A12™, B12™ & AC12™

Reference Manual

A12 Board

B12 Board

A12 Sensor

B12 Sensor

Part Number: 630871, Revision E

This product is CE certified.

NOTE: The CE certification was obtained with the product powered from the AC/DC converter supplied. The test temperatures did not exceed 30°C, as described in the AC/DC converter specification.

Acronyms Used In This Manual

2-D	Two-dimensional
3-D	Three-dimensional
ACK	Acknowledge
ASCII	American Standard Code for Information Interchange
BIT	Built-in Test
C/A	Coarse/Acquisition
CEP	Circular Error of Probability
CMOS	Complementary Metal-Oxide Semiconductor
COG	Course Over Ground
DB-9	Type of connector
DGPS	Differential GPS
E	East
EGNOS	European Geostationary Navigation Overlay System
ESD	Electrostatic Discharge
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
I/O	Input/Output
ID	Identification
L/C	Inductance/Capacitance
LNA	Low-Noise Amplifier
M	Meter
MSAS	Japanese Multi-function Transport System
MTCR	Missile Technology Control Regime
N	North
NAK	Not acknowledged
NMEA	National Marine Electronics Association
OEM	Original Equipment Manufacturer
P/N	Part Number
PC	Personal Computer
PDOP	Position Dilution of Precision
PPS	Pulse Per Second
PRN	Pseudo-random Number
RF	Radio Frequency
RHCP	Right-Hand Circular Polarization
RTCM	Radio Technical Commission for Maritime Services
S	South
S/A	Selective Availability
SBAS	Satellite-Based Augmentation System
SMA	Type of connector
SMB	Type of connector
SMT	Type of connector
SNR	Signal-to-Noise Ratio
SOG	Speed Over Ground
SPS	Standard Positioning Service
SV	Space Vehicle (Satellite)
TDOP	Time Dilution of Precision
TTFF	Time To First Fix
TTL	Transistor-Transistor Logic
UTC	Universal Time Coordinated
VDC	Volts Direct Current
VDOP	Vertical Dilution of Precision
W	West
WAAS	Wide Area Augmentation System
WGS	World Geodetic System

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Navigation GPS receivers use GPS or GPS+GLONASS to obtain position, velocity and time information. GPS is operated by the U.S. Government and GLONASS is the Global Navigation Satellite System of the Russian Federation, which are solely responsible for the accuracy and maintenance of their systems. Certain conditions can cause inaccuracies which could require modifications to the receiver. Examples of such conditions include but are not limited to changes in the GPS or GLONASS transmission.) Opening, dismantling or repairing of this product by anyone other than an authorized Magellan Navigation Service Center will void this warranty.

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Magellan Professional Products Limited Warranty (Europe, Middle East, Africa)

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1. MAGELLAN NAVIGATION WARRANTY

Magellan Navigation warrants their GPS receivers and hardware accessories to be free of defects in material and workmanship and will conform to our published specifications for the product for a period of one year from the date of original purchase or such longer period as required by law. THIS WARRANTY APPLIES ONLY TO THE ORIGINAL PURCHASER OF THIS PRODUCT.

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2. PURCHASER'S REMEDY

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To obtain service, contact and return the product with a copy of the original sales receipt to the dealer from whom you purchased the product.

Magellan Navigation reserves the right to refuse to provide service free-of-charge if the sales receipt is not provided or if the information contained in it is incomplete or illegible or if the serial number is altered or removed. Magellan Navigation will not be responsible for any losses or damage to the product incurred while the product is in transit or is being shipped for repair. Insurance is recommended. Magellan Navigation suggests using a trackable shipping method such as UPS or FedEx when returning a product for service.

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The following are excluded from the warranty coverage:

(1) periodic maintenance and repair or replacement of parts due to normal wear and tear;

(2) batteries;

(3) finishes;

(4) installations or defects resulting from installation;

(5) any damage caused by (i) shipping, misuse, abuse, negligence, tampering, or improper use; (ii) disasters such as fire, flood, wind, and lightning; (iii) unauthorized attachments or modification;

(6) service performed or attempted by anyone other than an authorized Magellan Navigations Service Center;

(7) any product, components or parts not manufactured by Magellan Navigation,

(8) that the receiver will be free from any claim for infringement of any patent, trademark, copyright or other proprietary right, including trade secrets

(9) any damage due to accident, resulting from inaccurate satellite transmissions. Inaccurate transmissions can occur due to changes in the position, health or geometry of a satellite or modifications to the receiver that may be required due to any change in the GPS. (Note: Magellan Navigation GPS receivers use GPS or GPS+GLONASS to obtain position, velocity and time information. GPS is operated by the U.S. Government and GLONASS is the Global Navigation Satellite System of the Russian Federation, which are solely responsible for the accuracy and maintenance of their systems. Certain conditions can cause inaccuracies which could require modifications to the receiver. Examples of such conditions include but are not limited to changes in the GPS or GLONASS transmission.).

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General Information

Overview

This manual describes physical, electrical, operational, and functional characteristics of the A12, B12, and AC12 GPS sensors and OEM boards. The documentation presented herein applies to all configurations except where noted otherwise.

This chapter presents a functional and hardware description of the A12 GPS OEM board, defines the RF interface and the power/input/output signal parameters, and lists power requirements and environmental specifications.

An A12 Evaluation and Development Kit, available separately, lets you rapidly set up and operate the A12 to determine suitability for your application. The kit offers:

- An A12 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 an A12 Evaluation and Development Kit and want to begin working with your kit immediately, go directly to Chapter 4 for initial setup instructions.

Magellan A12 is backward compatible with the G8 with a few exceptions.

1. The A12 board has an SMB RF connector while the G8 had a Hirose RF connector.
2. A12 does not output any messages by default while the G8 outputs GGA and VTG messages by default.
3. The A12 I/O signals are TTL compatible. However, there is a difference in signal levels between G8 and A12. A12 uses 2.7 V to power the CMOS output buffers and the signal levels are <0.8V for a valid low and >2.4V for a valid high. The signals on the G8 board were 5V CMOS level outputs.
4. A12 uses the same commands and interface as the G8 but does not support the commands listed below.
   (i) KFP - Enable Kalman Filter
   (ii) ITA - Enable ITA data message
   (iii) PWR - Set Sleep mode

Functional Description

The A12 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 A12 is designed for system integration, offering autonomous or DGPS positioning, low power, small size, and the standard NMEA protocol. The A12 utilizes any voltage between 3.3 and 5 VDC, and supports two TTL-compatible serial communication ports that are accessible through the I/O connector.

The A12 OEM board processes signals from the Global Positioning System (GPS) satellite constellation and Satellite-Based Augmentation System (SBAS) satellites to provide real-time position, velocity, and time measurements. The A12 uses ten separate and parallel channels for Coarse/Acquisition (C/A) code-phase (a.k.a. pseudo-range) on the L1 (1575.42 MHz) band, and two channels to receive signals from the SBAS satellites. The A12 can also be configured to track GPS satellites on all 12 channels. The A12 receives satellite signals via an L-band antenna with integral low-noise amplifier (an active antenna must be supplied separately). The A12 board is capable of using a passive antenna provided the RF cable length is less than 6 inches. The A12 outputs position, speed, and time information, either autonomously or differentially corrected using DGPS corrections in RTCM SC-104 Version 2.2 format or using corrections from SBAS signals.

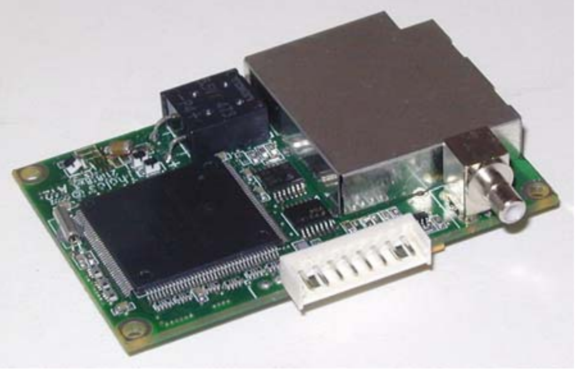


Figure 1.1: A12 OEM Board

Technical Specifications

Table 1.1 lists the more important technical specifications.

Table 1.1 Technical Specifications

Item	Specification
General	12-channel continuous tracking OEM GPS receiver board
GPS parameters	L1 frequency, C/A code (SPS)
Update rate	1 Hz
Communication interface	NMEA 0183 V3.0 using standard Magellan command set
Message types	RTCM V2.2 differential remote message types 1, 3, 9
Serial ports	One TTL full duplex for primary I/O One TTL half duplex for RTCM
Baud rate	Software selectable 1200 bps to 115,200 bps, except 2400 and 38400 bps. Maximum recommended character rate is 400 characters per second [a].
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. (20 gr) With mechanical shield case: 1.6 oz. (45.4 gr)
I/O interface	TTL compatible
Input voltage/ current consumption	3.3 to 5 VDC/55 to 70 mA typical
Backup power	2.7 to 3.6 VDC (6 µA)
Receiver noise figure	<7 dB typical without antenna

a. The current limit is 1024 characters per second. The maximum recommended character rate is not only defined by the baud rate value, but also by the size of the port output buffer. If the number of characters per second significantly exceeds the size of this output buffer then there is a chance that not all messages will be output.

Performance Specifications

Table 1.2 summarizes the more important performance specifications. Additional details are presented in Table 8.1 on page 128.

Table 1.2 Performance Specifications

Item	Specification		
Real-time position accuracy		Horizontal CEP	Horizontal 95%
	Autonomous:	3.0m	5.0m
	SBAS:	1.0m	3.0m
	DGPS (local):	0.8m	1.5m
Typical acquisition time **(Refer to note below)**	<10 sec hot start <45 sec warm start <150 sec cold start		
Typical reacquisition time	1 sec from total satellite blockage for less than 20 seconds 3-5 sec from total satellite blockage for less than 180 seconds		
Update rate	User-selectable from 1 second to 99 seconds in 1-second increments synchronized with GPS.		
1 PPS output	A12 calculates time and outputs the first 1 PPS pulse only after it has an initial position fix. 1 PPS pulse output is synchronized to GPS time ± 1 msec by default but can be set to ± 250 nsec by the set command $PASHS,PPS,ON. The A12 continues to output 1 PPS during position outages, but with reduced accuracy.		
Geoid model	Supported internally (see page 28)		
Magnetic variation model	Supported internally (see page 28)		

If the A12 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 A12 board is available in two different configurations. The A12 version 1 has a right-angled SMB RF connector and Molex I/O connector (Molex socket P/N 53254-0810) for cable interface and is enclosed in a mechanical shield case. The A12 version 1 board is shown on Figure 1.2. The A12 version 2 board is not enclosed in a shield case and has an MCB RF connector and a Samtec I/O connector for board-to-board interface. The A12 version 2 board is shown on Figure 1.3. 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 A12 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.

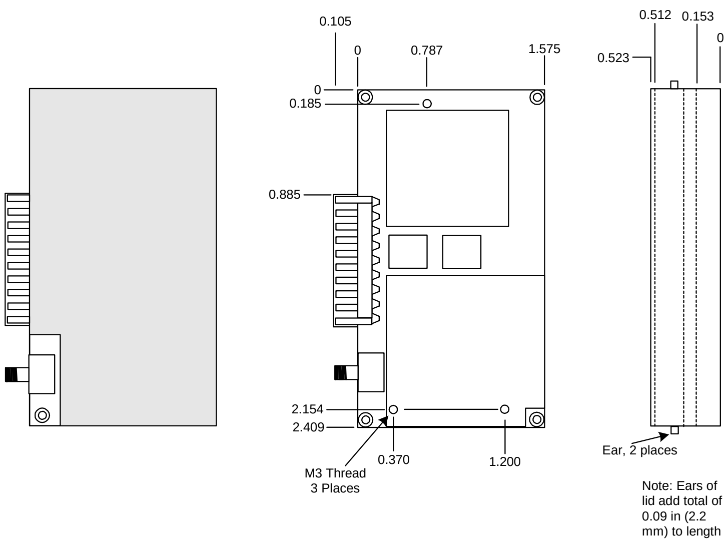


Figure 1.2: Mechanical Shield Case Configuration

When used outside the mechanical shield case, the A12 board can be mounted using the mounting holes provided in each corner as shown in Figure 1.3. A separate RF shield is soldered to the board, located as shown in Figure 1.3. The RF shield must always remain on the board.

