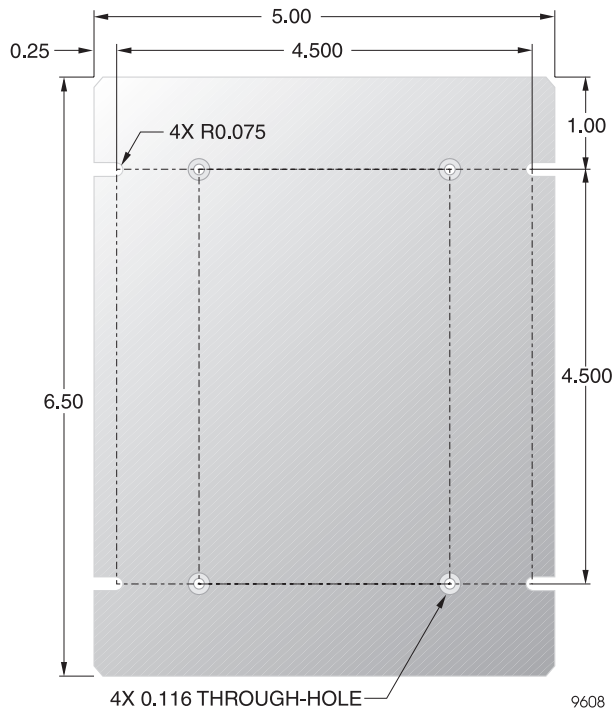


Figure 4.5: Mounting Dimensions (Inches)

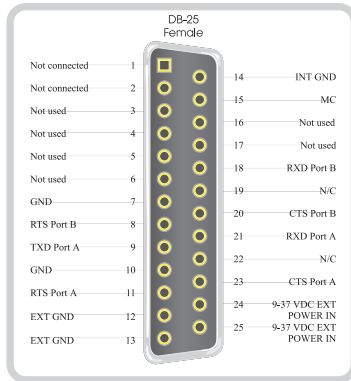
Power and Signal Connections

Figure 4.6 shows the physical configuration. Table 4.7 defines power and input/output connections on interface cable 730124.

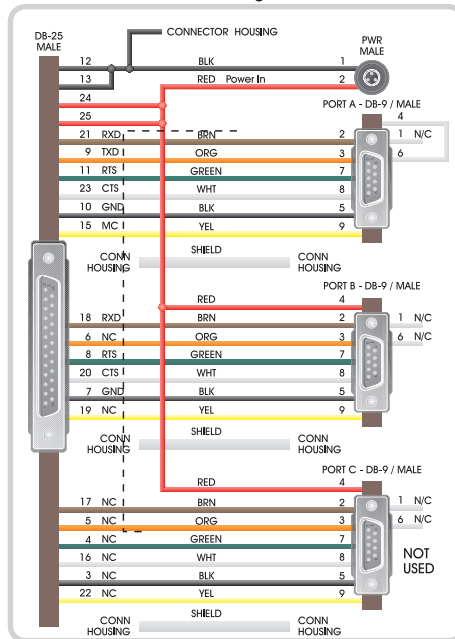


Port C is NEVER utilized for G8. Do not connect any cables to Port C.

G8 Evaluator
DB-25 Pinout Diagram



Interface Cable Pinout Diagram



9648

Figure 4.6: Interface Cable Layout

Table 4.7: Power/Input/Output Connections

Connector	Pin	Signal Designation	Function
Power J5	1	Ground	Connector housing-connected to DB25 pin 12
	2	Power in	Power input 9-37 Vdc-connected to DB25 pin 24
DB-25 J4	1	Not used	Not connected
	2	Not used	Not connected
	3	Ground	Connected to DB9 port C pin 5 - not used
	4	RTS	Connected to DB9 port C pin 7 - not used
	5	TXD	Connected to DB9 port C pin 3 - not used
	6	TXD	Connected to DB9 port B pin 3
	7	GND	Connected to DB9 port B pin 5
	8	RTS	Connected to DB9 port B pin 7 (also, directly connected to J4 pin 20)
	9	TXD	Connected to DB9 port A pin 3
	10	GND	Connected to DB9 port A pin 5
	11	RTS	Connected to DB9 port A pin 7 (also, directly connected to J4 pin 23)
	12	Ground	Connector housing-connected to power connector pin 1
	13	Ground	Connector housing-connected to pin 12
	14		Internal ground
	15	PPS	Connected to DB9 port A pin 9
	16	CTS	Connected to DB9 port C pin 8 - not used
	17	RXD	Connected to DB9 port C pin 2 - not used
	18	RXD	Connected to DB9 port B pin 2
	19	EVNT	Connected to DB9 port B pin 9
	20	CTS	Connected to DB9 port B pin 8
	21	RXD	Connected to DB9 port A pin 2
	22	Boot	Connected to DB9 port C pin 9
	23	CTS	Connected to DB9 port A pin 8
	24	Power in	9-37 Vdc - connected to power connector pin 2 and DB-25 pin 25
	25	Power in	9-37Vdc - connected to pin 24

Table 4.7: Power/Input/Output Connections (continued)

Connector	Pin	Signal Designation	Function
DB9-Port A J1	1	Not used	Not connected
	2	RXD	Connected to DB25 pin 21
	3	TXD	Connected to DB25 pin 9
	4		Jumpered to pin 6
	5	GND	Connected to DB25 pin 10
	6		Jumpered to pin 4
	7	RTS	Connected to DB25 pin 11
	8	CTS	Connected to DB25 pin 23
	9	PPS	Connected to DB25 pin 15
DB9-Port B J2	1	Not used	Not connected
	2	RXD	Connected to DB25 pin 18
	3	TXD	Connected to DB25 pin 6
	4	Vcc	Connected to DB25 pin 25
	5	GND	Connected to DB25 pin 7
	6	Not used	Not connected
	7	RTS	Connected to DB25 pin 8
	8	CTS	Connected to DB25 pin 20
	9	EVNT	Connected to DB25 pin 19
DB9-Port C J3 (THIS PORT IS NEVER USED FOR G8 OPERATION)	1	Not used	Not connected
	2	RXD	Connected to DB25 pin 17 - not used
	3	TXD	Connected to DB25 pin 5 - not used
	4	Power in - not used	9-37 Vdc - connected to DB25 pin 25 - not used
	5	Ground	9-37 Vdc - connected to DB25 pin 3 - not used
	6	Not used	Not connected
	7	RTS	Connected to DB25 pin 4 - not used
	8	CTS	Connected to DB25 pin 16 - not used
	9	Boot	Connected to DB25 pin 22 - not used

Command/Response Formats

Overview

This chapter details the formats and content of the serial port commands through which the receiver is controlled and monitored. These serial port commands set receiver parameters and request data and receiver status information. Use the program REMOTE.exe software or any other standard serial communication software (including Ashtech's Evaluate 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 default protocol setting is 8 data bits, 1 stop bit, no parity, and 4800 baud.

All commands sent by the user to the receiver are either **Set** commands or **Query** commands. **Set** commands generally change receiver parameters and 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 header and are required for all commands. All commands must end with <enter> or <CR><LF> to transmit the command to the receiver. If desired, an optional checksum may precede the <enter> characters. All response messages end with a <CR><LF>.

The serial commands are presented in three separate groups:

- **General Receiver commands** - relate to general receiver operations. The discussion of these commands begins on page 47.
- **NMEA message commands** - control standard NMEA data message output or NMEA style message output. The discussion of these commands begins on page 67.
- **RTCM commands** - control RTCM differential operation. The discussion of these commands begins on page 92.

Within each group, the commands are listed alphabetically and described in detail. Information about the command includes the syntax, a description, the range and default, and an example of how the command is used. The syntax includes the number and type of parameters that are used or required by the command. These parameters may be either characters or numbers depending upon the particular command. The parameter type is indicated by the symbol that is a part of the syntax. The formats of these parameters are as defined in Table 5.1.

Table 5.1: 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,ALT,f`

the parameter `f` indicates that the 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 `ALT` command the receiver will accept both 10 and 10.0.

Receiver Set/Query Commands and Responses

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



G8 utilizes two serial ports. Port A is full duplex and is used as the primary two-way communication port for the receiver. When commands are input to this port, the G8 returns the appropriate response to this port. Port B is half-duplex, therefore it accepts input messages but does not output messages. Port B is used primarily for inputting RTCM correction messages. It is possible to send a Set or Query command to port B, but the command must specify that the response message be sent to port A by using an “A” in the command field that identifies the serial port to which the response should be sent. If this is not done, a command sent to port B will generate no response through port A or B. In fact, there is no response feedback through port B to indicate if the command was rejected or accepted.

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 altitude of the antenna to 100.25 meters is

```
$PASHS,ALT,+100.25 <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 are 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 is sent to the current port. For example, if you are communicating with the receiver on Port A and send the following query command:

```
$PASHQ,PRT <enter>
```

the response will be sent to port A.



Responses to query and set commands are only sent to port A. If a query command is sent to port B, the port field must be included and must be set to port A. The resulting response will then be output through port A.

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 or response message.

Table 5.2 summarizes the set and query commands that do not have standard NMEA or NMEA style responses. These are used primarily to set receiver parameters or query the receiver for parameter information. Commands that generate standard NMEA responses are provided in “NMEA Data Message Commands & Responses” on page 67. The pages shown in the table presents detailed descriptions of each command/query/response.

Table 5.2: Summary of General Receiver Set/Query Commands

Command	Description	Page
\$PASHS,ALM	Upload almanac data	50
\$PASHS,ALT	Set ellipsoidal height of antenna	51
\$PASHS,DTM	Select datum to use	51
\$PASHS,FIX	Set altitude position fix mode	52
\$PASHS,HDP	Set HDOP mask for position computation	52
\$PASHS,KFP,DYN	Set Kalman filter dynamics	54
\$PASHQ,KFP,DYN	Query for Kalman filter dynamics setting	54
\$PASHS,LTZ	Set local time zone	54
\$PASHQ,PAR	Receiver parameters query	55
\$PASHS,PDP	Set PDOP mask	57
\$PASHS,PEM	Set position elevation mask angle	56
\$PASHS,PMD	Set position mode	57
\$PASHS,POS	Set antenna position	58
\$PASHQ,PRT	Serial port baud rate query	58
\$PASHS,PWR,OFF	Put receiver into sleep mode	59
\$PASHS,RAW,ITA	Set inverse differential message	59
\$PASHQ,ITA	Query for inverse differential message	60
\$PASHQ,RID	Receiver identification query	61

Table 5.2: Summary of General Receiver Set/Query Commands (continued)

Command	Description	Page
\$PASHS,RST	Reset receiver parameters to default values	62
\$PASHS,SAV	Save user parameters.	62
\$PASHS,SPD	Set serial port speed	63
\$PASHS,UDD	Set user-defined datum parameters	64
\$PASHQ,UDD	Query user-defined datum parameters	64
\$PASHS,UID	Set user ID to desired value	65
\$PASHQ,UID	Query for user ID	65
\$PASHS,USE	Set satellites to track or not track	65
\$PASHS,ZDA	Upload initial real-time clock value	66

ALM: Upload Almanac Data

\$PASHS,ALM

Allows data to be loaded into the almanac store. This is used during aided initialization, and should be used if it is known that the data available to the receiver is invalid. The structure is

\$PASHS,ALM,d1,d2,h1,h2,h3,h4,h5,h6,h7,h8,h9,h10,h11

where the parameters are as defined in Table 5.3.

Table 5.3: ALM Parameters

Parameter	Description	Range
d1	Satellite PRN number	1...32
d2	GPS week	0...9999
h1	SV health (in ASCII hex)	2 bytes
h2	Eccentricity (in ASCII hex)	4 bytes
h3	Almanac reference time (in ASCII hex)	2 bytes
h4	Inclination angle (semicircles - in ASCII hex)	4 bytes
h5	Rate of ascension (semicircles - in ASCII hex)	4 bytes
h6	Root of semi-major axis (in ASCII hex)	6 bytes
h7	Argument of perigee (semicircle - in ASCII hex)	6 bytes
h8	Longitude of ascension mode (semicircle - in ASCII hex)	6 bytes
h9	Mean anomaly (semicircle - in ASCII hex)	6 bytes
h10	Clock parameter (seconds - in ASCII hex)	3 bytes
h11	Clock parameter (sec/sec - in ASCII hex)	3 bytes

Data is in the format of the NMEA almanac message (\$GPALM). The data should be sent using 32 separate messages, one per satellite.

In normal usage, this command should not be needed. However, it can be used in cases where it is known that the almanac data is significantly different, as it speeds up acquisition of the satellites.

ALT: Set Ellipsoidal Height of Antenna

\$PASHS,ALT

Sets the ellipsoidal height of the antenna, where $f = \pm 99999.99$ meters and must include the sign (+ or -). The receiver uses this data in the position calculation for 2-D position computation. The structure is

\$PASHS,ALT,f1

where the parameters are as defined in Table 5.4.

Table 5.4: ALT Parameters

Parameter	Description	Range
sign		+ or -
value	Altitude in meters. Default is 0.	0...99999.99

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

\$PASHS,ALT,+100.25 <enter>

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

\$PASHS,ALT,-30.1 <enter>

DTM: Select Datum to Use

\$PASHS,DTM

Selects the geodetic datum used for position computation and measurements, where s is a 3-character string that defines a particular datum or USR (user-defined datum). Parameters for a user-defined datum are entered with the **\$PASHS,UDD** command. WGS-84 is the default datum. If this command is used to select a datum but no datum has been entered via the UDD command, then the output remains WGS-84.

Example: Select user-defined datum for position computation.

\$PASHS,DTM,USR <enter>

where the parameters are as defined in Table 5.5.

Table 5.5: DTM Parameters

Parameter	Description	Range
USR	WGS-84 or user-defined using the command \$PASHS,UDD.	W84 or USR

FIX: Altitude Position Fix Mode

\$PASHS,FIX

Sets altitude hold position fix mode for the altitude used (for 2D position determination), where d is 0 or 1. This command must be used with the \$PASHS,PMD command. The default is 0. The structure is

\$PASHS,FIX,d

where d is as defined in Table 5.6.

Table 5.6: FIX Parameters

Parameter	Description
d	d = 0 (default): The most recent antenna altitude is used in antenna hold position computation. The altitude is taken from either the altitude entered by the \$PASHS,ALT command, or the last altitude computed. d = 1: Always use the altitude set by the \$PASHS,ALT command.

Example: Fix altitude to always use the entered altitude:

\$PASHS,FIX,1 <enter>

HDP: Set HDOP Mask

\$PASHS,HDP

Set the value of the Horizontal Dilution of Precision (HDOP) mask, where d is a number between 0 and 99 (default = 4). The HDOP mask is used to set accuracy limits on G8 position outputs while operating in the fixed 2D mode. In this mode, if HDOP is exceeded no position is output. In 3D mode the HDOP mask is ignored. The command structure is

\$PASHS,HDP,d

where d is the value of the HDOP mask as defined in Table 5.7.

Example: Set the HDOP mask to 6.

\$PASHS,HDP,6 <enter>

Table 5.7: HDOP Parameters

Parameter	Range	Range
d	Value of the HDOP mask. Default is 4.	0...99

INI: Receiver Initialization

\$PASHS,INI,d1,d2,d3,d4,d5,c1

The INI command resets the receiver memory, and sets the serial port baud rate to the specified rates. Unlike other set commands, if the INI command is successfully entered, then the receiver does not return a receiver acknowledgement (\$PASHR,ACK), but immediately starts the initialization. The parameters are as defined in Table 5.8.

Table 5.8: INI Parameters

Parameter	Description	Range	Default
d1	Port A baud rate code: 0 = 300 baud 1 = 600 2 = 1200 3 = 2400 4 = 4800 5 = 9600 6 = 19200	0 through 6	4 (4800 baud)
d2	Port B baud rate code	0-6	4
d3	Reserved	null	n/a
d4	Reserved	null	n/a
d5	Memory reset code 0 = no memory reset 1 = reset internal memory 5 = clear ephemeris but not almanac, position, or time	0, 1,5	n/a
c1	Reserved	null	n/a



Parameters d3, d4, and c1 must be entered as null (i.e., include commas), or the command will respond with NAK.

Example: Set baud rate of port A to 4800, port B to 4800, and reset all memory.