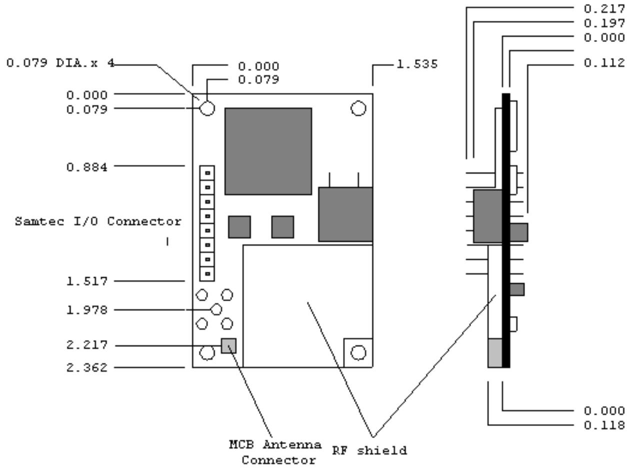


Figure 1.3: Bare Board Configuration

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	3 holes on bottom of shield case	3 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 A12 from external device
6	RXD	Receive Port A: Receive data at A12 from external device
7	TXD	Transmit Port A: Transmit data from A12 to external device
8	1 PPS	1 PPS output

Interfaces to External Equipment

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

The A12 returns responses in standard NMEA format or Magellan 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 0183 V3.0. In addition, Magellan has implemented a set of NMEA style messages that are maintained for compatibility with the Magellan GNSS Boards 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 A12 requires the following operating power (typical):

Main power: 3.3 to 5.0 VDC

Nominal current: 55 to 70 mA

Nominal power: 230 mW @ 3.3 VDC

Backup power: 6 µA at 2.7 to 3.6 VDC

Antenna power (V_ANT): 3.3 to 7.5 VDC, 50 mA max (active antenna must be supplied separately)

Upgrades and Updates

The A12/B12 firmware upgrades and updates require direct access to a serial port on the board. Upgrades and updates also require a TTL-to-RS-232 interface between the board and the PC for communications and firmware upload. Magellan recommends that system integrators keep these two requirements in mind while designing their A12/B12-based systems.

Environmental Limitations

The A12 operates within the environmental limitations listed in Table 1.5.

Table 1.5 Environmental Limitations

Condition	Specification	
Operating temperature	-30°C to +80°C	
Storage temperature	-40°C to +85°C	
Humidity	95% RH non-condensing @ +60°C	
Vibration	0.008 g^2/Hz 0.05 g^2/Hz 3 dB/octave	5 to 20 Hz 20 to 100 Hz 100 to 900 Hz
Speed limitations	1000 knots (514 m/sec)*	

Table 1.5 Environmental Limitations

Condition	Specification
Altitude limitations	60,000 feet (18,288 m)*
* The A12 produces no valid position information beyond these limits.	

Antenna

The A12 board is capable of using a passive antenna provided the RF cable length is less than 6 inches. For optimum performance, the A12 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 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 1 to 2 dBic at zenith
LNA gain	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 in the range 3.3 to 7.5 VDC.

The A12 contains an antenna supply circuit that utilizes an 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. The maximum current allowance through the V_ANT pin is 50 mA.

A diagram of the antenna supply circuit is shown in Figure 1.4. The A12 board provides short-circuit protection for the external power supply applying voltage to the V_{ant} line. The short-circuit protection is a current limiter that limits current (50 mA) in case of short circuit.

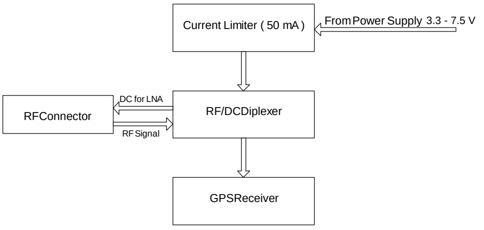


Figure 1.4: Antenna Supply Circuit

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 A12 board.

Radio Interference

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

The A12 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 A12 operates reliably without the mechanical shield case.

Getting Started

General

This section defines the procedures to get the A12 GPS OEM board operating as quickly as possible:

- Procedure for connecting the A12 to power, the antenna, and the user equipment or system electronics
- Important communication parameters
- Instructions for establishing communications with the A12 using typical communications software with an IBM-compatible PC
- Procedure for sending common commands to the A12

Quick Start

If you have the A12 Evaluation and Development Kit, use it for quick setup and evaluation. Go directly to Chapter 4 for instructions. If you do not have the A12 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 A12, always turn off the power supply before connecting or disconnecting to the 8-pin I/O connector.

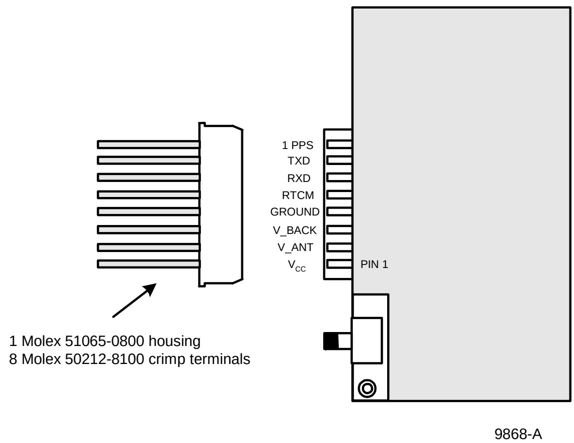


Figure 2.1: Power and I/O Connections for Bare OEM Board

1. To interface to the board, you will need to connect to two different interface connectors, **I/O** and **RF**:
   - **I/O connector** -The I/O connector on the A12 version 1 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.
     The I/O connector on the A12 version 2 is a Samtec I/O connector P/N TMM-108-03-S-S

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

   - **RF connector** - The RF connector is a right-angled SMB connector for version 1 and a straight MCB connector for version 2.
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 A12.

3. 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 A12 from external device
6	RXD	Receive Port A: Receive data at A12 from external device
7	TXD	Transmit Port A: Transmit data from A12 to external device
8	1 PPS	1 PPS event marker output TTL

4. Once you have constructed the antenna interface cable, connect the antenna cable to the RF antenna connector on the A12 and connect the antenna.

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

The A12 is designed to work with a passive antenna as well as an active antenna that includes an LNA. The active antenna can be powered via V_ANT, which 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 3.3 to 5 VDC power to the A12 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.

When the A12 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.

To ensure the fastest possible restart times, you should also connect the A12 to a power backup source at pin 3 (V_BACK). The backup source should be in the range of 2.7 to 3.6 VDC. Backup draws approximately 6 µA, depending upon the backup voltage. In the absence of the backup power, the A12 is able to retain the contents of the memory and RTC for a few hours with the aid of the supercap on-board that allows the A12 to provide a quick position fix. However, it is highly recommended that the integrator provide backup power on pin 3 to avoid long start times.

Serial Data Communication

Communication Port Setup

After performing the steps above, you are ready to command the A12 and receive data. The A12 serial port A must be connected to a PC, microprocessor, or other intelligent processing device, before you can issue commands. The A12 OEM board utilizes CMOS signal levels (+ 3.3 VDC, 0 VDC) for communication, not RS-232 levels (± 12 VDC). The A12 is also compatible with external TTL-level signals and will accept 5V signals on the receive port. If you plan to communicate directly with the A12 OEM board from a PC, 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 A12 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 A12.

Table 2.2 TTL I/O Interface Levels

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

Table 2.3 lists the default communication parameters of the A12 at first power-up.

Table 2.3 Default A12 Communication Parameters

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

When first establishing communication with the A12, the communications interface must use these parameters, otherwise the A12 will not recognize any serial input. Once communication is established at 4800 baud, the A12 can be reconfigured to operate at a different baud rate by issuing $PASHS commands to the serial port from the attached PC or other processing device.

RTS/CTS Considerations

Once you convert the A12 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 A12 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 A12 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 A12 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 A12. 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 the user interface design. The A12 Sensor (see Chapter 4) connects the RTS and CTS lines; the A12 OEM board does not.

Data Output

Even though the A12 may be calculating positions, it does not output any data until the user sends a message commanding it to do so.

Initial Operating Instructions

After the A12 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 A12 using an IBM-compatible PC. Many standard communications software packages allow you to interface with the A12. Be sure to send commands to Port A of the A12 receiver.

The user 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 A12 messages, send a few common commands to the A12 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 A12 is using its default communications setup 4, which is 4800 baud, eight data bits, no parity, and one stop bit. For details on this and other commands and responses, refer to Chapter 5.

3

Operation

This section summarizes system setup, 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 A12 is set up as described in Chapter 2.

Message Format

The A12 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

The input messages comprise **set** command messages, and **query** command messages. The **set** commands instruct the A12 to perform a specified and often continuous activity; the **query** commands instruct the A12 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 Magellan NMEA style, registered with NMEA (i.e., PASH)
- Message IDs are Magellan NMEA style
- Data items are separated by commas
- Checksum character delimiter and NMEA checksum bytes are recognized by the A12 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>. Command messages (set, query, or general) recognize **upper case** letters only. They are accepted by **<**enter**>**. A valid set command causes the A12 to return the **$PASHR,ACK*3D, “acknowledged”** response message. A set command containing a valid $PASHS set command header followed by character combinations unrecognized by the A12 causes return of the **$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 A12 to return the **$PASHR,NAK*30 “**not acknowledged**”** response message.

Output Messages

Output messages are messages the A12 sends to the PC or system electronics in response to a command message. These messages comprise general status messages, command acknowledged/not acknowledged messages, and GPS data messages. The general status messages have free-form Magellan 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 Magellan NMEA style
- Message IDs are standard NMEA or Magellan 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 default is 4800 baud for both RS-232 serial ports A and B.

The baud rates between the A12 and the interfacing equipment must be the same for both the port and the device connected to that port.

To maintain communication with the A12 while changing the baud rate, issue the **$PASHS,SPD** (set command) to change the A12 baud rate, then change the baud rate of the command device to match the new A12 rate.

Antenna Connection

The A12 requires that a compatible active or passive 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 A12 to meet the specifications defined in this manual.

Satellite Search Algorithm

When the A12 is operated for the first time after receipt from Magellan, or after the power and back-up battery have been disconnected, no almanac or ephemeris data are available. The A12 always assigns the first 12 elements of a 32-element table of SV PRN numbers to its 12 channels. Within 35 to 40 seconds after locking the first SV, the A12 time is set. The A12 computes its first position after three (for 2D) or four (for 3D) SVs are locked, provided that the satellite geometry is adequate. The A12 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 A12 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 A12 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 A12 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 45 seconds. The A12 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 A12 has been off for no more than two hours. This data allows the A12 to search only for visible SVs in known locations, and the first position is typically computed in about 10 seconds.

If the A12 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

Table 3.1 lists the default operational parameters. These parameters can be changed using the indicated set commands; detailed explanations of the set commands are presented in chapter 5. On initial power-up or after use of the **$PASHS,RST** (reset to default command), the A12 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 in a format shown on page 59.

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 3.1 Default Parameters

Item	Default Value	Set Command	Page
RECEIVER CONTROL COMMANDS			
Latitude	None	$PASHS,POS	62
Longitude	None	$PASHS,POS	62
Altitude	None	$PASHS,POS	62
Navigation position mode	4	$PASHS,PMD	62
2D altitude	0	$PASHS,ALT	53
Fast hot start mode	ON	$PASHS,FHS	56
Fix UTM zone	N	$PASHS,FUM	56
Select fixed UTM zone	None	$PASHS,FZN	57
HDOP mask	4	$PASHS,HDP	57
PDOP mask	6	$PASHS,PDP	61
Elevation mask	5 degrees above horizon	$PASHS,PEM	61
Datum	WGS-84	$PASHS,DTM	54
Reset receiver	None	$PASHS,RST	66
S/N mask for sat. signal use	0	$PASHS,SNM	68
Set user-defined datum param.	None	$PASHS,UDD	69
Unit identification	None	$PASHS,UID	71
Satellites inhibited	None	$PASHS,USE	71
Upload Initial Real-time Clock Value	None	$PASHS,ZDA	72
DGPS positioning	OFF	$PASHS,RTC	112
Auto differential mode	Enabled	$PASHS,RTC,AUT	114
Differential data age selection	15 seconds	$PASHS,RTC,MAX	114
Serial port A speed	4 (corresponds to 4800 bps)	$PASHS,SPD	69
Serial port B speed	4 (corresponds to 4800 bps)	$PASHS,SPD	69
Altitude position fix mode	0	$PASHS,FIX	55
Time zone offset	00:00	$PASHS,LTZ	59
Point positioning	N (disabled)	$PASHS,PPO	63
Save parameters	Y (save)	$PASHS,SAV	67
Initialize receiver & serial ports	4800 baud	$PASHS,INI	58
SBAS	Enabled and DGPS on	$PASHS,WAS	72
PPS	OFF (1 msec PPS accuracy)	$PASHS,PPS	64
NMEA COMMANDS			
Disable all NMEA messages	None	$PASHS,NME,ALL	76
Enable ALM msg to port	A, OFF	$PASHS,NME,ALM	76
Cartesian coordinates message	None	$PASHS,NME,CRT	78
Enable GGA msg to port	A, OFF	$PASHS,NME,GGA	80

Table 3.1 Default Parameters (continued)

Item	Default Value	Set Command	Page
Enable GLL msg to port	A, OFF	$PASHS,NME,GLL	82
Enable GSA msg to port	A, OFF	$PASHS,NME,GSA	84
Enable GSV msg to port	A, OFF	$PASHS,NME,GSV	89
Enable RMC message to port	A, OFF	$PASHS,NME,RMC	94
Satellite Range Residuals and Position Error	None	$PASHS,NME,RRE	96
Enable VTG msg to port	A, OFF	$PASHS,NME,VTG	105
Enable ZDA msg to port	A, OFF	$PASHS,NME,ZDA	108
Receiver update interval	1 second	$PASHS,NME,PER	91
Enable POS msg to port	A, OFF	$PASHS,NME,POS	91
Enable SAT msg to port	A, OFF	$PASHS,NME,SAT	99
UKOOA message	None	$PASHS,NME,UKO	101
Base station message	None	$PASHS,NME,MSG	87
Exception messages	None	$PASHS,NME,XMG	107
RTCM COMMANDS			
RTCM status query	None	$PASHQ,RTC	112
Set auto-differential mode	Y (ON)	$PASHS,RTC,AUT	114
Set RTCM differential data age	15	$PASHS,RTC,MAX	114
Disable RTCM	None	$PASHS,RTC,OFF	114
Enable remote RTCM	None	$PASHS,RTC,REM	115

Saving New Parameter Settings

If the user wants to save any parameters changed by a set command, parameter values can be saved by the **$PASHS,SAV,Y** set command. Once this command has been used, the A12 will use the saved parameters instead of the defaults as long as there is the appropriate battery backup voltage on pin 3 (V-back). Without battery backup, the parameters will **NOT** be saved. The command **$PASHS,RST** always reinstates the defaults.