```
$PASHS,INI,4,4,,,1, <enter>
```

KFP DYN: Set Kalman Filter Dynamics

\$PASHS,KFP,DYN

Sets dynamics operating mode for Kalman filter that best represents the motion of the receiver. The structure is

\$PASHS,KFP,DYN,d

where the parameter d is defined in Table 5.9.

Table 5.9: KFP DYN Parameter

Parameter	Description	Range
d	Dynamics mode of the Kalman filter 2: Walking 3: Automobile 4: Aircraft 5: Ship	2, 3, 4, 5



To minimize the impact of the Kalman Filter, choose parameter setting 4:aircraft. If you choose this setting, we recommend setting the PDOP mask to 12 using \$PASHS,PDP command.

\$PASHQ,KFP,DYN

The associated query command is \$PASHQ,KFP,DYN,c where c is the optional output port (port A is the only valid serial port for this query).

Example: Query the Kalman filter dynamics setting to port A:

\$PASHQ,KFP,DYN,A <enter>

\$PASHR,KFP,DYN

The response message is in the form \$PASHR,KFP,DYN,d where d is the dynamic setting of the filter as defined in Table 5.9.

LTZ: Set Local Timezone

\$PASHS,LTZ

Sets the timezone offset to be added to local time to get GMT. The structure is

\$PASHS,LTZ,d1,d2

where the parameters are as defined in Table 5.10.

Table 5.10: LTZ Parameters

Parameter	Description	Range
d1	GMT = localtime + timeoffset: hours	± 00...13
d2	GMT = localtime + timeoffset: minutes	00...59

The response is ACK/NAK.



The default is 00,00 i.e. a time offset of zero. This command affects the output of the \$GPZDA response.

PAR: Receiver Parameter Query

\$PASHQ,PAR

Returns the status of general receiver parameters. The structure is

\$PASHQ,PAR,x

where x is the optional output port (A is the only valid value for x).

A typical response is shown below.

```
PMD:4      FIX:0      PEM:05 PDP:06 HDP:04
DTM:W84    LTZ:+00.00 SAV:N
USE:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
CDS:  AUTO          .          .          .          .          .
LAT:0000.000000,N LON:00000.000000,E  ALT:+00000.00
NMEA:  ALM GGA GLL GSA GSV MSG POS RMC SAT UKO VTG ZDA XMG
PRTA:  . . . . .
PER:    001.0
```

CAUTION

The \$PASHQ,PAR response message is free-form and subject to change in future firmware versions. These messages are not intended to be computer-readable.

Table 5.11 defines the response parameters.

Table 5.11: PAR Parameters

Parameter	Description (Related Command)	Range
PMD	Navigation position mode (\$PASHS,PMD)	0 or 2
FIX	Altitude fix mode (\$PASHS,FIX)	0 or 1
PEM	Position elevation mask (\$PASHS,PEM)	0-90
PDP	PDOP mask (\$PASHS,PDP)	0-99
HDP	HDOP mask (\$PASHS,HDP)	0-99
DTM	Select datum (\$PASHS,DTM)	W84 or USR (user)
USE	Use satellite (\$PASHS,USE)	Y or N for each satellite
LTZ	Local timezone (\$PASHS,LTZ)	-13,59 to +13,59
SAV	Save parameters (\$PASHS,SAV)	Y (yes) or N (no)
CDS	Manual satellite selection (\$PASHS,CDS)	AUTO (applies to all channels) or else prn or - for each channel
DIF_RTCM MOD	RTCM differential mode (\$PASHS,RTC)	OFF/REM
PRT	Port receiving RTCM (\$PASHS,RTC)	A-D
AUT	Auto differential mode (\$PASHS,RTC,AUT)	Y or N
MAX	RTCM maximum age (\$PASHS,RTC,MAX)	0-3600
LAT	Latitude of the antenna position (\$PASHS,POS)	0-90, north or south
LON	Longitude of the antenna position (\$PASHS,POS)	0-180, east or west
ALT	Ellipsoidal height of the antenna (\$PASHS,ALT)	0-99999.99
NMEA	NMEA message type for output	
PRTA	Output to port A: period (if enabled) or disabled (\$PASHS,NME)	Message enabled: 1-999 Message disabled: "_"
PER	NMEA message output period (\$PASHS,NME,PER)	1-999.0

PEM: Set Position Elevation Mask Angle

\$PASHS,PEM

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 will not be used for position computation.

Example: Set position elevation mask to 15 degrees

```
$PASHS,PEM,15 <enter>
```

PDP: Set PDOP Mask for Position Computation

\$PASHS,PDP

Sets the Position Dilution of Precision mask. If the PDOP mask is exceeded, no navigation solution is reported. The PDOP mask is used to set accuracy limits on position outputs while operating in 3D mode. If PDOP is above the PDOP mask, no position is output. In fixed 2D mode, the PDOP mask is ignored. The command structure is

```
$PASHS,PDP,d
```

where the parameter d is as defined in Table 5.12.

Table 5.12: PDP Parameters

Parameter	Description	Range
d	Dilution of precision	0...99 Default = 6

PMD: Set Navigation Position Mode

\$PASHS,PMD

This command changes the receiver mode to 2D or 3D. The structure is

```
$PASHS,PMD,d
```

where d is as described in Table 5.13.

Table 5.13: PMD Parameters

Parameter	Description	Range
d	2: 2D position is generated; position is held 4: 3D position is generated. Default is 4.	2 or 4

POS: Set Antenna Position

\$PASHS,POS

Sets the position of the antenna. The command structure is

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

where the parameters are as defined in Table 5.14.



This command is most often used to load a position to help receivers without battery backup to improve satellite acquisition times.

Table 5.14: POS Parameter Table

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

Example: Set antenna position (latitude and longitude):

\$PASHS,POS,3722.291213,N,12159.799821,W,+15.25 <enter

CAUTION

Entering an incorrect position can cause a very long delay in acquiring satellites.

PRT: Serial Port Baud Rate Query

\$PASHQ,PRT

Displays the baud rate setting for the connected communication port. The structure is

\$PASHQ,PRT,x

where x is the optional output port. Note that to direct the response message to the current communication port, the x is not required.

Example: Query the baud rate of the current port.

```
$PASHQ,PRT <enter>
```

\$PASHR,PRT

The response to a serial port baud rate query is a message in the format:

```
$PASHR,PRT,x,d*cc
```

where the parameters are as defined in Table 5.15.

Table 5.15: PRT Message Structure

Field	Description	Range
x	serial port	A or B
d	baud rate code	0 = 300 baud 1 = 600 2 = 1200 3 = 2400 4 = 4800 5 = 9600 6 = 19200
*cc	checksum	n/a

PWR: Set Sleep Mode

\$PASHS,PWR,OFF

Directs the receiver to go into sleep mode. This command can only be sent through port A. In the sleep mode, the receiver uses reduced power. The receiver exits sleep mode when it detects serial port communication activity on either port A or port B. The message that "wakes up" the receiver may be lost. It is therefore recommended that a second message be sent to ensure that the receiver has retained the information.

Example: Put receiver into sleep mode:

```
$PASHS,PWR,OFF <enter>
```

RAW,ITA: Enable ITA Data Message

\$PASHS,RAW,ITA

Enable/disable the ITA raw data message. The structure is:

```
$PASHS,RAW,ITA,x,s1,d,s2
```

where x is the receiver port, s1 is ON or OFF, d is the optional reporting interval from 1 to 999 seconds, and s2 is the optional format (ASC for ASCII, BIN for Binary). The default message format is binary, reporting once per second.

Example: Enable the RAW ITA data message to receiver port A in ASCII format.

```
$PASHS,RAW,ITA,A,ON,ASC <enter>
```

\$PASHQ,ITA

The associated query command is:

```
$PASHQ,ITA,x
```

where x is the optional output port. Port A is the only valid value for 'x'.

Example: Query for the Raw ITA data message at port A.

```
$PASHQ,ITA,a
```



The G8 will respond to a query command using whatever format was specified by the last set command, even if that set command had subsequently been turned off.

\$PASHR,ITA

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

```
$PASHR,ITA,<structure>*cc
```

where parameters are listed in Table 5.16.

Table 5.16: \$PASHR,ITA Response Message Structure (Binary)

Field	Description	Size in Bytes	Type
UID	Unit ID. This ID will appear as 0000 if no unit ID has been set.	4 characters (always ascii)	letter or number
Time	GPS receive time (milliseconds)	4 bytes	unsigned long
Clock Offset	Clock offset (meters)	4 bytes	float
NSV	Number of SVs used in solution	1 byte	unsigned char
PRN	PRN number of first SV	1 byte	unsigned char
Pseudorange	Pseudo-range of first SV (seconds, scale factor = 3.0e10)	4 bytes	unsigned long
Doppler	Doppler of first SV (Hz, scale factor = 5.0e4, bias = 3.0e4)	4 bytes	unsigned long
*cc	checksum		



This message length is determined by the number of SVs used in the solution. For example, if n=4, then the PRN number, pseudo range, and doppler will appear in order for each of the 4 SVs. A message with only 4 SVs will be shorter than a message with 6 SVs (n=6) which would provide PRN, Pseudorange, and doppler for each of the six SVs.

The ITA response in the ASCII format is in the form:

\$PASHS,ITA,s1,d2,f3,d4,n(d5,d6,d7)*cc

where n is equal to the number of satellites. The fields are listed in Table 5.17.

Table 5.17: \$PASHR,ITA Response Message Structure (ASCII format)

Parameter	Description	Units
s1	Unit ID	n/a
d2	GPS time in milliseconds	milliseconds
d3	Clock Offset	meters
d4	Number of SVs used in the solution	n/a
d5	PRN number	n/a
d6	Pseudorange	seconds (scale factor =3.0e10)
d7	Doppler	Hz (scale factor =5.0e4, bias =3.0e4)
*cc	checksum	

RID: Receiver ID Query

\$PASHQ,RID

Requests information about the receiver type, firmware, and available options. The structure is

\$PASHQ,RID,c

where c is the optional output port. If c is not specified, output goes to the current port.

Example: Query the current port for receiver identification

\$PASHQ,RID <enter>

\$PASHR,RID

The return message is in the form:

`$PASHR,RID,EX,s1,*cc`

where the parameters are as defined in Table 5.18.

Table 5.18: \$PASHR,RID Structure

Parameter	Description	Range
s1	Firmware version	4 characters

Example: Query: `$PASHQ,RID <enter>`

Response: `$PASHR,RID,EX,HD00`

RST: Reset Receiver

\$PASHS,RST

Resets the receiver parameters to their default values. The RST command resets all parameters to their default values. For more information on default values, see Chapter 6.

Example: Reset receiver parameters

`$PASHS,RST <enter>`

SAV: Save User Parameters

\$PASHS,SAV

This command saves the current parameters of the system to battery-backed RAM. At the next power-on (e.g. hardware reset to exit the power saving mode) these saved parameters are restored. The structure is

`$PASHS,SAV,c`

where the c parameter is Y (yes) or N (no). Y saves parameters now, and restores them after a hard reset. N returns parameters to default values the next time the receiver is powered on.

If parameters were changed after issuing the `$PASHS,SAV,Y` command, but before power-down, those changes are lost at the next power up.

If the command `$PASHS,SAV,N` is sent, the parameters of the system are always set to default values the next time the receiver is powered up.

The response is ACK/NAK.

CAUTION

Battery backup voltage must be applied to G8 pin 3 (V-back) for new parameters to be saved after power to the G8 pin (VCC) has been removed.

SPD: Set Serial Port Speed

\$PASHS,SPD

Sets the baud rate of the receiver serial port. The structure is

\$PASH,SPD,c,d

where c is port A or B, and d is a number between 0 and 6 specifying the baud rate as listed in Table 5.19. Default is 4800 baud.

Table 5.19: \$PASH,SPD Baud Rate Codes

Code	Baud Rate	Code	Baud Rate
0	300	4	4800
1	600	5	9600
2	1200	6	19200
3	2400		



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

Example: Set port A to 19200 baud
\$PASHS,SPD,A,6 <enter>

UDD: Set User-Defined Datum Parameters

\$PASHS,UDD

Sets the user-defined datum parameters in the receiver memory. The structure is

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

where the parameters are as defined in Table 5.20.

Table 5.20: \$PASHS,UDD Structure

Field	Description	Range	Units
d1	Geodetic datum id. Always 0 for WGS 84.	0	n/a
d2	Semi-major axis	6300000.0-6400000.0	meters
f1	Flattening in meters.	290.0 to 300.0	meters
f2	Translation in x direction	-1000.0 to +1000.0	meters
f3	Translation in y direction	-1000.0 to +1000.0	meters
f4	Translation in z direction	-1000.0 to +1000.0	meters
f5	Rotation in x axis + rotation is counter clockwise, and - rotation is clockwise rotation.	always 0.0	radians
f6	Rotation in y axis	always 0.0	radians
f7	Rotation in z axis	always 0.0	radians
f8	Scale factor. Range -10.00 to +10.00.	always 0.0	n/a



Fields f5 - f8 are reserved for future use and should always be set to zero.

Example: Set datum parameters

\$PASHS,UDD,0,637 8240, 297.3, 34.2, 121.4, 18.9, 0, 0, 0, 0 <enter>

\$PASHQ,UDD

The associated query command is \$PASHS,UDD,a where a 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 A

\$PASHQ,UDD,A <enter>

\$PASHR,UDD

The response is in the format.

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

where the fields are as defined in Table 5.20.

UID: Set User ID

\$PASHS,UID

Sets the Unit ID for the receiver. The structure is:

\$PASHS,UID,s

where s is a 4 character identification number selected by the user.

Example: Set user ID to A179

\$PASHS,UID,A179



The UID set command also sets the user identification number in the POS and ITA messages.

\$PASHQ,UID

The associated query command is \$PASHQ,UID,c, where c is the optional output port. This query returns unit ID to the port specified. Port A is the only valid value for s.

\$PASHR,UID

The response is in the format:

\$PASHR,UID,d*cc

where d is the user identification number.

Example: The response to \$PASHQ,UID for the ID number set in the earlier example is:

\$PASHR,UID,A179



If no value has been entered through the \$PASHS,UID command, then the default value (null) will be reported in the \$PASHR,UID response and the \$PASHR,POS response. The \$PASHR,ITA response will report all zeros in the unit identification field.

USE: Set Satellites to Use

\$PASHS,USE

Selects satellites to track or not track. The structure is

\$PASHS,USE,d,c

where d is the PRN number of the satellite (range from 1 to 32) or ALL for all satellites, and c is Y (enable) or N (disable).

Example: Do not track satellite 14

```
$PASHS,USE,14,N <enter>
```

ZDA: Upload Initial Real-time Clock Value

\$PASHS,ZDA

Allows data to be loaded into the real-time clock. This is used to aid acquisition for receivers that use no battery backup. In normal usage, this command should not be needed. However, it can be used if it is known that the clock data is significantly different, as it will speed up acquisition of the satellites. The command structure is

```
$PASHS,ZDA,f1,d1,d2,d3,d4
```

where the parameters are as defined in Table 5.21.

Table 5.21: ZDA Parameters

Parameter	Description	Range
f1	UTC time (hhmmss.ss)	000000.00 through 235959.99
d1	UTC day (dd)	01 through 31
d2	UTC month (mm)	01 through 12
d3	UTC year (yyyy)	0000 through 9999
d4	UTC time zone offset. Must be null.	Null



The time zone offset field must be null. Any other value will generate a NAK response.

CAUTION

Entering the wrong time can cause long delays in acquiring satellites.

Example: Upload real-time clock values where the UTC time is 13:1530 on 1/15/98 and the local time is 8:15:30:

```
$PASHS,ZDA,131530.00,01,15,1998 <enter>
```

NMEA Data Message Commands & Responses

The NMEA message commands control all query and set commands related to NMEA format messages and miscellaneous messages in an Ashtech NMEA style format. All standard NMEA messages are a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standard Version 2.2. All non-standard messages are a string of ASCII characters delimited by commas in the Ashtech NMEA style format. Any combination of these messages can be output as long as the character I/O rate for the receiver is not exceeded (400 characters per second). The output interval is determined by the \$PASHS,NME,PER command or the specific \$PASHS,NME command, and can be set to any value between 1 and 999 seconds.

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 specified period. The query outputs a NMEA response message only once.

Set Commands

The general structure of the NMEA set commands is

```
$PASHS,NME,str,x,s,d <enter>
```

where x is the serial port to which the response message should be sent, s is either ON or OFF, and d is an optional parameter to specify the reporting interval. ON enables the message and OFF disables the message. The **str** is a 3-character string that identifies the NMEA message to be output. If the reporting interval is not set, the output interval set by the \$PASHS,NME,PER command is used. The available strings are:

ALM, GGA, GLL, GSA, GSV, MSG, POS, RMC, SAT, ZDA

When a set command is sent correctly, the receiver sends a \$PASHR,ACK (command acknowledge) message. If the command is sent incorrectly or the syntax is wrong, the receiver sends a \$PASHS,NAK (command not acknowledged) message. Once acknowledged, the receiver will output the corresponding NMEA data message at the interval defined, unless a necessary condition for the message to be output is not present. For example, the MSG message is not output unless RTCM differential has been enabled.



Port A is the only port that can be used to output NMEA messages.

To disable all NMEA messages, 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>

Example: Output enabled NMEA messages every 5 seconds
\$PASHS,NME,PER,5 <enter>

Query Commands

The general structure of the NMEA query commands is

\$PASHQ,str,x, <enter>

where str is one of the 3-character NMEA strings and x is the serial port to which response message should be sent (port A is the only valid port). The serial port field is optional. If a port is not included, the receiver sends the response to the current port. Unlike the set commands, the query command initiates a single response message.

Example: Query POS message and send the response to port A
\$PASHQ,POS,A <enter>

Example: Query GSA message and send the response to the current port.
\$PASHQ,GSA <enter>



If the optional port field is not included, the query must be sent from port A, as messages can not be output to port B.

Table 5.22 summarizes the NMEA data message commands and responses. A detailed description of each NMEA command follows Table 5.22.

Table 5.22: NMEA Data Message Commands and Responses

Command	Description	Page
\$PASHS,NME,ALL	Disable all NMEA messages	69
\$PASHS,NME,ALM	Enable/disable almanac data message	70
\$PASHQ,ALM	Query almanac data message	70
\$GPALM	GPS almanac response message	70
\$PASHS,NME,GGA	Enable/disable position response message	72
\$PASHQ,GGA	Query position response message	72
\$GPGGA	Position response message	72
\$PASHS,NME,GLL	Enable/disable latitude/longitude message	74
\$PASHQ,GLL	Query latitude/longitude message	74
\$GPGLL	Latitude/longitude response message	74

Table 5.22: NMEA Data Message Commands and Responses (continued)

Command	Description	Page
\$PASHS,NME,GSA	Enable/disable satellites used message	76
\$PASHQ,GSA	Query satellite used message	76
\$GPGSA	Satellites used response message	76
\$PASHS,NME,GSV	Enable/disable satellites in view message	77
\$PASHQ,GSV	Query satellites in view message	78
\$GPGSV	Satellites-in-view response message	78
\$PASHS,NME,MSG	Enable/disable base station message	79
\$PASHQ,MSG	Query base station message	80
\$GPMSG	RTCM differential response message	80
\$PASHS,NME,PER	Set send interval - all NMEA messages	82
\$PASHS,NME,POS	Enable position message	82
\$PASHQ,POS	Position message query	82
\$PASHR,POS	Position response message	83
\$PASHS,NME,RMC	Enable recommended minimum course response message	85
\$PASHQ,RMC	Recommended minimum course query	85
\$GPRMC	Recommended minimum course response message	85
\$PASHS,NME,SAT	Enable/disable satellite status message	87
\$PASHQ,SAT	Satellite status query	87
\$PASHR,SAT	Satellite status response message	87
\$PASHS,NME,VTG	Enable/disable velocity/course message	89
\$PASHQ,VTG	Query velocity/course message	89
\$GPVTG	Course over ground and ground speed response message	89
\$PASHS,NME,ZDA	Enable/disable time and date message	90
\$PASHQ,ZDA	Query time and date message	90
\$GPZDA	Time and date response message	91

ALL: Disable All NMEA Messages

\$PASHS,NME,ALL

Turn off all enabled NMEA messages. The structure is

\$PASHS,NME,ALL,x,OFF

where x is the specified serial port.

Example: Turn off all NMEA message currently sent out through port A

```
$PASHS,NME,ALL,A,OFF <enter>
```

ALM: Almanac Message

\$PASHS,NME,ALM

Enable/disable the almanac message. The structure is

```
$PASHS,NME,ALM,x,s,d
```

where x is the receiver serial port, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable ALM message on port A, reporting interval 5 seconds

```
$PASHS,NME,ALM,A,ON,5 <enter>
```

\$PASHQ,ALM

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

Example: Query almanac data message to receiver port A

```
$PASHQ,ALM,A <enter>
```

\$GPALM

There is one response message for each satellite in the GPS constellation. The response to the set or query command is in the form:

```
$GPALM,d1,d2,d3,d4,h1,h2,h3,h4,h5,h6,h7,h8,h9,h10,h11*cc
```

where the parameters are as defined in Table 5.23.

Table 5.23: GPALM Response Message Structure

Parameters	Description	Range
d1	Total number of messages	01 -32
d2	Number of this message	01 -32
d3	Satellite PRN number	01 - 32
d4	GPS week	4 digits
h1	SV health (In ASCII hex)	2 bytes
h2	Eccentricity (In ASCII hex)	4 bytes
h3	Almanac reference time (seconds. In ASCII hex)	2 bytes
h4	Inclination angle (semicircles. In ASCII hex)	4 bytes
h5	Rate of ascension (semicircles/sec. In ASCII hex)	4 bytes

Table 5.23: GPALM Response Message Structure (continued)

Parameters	Description	Range
h6	Root of semi-major axis (In ASCII hex)	6 bytes
h7	Argument of perigee (semicircle. In ASCII hex)	6 bytes
h8	Longitude of ascension mode (semicircle. In ASCII hex)	6 bytes
h9	Mean anomaly (semicircle. In ASCII hex)	6 bytes
h10	Clock parameter (seconds. In ASCII hex)	3 bytes
h11	Clock parameter (sec/sec. In ASCII hex)	3 bytes
*cc	Checksum	

Example:

Query: \$PASHQ,ALM <enter>

Typical response (Table 5.24):

\$GPALM,26,01,01,0899,00,1E8C,24,080B,FD49,A10D58,EB4562,BFE
F85,227A5B,011,000*0B

Table 5.24: Typical GPALM Response Message

Item	Significance
\$GPALM	Header
26	Total number of messages
01	Number of this message
01	Satellite PRN Number
0899	GPS week number
00	Satellite Health
1E8C	Eccentricity
24	Almanac Reference Time
080B	Inclination angle
FD49	Rate of ascension
A10D58	Root of semi-major axis
EB4562	Argument of perigee
BFEF85	Longitude of ascension mode
227A5B	Mean anomaly

Table 5.24: Typical GPALM Response Message (continued)

Item	Significance
011	Clock parameter
000	Clock parameter
*0B	checksum

GGA: GPS Position Message

\$PASHS,NME,GGA

This command enables/disables the GPS position message. The structure is

\$PASHS,NME,GGA,x,s,d

where x is port A or B, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable GGA on port A

\$PASHS,NME,GGA,A,ON <enter>

\$PASHQ,GGA,x

The associated query message is \$PASHQ,GGA,x where x is optional the receiver port where the message will be output. If no position is being computed, an empty message is output.

Example: \$PASHQ,GGA <enter>

\$GPGGA

The GGA response message is not output unless position is computed. The response message is in the form:

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

Table 5.25: GGA Message Structure

Parameters	Description	Range
m1	Current UTC time of position fix in hours, minutes, and seconds (ddmmss.ss)	00-235959.50
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmmm)	0-90
c1	Direction of latitude N= North, S= South	N or S
m3	Longitudinal component of position in degrees and decimal minutes (dddmm.mmmmmm)	0-180

Table 5.25: GGA Message Structure (continued)

Parameters	Description	Range
c2	Direction of longitude E = East, W= West	E or W
d1	Position type 1. Autonomous position 2. RTCM differential corrected position or CPD float position 9. Position computed using almanac information	1, 2, 9
d2	Number of GPS satellites being used in the position computation	0-8
f1	Horizontal dilution of precision (HDOP)	0 - 99.9
f2	Altitude in meters above the reference ellipsoid. For 2-D position computation, this item contains the user entered altitude used to compute the position computation.	-30000.00 to 30000.00
M	Altitude units M = meters	M
f3	Geoidal separation in meters	±999.99
M	Geoidal separation units M = meters	M
d3	Age of differential corrections (seconds)	0-999 (RTCM mode)
d4	Base station ID (RTCM only)	0-1023
cc	checksum	

Example: Query: \$PASHQ,GGA <enter>

Typical response (Table 5.26):

\$GPGGA,015454.00,3723.285132,N,12202.238512,W,2,4,03.8,00012.12
3,M,-032.121,M,014,0000*75

Table 5.26: Typical GGA Message

Item	Significance
\$GPGGA	Header
015454.00	UTC time
3723.285132	Latitude (ddmm.mmmmmm)
N	North Latitude
12202.238512	Longitude (dddmm.mmmmmm)
W	West longitude
2	RTCM differential position

Table 5.26: Typical GGA Message (continued)

Item	Significance
4	Number of satellites used in position
3.8	HDOP
00012.123	Altitude
M	Units of altitude (M = meters)
-032.121	Geoidal separation
M	Units of geoidal separation (M=meters)
14	Age of correction
0000	Base station ID
*75	checksum

GLL: Latitude/Longitude Message

\$PASHS,NME,GLL

This command enables/disables the latitude/longitude response message. The structure is

`$PASHS,NME,GLL,x,s,d`

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable GLL message on port A

`$PASHS,NME,GLL,A,ON <enter>`

\$PASHQ,GLL

The associated query message is `$PASHQ,GLL,x` where x is the optional output serial port. If port is not specified, the current port is used. If no position is being computed, an empty message is output.

Example: Display GLL message on current port:

`$PASHQ,GLL <enter>`

\$GPGLL

The response message is in the form:

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

where the fields are as defined in Table 5.27.

Table 5.27: GLL Message Structure

Parameters	Description	Range
m1	Position latitude in degrees and decimal minutes (ddmm.mmmmmm)	0 - 90°
c1	Direction of latitude N = North, S = South	'N' / 'S'
m2	Position longitude in degrees and decimal minutes (dddmm.mmmmmm)	0 - 180°
c2	Direction of longitude W = West, E = East	'W' / 'E'
m3	UTC Time of position in hours, minutes, and seconds (hhmmss.ss)	00-235959.50
c3	Status, A: valid, V: invalid	'A' / 'V'
*cc	Checksum	

Example: Query: \$PASHQ,GLL <enter>

Typical response:

\$GPGLL,3722.414292,N,12159.852825,W,202556.00,A*12

Table 5.28 describes each item in a typical GLL response message.

Table 5.28: Typical GLL Response Message

Item	Significance
\$GPGLL	Header
3722.414292	Latitude
N	North Latitude
12159.852825	Longitude
W	West Longitude
202556.00	UTC time of position
A	Status valid
*12	checksum

GSA: DOP and Active Satellite Messages

\$PASHS,NME,GSA

This command enables/disables the DOP and active satellite message to be sent out to serial port x. The structure is

\$PASHS,NME,GSA,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable GSA message on port A

\$PASHS,NME,GSA,A,ON <enter>

\$PASHQ,GSA

The associated query message is \$PASHQ,GSA,x where x is the optional output serial port.

Example: Display GSA message on the current port.

\$PASHQ,GSA <enter>

\$GPGSA

The response message is in the form (Table 5.29):

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

Table 5.29: GSA Message Structure

Parameters	Description	Range
c1	Mode: M: manual, A: automatic	'M' / 'A'
d1	Mode: 1: fix not available, 2: 2D, 3: 3D	1 -3
d2 - d13	Satellites used in solution (null for unused channel)	1 -32
f1	PDOP	0 - 9.9
f2	HDOP	0 - 9.9
f3	VDOP	0 - 9.9
*cc	Checksum	

Example:

Query: \$PASHQ,GSA <enter>

Typical response (Table 5.30):

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

Table 5.30: Typical GSA Message

Item	Significance
\$GPGSA	Header
M	Manual mode
3	3D mode
empty field	Satellite in channel 1
02	Satellite in channel 2
empty field	Satellite in channel 3
04	Satellite in channel 4
27	Satellite in channel 5
26	Satellite in channel 6
07	Satellite in channel 7
empty field	Satellite in channel 8
empty field	Satellite in channel 9
empty field	Satellite in channel 10
empty field	Satellite in channel 11
empty field	Satellite in channel 12
3.2	PDOP
1.4	HDOP
2.9	VDOP
*38	checksum

GSV: Satellites in View Message

\$PASHS,NME,GSV

This command enables/disables the satellites-in-view message on the serial port. The structure is

\$PASHS,NME,GSV,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Output GSV message on port A
 \$PASHS,NME,GSV,A,ON <enter>

\$PASHQ,GSV

The associated query message is \$PASHQ,GSV,x where x is the optional output serial port.

Example: Query the GSA message on port A.
 \$PASHQ,GSV,A <enter>

\$GPGSV

The response message is in the form:

\$GPGSV,d1,d2,d3,n(d4,d5,d6,f1)*cc

where the fields are as described in Table 5.31.

Table 5.31: GSV Message Structure

Field	Description	Range
d1	Total number of messages	1-3
d2	Message number	1-3
d3	Total number of satellites in view	1-12
d4	Satellite PRN	1-32
d5	Elevation in degrees	0-90
d6	Azimuth in degrees	0-359
f1	SNR in DB-Hz	30.0-60.0
*cc	checksum	

Example:

Query: \$PASHQ,GSV <enter>

Typical response:

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

where each item is as described in Table 5.32.

Table 5.32: Typical GSV Message

Item	Significance
2	Total number of messages 1..3
1	message number 1..3
8	number of SVs in view 1..12
16	PRN of first satellite 1..32
23	elevation of first satellite 0..90
293	azimuth of first satellite 0...351
50.3	signal-to-noise of first satellite
19	PRN of second satellite
63	elevation of second satellite
050	azimuth of second satellite
52.1	signal-to-noise of second satellite
28	PRN of third satellite
11	elevation of third satellite
038	azimuth of third satellite
51.5	signal-to-noise of third satellite
29	PRN of fourth satellite
14	elevation of fourth satellite
145	azimuth of fourth satellite
50.9	signal-to-noise of fourth satellite
78	message checksum in hexadecimal

MSG: Base Station Message

\$PASHS,NME,MSG

This command enables/disables the message containing RTCM reference (base) station message types 1, 3, 9, and 16. The structure is

\$PASHS,NME,MSG,x,s,d

where x is the output port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.



Unless the unit is receiving differential corrections, this command is ignored.

Example: Enable MSG on port A

\$PASHS,NME,MSG,A,ON <enter>

\$PASHQ,MSG,x

The associated query message is \$PASHQ,MSG,x where x is the optional output serial port.

Example: \$PASHQ,MSG,A <enter>

\$GPMSG

The response message varies depending upon the message.

RTCM Message

Message Type 1 format:

\$GPMSG,d1,d2,f1,d3,d4,d5,m1,n(d6,d7,f2,f3,d8)*cc

Message Type 3 format:

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

Message Type 9 format:

\$GPMSG,d1,d2,f1,d3,d4,d5,m1,n(d6,d7,f2,f3,d8)*cc

Message Type 16 format:

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

Table 5.33 lists the common fields of message Types 1, 3, 9, and 16

Table 5.33: Common Fields of Type 1, 3, 9, and 16

Parameters	Description	Range
d1	RTCM message type	1,3,9,16
d2	Station Identifier	0 - 1023
f1	Z count	0 - 9999.9
d3	Sequence number	0 - 9
d4	Station health	0 - 7
d5	Total number of characters after the time item	0 - 999
m1	Current GPS time of position fix (hhmmss)	00-235959

Table 5.34 lists the remaining fields for message Type 1 and 9.

Table 5.34: Remainder for Types 1 and 9

Range	Description	Range
d6	User differential range error (UDRE)	0-9
d7	Satellite PRN number	1-32
f2	Pseudo range correction (PRC) in meters	±9999.99
f3	Range rate correction (RRC) in meters/sec	±9.999
d8	Issue of data (IODE)	0-999
*cc	checksum	

Table 5.35 lists the remaining fields for message Type 3.

Table 5.35: Remainder for Type 3

Range	Description	Range
f2	Station X component	±9999999.99
f3	Station Y component	±9999999.99
f4	Station Z component	±9999999.99
*cc	checksum	

Table 5.36 lists the remaining fields for message Type 16.

Table 5.36: Remainder for Type 16

Range	Description	Range
s1	text message sent from base receiver	Up to 80 alpha-numeric characters
*cc	checksum	

Examples:

```
$GPMSG,01,0000,2220.0,1,0,127,003702,2,12,-0081.30,  
+0.026,235,2,13,0022.86,+0.006, 106,2,26,-0053.42,-0.070,  
155,2,02,+0003.56,+0.040,120,2,27,+0047.42,-0.004,145*cc
```

```
$GPMSG,03,0000,1200.0,7,0,038,231958,-2691561.37,-4301271.02,  
+3851650.89*cc
```

```
$GPMSG,16,0000,1209.6,5,0,036,232008,THIS IS A MESSAGE SENT  
FROM BASE*cc
```

PER: Set NMEA Send Interval

\$PASHS,NME,PER,d

Sets send interval of the NMEA response messages in seconds, where d is a value between 1 and 999.

Example: Output NMEA messages every 5 seconds:

```
$PASHS,NME,PER,5 <enter>
```



Longer intervals conserve power.

If a \$PASHS,NME,PER command is sent after individual NMEA message output periods were set, the previous individual message periods are superseded by the more recent NME,PER value.

POS: Position Message

\$PASHS,NME,POS

Enable/disable NMEA position response message on specified port. The structure is

```
$PASHS,NME,POS,x,s,d
```

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable position message on port A

```
$PASHS,NME,POS,A,ON <enter>
```

\$PASHQ,POS

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

Example: Send POS message to current port