Please note that the default setting for SAV command is 'Y' and hence $PASHS,SAV,Y command is not required initially for saving parameters. If the user wishes not to save parameters changed by set commands, $PASHS,SAV,N command is required

Position Modes

The A12 operates in two position modes, 3D and 2D. These modes are explained in detail in “Position Modes” on page 126.

Altitude Hold Definition

Two modes are available to determine what altitude is selected when the A12 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 A12 allows the user to output messages in NMEA format, and other messages through serial port A (see Table 6.2 on page 50).

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*.

All standard NMEA messages are a string of ASCII characters delimited by commas and that comply with the NMEA Standard 0183, Version 3.0. All non-standard messages are a string of ASCII characters delimited by commas using the Magellan NMEA style response format.

Differential Operation

This section discusses differential operation, sources of error, 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 SV range corrections and transmitting them to a remote (rover) unit. The A12 operates as a remote unit. When a reference station transmits these corrections in real time to the A12 via a communications link, the A12 applies the corrections to its measured ranges and uses the corrected ranges to compute its position.

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.

SBAS Operation

The A12 unit has two channels dedicated for tracking Satellite-Based Augmentation System (SBAS) satellites. The user can configure the A12 receiver to track GPS satellites on all 12 channels by disabling WAAS reception using command $PASHS,WAS,OFF (refer to page 72). In the DGPS remote mode, the A12 automatically utilizes corrections from the SBAS (WAAS/EGNOS/MSAS) satellites to provide differentially corrected position. However, RTCM (local) corrections take priority over SBAS, i.e., if both corrections are available, RTCM corrections will be used. The A12 does not use the ranging information provided in the SBAS signals for position computation.

As a stand-alone receiver, and with SA (Selective Availability) off, the A12 typically computes a position within about 3 meters (50%) of truth but mostly within 5 meters (95%). In differential mode, the A12 can achieve 1 m or better precision using local corrections, and 2-4 m accuracy utilizing SBAS (WAAS/EGNOS/MSAS) corrections. For local 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

In DGPS mode the A12 accepts RTCM SC-104 Version 2.2 differential formats. The A12 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 A12 processes type 3 for station location, and types 1 and 9 for RTCM differential corrections. The differential corrections are automatically processed by the A12.

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

RTCM message type 3 provides 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 type 3 periodically. 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 **$PASHS,RST** (reset to defaults command) the A12 default automatic differential mode is OFF, and the default is 15 seconds for the maximum age of an RTCM differential correction, above which it is not be used. If the automatic mode is not enabled by the **$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 A12 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 A12 returns the uncorrected position or an SBAS DGPS position.

RTCM 104 Format, Version 2.2

The A12 uses six-of-eight format (data bits a1 through a6 of an eight-bit byte) for communication between the reference station and user equipment.

The A12 can accept any type of RTCM message, however it decodes types 1, 3, and 9, as detailed in Table 3.2, and uses only types 1 and 9 for differential corrections.

Table 3.2 RTCM Format

Message Type	Contents of message
1	Differential GPS corrections
3	Reference station parameters
9	High-rate differential GPS corrections

Pulse Generation (1 PPS)

The A12 calculates time and outputs the first 1 PPS pulse only after it has obtained an initial position fix. The A12 continues to output 1 PPS during position outages, but with reduced accuracy. Figure 3.1 shows the timing relationships. The 1 PPS output is accurate to ±1 msec by default if the receiver is within 300 meters of the last valid position. The 1PPS accuracy can be set to ±250 nsec by the set command $PASHS,PPS,ON, refer to page 64 for more details. The 1PPS pulse width is 1 msec for 1 msec accuracy mode and is 1 µsec for 250 nsec accuracy mode. Time is reported in the NMEA message ZDA. The 1 PPS output is available on pin 8 of the A12 8-pin I/O connector.

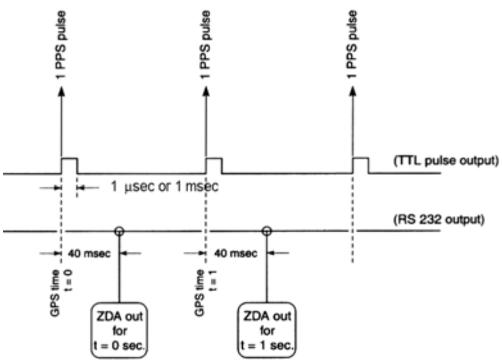


Figure 3.1: Relationship of GPS Time in PRN Record to 1 PPS Pulse

Figure 3.2 shows the 1 PPS pulse characteristics. The 1 PPS pulse occurs when the signal goes high. The 1 PPS pulse is synchronized to the GPS second with an accuracy of ±250 nsec or ±1 msec depending on the PPS command setting and the pulse remains high for 1 µsec (PPS,ON) or 1 msec (PPS,OFF).

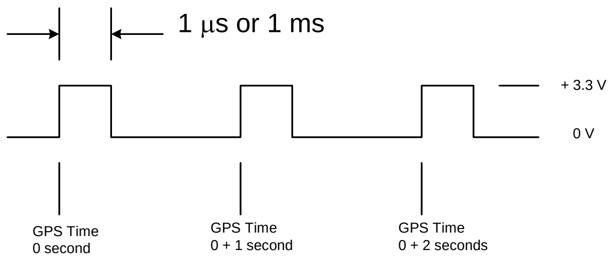


Figure 3.2: PPS Pulse

Magnetic Variation and Geoid Models

The A12 magnetic variation model is based on WMM 2000 converted to first-order polynomial fits (in time) at 10-degree intervals over the globe. The variation is then interpolated from the computed values at the four corners of the 10x10 degree (latitude/longitude) grid square containing the position. Details of this model can be obtained from the National Geophysical Data Center in Boulder, CO.

The A12 uses a proprietary geoidal height model based on data from the late 1980s, with a resolution of 10 degrees latitude and longitude, using interpolation to obtain orthometric height at a particular location.

4

A12/AC12 Sensor & Development Kit

This chapter describes the A12/AC12 Sensor and Development Kit. Please note that the sensor and development kit are common to both A12 and AC12 receivers. For convenience, the AC12 Sensor and Development Kit will be referred to as A12 Sensor and Development kit in this manual.

Overview

The A12 Development Kit, Figure 4.1, lets the user rapidly set up and operate the A12 to determine suitability for the application. The kit can also be used for software development (experimenting with commands, etc.) and for troubleshooting once the user system is deployed.

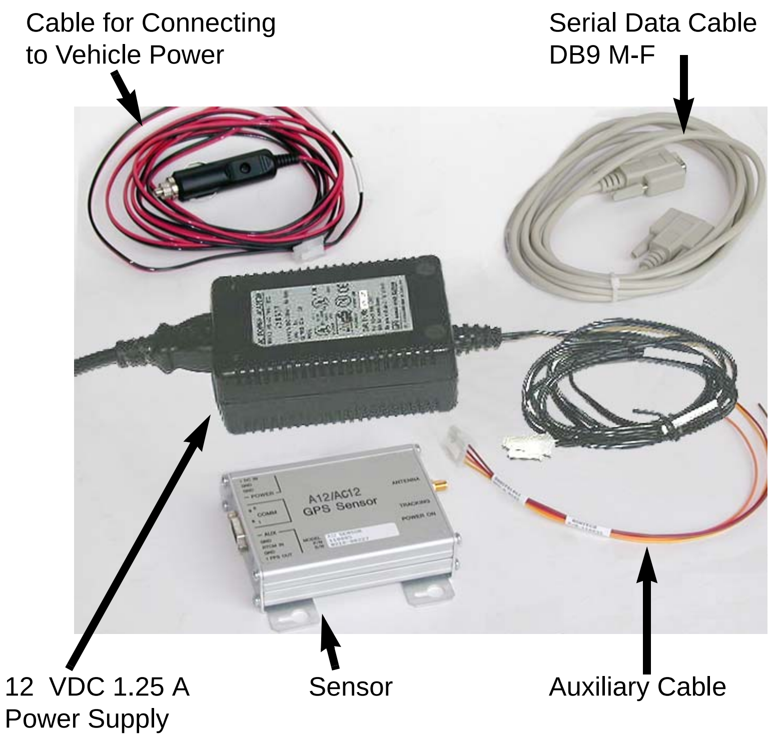


Figure 4.1: A12/AC12 Development Kit

The kit provides the following conveniences which you would otherwise have to devise yourself:

- Built-in RS-232 interface does TTL to RS-232 conversion
- Standard SMA antenna connector
- Standard serial interface connector connects directly to PC
- 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

Mounting the A12 Sensor

The A12 Sensor can be mounted in any orientation. Mounting flanges are provided to accommodate the four #6 mounting screws. Keyhole-shaped holes on the mounting flanges allow installation and removal of the unit while leaving the screws in place. A full-size mounting template is supplied with each A12 Sensor. Table 4.1 lists dimensions of interest.

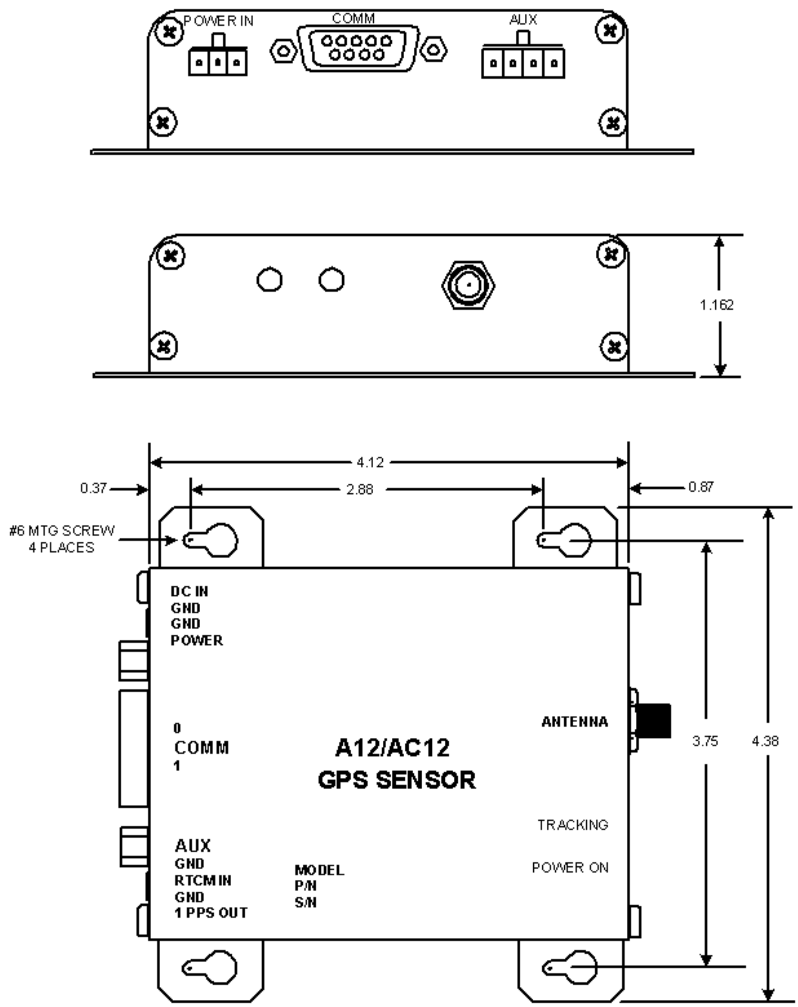


Figure 4.2: A12/AC12 Sensor Dimensions (Inches)

Table 4.1 A12 Sensor Dimensions

Characteristic	Description
Length	4.12 in (104.6 mm)
Width	4.38 in (111.2 mm)
Thickness	1.162 in (29.5 mm)
Weight	8.5 oz (240 g)
Mounting Method	Four #6 screws
Mounting hole diameter	0.125 in (3 mm)
Mounting hole location	Template supplied
Power	10 to 18 VDC, 12 VDC nominal Typical current consumption is 110 mA using recommended antenna (Aromat VIC-1)

Configuring the Kit for Operation

To configure and operate the A12 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 the Equipment

Check the A12 Development Kit to ensure that all items are available, as shown in Figure 4.1 and listed in Table 4.2.

Table 4.2 Evaluation and Development Kit Inventory

Part Number	Description
111050	A12/AC12 sensor
110981	12-V Universal power Supply with cable
110030	Cigarette lighter adapter cable
110031	DB9 male-to-female I/O cable
110032	Auxiliary cable, 1 PPS out, RTCM in
630871	Manual User guide
	Evaluator software

Step 2 - Load the Evaluate software into the 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 6.05 or later, earlier versions will not work with the A12. After the 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 The Equipment for Operation

Connect devices as shown in Figure 4.3. It is very important to follow instructions 1 through 6 below.

CAUTION
DO NOT connect power at any time during this step.