```
$PASHQ,POS <enter>
```

\$PASHR,POS

The 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

where the fields are as defined in Table 5.37.

Table 5.37: POS Message Structure

Parameters	Description	Range
d1	Raw/differential position 0: Raw; position is not differentially corrected 1: Position is differentially corrected with RTCM code 2: Position is differentially corrected with CPD float solution 3: Position is CPD fixed solution	0 through 3
d2	Number of SVs used in position fix	3 through 12
m1	Current UTC time of position fix (hhmmss.ss)	00 through 235959.50
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmm)	0 through 90
c1	Latitude sector, N = North, S = South	N or S
m3	Longitude component of position in degrees and decimal minutes (dddmm.mmmmm)	0 through 180
c2	Longitude sector E = East, W = West	W or E
f1	Altitude above WGS-84 reference ellipsoid in meters. For 2-D position computation this item contains the altitude held fixed.	-30000.000 through 30000.000
f2	Unit ID (firmware HD00 or later)	0 to 4 character string
f3	True track/course over ground in degrees	0 through 359.9
f4	Speed over ground in kilometers per hour	0 through 999.9
f5	Vertical velocity in meters per second	-999.9 through +999.9
f6	PDOP - position dilution of precision,	0 through 99.9
f7	HDOP - horizontal dilution of precision.	0 through 99.9
f8	VDOP - vertical dilution of precision.	0 through 99.9
f9	TDOP - time dilution of precision.	0 through 99.9
s	Firmware version ID	4 char string
*cc	checksum	

Example:

Query: \$PASHQ,POS

Typical response:

\$PASHR,POS,0,06,214619.50,3722.385158,N,12159.833768,W,00043.1
10,1234,331.0,000.7,000.0,02.7,01.2,02.4,01.6,HC00*6C

Table 5.38 describes each item in a typical POS message.

Table 5.38: Typical POS Message

Item	Significance
\$PASHR,POS	Header
0	Raw Position
06	Number of SVs used in position fix
214619.50	UTC time of position fix
3722.385158	Latitude
N	North Latitude
12159.833768	Longitude
W	West Longitude
00043.110	Altitude above ellipsoid (meters)
1234	Unit ID
331.0	Course over ground (degrees)
000.7	Speed over ground (km/hr)
000.0	Vertical velocity (m/sec)
02.7	PDOP
01.2	HDOP
02.4	VDOP
01.6	TDOP
HC00	Firmware version ID
*6C	checksum

RMC: Recommended Minimum Course

\$PASHS,NME,RMC

Enables or disables NMEA recommended minimum course on specified port. The command structure is

```
$PASHS,NME,RMC,c,s,d <enter>
```

where c is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable RMC message on port A at the PER period:

```
$PASHS,NME,RMC,A,ON <enter>
```

Example: Enable RMC message on port A at 2-second period:

```
$PASHS,NME,RMC,A,ON,2 <enter>
```

\$PASHQ,RMC

The corresponding query command is \$PASHQ,RMC,x where x is the optional output serial port. If no position is being computed, an empty message is output.

Example: Send RMC message to port A:

```
$PASHQ,RMC,A <enter>
```

\$GPRMC

The RMC response message is in the form:

```
$GPRMC,f1,c2,f3,c4,f5,c6,f7,f8,s9,f10,c11*cc
```

where the parameters are as defined in Table 5.39.

Table 5.39: GPRMC Parameters

Parameter	Description	Range
f1	UTC time of the GGA fix associated with this sentence (hhmmss.ss)	000000.00...235959.00
c2	Status	A = data valid V = navigation receiver warning
f3	Latitude (ddmm.mmmm)	0000.0000...8959.99999
c4	Latitude direction	N = North S = South
f5	Longitude (dddmm.mmmm)	00000.0000...17959.9999
c6	Longitude direction	E = East W = West

Table 5.39: GPRMC Parameters (continued)

Parameter	Description	Range
f7	Speed over ground, knots	000.0...999.9
f8	Course over ground, degrees true	000.0...359.9
s9	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	Hexadecimal checksum computed by exclusive-ORing all of the bytes in the message between, but not including, the \$ and the *. The result is *hh where h is a hex character 0 - 9 or A-F.	0 through 9 or A through F

A typical response message is shown below and described in Table 5.40:

```
$GPRMC,174820.20,A,3759.2459,N,12159.8404,W,518.36,123.12,061697,13.50,W
*cc
```

Table 5.40: Typical RMC Response Message

Item	Significance
\$GPRMC	Header
174820.20	UTC time of GGA fix
A	Status valid
3759.2459	Latitude
N	North
12159.8404	Longitude
W	West
518.36	Speed over ground, knots
123.12	Course over ground, degrees true
061697	Date
13.50	Magnetic variation, degrees
W	West (adds to true course)
*cc	Checksum

SAT: Satellite Status Query

\$PASHS,NME,SAT

This command enables/disables the satellite status message to the specified port. The command structure is

\$PASHS,NME,SAT,x,s,d

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable SAT message on port A

\$PASHS,NME,SAT,A,ON <enter>

\$PASHQ,SAT

The associated query message is \$PASHQ,SAT,x where x is the optional output serial port.

Example: Send SAT message to port A

\$PASHQ,SAT,A <enter>

\$PASHR,SAT

The response message is in the form:

\$PASHR,SAT,d1,n(d2,d3,d4,f1,c)*cc

where the parameters are as defined in Table 5.41.

Table 5.41: SAT Message Structure

Parameter	Description	Range
d1	Number of SVs locked	1 to 2
d2	SV PRN number,	1 to- 32
d3	SV azimuth angle in degrees	0 to 359
d4	SV elevation angle in degrees	0 to 90
f1	SV signal/noise ratio in dB Hz	30.0 to 60.0
c	SV used in position computation U = used, - = not used	U or -
*cc	checksum	

Example:

Query: \$PASHQ,SAT

Typical response:

\$PASHR,SAT,04,03,103,56,50.5,U,23,225,61,52.4,U,16,045,02,51.4,U,40,160,46,53.6,U*6E

Table 5.42 describes each item in a typical SAT response message.

Table 5.42: Typical SAT Message

Item	Significance
\$PASHR,SAT	Header
04	Number of SVs locked
03	PRN number of the first SV
103	Azimuth of the first SV in degrees
56	Elevation of the first SV in degrees
50.5	Signal strength of the first SV
U	SV used in position computation
23	PRN number of the second SV
225	Azimuth of the second SV in degrees
61	Elevation of the second SV in degrees
52.4	Signal strength of the second SV
U	SV used in position computation
16	PRN number of the third SV
045	Azimuth of the third SV in degrees
02	Elevation of the third SV in degrees
51.4	Signal Strength of the third SV
U	SV used in position computation
40	PRN number of fourth SV
160	Azimuth of fourth SV in degrees
46	Elevation of fourth SV in degrees
53.6	Signal strength of fourth SV
U	SV used in position computation
6E	Message checksum in hexadecimal

VTG: Velocity/Course Message

\$PASHS,NME,VTG

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

\$PASHS,NME,VTG,x,s,d

where x is port A, s is ON or OFF, and d is the (optional) reporting interval from 1 to 999 seconds. If no position is being computed, an empty message is output.

Example: Enable VTG message on port A, reporting interval 5 seconds

\$PASHS,NME,VTG,A,ON,5 <enter>

\$PASHQ,VTG

The associated query message is \$PASHQ,VTG,x where x is the optional output serial port. If no position is being computed, an empty message is output.

Example: Send VTG message to port A

\$PASHQ,VTG,A <enter>

\$GPVTG

The response message is in the form:

\$GPVTG,f1,T,f2,M,f3,N,f4,K*cc

where the fields are as described in Table 5.43.

Table 5.43: VTG Message Structure

Parameter	Description	Range
f1	COG (Course Over Ground) true north	0 - 359.99
T	COG orientation (T = true north)	T
f2	COG magnetic north	0 - 359.99
M	COG orientation (M = magnetic north)	M
f3	SOG (Speed Over Ground) and N for knots	0 - 999.99
N	SOG units (N = knots)	N
f4	SOG (Speed Over Ground)	0 - 999.99
K	SOG units (K = Km/hr)	K
*cc	checksum	

Example:

Query: \$PASHQ,VTG <enter>

Typical response:

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

Table 5.44 describes each item in a typical VTG message.

Table 5.44: Typical VTG Message

Item	Significance
\$GPVTG	Header
004.58	Course over ground (COG) oriented to true north
T	True north orientation
349.17	Course over ground (COG) oriented to magnetic north
M	Magnetic north orientation
000.87	Speed over ground (SOG) in knots
N	SOG units (N=knots)
001.61	Speed over ground (SOG) in km/hr
K	SOG units (K=km/hr)
*46	checksum

ZDA: Time and Date

\$PASHS,NME,ZDA

Enable/disable NMEA time and date message. The command structure is

\$PASHS,NME,ZDA,x,s,d <enter>

where x is port A, s is ON or OFF, and d is the optional reporting interval from 1 to 999 seconds.

Example: Enable ZDA message on port A at 10-second interval:

\$PASHS,NME,ZDA,A,10 <enter>

\$PASHQ,ZDA

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

Example: Send ZDA message to port A:

\$PASHQ,ZDA,A <enter>

\$GPZDA

The NMEA time and date response message is in the form:

\$GPZDA,f1,d1,d2,d3,d4,d5*cc

Table 5.45 defines each field of the \$GPZDA message structure.

Table 5.45: GPZDA Time and Date Message Structure

Field	Description	Range
f1	UTC time	000000.00 through 235959.99
d1	Current day	01 through 31
d2	Current month	01 through 12
d3	Current year	0000 through 9999
d4	Local zone offset from UTC time (hours)	-13 through 13
d5	Local zone offset from UTC time (minutes)	
*cc	Checksum	

Example: Query: \$PASHQ,ZDA,A <enter>

Typical response: \$GPZDA,132123.00,10,03,1996,07,00*ss

Table 5.46 describes each item in a typical \$GPZDA response message.

Table 5.46: Typical GPZDA Response Message

Item	Description
123123.00	UTC time
10	Current day
03	Current month
1996	Current year
07	Local time zone offset (hours portion)
00	Local time zone offset (minutes portion)
*22	Checksum

RTCM Commands and Responses

The RTCM commands allow you to control and monitor RTCM real-time differential operations. For a more detailed discussion of RTCM differential, refer to the RTCM differential section of the Operations chapter.

Set Commands

All RTCM commands except one are set commands. Using the set commands, you can modify and enable a variety of differential parameters. If the set command is sent correctly, the receiver responds with the \$PASHR,ACK acknowledgment. If a parameter is out of range or the syntax is incorrect, then the receiver responds with a \$PASHR,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, while the command:

```
$PASHQ,RTC,A <enter>
```

will output an RTCM status message to port A.

Table 5.47 summarizes the RTCM commands.

Table 5.47: RTCM Commands

Function	Command	Description	Page
General parameters	\$PASHS,RTC,OFF	Disables differential mode	94
	\$PASHQ,RTC	Requests differential mode parameters and status	92
Remote parameters	\$PASHS,RTC,AUT	Turns auto differential mode on or off	94
	\$PASHS,RTC,MAX	Sets maximum age of RTCM differential corrections	94
	\$PASHS,RTC,REM	Sets receiver to operate as differential remote station	94

RTC: RTCM Status Query

\$PASHQ,RTC

Queries the RTCM differential status. The structure is

```
$PASHQ,RTC,x
```

where x is the optional output port (A is the only valid value for port).

The return message is a free-form response format. A typical response message is shown below.

```

STATUS:
SYNC:*          TYPE:00          STID:0000      STHE:0
AGE:±000       QA:100.00%       OFFSET:00
SETUP:
MODE:OFF       PORT:B          AUT:N
MAX:0015
    
```

where the parameters are as defined in Table 5.48.

Table 5.48: RTC Parameters

Parameter	Description	Range
STATUS		
SYNC	Sync to last received RTCM message between receiver (remote) and base stations.	* = in sync
TYPE	RTCM message type being received.	1, 3, 9, 16
STID	Station ID received from the base station.	0...1023
STHE	Station health received from the base station.	0...7
AGE	Age of the received messages (seconds)	0...999
QA	Communication quality factor between base and remote	0...100%
OFFSET	Number of bits from the beginning of RTCM byte (in case of bit slippage)	
SETUP		
MODE	RTCM mode	REM, OFF
PORT	Communication port	A, B
AUT	Automatic differential mode	Y, N
CODE	Code type used in differential	C/A
MAX	Maximum age, in seconds, required for a message to be used	0...3599
MSG	Displays message up to 90 characters from base station	

AUT: Set Auto Differential Mode

\$PASHS,RTC,AUT

Turns auto differential mode on or off. The structure is

```
$PASHS,RTC,AUT,c
```

where c is Y (or ON) or N (or OFF). When in auto-diff mode, the receiver generates uncorrected positions automatically if differential corrections are older than the maximum age, or are not available. Default is Y (ON).

Example: Turn auto differential mode off

```
$PASHS,RTC,AUT,N <enter>
```

MAX: Set RTCM Differential Data Age

\$PASHS,RTC,MAX

Set the maximum age in seconds of an RTCM differential correction above which it will not be used. The structure is

```
$PASHS,RTC,MAX,d
```

where d is any number between 1 and 1199. Default is 15.

Example: Set maximum age to 30 seconds

```
$PASHS,RTC,MAX,30 <enter>
```

OFF: Disable RTCM

\$PASHS,RTC,OFF

Disables base or remote differential mode.

Example: Turn RTCM off

```
$PASHS,RTC,OFF <enter>
```

REM: Enable Remote RTCM

\$PASHS,RTC,REM

Set the receiver to operate as an RTCM differential remote station. The structure is

```
$PASHS,RTC,REM,x
```

where x is port A or B for differential inputs.

Example: Set receiver as differential remote using port B for input of corrections.