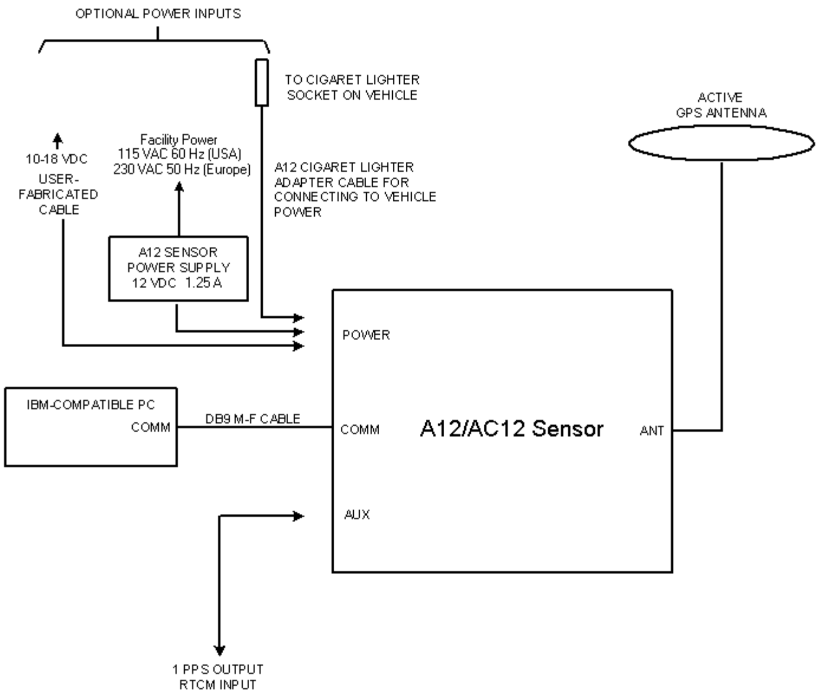


Figure 4.3: Setup Using A12/AC12 Development Kit

1. Connect the serial data cable DB9 M-F to the COMM port (DB9 connector) on the A12 sensor.
2. Connect the other end of the serial data cable to an initialized serial port on your IBM-compatible computer. If the serial port of the computer is not initialized, it will not be recognized by the Evaluate software.

Within the A12 sensor, the RTS/CTS lines of the interface cable are connected. This is done to ensure that the computer will always receive an immediate CTS signal when it asserts RTS as part of its communication process. Refer to Table 4.3 on page 36 for specific interconnection details.

3. Connect the power connector on the A12 sensor to the appropriate adapter (power supply, 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 A12 Sensor. You may connect a different active antenna to the A12 Sensor, but please refer to Table 1.6 on page 9 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 the antenna and A12 Sensor.

CAUTION
The user must provide a DC block if external power is provided to the antenna.

   Also note that if you are using a passive antenna with the A12 Sensor, make sure that it has enough gain to provide the RF signal strength needed at the input to the OEM board for reliable operation. The suggested RF cable length for a passive antenna is six inches. If the user antenna is used, it must meet the specifications listed in Table 1.6 on page 9.

5. If you are using the 1PPS output, connect the 1 PPS output and signal ground from the auxiliary cable connector on the A12 sensor to the appropriate recording device.
6. If you are using RTCM corrections, connect RTCM IN and signal ground from the auxiliary cable connector to the device port that is outputting the RTCM corrections.

Power and Signal Connections

Figure 4.4 shows the physical configuration of the connector pinouts. Table 4.3 defines power and input/output signals.

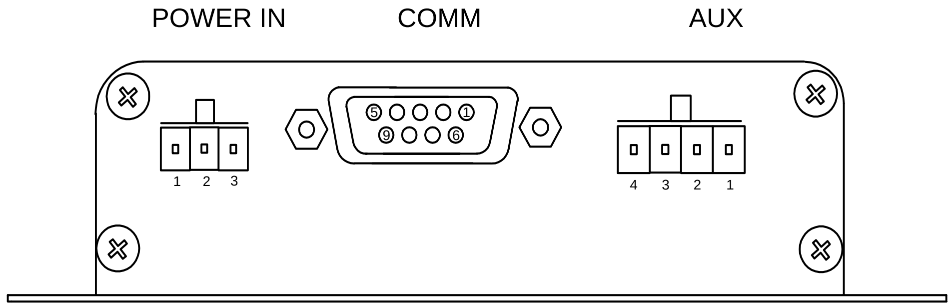


Figure 4.4: Connector Pinouts

Table 4.3 Power/Input/Output Connections

Connector	Pin	Signal	Function
Power In	1	Ground	BLACK - Chassis ground (= 12 VDC return)
	2	Power return	DC ground
	3	Power In (DC)	10-18 VDC +
	Molex P/N 39-30-3035	Mate 39-01-4030	Terminals 39-00-0039
COMM (DB9 M-F)	1	CD	Carrier detect out - true (+V) when power applied to A12. Tied to DSR.
	2	RXD	Received data out - TXD from A12
	3	TXD	Transmitted data in - RXD into A12‘
	4	DTR	Data terminal ready - not connected
	5	Ground	Signal ground - connected to DC return in A12
	6	DSR	Data set ready out - true (+V) when power applied to A12. Tied to CD
	7	RTS	Request to send in
	8	CTS	Clear to send out
	9	RI	Ring indicator out - not connected

Table 4.3 Power/Input/Output Connections (continued)

Connector	Pin	Signal	Function
Auxiliary	1	1 PPS out	Brown wire - Unbuffered TTL output
	2	Ground	Red wire - Signal ground for 1 PPS
	3	RTCM IN	Orange wire - RS-232 RXD (RTCM) into A12
	4	Ground	Yellow wire - Signal ground for RTCM IN
	Molex P/N 39-30-3045 Mate 39-01-4040 Terminals 39-00-0039		

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 A12 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 A12 Sensor is connected to power it automatically provides +5VDC power to its internal A12 OEM board and 4.5 VDC power to the GPS antenna connector on the rear of the A12 Sensor. 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 A12 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 9, 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 A12 Sensor rear panel and your antenna cable.

Connect the power cable to a power source. The PWR ON light should now be lit.

When the A12 Sensor is turned on for the first time, be aware of the following conditions:

1. The first power-on may require that A12 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 A12 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 A12 serial interface turns on at 4800 baud, B12 at 9600. Your external device (e.g., P.C.) must initially communicate with the A12/B12 at this rate. After communication is established, you can use the PC to change the baud rate.
3. Once the A12 is powered on and has completed its initial start process, it immediately begins calculating position. To output position messages, you must turn on the outputs you want by using the external device (PC) to issue the appropriate commands (refer to Chapter 5). The messages will contain valid data once the A12 has completed its cold, warm, or hot start sequence.
4. Once the A12 starts tracking satellites and has a valid position fix, the tracking LED flashes to indicate status. Refer to Table 4.4 for tracking LED operation.

Table 4.4 Tracking LED Operation

Tracking LED State	1 PPS Signal Status	NMEA Affirmative Message*	NMEA Negative Message*	Tracking Status
Off	No	-	-	Not tracking satellites
Green flash	Yes	Yes	No	Tracking satellites
Off	Yes	No	Yes	Not tracking satellites
Red flash	Yes	No	No	No NMEA messages available on port A to confirm tracking

*Tracking LED operation requires 1 PPS output and at least one NMEA message to be output on port A which includes Universal time. The NMEA messages that output Universal time are GGA, GLL, POS, and RMC. A12 stops incrementing time in these messages when it is not tracking satellites. An affirmative message indicates that A12 is tracking satellites and the Universal time in the NMEA messages is changing. A negative message indicates Universal time that is not updated or a null field for time in these messages.

The Evaluate software provides simple communication programs designed to interface to A12 Sensor. Move on to Step 6 to initiate communication with the A12 Sensor.

Magellan recommends that first time users always operate the A12 Sensor 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 A12 Sensor for

RTCM operation, refer to Chapter 3, *Operation* and Chapter 5, *Command/Response Formats*.

Step 6 - Using Evaluate Software

With your A12 Sensor 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 4.5, 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*.

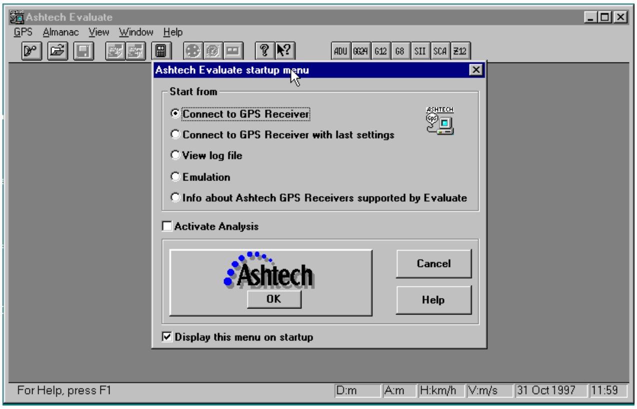


Figure 4.5: Evaluate Opening Screen

5

B12 Board and Sensor

Overview

This chapter presents a hardware description of the B12 GPS OEM board and sensor, defines the RF interface and the power/input/output signal parameters, and lists power requirements and environmental specifications. The B12 board and sensor have the same firmware as the A12, and support all commands and messages described for the A12.

B12 Board

The B12 GPS board, Figure 5.1, is identical to the A12 in functionality and operation. It differs only in dimensions and hardware specifications.

Figure 5.1: B12 OEM Board

Physical Configuration

The B12 GPS board has an 8-pin I/O connector (0.1 inch header) and supports CMOS/ TTL level signals. Table 5.1 describes I/O connector pinout. The B12 board has a standard SMB RF connector to connect to a GPS antenna. A right-angle bulk-head mount male SMB is used for easy integration. The center conductor supplies power to the low-noise amplifier (LNA) of an active antenna. The power supplied to the antenna is the same as the power input to the board on

I/O pin 2. The antenna open/short status information is available in the PAR query response message (see page 59).

Table 5.1 Connector Pinout

Pin	Function	Description
1	TXD 2	Port B transmit, CMOS/TTL
2	VCC	5VDC ±5%, 55-70 mA typical
3	TXD 1	Port A transmit, CMOS/TTL
4	V_{backup}	Battery back-up power (BBU) +2.7 VDC to +3.6VDC, 6µA typical
5	RXD 1	Port A receive, CMOS/TTL
6	1 PPS	1PPS (pulse-per-second), CMOS/TTL, active high signal
7	RXD 2	Port B receive, CMOS/TTL
8	GND	Ground, power and signal

The B12 board provides four 0.125 inch mounting holes that will accept 3/16 inch round or hex standoffs with 3/8 inch height, and # 2-56 or M2 mounting screws. Space-constrained environments may require different stand-offs. Low-profile RF shields are used to enclose the RF circuitry. These shields reduce emissions and provide some degree of ESD protection while handling. Refer to the mechanical drawing (Figure 1.2 on page 5) for dimensions and clearances.

Interface Connector and Power Requirements

The I/O connector is an 8-pin header (2 x 4) that uses 0.023 inch (0.584 mm) long square pins on a 0.100 inch (2.54 mm) spacing. The B12 board requires +5 VDC ± 5% on pin 2. The current consumption is typically 55 - 70 mA, excluding the antenna. The B12 board also requires a 2.7 – 3.6 VDC for battery back-up (BBU) power to keep the receiver's RAM memory alive during power off. However, the design allows you to apply 5VDC to the backup power (pin 4) when the board is powered. Care should be taken not to apply more than 3.6 VDC when the unit is powered off. The RAM memory is used to store the setup parameters, GPS time, almanac, ephemeris and the last position fix for faster acquisition and better start times. The current consumption for battery back-up is typically 6 µA. Table 5.2 below lists all the power specifications for the B12 board.

Table 5.2 Power Requirements

Signal	Voltage	Current	Pin No.
V_{CC}	+4.75 to +5.25	55 to 70 mA typical	2
Battery backup	+2.7 to +3.6	0 µA with prime power 6µA typical @ 3.3V, 25°C without prime power	4
Ground	0	-	8

Serial Interface and Signal Levels

The B12 board has 2 serial ports. Ports A and B support communications with the B12 board using I/O commands and can also receive RTCM corrections for DGPS operations. The B12 has the same serial interface as A12 and supports all commands and messages listed in this manual. However, the signal levels on the serial ports are CMOS/TTL compatible. Output signal high is equal to V_{CC}. Output signal low is equal to 0 V.

For DGPS input, the board will accept the standard RTCM-SC-104 V2.2, type 1, 3, and 9 messages in the 6 of 8 bits rolled format.

The data configuration on both ports is the standard 8 data bits, 1 start bit, 1 stop bit, no parity. The baud rates supported are: 1200, 4800, 9600, 19200, 57600 and 115200. Please refer to the command SPD on page 69 to change the baud rate of the serial ports. Default baud rate for port A is 9600.

The 1PPS pulse is output on I/O pin 6 and is also CMOS/TTL compatible. The 1 PPS pulse in B12 is active high. The accuracy of the 1PPS signal is the same as in A12, please refer to page 27 for more details on 1PPS operation.

Environmental Specifications and Dimensions

The environmental specifications and other limitations for the B12 board are listed in Table 5.3.

Dimensions and mounting Configuration

Dimensions and mounting configuration are shown in Figure 5.2.