```
$PASHS,RTC,REM,B <enter>
```

Reference

G8 Search Strategy & Position Algorithms

Satellite Selection

The G8 search manager tracks the eight satellites with the highest elevation. Only healthy satellites are tracked; unhealthy satellites are ignored. If fewer than eight satellites are available above the horizon, the remaining channels are drawn from a list of all GPS satellites. The list is maintained in ROM.

During cold start conditions, when satellite visibility information cannot be computed, the search manager selects satellites by drawing in turn from the ROM list. This satellite selection maximizes the probability of quickly selecting a visible satellite.

When satellite visibility is available for only a subset of the satellites (e.g. for several minutes after cold start), the search manager selects the eight satellites with the highest elevation with known visibility. If fewer than eight satellites are known to be visible, the remaining channels are assigned to satellites with unknown visibility by drawing from the ROM list used for cold start.

False Position Condition

If the receiver has been powered on for five minutes and no position has been computed, one channel of the receiver is dedicated to sequentially searching for satellites that are calculated to be below the horizon. If any of these satellites are locked the search manager resets and performs a cold start.

Once a position is obtained, the search manager ceases searching for satellites below the horizon. The strategy can be re-invoked only by cycling power or resetting the receiver.

The intent here is to ensure that the receiver will successfully acquire even if the last known position is invalid or if the real-time clock time is incorrect.

CAUTION

If the G8 has a valid Almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the \$PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Search Strategy

During normal operation conditions, the search strategy dedicates one channel to each satellite in the satellite assignment.

During startup and reacquisition conditions the search strategy dedicates seven or eight channels to a single satellite for searching. Satellites are searched for sequentially, cycling among the highest five satellites in the satellite selection. This strategy improves acquisition time when the clock uncertainty is very large.

Position Modes

The G8 may operate in either of two modes to return a position computation. The \$PASHS,PMD command, or equivalent, is used to select the mode.

3D Mode

3D mode is the standard mode of operation. In 3D mode, four satellites are required to be locked for the initial position fix. After the initial fix, however, there is no requirement for any particular number of satellites to be locked. Rather, G8 continues to operate by using whatever satellites are locked, propagating its internal solution and reporting the predicted position until PDOP exceeds PDOP mask. Latitude, longitude, altitude, and time are computed in this mode.

2D Mode

In 2D mode, the G8 calculates latitude, longitude, and time, and holds altitude constant. The value to use for altitude is determined by the \$PASHS,ALT and \$PASHS,FIX commands.

When FIX is set to 1, the 2D altitude is always the altitude entered via the \$PASHS,ALT command. However, when FIX is set to 0, the altitude is the most-recently-determined altitude, which may be either that entered via the \$PASHS,ALT command, or the altitude from the last computed 3D determination that passed the PDOP test.

The G8 requires at least three satellites to be locked for the initial 2D position fix. After the initial fix, however, there is no requirement for any particular number of satellites to be locked. Rather, G8 continues to operate by making use of whatever satellites are locked, propagating its internal solution and reporting the predicted position until HDOP exceeds HDOP mask.

Position Filtering and Prediction

The G8 firmware includes a position filtering and prediction algorithm (Kalman filter) that provides smooth and continuous positioning information under conditions such as city driving, where satellites are being constantly obscured. This capability

provides the highest availability and the fewest discontinuities (e.g. position jumps) consistent with stand-alone GPS accuracy.

The algorithm operates at a 1 Hz rate. In each cycle, the position and velocity estimates are updated based on previous position and velocity information and new GPS measurements, if available. The update accounts for the relative uncertainties associated with the predicted and measured data. The filter uses dynamics chosen by the user (\$PASHS,KFP,DYN command or equivalent), e.g. an automotive environment (limited acceleration, especially along the Z axis), and clock dynamics associated with a crystal oscillator. The filter has a cutoff so that no positions are output when the expected accuracy falls below an accuracy threshold set by the PDOP mask.

The algorithm makes use of GPS measurements even when too few satellites are locked to allow a new position to be computed.

A command is provided so that the G8 will operate optimally under differing dynamic conditions. The \$PASHS,KFP,DYN command selects position-algorithm parameters for pedestrian, automobile, aircraft, and ship applications. In any dynamics mode, the G8 produces a smooth position track rather than the best instantaneous location measurement of each individual epoch. The filter has been tuned for each expected dynamic environment, chiefly characterized by the maximum acceleration that can be expected, as listed in Table 6.1. The track reported will show some overshoot when these limits are exceeded. Extreme accelerations (perhaps several times the value shown in the table) may cause the reported position to deviate from the true position.

Table 6.1: Dynamics Parameters

Dynamics Mode	Expected Maximum Acceleration
Pedestrian	0.1 G
Automobile	0.5 G
Aircraft	10 G
Ship	0.1 G



To minimize the impact of the Kalman Filter, choose parameter setting 4:aircraft. If you choose this setting, we recommend setting PDOP to 12 using \$PASHS,PDP command.

Missile Technology Control Regime (MTCR)

Whenever the G8 has calculated a position and has determined that either the G8 altitude is greater than 60,000 feet (18,288 m), or the velocity is greater than 1,000 knots (514 m/sec), then the MTCR limits are considered to be exceeded. In either case, the G8 produces no valid position information.

Other G8 Operational Characteristics

Conversions

The G8 can perform the following conversions:

- Convert latitude and longitude rates to course over ground (COG) and speed over ground (SOG). In case of speeds below 1 m/s, the last known course is held.
- Convert course over ground from true bearing to magnetic bearing. This is computed from a table containing global magnetic variations.
- Convert altitude from height above WGS-84 ellipsoid to mean sea level, using a table containing a geoid undulation model

Self Test

Built In Test (BIT) algorithms determine the general health of the G8 memory and verify the integrity of information saved in backup RAM. Invalid data are not used.

Watchdog Timer

The G8 utilizes a watchdog timer to enable it to recover from firmware errors. In normal operation, the timer is regularly reset. If an irreversible firmware error occurs, the timer will expire and the receiver automatically restarts.

System Parameter Settings

The G8 can save all current parameter settings using a \$PASHS command such that during a power interruption these settings will be utilized when power is restored. A \$PASHS command can also be used to revert to default settings.

Sleep Mode

The G8 can be set via software command to enter a sleep mode where less power is consumed. The sleep mode has the following characteristics:

- The \$PASH,PWR command places the G8 in a sleep state.
- Activity on the RS-232 port returns the G8 to the power-on state.

Long-Term Operation

The G8 is capable of long-term non-stop operation. None of the following events will affect operation or cause any change in performance during continuous operation for

one week:

- Week rollover (weekly)
- Week 1023 rollover
- Year 2000 rollover
- Leap second change

Datum Support

The standard datum supported is WGS-84. Other datums (user-defined) can be loaded using the \$PASHS,UDD command described on page 64.

Detailed G8 Performance Characteristics

Accuracy

G8 accuracy is defined in terms of horizontal 95% and circular error probable (CEP) as listed in Table 6.2. All measurements assume SA is on.

Table 6.2: Accuracy Specifications

Mode	G8	Test Conditions
Autonomous CEP (50%)	40m	Autonomous Guidelines:
Autonomous horizontal 95%	100m	Precision antenna
Autonomous vertical 95%	156m	10° elevation angle
Autonomous speed	0.2 km/h	
Autonomous directional at 40 km/h	0.2 degree	
DGPS CEP (50%)	3m	DGPS Guidelines
DGPS horizontal 95%	5m	Magnetic mount antenna
DGPS vertical (50%)	6.5m	10° elevation angle
DGPS speed	0.1 km/h	Test horz. position per note 4 below
DGPS directional at 40 km/h	0.1°	Test speed and direction per note 3 below

ACCURACY NOTES:

1. Horizontal 95% accuracy definition: The circle, centered at the known antenna position, that contains 95% of the points in a horizontal scatter plot.

2. CEP accuracy definition: The circle, centered at the known antenna position, that contains 50% of the points in a horizontal scatter plot. This is the same as typical accuracy, since half the positions are more accurate than this, half are less accurate.

3. Speed and Direction: Measured with simulator, without S/A, speed of 40 km/h.

4. Measure DGPS accuracy using an Ashtech G12 reference station with Marine/Survey antenna on a short baseline (<10km), with a rate of differential corrections set at once per second at 300bps. Disregard wireless communication latency by utilizing hardwire connection.

5. Accuracy measurement assumes the antenna has a clear view of the sky and uses the highest satellites above a 10° elevation, with HDOP ≤4, PDOP ≤6.

TTFF (Time To First Fix)

TTFF (Time To First Fix) is defined as the time from when the receiver is turned on to the time that three or more satellites are tracked and a valid position is calculated. Performance is as specified in Table 6.3.

Table 6.3: TTFF and Reacquisition Performance

Mode	Typical Example	Approximate Position (w/in several 100 km)	Valid Almanac	Valid Ephemeris (2-4 hours old)	Valid Time (w/in 10 min)	Average Time in Seconds (50th percentile)
Cold start - TTFF	Fresh out of the box	no	no	no	no	120
Warm start TTFF	Receiver off overnight	yes	yes	no	yes	45
Hot start-TTFF	Receiver off at lunch	yes	yes	yes	yes	10

TTFF NOTES:

For a receiver that starts with an estimated position which is wildly incorrect (the estimated position is the diametrically-opposite point on the earth) the TTFF time is approximately 25 minutes in the warm start and hot start cases.

Four satellites (3D) are required for cold start in the default configuration. The receiver may be commanded to start in a 3 satellite mode (2D).

CAUTION

If the G8 has a valid almanac and ephemeris, but has retained a last known position more than 1000 km from its actual location, the receiver should be reset using the \$PASHS,INI command to minimize start time. If not reset, this condition may cause a long delay in the start time of the receiver.

Reacquisition Times

Reacquisition is defined as the time between signal blockage from all satellites and the time that three or more satellites are tracked and a valid position is calculated. Performance is as specified in Table 6.4.

Table 6.4: Reacquisition Times

Mode	Description	Typical Example	Average (50th Percentile)
Reacquisition (<10 sec blockage)	Temporary blockage	Under over-pass	< 1 sec
Reacquisition (<1 min blockage)	Temporary blockage	In short tunnel	< 3 sec
Reacquisition (10 min blockage)	Temporary blockage	In parking garage	< 10 sec

Default Operational Parameters

The G8 has the default operational parameters listed in Table 6.5. These parameters can be changed using the indicated set command; detailed explanations of the set commands are presented in chapter 5.

Table 6.5: Default Parameters

Item	Default Value	Set Command	Page
Latitude	None	\$PASHS,POS	58
Longitude	None	\$PASHS,POS	58
Altitude	None	\$PASHS,POS	58
Navigation Position Mode	4	\$PASHS,PMD	57
2D Altitude	0	\$PASHS,ALT	51
HDOP Mask	4	\$PASHS,HDP	52
PDOP Mask	6	\$PASHS,PDP	55
Elevation Mask	5 degrees above horizon	\$PASHS,PEM	55
Datum	WGS-84	\$PASHS,DTM	51
Satellites inhibited	none	\$PASHS,USE	65
DGPS positioning	OFF	\$PASHS,RTC	92
Auto Differential Mode	Enabled	\$PASHS,RTC,AUT	94

Table 6.5: Default Parameters (continued)

Item	Default Value	Set Command	Page
Differential Data Age Selection	15 seconds	\$PASHS,RTC,MAX	94
Serial port A speed	4 (corresponds to 4800 bps)	\$PASHS,SPD	63
Serial port B speed	4 (corresponds to 4800 bps)	\$PASHS,SPD	63
Altitude Position Fix Mode	0	\$PASHS,FIX	52
Kalman filter dynamics mode	3	\$PASHS,KFP,DYN	54
Timezone offset	00:00	\$PASHS,LTZ	54
Enable ALM msg to port	A, OFF	\$PASHS,NME,ALM	70
Enable GGA msg to port	A, ON (HD00 or later)	\$PASHS,NME,GGA	72
Enable GLL msg to port	A, OFF	\$PASHS,NME,GLL	74
Enable GSA msg to port	A, OFF	\$PASHS,NME,GSA	76
Enable GSV msg to port	A, OFF	\$PASHS,NME,GSV	77
Set RMC	A, OFF	\$PASHS,NME,RMC	85
Enable VTG msg to port	A, ON (HD00 or later)	\$PASHS,NME,VTG	89
Enable ZDA msg to port	A, OFF	\$PASHS,NME,ZDA	90
Enable MSG msg to port	A, OFF	\$PASHS,NME,MSG	79
Enable POS msg to port	A, OFF	\$PASHS,NME,POS	82
Enable UKO msg to port	A, OFF	n/a	n/a
Enable SAT msg to port	A, OFF	\$PASHS,NME,SAT	87
Enable XMG msg to port	A, OFF	n/a	n/a
Receiver update interval	1 second	\$PASHS,NME,PER	82

Troubleshooting

Listed below are some tests and fixes for common problems that you may encounter when installing and configuring the G8 GPS OEM board.

TTL-to-RS-232 Conversion

If you are using a TTL-to-RS-232 converter for your G8 OEM board, verify that the level conversion is correct (i.e., 5 volts to 12 volts), as described in “Communication Port Setup” on page 14.

Port Setup

Verify the port default setup of 8 bits, no parity, 1 stop bit, 4800 baud as described in “Communication Port Setup” on page 14. This setup must be consistent with the communication parameters used by your computer or other processing device.

RTS/CTS

RTS/CTS are connected together in the G8 Evaluator, but not in the G8 OEM board. If you do not have the G8 Evaluator, you will have to manage the RTS/CTS required by your computer or other processing device, as described in “RTS/CTS Considerations” on page 15.

Factory Defaults

To clear unknown parameters, you can reset to factory defaults using the \$PASHS,INI command, as described on page 53.