Table 5.3 Environmental Limitations

Condition	Specification
Operating Temperature	-30°C to +80°C
Storage Temperature	-40°C to +85°C
Humidity	95% RH non-condensing @ +60°C
Vibration	0.008 g 2 /Hz 5 to 20 Hz 0.05 g 2 /Hz 20 to 100 Hz 3 dB/octave 100 to 900 Hz
Speed limitations	1000 knots (514 m/sec)*
Altitude limitations	60,000 feet (18,288 m)*
* The B12 produces no valid position information beyond these limits.	

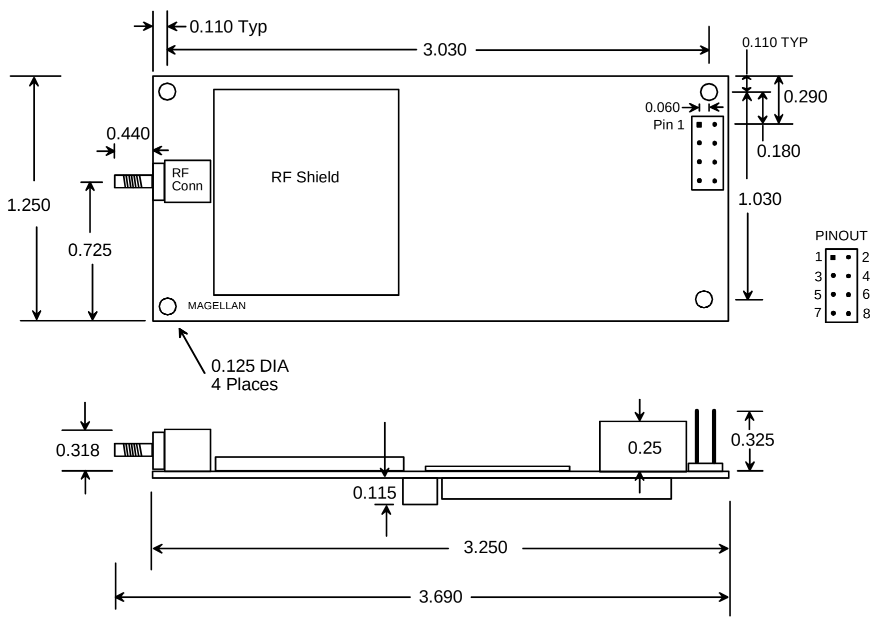


Figure 5.2: B12 Dimensions and Mounting Configuration

B12 Sensor

The B12 Sensor, Figure 5.3, is similar to the A12 Sensor and has the same I/O connectors and interface. It only differs from the A12 in dimensions. The B12 specifications and dimensions are listed below. The B12 is also available in a development kit similar to the A12. Please refer to Chapter 4, **A12/AC12 Sensor & Development Kit** for more details on the development kit features.

Figure 5.3: B12 Sensor

Specifications

Table 5.4 lists the specifications of the B12 Sensor.

Table 5.4 B12 Sensor Specifications

Characteristic	Description
Length	5.12 inches 130 mm
Width	4.38 Inches 111.2 mm
Thickness	1.16 Inches 29.5 mm
Weight	8.5 oz 240.0 gr
Operating temp	-30 C to +70 C -22 F to 158 F
Storage temp	-40 C to +85 C -40 F to +185 F
I/O ports	Two RS-232
Input voltage	10 to 18 VDC

Table 5.4 B12 Sensor Specifications (continued)

Characteristic	Description
Current consumption	70 to 90 mA
Power consumption	1 watt typical

Table 5.5 Power/Input/Output Connections

Connector	Pin	Signal	Function
Power In	1	Ground	BLACK - Chassis ground (= 12 VDC return)
	2	Power return	DC ground
	3	Power In (DC)	10-18 VDC +
	Molex P/N 39-30-3035	Mate 39-01-4030	Terminals 39-00-0039
COMM (DB9 M-F)	1	CD	Carrier detect out - true (+V) when power applied to B12. Tied to DSR.
	2	RXD	Received data out - TXD from B12
	3	TXD	Transmitted data in - RXD into B12‘
	4	DTR	Data terminal ready - not connected
	5	Ground	Signal ground - connected to DC return in B12
	6	DSR	Data set ready out - true (+V) when power applied to B12. Tied to CD
	7	RTS	Request to send in
	8	CTS	Clear to send out
	9	RI	Ring indicator out - not connected
Auxiliary	1	1 PPS out	Brown wire - Unbuffered TTL output, active low signal
	2	Ground	Red wire - Signal ground for 1 PPS
	3	RTCM IN	Orange wire - RS-232 RXD (RTCM) into B12
	4	Ground	Yellow wire - Signal ground for RTCM IN
	Molex P/N 39-30-3045	Mate 39-01-4040	Terminals 39-00-0039

6

Command/Response Formats

Overview

The commands and queries described in this chapter are common to A12, A12 Sensor, B12, and B12 Sensor.

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 Magellan'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. Default baud rate for A12 is 4800 for ports A and B. Default baud rates for B12 are 9600 for port A, and 4800 for port B.

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 49.
- **NMEA message commands -** control standard NMEA data message output or NMEA style message output. The discussion of these commands begins on page 73.
- **RTCM commands** - control RTCM differential operation. The discussion of these commands begins on page 111.

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. Table 6.1 defines the parameter symbols.

Table 6.1 Command Parameter Symbols

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

For example, for the receiver command

$PASHS,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 Commands and Responses

The receiver commands are used to 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.

A12 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 A12 returns the appropriate response to this port. Port B is half-duplex, therefore it accepts input messages but does not output messages; Port B accepts only RTCM correction input. 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 is returned in the form:

$PASHR,ACK*3D

If a set command is not accepted, an non-acknowledgment 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.

The response message may be in comma-delimited or 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 6.2 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 receiver for parameters. Commands that generate standard NMEA responses are described in "NMEA Data Message Commands & Responses" on page 73. The pages shown in the table presents detailed descriptions of each command/query/response.

Table 6.2 Summary of General Receiver Set/Query Commands

Command	Description	Page
$PASHS,ALM	Upload almanac data	52
$PASHS,ALT	Set ellipsoidal height of antenna	53
$PASHS,DTM	Select datum to use	54
$PASHS,FIX	Set altitude position fix mode	55
$PASHS,FHS	Set receiver in fast hot start mode	56
$PASHS,FUM	Fix UTM zone	56
$PASHS,FZN	Select fixed UTM zone	57
$PASHS,HDP	Set HDOP mask for position computation	57
$PASHS,INI	Initialize receiver, set baud rate to specified value	58
$PASHS,LTZ	Set local time zone	59
$PASHQ,PAR	Receiver parameters query	59
$PASHS,PDP	Set PDOP mask	61

Table 6.2 Summary of General Receiver Set/Query Commands (continued)

Command	Description	Page
$PASHS,PEM	Set position elevation mask angle	61
$PASHS,PMD	Set position mode	62
$PASHS,POS	Set antenna position	62
$PASHS,PPO	Set point positioning mode	63
$PASHQ,PPO	Query point positioning status	63
$PASHR,PPO	Point positioning response message	64
$PASHS,PPS	Set 1PPS output acccuracy	64
$PASHQ,PPS	Query 1PPS output accuracy	64
$PASHR,PPS	1PPS response message	64
$PASHQ,PRT	Serial port baud rate query	65
$PASHR,PRT	Baud rate response message	65
$PASHQ,RID	Receiver identification query	66
$PASHR,RID	Receiver identification response message	66
$PASHS,RST	Reset receiver parameters to default values	66
$PASHS,RTC	Set receiver to RTCM remote mode	115
$PASHQ,RTC	Query RTCM status	112
$PASHS,SAV	Save user parameters.	67
$PASHS,SNM	Set satellite signal-to-noise mask	68
$PASHS,SPD	Set serial port speed	69
$PASHS,UDD	Set user-defined datum parameters	69
$PASHQ,UDD	Query user-defined datum parameters	70
$PASHR,UDD	User-defined datum response message	70
$PASHS,UID	Set unit ID number	71
$PASHQ,UID	Query unit ID	71
$PASHR,UID	Unit ID response message	71
$PASHS,USE	Set satellites to track or not track	71
$PASHS,WAS	Enable/disable WAAS reception	72
$PASHS,ZDA	Upload initial real-time clock value	72

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 ALM parameters are as defined in Table 6.3.

Table 6.3 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 may speed up acquisition of the satellites.

ALT: Set Ellipsoidal Height of Antenna

$PASHS,ALT

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

$PASHS,ALT,f1

where the parameters are as defined in Table 6.4.

Table 6.4 ALT Parameters

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

Example: Set ellipsoidal height of antenna to 100.25 meters:

$PASHS,ALT,+100.25 <Enter>

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

$PASHS,ALT,-30.1 <Enter>

DRC: Reset Receiver Automatically Every x Days

$PASHS,DRC

Sets a time interval, in days, at the end of which the receiver is automatically reset. The command structure is:

$PASHS,DRC,x

Where the parameters are as defined in **Table 6.5:**

Table 6.5 DRC Parameters

Parameter	Description	Range
x	Reset interval, i.e. number of days elapsed before the receiver is reset. (Default: 24) x=OFF means no reset	1-24 or OFF

$PASHQ,DRC will cause the following string to be returned:

$PASHR,DRC,x

Where x is as defined above.

DTM: Select Datum to Use

$PASHS,DTM,s

Selects the geodetic datum used for position computation and measurements. The datum can be user-defined as described below, or pre-defined as listed in Appendix B.

The parameter **s** is a 3-character string that selects a particular datum. USR is the string for a 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.

To use one of the supported pre-defined datums, refer to Appendix B and select the applicable 3-character string listed in the “Datum ID” column. Enter this string for the parameter s in the $PASHS,DTM,s command.

Example: Select user-defined datum for position computation:

$PASHS,DTM,USR <Enter>

where the parameters are as defined in Table 6.6.

Table 6.6 DTM Parameters

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

Example: Select Australian Geodetic Datum 1984 (Appendix B, Datum ID AUG):

$PASHS,DTM,AUG<Enter>

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 6.7.

Table 6.7 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>

FHS: Fast Hot Start Mode

$PASH,FHS,ON/OFF

This command sets the receiver in fast hot start mode. If FHS is set to "ON", the receiver quickly acquires satellites and provides a position fix in a hot start condition. If FHS is set to "OFF", the receiver takes 6 seconds longer to re-acquire satellites and output a position fix, but is less susceptible to in-band jamming and interfering signals. The default setting for FHS is ON.

$PASHQ,FHS

The associated fast hot start mode query command is $PASHQ,FHS.

$PASHR,FHS

The FHS response message is $PASHR,FHS,ON or $PASHR,FHS,OFF, as applicable.

FUM: Fix UTM Zone

$PASHS,FUM,c1

This command enables/disables the fixing of the UTM zone, where c1 is Y (enable) or N (disable). The default is N. This command is typically enabled when the user is near a UTM boundary and wants to avoid the coordinate shift that occurs when crossing from one UTM zone into another. This command is used in conjunction with the **$PASHS,FZN** command which is used to select the zone to be fixed by the FUM command.

Example: Enable the fixed zone setting:

$PASHS,FUM,Y

DEFAULT SETTING
FUM—N

FZN: Select Fixed UTM Zone

$PASHS,FZN,d1

This command selects the UTM zone that will be held fixed, where d1 is the UTM zone number ranging from 1 to 60. This command is typically used when the user is near a UTM boundary and wants to avoid the coordinate shift that occurs when crossing from one UTM zone into another. This command is used in conjunction with the command **$PASHS,FUM**, which holds fixed the zone selected by the FZN command.

Example

Select UTM zone 10 as the zone to be held fixed:

$PASHS,FZN,10

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 A12 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 6.8.

Example: Set HDOP mask to 6 (Table 6.8).

$PASHS,HDP,6 <Enter>

Table 6.8 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 6.9.

Table 6.9 INI Parameters

Parameter	Description	Range	Default
d1	Port A baud rate code: 2 = 1200 4 = 4800 5 = 9600 6 = 19200 8 = 57600 9 = 115200	2 - 9	A12 = 4 B12 = 5
d2	Port B baud rate code	2-9	A12 = 4 B12 = 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>

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 defined in Table 6.10. The response is ACK/NAK.

Table 6.10 LTZ Parameters

Parameter	Description	Range
d1	GMT = local time + time offset: hours	± 00...13
d2	GMT = local time + time offset: minutes	0, 15, 30, 45

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:00  PDP:06  HDP:04
DTM:W84  LTZ:000,00  SAV:Y
ANT:Y  WAAS:Y
USE:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
CDS:AUTO  DIF_RTCM_MODE:OFF  PRT:?  AUT:Y  MAX:0030
LAT:0000.000000,N  LON:00000.000000,E  ALT:00000.00
NMEA: ZDA GGA GLL GSA GSV MSG POS RMC SAT VTG ALM RRE UKO CRT XMG
UTM
PRTA: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
PRTB: ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
PER:001  SPD: PORT A:4 PORT B:4
```

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 6.11 defines the PAR response parameters.

Table 6.11 PAR Parameters

Parameter	Description/Related Command	Range
PMD	Navigation position mode ($PASHS,PMD)	2 or 4
FIX	Altitude fix mode ($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)	See Table B.1, page 133
LTZ	Local timezone ($PASHS,LTZ)	-13,59 to +13,59
SAV	Save parameters ($PASHS,SAV)	Y (yes) or N (no)
ANT	Antenna status This field is applicable only to B12.	Y = antenna detected O = no antenna connected S = short circuit in antenna connection
WAAS	SBAS reception enabled or disabled	Y = enabled, N = disabled
USE	Use satellite ($PASHS,USE)	Y or N for each satellite
CDS	Manual satellite selection ($PASHS,CDS)	AUTO (applies to all channels) or else PRN or - for each channel
DIF_RTCM MOD	External RTCM differential mode ($PASHS,RTC)	OFF/REM
PRT	Port receiving RTCM ($PASHS,RTC)	A, B
AUT	Auto differential mode ($PASHS,RTC,AUT)	Y or N
MAX	RTCM maximum age ($PASHS,RTC,MAX)	0-3600
LAT	Latitude of antenna position ($PASHS,POS)	0-90, north or south
LON	Longitude of antenna position ($PASHS,POS)	0-180, east or west
ALT	Ellipsoidal height of 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: "_"
PRTB	(Data cannot be output on port B) (it is Receive-Only port for RTCM corrections)	
PER	NMEA message output period ($PASHS,NME $PASHS,NME,PER)	1-999.0

Table 6.11 PAR Parameters (continued)

Parameter	Description/Related Command	Range	
SPD	Indicates baud rate code for port A and port B ($PASHS,SPD)	2 = 1200 4 = 4800 5 = 9600	6 = 19200 7 = 57600 9 = 115200

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 0 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>

The $PASHS,PEM command also sets the elevation mask for MCA raw data (page 120).

PDP: Set PDOP Mask for Position Computation

$PASHS,PDP

Sets the Position Dilution of Precision (PDOP) 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 6.12.

Table 6.12 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 6.13.

CAUTION

In 2D or when altitude is held fixed, the horizontal position is subject to greater error.

Table 6.13 PMD Parameters

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

When PMD is set to 4, altitude is held fixed at the last computed value and does not use altitude entered by the ALT command.

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 6.14.

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

Table 6.14 POS Parameters

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 or less than the full position can cause a very long delay in acquiring satellites.

PPO: Point Positioning

$PASHS,PPO,c[,f1]

This command enables/disables point positioning mode, where c is Y (enable) or N (disable) and [f1] is the optional horizontal velocity threshold in meters per second. Point positioning is an averaging algorithm that improves the stand-alone accuracy of a static point after about 4 hours. If PPO is enabled, when the horizontal velocity falls below the threshold, the A12 assumes that the receiver is stationary and begins averaging computed positions. The default for horizontal velocity threshold is 0.04 meters per second.

Example: Enable point positioning and set horizontal velocity threshold to 1.0 meter per second:

$PASHS,PPO,Y,1.0 <Enter>

$PASHQ,PPO

The associated point positioning mode query command is $PASHQ,PPO..

$PASHR,PPO

The point positioning response message is in the form:

$PASHR,PPO,c,xx.xx

If c is Y (enabled), xx.xx indicates the value of the horizontal velocity threshold. If c is N (disabled), the field xx.xx is not displayed.

Example: PPO enabled, threshold set to 0.04 meters per second:

$PASHR,PPO,Y,00.04*48

PPS: 1PPS On/Off

$PASHS,PPS,On/Off

This command sets accuracy of the 1PPS output pulse. Two accuracies are available: 1 msec or 250 nsec. The 1 msec accuracy applies if all 12 GPS channels are needed. The 250 nsec accuracy requires one channel, leaving 11 GPS channels for position computation.

The $PASHS,PPS,ON command enables PPS with 250nsec accuracy. The $PASHS,PPS,OFF command enables PPS with 1 msec accuracy. Default is OFF (12 channels, 1 msec).

The $PASHS,PPS command does not take effect immediately upon being issued; the proper procedure is to issue the $PASHS,PPS command, then save by issuing the $PASHS,SAV,Y command, then power cycle the receiver. The new PPS setting takes effect after the power cycle.

The PPS pulse width for 250 nsec accuracy is about 1 µsec, and for 1 msec accuracy is about 1 msec.

$PASHQ,PPS

This command queries the PPS setting. The command returns the new setting immediately, even though the new setting is not effective until the next power cycle.

$PASHR,PPS

The PPS response message is $PASHR,PPS,ON or $PASHR,PPS,OFF, as applicable.

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, A or B. Note that to direct the response message to the current communication port, the x parameter 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 6.15.

Table 6.15 PRT Parameters

Field	Description	Range
x	Serial port	A or B
d	Baud rate code	2 = 1200 4 = 4800 5 = 9600 6 = 19200 8 = 57600 9 = 115200
*cc	Checksum	n/a

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, A or B. If a port is not specified, output goes to the current port.

Example: Query the current port for receiver and firmware identification

$PASHQ,RID <Enter>

$PASHR,RID

The response message is in the form:

$PASHR,RID,s1,s2*cc

where s1 is receiver ID and s2 is firmware version as defined in Table 6.16.

Table 6.16 $PASHR,RID Structure

Parameter	Description	Range
s1	Receiver ID A12_ for A12 and B12 AC12 for AC12	A12_ or AC12
s2	Firmware version, 4-character alphanumeric	

Typical response:

$PASHR,RID,A12_,HN00

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.

Once the $PASHS,SAV,Y command is issued, all user parameters that were changed before power-down will be saved.

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 A12 pin 3 (V-back) for new parameters to be saved after power to the A12 pin (VCC) has been removed.

SMI: Code Measurement Smoothing

$PASHS,SMI,d1,d2

Set the interval in seconds of code measurements smoothing, which reduces the effect of noise, where d is the smoothing interval in seconds ranging from 0 to 1200, and d2 is the order of smoothing, 0, 1 or 2. If d2 is omitted, then the device assumes first order of smoothing. This smoothing setting is independent of the internal receiver update interval. The command **$PASHS,SMI,0** without order disables smoothing.

If d2 = 1, then the maximum value for d1 is 100. If d2 = 2, then the maximum value for d1 is 1200.

The smoothing correction is provided in the MCA message along with the smoothing count. If the internal smoothing count is greater than 255, then the smoothing count in the MCA is set to 255.

Example:

Set code measurement smoothing to 100 seconds.

$PASHS,SMI,100

DEFAULT SETTING		
SMI	**Smoothing Interval**	**100 second**
	Order of Smoothing	**1**

$PASHQ,SMI,[c1]

The associated query command is $PASHQ,SMI,[c1], where c1 is the optional output port.

$PASHR,SMI

The response message is in the form:

$PASHR,SMI,d1,d2*cc

where d1 is smoothing interval in seconds, and d2 is order of smoothing (1 or 2).

SNM: S/N Mask for Satellite Signal Use

$PASHS,SNM

This command is similar to the USE command (page 71). The structure is $PASHS,SNM,d where d is the S/N value in dB. This is the threshold value for the satellite signal-to-noise value below which the satellite will not be used in determination of position/velocity/time solution. The query response for $PASHQ,PAR includes a field to indicate the current SNM setting. Default value for SNM is 0.

Table 6.17 SNM Parameters

Parameter	Description	Range
d	Signal-to-noise ratio mask	0-57 0-All satellites used 57-no satellites used

SPD: Set Serial Port Speed

$PASHS,SPD

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

$PASH,SPD,c,d

where c is port A or B, and d is a number between 2 and 9 specifying the baud rate as listed in Table 6.18.

Table 6.18 SPD Parameters

Code	Baud Rate	Code	Baud Rate
2	1200	6	19200
4	4800	8	57600
5	9600	9	115200

Default for port A is 4800 baud on A12, 9600 on B12; default for port B is 4800 for A12 and B12 . 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.

Baud rate can not be set to 38,400 baud.

Example: Set port A to 19200 baud:

$PASHS,SPD,A,6 <Enter>

UDD: Set User-Defined Datum Parameters

$PASHS,UDD

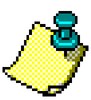
Sets the user-defined datum parameters in receiver memory. The structure is:

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

where the parameters are as defined in Table 6.19.

Table 6.19 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 counterclockwise - 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, A or B, 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 6.19.

UID: Unit Identification

$PASHS,UID

Sets the unit ID for the receiver. The structure is

$PASHS,UID,s

where s is a user-selected 4-character unit identification number. The UID set command also sets the unit identification number in the POS message.

Example: Set unit ID to A179:

$PASHS,UID,A179<Enter>

$PASHQ,UID

The associated query command is $PASHQ,UID,c   where c is the optional output port, A or B. This query returns the unit ID to the specified port. 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 unit identification number.

Example: **$PASHR,UID,A179**

If no value has been entered using the $PASHS,UID command, the default value (null) is reported in the $PASHR,UID response and the $PASHR,POS response.

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>

WAS: Wide-Area Augmentation

$PASHS,WAS,ON/OFF

This command enables/disables the reception of SBAS (WAAS/EGNOS/ MSAS) signals. When turned off the receiver uses all 12 channels for tracking GPS satellites. The $PASHQ,PAR query command can be used to view current WAAS settings. The $PASHQ,RTC query command will display if WAAS corrections are applied to the solution.

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 6.20.

Table 6.20 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 1/15/04 and the local time is 8:15:30:

$PASHS,ZDA,131530.00,01,15,2004 <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 Magellan NMEA style format. All standard NMEA messages are a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standard Version 3.0. All non-standard messages are a string of ASCII characters delimited by commas in the Magellan 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 integer 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:

ZDA, GGA, GLL, GSA, GSV, MSG, POS, RMC, SAT, VTG, ALM, RRE, UKO, CRT, XMG, UTM

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.

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 to be outpu every 2 seconds on port A:

$PASHS,NME,GGA,A,ON,2 <Enter>

Example:Output enabled NMEA messages every 5 seconds:

$PASHS,NME,PER,5 <Enter>

If the command is set without a period, the A12 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

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 where the response message will 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>

Table 6.21 summarizes the NMEA data message commands and responses. A detailed description of each NMEA command follows Table 6.21.

Table 6.21 NMEA Data Message Commands and Responses

Command	Description	Page
$PASHS,NME,ALL	Disable all NMEA messages	76
$PASHS,NME,ALM	Enable/disable almanac data message	76
$PASHQ,ALM	Query almanac data message	77
$GPALM	GPS almanac response message	77
$PASHS,NME,CRT	Cartesian coordinates message	78
$PASHQ,CRT	CRT query	79
$PASHR,CRT	CRT response message	79
$PASHS,NME,GGA	Enable/disable position response message	80
$PASHQ,GGA	Query position response message	80
$GPGGA	Position response message	80
$PASHS,NME,GLL	Enable/disable latitude/longitude message	82
$PASHQ,GLL	Query latitude/longitude message	83
$GPGLL	Latitude/longitude response message	83
$PASHS,NME,GSA	Enable/disable satellites used message	84
$PASHQ,GSA	Query satellite used message	84
$GPGSA	Satellites used response message	85
$PASHS,NME,GSV	Enable/disable satellites in view message	89
$PASHQ,GSV	Query satellites in view message	89
$GPGSV	Satellites-in-view response message	89
$PASHS,NME,MSG	Enable/disable base station message	87
$PASHQ,MSG	Query base station messages	87
$GPMSG	Base station message	87
$PASHS,NME,POS	Enable position message	91
$PASHQ,POS	Position message query	91
$PASHR,POS	Position response message	92
$PASHS,NME,PER	Set send interval - all NMEA messages	91
$PASHS,NME,RMC	Enable/disable recommended minimum course message	94
$PASHQ,RMC	Query recommended minimum course message	94
$GPRMC	Recommended minimum course response message	94
$PASHR,NME,RRE	Enable/disable range residuals & position error message	96
$PASHQ,RRE	Query range residuals & position error message	96
$GPRRE	Range residuals & position error response message	96
$PASHS,NME,SAT	Enable/disable satellite status message	99
$PASHQ,SAT	Query satellite status message	99
$PASHR,SAT	Satellite status response message	99

Table 6.21 NMEA Data Message Commands and Responses (continued)

Command	Description	Page
$PASHS,NME,UKO	Enable/disable UKOOA message	101
$PASHQ,UKO	Query UKOOA message	
$GPUKO	UKOOA response message	101
$PASHS,NME,UTM	Enable/disable UTM coordinates message	103
$PASHQ,UTM	Query UTM coordinates message	103
$PASHR,UTM	UTM coordinates response message	103
$PASHS,NME,VTG	Enable/disable velocity/course message	105
$PASHQ,VTG	Query velocity/course message	105
$GPVTG	Velocity/course response message	106
$PASHS,NME,ZDA	Enable/disable time and date message	108
$PASHQ,ZDA	Query time and date message	109
$GPZDA	Time and date response message	109
$PASHS,NME,XMG	Enable/disable exception messages	107
$PASHQ,XMG	Query exception messages	107
$PASHR,XMG	Exception messages	108

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, A or B.

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, A or B.

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 6.22.

Table 6.22 GPALM Response Message Structure

Field	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
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>**

A typical response message is shown below and detailed in Table 6.23.

$GPALM,26,01,01,0899,00,1E8C,24,080B,FD49,A10D58,EB4562,BFEF85,227A5B,011,000*0B

Table 6.23 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 perigree
BFEF85	Longitude of ascension mode
227A5B	Mean anomaly
011	Clock parameter
000	Clock parameter
*0B	checksum

CRT: Cartesian Coordinates Message

$PASHS,NME,CRT,x,c,[f]

This command outputs the computed Cartesian coordinates and velocities. Enable or disable the NMEA position response message on output port x, where x is port A or port B; c is ON or OFF, and f is the optional message output rate ranging from 1 to 999 seconds depending upon the measurement update rate option installed.

If the receiver is not computing a position, it outputs an empty message.

$PASHQ,CRT,x

This command queries the CRT command, where x is the optional output port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,CRT

The Cartesian coordinates and velocities message contains information on the antenna position, number of satellites, altitude, speed, velocity, and dilution of precision. The message is output in the format:

$PASHR,CRT,d1,d2,m1,m2,m3,m4,f2,f3,f4,f5,f6,f7,f8,f9,f10,s*cc

Table 6.24 defines the CRT message format.

Table 6.24 $PASHR,CRT Message Format

Parameter	Description	Range
d1	Position solution type: 0 = autonomous 1 = position differentially corrected with RTCM code	0 or 1
d2	Number of satellites used in position computation	3 to 12
m1	Current UTS time, (hhmmss), of position computation in hours, minutes, and seconds	00 to 235959.50
m2	Antenna position ECEF x coordinate in meters	
m3	Antenna position ECEF y coordinate in meters	
m4	Antenna position ECEF z coordinate in meters	
f2	Receiver clock offset in meters	
f3	X-component of velocity vector in m/s	
f4	Y-component of velocity vector in m/s	
f5	Z-component of velocity vector in m/s	
f6	Receiver clock drift in m/s	
f7	PDOP—position dilution of precision	0 to 99.9
f8	HDOP—horizontal dilution of precision	0 to 99.9
f9	VDOP—vertical dilution of precision	0 to 99.9
f10	TDOP—time dilution of precision	0 to 99.9
s*cc	Firmware version ID	4-character string

The ECEF coordinates reported are in the datum set by the user. ECEF coordinates are reported in meters (with two decimal places) without leading zeros or positive signs.

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. Default is **disabled**.

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 the optional receiver port where the message will be output, port A or B. 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

where the parameters are as defined in Table 6.25.

Table 6.25 GGA Message Structure

Parameter	Description	Range
m1	Current UTC time of position fix in hours, minutes, and seconds (hhmmss.ss)	00-235959.99
m2	Latitude component of position in degrees and decimal minutes (ddmm.mmmmm)	0-90
c1	Direction of latitude N= North, S= South	N or S
m3	Longitudinal component of position in degrees and decimal minutes (dddmm.mmmmm)	0-180
c2	Direction of longitude E = East, W= West	E or W
d1	Position type: 0. Invalid or not available 1. Autonomous position 2. RTCM or SBAS differentially corrected	0, 1, 2
d2	Number of satellites used in position computation	0 - 12
f1	Horizontal dilution of precision (HDOP)	0 - 99.9
f2	Altitude in meters above Mean Sea Level (orthometric height). 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 above WGS-84 reference ellipsoid	±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	

CAUTION

Fields may contain old or erroneous data. Use the position type field to determine validity.

Note: Latency between 1 PPS pulse and GGA message is approximately 1 second.

Example: Query: **$PASHQ,GGA <Enter>**

A typical GGA response is shown below and described in Table 6.26.

$GPGGA,185333.00,3721.077440,N,12156.114654,W,2,08,1.0,00036.81,M,-28.3,M,,*66

Table 6.26 Typical GGA Response Message

Field	Description
$GPGGA	Header
185333.00	UTC time of position fix
3721.077440	Latitude (ddmm.mmmmm)
N	North latitude
12156.114654	Longitude (dddmm.mmmmm)
W	West longitude
2	RTCM or SBAS differential position
08	Number of satellites used in position
1.0	HDOP
00036.81	Altitude
M	Units of altitude (M = meters)
-28.3	Geoidal separation
M	Units of geoidal separation (M=meters)
,,	Null field
*66	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 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 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, A or B. If a 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 shown below and defined in Table 6.27.

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

Table 6.27 GLL Message Structure

Field	Description	Range
m1	Latitude in degrees, decimal minutes (ddmm.mmmm)	0 - 90°
c1	Direction of latitude N = North, S = South	N or S
m2	Longitude in degrees, decimal minutes (dddmm.mmmm)	0 - 180°
c2	Direction of longitude W = West, E = East	W or E
m3	UTC time of position fix in hours, minutes, and seconds (hhmmss.ss)	00-235959.50
c3	Status, A: valid, V: invalid	A or V
c4	Mode indicator	A = autonomous D = differential E = estimated (dead reckoning) M = manual input S = simulator N = data not valid
*cc	Checksum	