Saving Parameters

If you are losing your user-defined parameters during a power cycle, be sure to save them prior to the power cycle by using the \$PASHS,SAV,Y command, as described on page 62. Also, for parameters to be saved through a power cycle, there must be appropriate battery backup power provided at pin 3 (V_BACK).

Logging Data

Ashtech does not recommend logging data with unique PC application programs other than Ashtech’s Evaluate program.

Glossary

Aerotriangulation (phototriangulation)

A complex process vital to aerial

Photogrammetry that involves extending vertical and/or horizontal control so that the measurements of angles and/or distances on overlapping photographs are related to a spatial solution using the perspective principles of the photographs. Aerotriangulation consists of mathematically extending the vectors/angles of the triangular pattern of known reference points on or near the designated photo-block terrain upward through a rectangle representing the area of the photo-block (as seen by the camera's optical center) in such a way that the three-point terrain triangle and the camera's eye three-point triangle (within the photographic frame) are analogous.

AFT

After

AGE

Age of Data

ALM

See **Almanac**

Almanac

A set of parameters used by a GPS receiver to predict the approximate locations of all GPS satellites and the expected satellite clock offsets. Each GPS satellite contains and transmits the almanac data for all GPS satellites (See **Ellipsoid**).

ALT

Altitude

Ambiguity

The initial bias in a carrier-phase observation of

an arbitrary number of carrier cycles; the uncertainty of the number of carrier cycles a receiver is attempting to count. If wavelength is known, the distance to a satellite can be computed once the number of cycles is established via carrier-phase processing.

AMI

ATM Management Interface

ANT

Antenna

Antenna

A variety of GPS antennas ranging from simpler microstrip devices to complex choke ring antennas that mitigate the effects of multipath scattering.

Anti-Spoofing (AS)

The process of encrypting the P-Code modulation sequence so the code cannot be replicated by hostile forces. When encrypted, the **P-Code** is referred to as the **Y-Code**.

ASCII

American Standard Code for Information Interchange. A set of characters (letters, numbers, symbols) used to display and transfer digital data in human-readable format.

Atomic clock

A clock whose frequency is maintained using electromagnetic waves that are emitted or absorbed in the transition of atomic particles between energy states. The frequency of an atomic transition is very precise, resulting in very stable clocks. A cesium clock has an error of about one second in one million years. For redundancy purposes, GPS satellites carry multiple atomic clocks. GPS satellites have used

rubidium clocks as well as cesium clocks. The GPS Master Control Station uses cesium clocks and a hydrogen master clock.

Argument of latitude

The sum of the true anomaly and the argument of perigee.

Argument of perigee

The angle or arc from the ascending node to the closest approach of the orbiting body to the focus or perigee, as measured at the focus of an elliptical orbit, in the orbital plane in the direction of motion of the orbiting body.

Ascending node

The point at which an object's orbit crosses the reference plane (e.g., equatorial plane) from south to north.

AZM

See **AZM**

Bandwidth

A measure of the information-carrying capacity of a signal expressed as the width of the spectrum of that signal (frequency domain representation) in Hertz.

Baseline

The measured distance between two receivers or two antennas

Bias

See **Integer bias terms**

BIN

Binary Index (file)

C/A

Coarse Acquisition

C/A code

A sequence of 1023 bits (0 or 1) that repeats every millisecond. Each satellite broadcasts a unique 1023-bit sequence that allows a receiver to distinguish between various satellites. The C/

A-Code modulates only the L1 carrier frequency on GPS satellites. GPS satellite navigation signals are broadcast on two L-band frequencies, L1 is 1575.42 MHz, and L2 is 1227.6 MHz.

Carrier phase

The phase of either the L1 or L2 carrier of a GPS signal, measured by a receiver while locked-on to the signal (also known as integrated Doppler).

CEP

Circular error probable. That vertical circle through the elevated celestial pole, It also passes through the other celestial pole, the astronomical zenith, and the nadir..

Channel

Refers to the hardware in a receiver that allows the receiver to detect, lock-on and continuously track the signal from a single satellite. The more receiver channels available, the greater number of satellite signals a receiver can simultaneously lock-on and track.

Chip

The length of time to transmit either a zero or a one in a binary pulse code..

Chip rate

Number of chips per second (e.g., C/A code = 1.023 MHz).

Circular Error Probable

The radius of a circle, centered at the true location, within which 50% of position solutions fall. CEP is used for horizontal accuracy..

Clock offset

The difference in time between GPS time and a satellite clock or a sensor clock (less accurate). radios use the same frequency both with each one having a separate and unique code. GPS uses CDMA techniques with Gold's code from their unique cross-correlation properties.

COG

Course Over Ground

Constellation

Refers to the collection of orbiting GPS satellites. The GPS constellation consists of 24 satellites in 12-hour circular orbits at an altitude of 20,200 kilometers. In the nominal constellation, four satellites are spaced in each of six orbital planes. The constellation was selected to provoke a very high probability of satellite coverage even in the event of satellite outages..

CTD

Course To Destination

Cycle slip

A loss of count of carrier cycles as they are being measured by a GPS receiver. Loss of signal, ionospheric interference and other forms of interference cause cycle slips to occur.

DGPS

Differential Global Positioning System

Differential GPS (DGPS)

A technique whereby data from a receiver at a known location is used to correct the data from a receiver at an unknown location. Differential corrections can be applied in real-time or by post-processing. Since most of the errors in GPS are common to users in a wide area, the DGPS-corrected solution is significantly more accurate than a normal SPS solution.

Differential processing

GPS measurements can be differenced between receivers, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS measurements is to take differences between receivers (single difference), then between satellites (double difference), then between measurement epochs (triple difference). A

single-difference measurement between receivers is the instantaneous difference in phase of the signal from the same satellite, measured by two receivers simultaneously. A double-difference measurement is the difference for a chosen reference satellite. A triple-difference measurement is the difference between a double difference at one epoch and the same double difference at the previous epoch.

Differential (relative) positioning

Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Dynamic differential positioning is a real-time calibration technique achieved by sending corrections to the roving user from one or more reference stations. Static differential GPS involves determining baseline vectors between pairs of receivers.

Dilution of Precision (DOP)

A measure of the receiver-satellite(s) geometry. DOP relates the statistical accuracy of the GPS measurements to the statistical accuracy of the solution. Geometric Dilution of Precision (GDOP) is composed of Time Dilution of Precision (TDOP); and Position Dilution of Precision (PDOP), which are composed of Horizontal Dilution of Precision (HDOP); and Vertical Dilution of Precision (VDOP).

DOP

Dilution of Precision

Doppler aiding

The use of Doppler carrier-phase measurements to smooth code-phase position measurements.

Doppler shift

An apparent change in signal frequency which occurs as the transmitter and receiver move toward or away from one another.

Double difference

The arithmetic differencing of carrier phases

measured simultaneously by a pair of receivers tracking the same pair of satellites. Single differences are obtained by each receiver from each satellite; these differences are then differenced in turn, which essentially deletes all satellite and receiver clock errors.

DTD

Distance to Destination

Dynamic positioning

Determination of a timed series of sets of coordinates for a moving receiver, each set of coordinates being determined from a single data sample, and usually computed in real-time.

Earth Centered, Earth Fixed (ECEF)

A cartesian coordinate system centered at the earth's center of mass. The Z-axis is aligned with the earth's mean spin axis. The X-axis is aligned with the zero meridian. The Y-axis is 90 degrees west of the X-axis, forming a right-handed coordinate system.

ellipse to its focus to the semimajor axis.

$e = (1 - b^2/a^2)^{-1/2}$ where a and b are the semimajor and semiminor axes of the ellipse.

EDOP

Elevation Dilution of Precision

ELEV

Elevation

Elevation

Height above mean sea level. Vertical distance above the geoid.

Elevation mask

An adjustable feature of GPS receivers that specifies that a satellite must be at least a specified number of degrees above the horizon before the signals from the satellite are to be used. Satellites at low elevation angles (five degrees or less) have lower signal strengths and are more prone to loss of lock thus causing noisy solutions.

Elevation mask angle

That angle below which it is not advisable to track satellites. Normally set to 15 degrees to avoid interference problems caused by buildings and trees and multipath reflections.

Ellipsoid

In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid; the length of the semimajor axis, a, and the flattening, $f = (a - b)/a$, where b is the length of the semiminor axis. Prolate and triaxial ellipsoids are invariably described as such.

Ellipsoid height

The measure of vertical distance above the ellipsoid. Not the same as elevation above sea level. GPS receiver output position fix height in the WGS-84 datum.

Ephemeris

A set of parameters used by a GPS receiver to predict the location of a single GPS satellite and its clock behavior. Each GPS satellite contains and transmits ephemeris data for its own orbit and clock. Ephemeris data is more accurate than the almanac data but is applicable over a short time frame (four to six hours). Ephemeris data is transmitted by the satellite every 30 seconds.

Epoch

Measurement interval or data frequency, as in making observations every 15 seconds. Loading data using 30-second epochs means loading every other measurement.

FCC

Federal Communications Commission

Firmware

The coded instructions relating to receiver function, and (sometimes) data processing

algorithms, embedded as integral portions of the internal circuitry.

Flattening

$f = (a - b)/a = 1 - (1 - e^2)^{1/2}$ where
 a = semimajor axis
 b = semiminor axis
 e = Eccentricity

GDOP

Geometric Dilution of Precision. The relationship between errors in user position and time and in satellite range. $GDOP^2 = PDOP^2 + TDOP^2$. See Position Dilution of Precision.

Geodetic datum (horizontal datum)

A specifically oriented ellipsoid typically defined by eight parameters which establish its dimensions, define its center with respect to Earth's center of mass and specify its orientation in relation to the Earth's average spin axis and Greenwich reference meridian.

Geodetic height (ellipsoidal height)

The height of a point above an ellipsoidal surface. The difference between a point's geodetic height and its orthometric height equals the geoidal height.

Geoid

The equipotential surface of the Earth's gravity field which best fits mean sea level. Geoids currently in use are GEOID84 and GEOID90.

Geoidal height (geoidal separation; undulation)

The height of a point on the geoid above the ellipsoid measured along a perpendicular to the ellipsoid.

GLL

Position Latitude/Longitude

GMST

Greenwich Mean Sidereal Time

GPS DIFF

Differential

GPS ICD-200

The GPS Interface Control Document is a government document that contains the full technical description of the interface between the satellites and the user. GPS receiver must comply with this specification if it is to receive and process GPS signals properly.

GPS week

GPS time started at Saturday/Sunday midnight, January 6, 1980. The GPS week is the number of whole weeks since GPS time zero.

Greenwich mean time (GMT)

See universal time. In this text, they are often used interchangeably.

HDOP

Horizontal Dilution of Precision. See Dilution of Precision.

HI

Height of Instrument

HTDOP

Horizontal/Time Dilution of Precision. See Dilution of Precision.

ID

Identification or Integrated Doppler

Integer bias terms

The receiver counts the carrier waves from the satellite, as they pass the antenna, to a high degree of accuracy. However, it has no information of the number of waves to the satellite at the time it started counting. This unknown number of wavelengths between the satellite and the antenna is the integer bias term.

Integrated Doppler

A measurement of Doppler shift frequency or phase over time.

Ionosphere

Refers to the layers of ionized air in the atmosphere extending from 70 kilometers to 700 kilometers and higher. Depending on frequency, the ionosphere can either block radio signals completely or change the propagation speed. GPS signals penetrate the ionosphere but are delayed. The ionospheric delays can be predicted using models, though with relatively poor accuracy, or measured using two receivers.

Ionospheric delay

A wave propagating through the ionosphere [which is a nonhomogeneous (in space and time) and dispersive medium] experiences delay. Phase delay depends on electron content and affects carrier signals. Group delay depends on dispersion in the ionosphere as well, and affects signal modulation (codes). The phase and group delay are of the same magnitude but opposite sign.

Julian date

The number of days that have elapsed since 1 January 4713 B.C. in the Julian calendar. GPS time zero is defined to be midnight UTC, Saturday/Sunday, 6 January 1980 at Greenwich. The Julian date for GPS time zero is 2,444,244.5.

Kalman filter

A numerical method used to track a time-varying signal in the presence of noise. If the signal can be characterized by some number of parameters that vary slowly with time, then Kalman filtering can be used to tell how incoming raw measurements should be processed to best estimate those parameters as a function of time.

Kinematic surveying