Example: Query: **$PASHQ,GLL <Enter>**

Typical response:

$GPGLL,3721.0752,N,12156.1148,W,220949.00,A,A*75

Table 6.28 describes each item in a typical GLL response message.

Table 6.28 Typical GLL Response Message

Field	Description
$GPGLL	Header
3721.0752	Latitude
N	North latitude
12156.1148	Longitude
W	West longitude
220949.00,	UTC time of position fix
A	Status valid
A	Autonomous mode
*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 or B, 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, A or B.

Example: Display GSA message on the current port:

$PASHQ,GSA <Enter>

$GPGSA

The response message is in the form shown below and defined inTable 6.29.

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

Table 6.29 GSA Message Structure

Field	Description	Range
c1	Mode: M: manual, A: automatic	M or 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>

A typical response is shown below and described in Table 6.30.

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

Table 6.30 Typical GSA Message

Item	Description
$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

Table 6.30 Typical GSA Message

Item	Description
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

MSG: Base Station Message

$PASHS,NME,MSG

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

$PASHS,NME,MSG,x,s

where x is output port A or B, and s is ON or OFF.

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, A or B.

Example: **$PASHQ,MSG,A <Enter>**

$GPMSG

The response message varies depending upon the 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

Table 6.31 lists the common fields of message Types 1, 3, and 9.

Table 6.31 MSG Common Fields

Field	Description	Range
d1	RTCM message type	1, 3, 9
d2	Station Identifier	0 - 1023
f1	Z count	0000.0 - 3599.9
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 6.32 lists the remaining fields for message Type 1 and 9.

Table 6.32 Remainder for Types 1 and 9

Field	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 6.33 lists the remaining fields for message Type 3.

Table 6.33 Remainder for Type 3

Field	Description	Range
f2	Station X component	±9999999.99
f3	Station Y component	±9999999.99
f4	Station Z component	±9999999.99
*cc	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 or B, 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, A or B.

Example: Query the GSA message on port A:

$PASHQ,GSV,A <Enter>

$GPGSV

The GSV response message is in the form:

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

where the fields are as defined in Table 6.34.

Table 6.34 GSV Message Structure

Field	Description	Range
d1	Total number of messages	1-4
d2	Message number	1-4
d3	Total number of satellites in view	1-16
d4	Satellite PRN	1 - 32 for GPS 33 - 64 for SBAS
d5	Elevation in degrees	0 - 90
d6	Azimuth in degrees	0 - 359
d7	SNR in dB-Hz	30 - 60
*cc	checksum	

Example:

Query: **$PASHQ,GSV <Enter>**

Typical GSV response message:

$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 6.35.

Table 6.35 Typical GSV Message

Item	Description
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

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.

The PER command also controls the periodicity of the raw data messages PBN, MCA and SNV (page 118).

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 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 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 A or B.

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 6.36.

Table 6.36 POS Message Structure

Parameter	Description	Range
d1	Raw/differential position 0: Raw position is not differentially corrected 1: Position is differentially corrected with RTCM or SBAS	0, 1
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 (ddmm.mmmmm)	0 through 180
c2	Longitude sector E = east W = west	E or W
f1	Altitude in meters above WGS-84 reference ellipsoid. For 2-D position computation this item contains the altitude held fixed.	-30000.00 through 30000.00
f2	Unit ID	Null or 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 +999.99
f6	PDOP - position dilution of precision	0 through 99.9
f7	HDOP - position dilution of precision	0 through 99.9
f8	PDOP - position dilution of precision	0 through 99.9
f9	TDOP - position dilution of precision	0 through 99.9
s	Firmware version ID	4-character string
*cc	checksum	

Example:

Query: **$PASHQ,POS<Enter>**

A typical POS response might be:

**$PASHR,POS,1,08,185333.00,3721.077440,N,12156.114654,W,
00008.50,A111,015.0,000.0,-00.0,1.8,1.0,1.5,1.0,HM00*7C**

Table 6.37 describes each item in a typical POS message.

Table 6.37 Typical POS Message

Item	Description
$PASHR,POS	Header
0	Raw position, not differentially corrected
06	Number of SVs used in position fix
185333.00	UTC time of position fix
3722.385158	Latitude
N	North latitude
12156.114654	Longitude
W	West longitude
00008.50	Altitude above ellipsoid (meters)
A111	unit ID
015.0	Course over ground (degrees)
000.0	Speed over ground (km/hr)
-00.0	Vertical velocity (m/sec)
1.8	PDOP
1.0	HDOP
1.5	VDOP
1.0	TDOP
HM00	Firmware version ID
*7C	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 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 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, A or B. 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,c12*cc

where the parameters are as defined in Table 6.38.

Table 6.38 GPRMC Message Structure

Field	Description	Range
f1	UTC time of the GGA position 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

Table 6.38 GPRMC Message Structure (continued)

Field	Description	Range
c4	Latitude direction	N = North S = South
f5	Longitude (dddmm.mmmm)	00000.0000...17959.9999
c6	Longitude direction	E = East W = West
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 (see page 28)	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
c12	Mode indicator	A = autonomous D = differential E = Estimated (dead reckoning) M = manual input S = simulator N = data not valid
*cc	Hexadecimal checksum computed by exclusive-ORing all 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, A through F

A typical RMC response message is shown below and described in Table 6.39.

$GPRMC,215734.00,A,3721.0760,N,12156.1138,W,00.0,015.0, 040902,15,E,D*39

Table 6.39 Typical RMC Response Message

Item	Significance
$GPRMC	Header
215734.00	UTC time of GGA position fix
A	Status valid
3721.0760	Latitude
N	North
12156.1138	Longitude
W	West
00.0	Speed over ground, knots

Table 6.39 Typical RMC Response Message (continued)

Item	Significance
015.0	Course over ground, degrees true
040902	Date
15	Magnetic variation, degrees
E	East (subtracts from true course)
D	Differential
*39	Checksum

RRE: Satellite Range Residuals and Position Error

$PASHS,NME,RRE,x,c,[f]

Enable or disable satellite residual and position error message to port x, where x is the output port A or B, c is ON or OFF, and f is the optional message output rate ranging from 1 to 999 seconds depending upon the measurement update rate option installed.

The A12 does not output this message unless it computes a position.

If the command is set without a period, the A12 uses the period set by the **$PASHS,NME,PER** command. If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example: Enable RRE message on port A:

$PASHS,NME,RRE,A,ON

$PASHQ,RRE,[c1]

This command queries the RRE message, where c1 is the optional port designator for the output of the response (port A or B). If a port is not specified, the receiver sends the response to the current port.

$GPRRE

This message contains residual error values for the each pseudo-range measurement and RMS values for horizontal and vertical position error. The RRE message is not output unless positions are being computed. Residual errors and position errors are computed only if a minimum of 5 locked satellites are used to compute position; otherwise zero values are registered in the data fields. The message is output in the format:

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

Table 6.40 defines the RRE message format.

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

Table 6.40 $GPRRE Message Format

Parameter	Description	Range
d1	The number of satellites used to compute position	0 to 12
d2	PRN number for each satellite used in position computation	1 to 32 for GPS 33 to 64 for SBAS
f1	Magnitude of the residual range error (meters) for each satellite used in the position computation	-999.9 to +999.9
f2	RMS value for the horizontal position error (meters)	-9999.9 to +9999.9
f3	RMS value for the vertical position error (meters)	-9999.9 to +9999.9
*cc	Checksum	

Typical RRE response message:

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

Table 6.41 describes a typical RRE response message.

Table 6.41 Typical RRE Message

Field	Description
$GPRRE	Header
05	Number of satellites used to compute position
18	PRN of first satellite
000.2	Range residual for first satellite (meters)
29	PRN of second satellite
000.2	Range residual for second satellite (meters)
22	PRN of third satellite
-000.1	Range residual for third satellite (meters)

Table 6.41 Typical RRE Message (continued)

Field	Description
19	PRN of fourth satellite
-000.1	Range residual for fourth satellite (meters)
28	PRN of fifth satellite
000.5	Range residual for fifth satellite (meters)
0002.0	Horizontal position error (meters)
0001.3	Vertical position error (meters)
*76	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 or B, 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, A or B.

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,d5,c)*cc

where the parameters are as defined in Table 6.42.

Table 6.42 SAT Message Structure

Field	Description	Range
d1	Number of SVs locked	1 to 12
d2	SV PRN number,	1 to 32 for GPS 33 to 64 for SBAS
d3	SV azimuth angle in degrees	0 to 359
d4	SV elevation angle in degrees	0 to 90
d5	SV signal/noise ratio in dB Hz.	30 to 60
c	SV used in position computation U = used, - = not used	U or -
*cc	checksum	

Example:

Query: **$PASHQ,SAT<Enter>**

Typical SAT response message:

> **$PASHR,SAT,04,03,103,56,50,U,23,225,61,52,U,16,045,02,
> 51,U,40,160,46,53,U*6E**

Table 6.43 describes each item in a typical SAT response message.

Table 6.43 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	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	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	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	Signal strength of fourth SV
U	SV used in position computation
6E	Message checksum in hexadecimal

UKO: UKOOA Message

$PASHS,NME,UKO,A,ON

This command enables or disables the UKOOA message on port A.

$PASHQ,UKO

The associated UKOOA query command is **$PASHQ,UKO**.

$GPUKO

The UKOOA response message is in the format

$GPUKO,d1,f1,d2,f2,d2*(d3,d4,d5,d6,d7,d8)

where the parameters are as described in Table 6.44.

Table 6.44 UKO Parameters

Parameter	Description	Range
$GPUKO	Header	
d1	GPS week number	0 to 9999
f1	TOW (time of week) (seconds)	0.00 to 604799.99
d2	Number of SVs used in solution	0 to 12
f2	sf (scale factor)	Always 1.0
d3	PRN number	1 to 32 for GPS 33 to 64 for SBAS
d4	Post-fit residuals, m	-999.9 to +999.9
d5	Line of sight, latitude sensitivity sf = 7 ÷ 100 (m/rad)	-100 000 000 to +100 000 000
d6	Line of sight, longitude sensitivity sf = 7 ÷ 100 (m/rad)	-100 000 000 to +100 000 000
d7	Line of sight, altitude sensitivity sf = 1.0×10^{-8}	-100 000 000 to +100 000 000
f3	Weight of SV	0.0 to 99.99999

Example:

Command/Response

$GPUKO,1243,159258,11,1.0000,29,-000.8,-64950617,45870185,-29358180,+0.018095,27,-000.4,-23269383,-24579757,-90508736,+0.067006,3,-003.4,-68143459,-46028991,-17794798,+0.013181,7,+003.5,88192835,14086546,-12277689,+0.010921,1,-001.9,74529584,-40196456,-12780573,+0.011573,8,-000.0,-37369797,17524163,-87837504,+0.051278,10,+002.3,-16614523,65205789,-39741220,+0.021978,13,-000.7,65647383,-26964014,-58046364,+0.032779,28,-000.6,25922400,40679536,-77686232,+0.045122,31,+002.7,-29131302,-52746155,-60633948,+0.034407,47,-030.9,28746758,66148426,-25956522,+0.000664*6B

Explanation for fields d5 through f3:

Line of sight parameters Hlat, Hlon, Halt of UKO message have such meaning:

d5: Hlat = (dR/dLat) / 0.07

d6: Hlon = (dR/dLon) / 0.07

d7: Halt = (dR/dAlt) * 1.0e8

where:

(dR/dLat) [m/radian]: derivatives of range to the SV over latitude angle value

(dR/dLon) [m/radian]: derivatives of range to the SV over longitude angle value

(dR/dAlt) [unitless]: derivatives of range to the SV over altitude value

These derivatives are the partial derivatives used in position computation procedure.

Ranges:

Hlat: (-100 000 000) - (+100 000 000)

Hlon: (-100 000 000) - (+100 000 000)

Halt: (-100 000 000) - (+100 000 000)

f3: The receivers stand-alone and code differential position is computed by means of Weighted Least Square algorithm. In this algorithm, each satellite has associated weight, which is inversely proportional to satellite error estimate. Higher the satellite's error estimate - lower the satellite's weight. And vice versa. This field of UKOOA message contains actual satellites' weights used in Weighted Least Square position solution.

UTM: Universal Transverse Mercator (UTM) Coordinates

$PASHS,NME,UTM,x,s,[f]

This command enables or disables the UTM message on port x, where x is the output port A or B, and y is ON or OFF, and f is the optional message output rate ranging from 1 to 999 seconds depending on the measurement update rate option installed.

The A12 does not output this message unless it computes a position.

If the command is set without a period, the A12 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,UTM,[c1]

This command queries the UTM message, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,UTM

This response message is not output unless positions are being computed. The UTM message contains position rendered in UTM coordinates, plus UTC time, the number of satellites used to compute the position, the mode of the position fix (i.e., autonomous or corrected), and more. The message is output in the format:

$PASHR,UTM,m1,m2,f3,f4,d5,d6,f7,f8,m,f9,m,d10,s11*hh

Table 6.45 defines the UTM message format.

Table 6.45 $PASHR,UTM Message Format

Parameter	Description	Range
m1	UTC of position in hours, minutes, and decimal seconds (hhmmss.ss)	0 to 235959.90
m2	Zone number for the coordinates	1 to 60, 99 N = North S = South
f3	East UTM coordinate (meters)	-9999999.999 to +9999999.999
f4	North UTM coordinate (meters)	-9999999.999 to +9999999.999

Table 6.45 $PASHR,UTM Message Format (continued)

Parameter	Description	Range
d5	Position fix mode indicator. 1 = Raw position 2 = RTCM differential	1, 2
d6	Number of GPS satellites being used to compute positions	3 to 12
f7	Horizontal dilution of precision (HDOP)	0.00 to 999.9
f8	Antenna ellipsoidal height (altitude) (meters)	-99999.999 to +99999.999
m	Antenna height (altitude) units	M = meters
f9	Geoidal separation in meters	±999.999
m	Geoidal separation units (meters)	M
d10	Age of differential corrections	0 to 999
s11	Differential reference station ID	4-character string
*hh	Checksum	

Geoidal altitude can be derived by subtracting geoidal separation from ellipsoidal altitude.

Typical UTM response message:

**$PASHR,UTM,015454.00,10S,588757.623,4136720.056,1,04,03.8,
00012.123,M,-031.711,M,014,1010*3A**

Table 6.46 describes a typical UTM response message.

Table 6.46 Typical UTM Message

Item	Description
015454.00	UTC time
10S	UTM zone 10; southern hemisphere
588757.623	UTM easting coordinate
4136720.056	UTM northing coordinate
1	Raw position
04	Number of satellites used to compute position
03.8	HDOP
00012.123	Altitude
M	Altitude units (meters)
-031.711	Geoidal separation
M	Geoidal separation units (meters)
014	Age of corrections
1010	Differential station ID
*3A	Checksum

VTG: Velocity/Course Message

$PASHS,NME,VTG

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

$PASHS7,NME,VTG,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. Default is **disabled**.

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, A or B. 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,c5*cc

where the fields are as described in Table 6.47.

Table 6.47 VTG Message Structure

Field	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
c5	Mode indicator	A = autonomous D = differential E = estimated (dead reckoning) M = manual input S = simulator N = data not valid
*cc	checksum	

Example:

Query: **$PASHQ,VTG <Enter>**

Typical VTG response message:

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

Table 6.48 describes each item in a typical VTG message.

Table 6.48 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)
A	Autonomous mode
*46	checksum

XMG: Exception Messages

$PASHS,NME,XMG,x,c,[f]

This command enables or disables the exception messages or port x, where x is the output port, c is ON or OFF, and f is the optional message output rate ranging from 1 to 999 seconds.

The receiver does not output this message unless it computes a position. If the command is set without a period, the A12 uses the period set by the **$PASHS,NME,PER** command. If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example: Enter the following command to enable XMG message on port B.

$PASHS,NME,XMG,B,ON

$PASHQ,XMG,[c1]

This command queries the exception messages, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,XMG, d1,d2

The response is in the format **$PASHR,XMG,d1,d2** where **d1** is the exception number and **d2** is a description of the exception message. Table 6.49 describes the exception numbers.

Table 6.49 Exception Numbers

Exception Number (d1)	Description	Meaning
01	SRAM corrupted	The receiver enters Set Defaults state due to lost data.
02	Real Time Clock Corrupted	The receiver initiates a cold start due to loss of time information.
03	No Position or Almanac	The receiver initiates a cold start due to lack of position or almanac data.
04	BIT completed	End of built-in-test routines.
05	Cannot converge with 4 or more satellites	No navigation solution in auto mode with 4 satellites.
06	Cannot converge with 3 satellites	No navigation solution in auto mode with 3 satellites.
07	Too few satellites for 3D solution	No navigation solution in 3D mode with 3 or fewer satellites.
08	No 3D solution - PDOP mask exceeded	No navigation solution possible in 3D mode because of bad PDOP.
09	Too few satellites for 2D solution	No navigation solution in 2D mode with 2 or fewer satellites.
10	No 2D solution - PDOP mask exceeded	No navigation solution possible in 2D mode because of bad PDOP.
11	Time only - No Solution	No satellites above mask angle.
12	Solution valid.	A valid solution is now being generated.

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 or B, 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 6.50 defines each field of the $GPZDA message structure.

Table 6.50 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)	0 through 59
*cc	Checksum	

Example:

Query: **$PASHQ,ZDA,A <Enter>**

Typical response:

$GPZDA,132123.00,10,03,1996,07,00*ss

Table 6.51 describes each item in a typical $GPZDA response message.

Table 6.51 Typical ZDA 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
*Offset will be 00 unless offset is input using the LTZ command.	

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, 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 empty, the response is sent to the current port. For example, the query

$PASHQ,RTC <Enter>

outputs an RTCM status message to the current port, while the command:

$PASHQ,RTC,A <Enter>

outputs an RTCM status message to port A. Table 6.52 summarizes the RTCM commands.

Table 6.52 RTCM Commands

Command	Description	Page
GENERAL PARAMETERS		
$PASHS,RTC,OFF	Disables differential mode	114
$PASHQ,RTC	Requests differential mode parameters and status	112
REMOTE PARAMETERS		
$PASHS,RTC,AUT	Turns auto differential mode on or off	114
$PASHS,RTC,MAX	Sets maximum age of RTCM differential corrections	114
$PASHS,RTC,REM	Sets receiver to operate as differential remote station	115

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 or B.

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