A method which initially solves wavelength ambiguities and retains the resulting

measurements by maintaining a lock on a specific number of satellites throughout the entire surveying period.

L1

The primary L-band signal radiated by each NAVSTAR satellite at 1575.42 MHz. The L1 beacon is modulated with the C/A and P codes, and with the NAV message. L2 is centered at 1227.60 MHz and is modulated with the P code and the NAV message.

L1 & L2

Designations of the two basic carrier frequencies transmitted by GPS satellites that contain the navigation signals. L1 is 1,575.42 MHz and L2 is 1,227.60 MHz.

Lane

The area (or volume) enclosed by adjacent lines (or surfaces) of zero phase of either the carrier beat phase signal or of the difference between two carrier beat phase signals. On the earth's surface a line of zero phase is the focus of all points for which the observed value has an exact integer value for the complete instantaneous phase measurement. In three dimensions, this locus becomes a surface.

L-band

A nominal portion of the microwave electromagnetic spectrum ranging from 390 MHz to 1.55 GHz.

LNA

Low-Noise Amplifier

MSG

RTCM Message

MSL

Mean Sea Level

Multichannel receiver

A receiver containing many independent channels. Such a receiver offers highest SNR

because each channel tracks one satellite continuously.

Multipath

The reception of a signal both along a direct path and along one or more reflected paths. The resulting signal results in an incorrect pseudorange measurement. The classical example of multipath is the "ghosting" that appears on television when an airplane passes overhead.

Multipath error

A positioning error resulting from interference between radio waves which have traveled between the transmitter and the receiver by two paths of different electrical lengths.

Multiplexing

A technique used in some GPS receivers to sequence the signals of two or more satellites through a single hardware channel. Multiplexing allows a receiver to track more satellites than the number of hardware channels at the cost of lower effective signal strength.

Multiplexing channel

A receiver channel which is sequenced through several satellite signals (each from a specific satellite at a specific frequency) at a rate which is synchronous with the satellite message bit-rate (50 bits per second, or 20 milliseconds per bit). Thus, one complete sequence is completed in a multiple of 20 milliseconds.

NMEA

National Marine Electronics Association

NV

Non-Volatile. Usually refers to a memory device that retains data after power is removed.

Outage

The occurrence in time and space of a GPS dilution of precision value exceeding a specified maximum.

P-Code

Precise or protected code which is bi-phase shift modulated on both the L1 and L2 carrier frequencies. P-code has a 10.23MHz bit rate and, as implemented in GPS, a period of 267 days. Each satellite has a unique one-week P-code segment that is used to distinguish the satellite from all other GPS satellites.

Position Dilution of Precision (PDOP)

A unitless figure of merit expressing the relationship between the error in user position and the error in satellite position. Geometrically, PDOP is proportional to 1 divided by the volume of the pyramid formed by lines running from the receiver to four satellites observed. Values considered 'good' for positioning are small, say 3. Values greater than 7 are considered poor. Thus, small PDOP is associated with widely separated satellites. PDOP is related to horizontal and vertical DOP by $PDOP^2 = HDOP^2 + VDOP^2$. Small PDOP is important in positioning, but much less so in surveying.

Photogrammetry

An aerial remote sensing technique whose latest innovations employ a high-resolution aerial camera with forward motion compensation and uses GPS technology for pilot guidance over the designated photo block(s). Photogrammetry forms the baseline of many Geographic Information Systems (GIS) and Land Information System (LIS) studies .

Point positioning

A geographic position produced from one receiver in a stand-alone mode. At best, position accuracy obtained from a stand-alone receiver is 15-25 meters, depending on the geometry of the satellites.

POS

Position

Post-processing

The reduction and processing of GPS data after the data was collected in the field. Post-processing is usually accomplished on a computer in an office environment where appropriate software is employed to achieve optimum position solutions.

Precise Positioning System (PPS)

The more accurate GPS capability that is restricted to authorized, typically military, users.

Pseudo-kinematic surveying

A variation of the kinematic method where roughly five-minute site occupations are repeated at a minimum of once each hour.

Pseudorandom noise (PRN)

The P(Y) and C/A codes are pseudo-random noise sequences which modulate the navigation signals. The modulation appears to be random noise but is, in fact, predictable hence the term "pseudo" random. Use of this technique allows the use of a single frequency by all GPS satellites and also permits the satellites to broadcast a low power signal.

Pseudorange

The measured distance between the GPS receiver antenna and the GPS satellite. The pseudorange is approximately the geometric range biased by the offset of the receiver clock from the satellite clock. The receiver actually measures a time difference which is related to distance (range) by the speed of propagation.

PZ-90

The proper designators for the GLONASS reference system. Sometimes referred to as E-90 or PE-90.

RAM

Random-Access Memory. A memory device whose data can be accessed at random, as

approved to sequential access. RAM data is lost when power is removal.

Range rate

The rate of change of range between the satellite and receiver. The range to a satellite changes due to satellite and observer motions. Range rate is determined by measuring the doppler shift of the satellite beacon carrier.

RDOP

Relative Dilution of Precision. See Dilution of Precision.

Reconstructed carrier phase

1. The difference between the phase of the incoming Doppler-shifted GPS carrier and the phase of a nominally constant reference frequency generated in the receiver. For static positioning, the reconstructed carrier phase is sampled at epochs determined by a clock in the receiver. The reconstructed carrier phase changes according to the continuously integrated Doppler shift of the incoming signal biased by the integral of the frequency offset between the satellite and receiver reference oscillators.

- or -

2. The reconstructed carrier phase can be related to the satellite-to-receiver range, once the initial range (or phase ambiguity) has been determined. A change in the satellite-to-receiver range of one wavelength of the GPS carrier (19 cm for L1) will result in a one-cycle change in the phase of the reconstructed carrier.

Real-time

Refers to immediate, GPS data collection, processing and position determination (usually) within a receiver's firmware after the fact with a computer in an office environment.

Real-time kinematic (RTK)

A DGPS process where carrier-phase corrections are transmitted in real-time from a reference receiver at a known location to one or more

remote rover receiver(s).

Real-Time Z

Ashtech's proprietary technique that includes Carrier Phase Differential (CPD) processing. Real-Time Z features "on-the-fly" (OTF) ranging data acquisition and differential processing.

Reference Network

A series of monuments or reference points with accurately measured vectors/distances that is used as a reference basis for cadastral and other types of survey.

Reference station

A point (site) where crustal stability, or tidal current constants, have been determined through accurate observations, and which is then used as a standard for the comparison of simultaneous observations at one or more subordinate stations. Certain of these are known as Continuous Operating Reference Stations (CORS), and transmit reference data on a 24-hour basis.

Relative positioning

The process of determining the relative difference in position between two points with greater precision than that to which the position of a single point can be determined. Here, a receiver (antenna) is placed over each point and measurements are made by observing the same satellite at the same time. This technique allows cancellation (during computations) of all errors which are common to both observers, such as satellite clock errors, propagation delays, etc. See also Translocation and Differential Navigation.

RF

Radio Frequency

RFI

Radio Frequency Interference

RINEX

The Receiver-INdependent EXchange format for GPS data, which includes provisions for pseudorange, carrier-phase, and Doppler observations.

RMS

Root Mean Square. A statistical measure of the scatter of computed positions about a "best fit" position solution. RMS can be applied to any random variable.

RTCM

Radio Technical Commission for Maritime Services
P.O. Box 19087
Washington, DC. 20036-9087

RTCM SC-104 Format

A standard format used in the transmission of differential corrections.

SE

Site Editor or Standard Error

Selective Availability (SA)

The process whereby DOD dithers the satellite clock and/or broadcasts erroneous orbital ephemeris data to create a pseudorange error

Spherical Error Probable (SEP)

A statistical measure of precision defined as the 50th percentile value of the three-dimensional position error statistics. Thus, half of the results are within a 3D SEP value.

Sidereal day

Time between two successive upper transits of the vernal equinox.

Sidereal time

The hour angle of the vernal equinox. Taking the mean equinox as the reference yields true or apparent Sidereal Time. Neither Solar nor Sidereal Time are constant, since angular velocity varies due to fluctuations caused by the Earth's

polar moment of inertia as exerted through tidal deformation and other mass transports.

Single difference

The arithmetic differencing of carrier phases simultaneously measured by a pair of receivers tracking the same satellite (between receivers and satellite), or by a single receiver tracking two satellites (between-satellite and receivers); the former essentially deletes all satellite clock errors, while the latter essentially deletes all receiver errors.

Spherical Error Probable (SEP)

A navigational measure of accuracy equaling the radius of a sphere, centered on the true location, inside which 50% of the computed solutions lie.

Spoofing

The process of replicating the GPS code in such a way that the user computes incorrect position solutions.

Standard Positioning Service (SPS)

Uses the C/A code to provide a minimum level of dynamic- or static-positioning capability. The accuracy of this service is set at a level consistent with national security.

Standard Positioning System

The less accurate GPS capability which is available to all.

Static observations

A GPS survey technique requiring roughly one hour of observation, with two or more receivers observing simultaneously, and results in high accuracies and vector measurements.

Static positioning

Positioning applications in which the positions of static or near static points are determined.

SV

Satellite Vehicle, Satellite Visibility or Space

Vehicle.

Switching channel

A receiver channel which is sequenced through a number of satellite signals (each from a specific satellite and at a specific frequency) at a rate which is slower than, and asynchronous with, the message data rate.

TDOP

Time Dilution of Precision. See Dilution of Precision.

TOW

Time of week, in seconds, from midnight Sunday UTC.

Translocation

A version of relative positioning which makes use of a known position, such as a USGS survey mark, to aid in the accurate positioning of a desired point. Here, the position of the mark, determined using GPS, is compared with the accepted value. The three-dimensional differences are then used in the calculations for the second point.

Triple difference

The arithmetic difference of sequential, double-differenced carrier-phase observations that are free of integer ambiguities, and therefore useful for determining initial, approximate coordinates of a site in relative GPS positioning, and for detecting cycle slips in carrier-phase data.

Tropospheric correction.

The correction applied to the measurement to account for tropospheric delay. This value is obtained from the modified Hopfield model.

True anomaly

The angular distance, measured in the orbital plane from the earth's center (occupied focus) from the perigee to the current location of the satellite (orbital body).

Universal Time Coordinated (UTC)

Time as maintained by the U.S. Naval Observatory. Because of variations in the Earth's rotation, UTC is sometimes adjusted by an integer second. The accumulation of these adjustments compared to GPS time, which runs continuously, has resulted in an 11 second offset between GPS time and UTC at the start of 1996. After accounting for leap seconds and using adjustments contained in the navigation message, GPS time can be related to UTC within 20 nanoseconds or better.

User Range Accuracy (URA)

The contribution to the range-measurement error from an individual error source (apparent clock and ephemeris prediction accuracies), converted into range units, assuming that the error source is uncorrelated with all other error sources. Values less than 10 are preferred.

UT

Universal Time

UTM

Universal Transverse Mercator Map Projection. A special case of the Transverse Mercator projection. Abbreviated as the UTM Grid, it consists of 60 north-south zones, each 6 degrees wide in longitude.

VDC

Volts Direct Current

VDOP

Vertical Dilution of Precision. See Dilution of Precision and Position Dilution of Precision.

WGS

World Geodetic System

World Geodetic System 1984 (WGS-84)

A set of U.S. Defense Mapping Agency parameters for determining global geometric and physical geodetic relationships. Parameters include a geocentric reference ellipsoid; a

coordinate system; and a gravity field model. GPS satellite orbital information in the navigation message is referenced to WGS-84.

World Geodetic System (1972)

The mathematical reference ellipsoid previously used by GPS, having a semimajor axis of 6378.135 km and a flattening of 1/298.26.

WP

Waypoint

Y-Code

The designation for the end result of P-Code during Anti-Spoofing (AS) activation by DoD.

Y-code tracking, civilian

Signal squaring (now obsolete) multiplies the signal by itself, thus deleting the carrier's code information and making distance measurement (ranging) impossible. Carrier phase measurements can still be accomplished, although doubling the carrier frequency halves the wavelength.

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