```
STATUS:
SYNC:*TYPE:00, STID:0000,  STHE:00,
AGE:0.00,QA:           ,OFFSET:    0,WAAS:Y
SETUP:
MODE:OFF, PORT:B, AUT:Y,MAX:0015
```

where the parameters are as defined in Table 6.53.

Table 6.53 RTC Parameters

Parameter	Description	Range
STATUS		
SYNC	Sync to last received RTCM message between receiver (remote) and base stations.	* = in sync

Table 6.53 RTC Parameters (continued)

Parameter	Description	Range
TYPE	RTCM message type being received.	1, 3, 9
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)	0.00...1199.99
QA	Communication quality factor between base and remote (not implemented)	0...100%
OFFSET	Number of bits from beginning of RTCM byte (in case of bit slippage)	
WAAS	Indicates if WAAS corrections can be used in DGPS solution	Y = yes N = no
SETUP		
MODE	RTCM mode	ON or OFF
PORT	Communication port	A, B, ?
AUT	Automatic differential mode	Y, N
MAX	Maximum age, in seconds, required for a message to be used	1...1199

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 (ON) or N (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 remote differential mode.

Example: Turn RTCM off:

$PASHS,RTC,OFF <ENTER>

REM: Enable Remote RTCM

$PASHS,RTC,REM

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

$PASHS,RTC,REM,x

where x is the RTCM communication port. If WAAS corrections are available, they will be used automatically. However, RTCM corrections through the serial port take priority over WAAS, i.e., if both corrections are available, RTCM corrections will be used in the position solution.

Example: Set receiver as differential remote using external corrections via port B:

$PASHS,RTC,REM,B <Enter>

7

AC12 Board and Sensor

Overview

The AC12 has the same physical and electrical properties as A12. It incorporates all functions of A12, and has the additional capability of outputting raw data including carrier phase. The applicable commands are:

$PASHS,NME,PBN

$PASHS,NME,MCA

$PASHS,NME,SNV

SECURITY WARNING
The GPS raw data commands listed in this section are implemented only on the AC12. To accommodate the raw data output capability, the AC12 hardware is different from the A12 hardware. Further, AC12 firmware can not be loaded on A12 hardware. However, A12 firmware can be loaded on AC12 hardware, but will not support the commands listed below.

The AC12 receiver is available in board and sensor versions. The AC12 Sensor is identical to the A12 Sensor. The AC12 Sensor is also available as a part of a development kit for easy evaluation. Please refer to **Chapter 4,** A12/AC12 Sensor & Development Kit for more details on the AC12 Sensor and Development Kit features.

The output interval for the messages described in this chapter 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.

PBN: Raw Position Data in PBN Messages

$PASHS,NME,PBN

This command enables/disables raw position data in PBN messages. The structure is

$PASHS,NME,PBN,c,s,d

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

If the command is set without a period, the AC12 uses the period set by the $PASHS,NME,PER command. If the $PASHS,NME,PER command is issued after this message period has been set, the period resets to the PER setting.

Example: Turn on PBN message at port B:

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

$PASHQ,PBN

The associated query command is $PASHQ,PBN. This command outputs the PBN message one time (i.e., not continuously).

$PASHR,PBN

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

The message is output in the format:

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

Table 7.1 defines the response message format and parameters.

Table 7.1. PBN Data String

Field	Bytes	Content
long [rcvtime]	4	Time at which the signal was received in milliseconds of the week referenced to GPS system time. This time tag is used as a reference for all time and position measurements
char [sitename]	4	4 character ASCII string entered by the user
double [navx]	8	X coordinate of the antenna position (ECEF) in meters.
double navy	8	Antenna position ECEF y coordinate in meters.
double navz	8	Antenna position ECEF z coordinate in meters.
float navt	4	Receiver clock offset (error) in meters.

Table 7.1. PBN Data String (continued)

Field	Bytes	Content
float navxdot	4	The antenna x velocity in meters per second.
float navydot	4	The antenna y velocity in meters per second.
float navzdot	4	The antenna z velocity in meters per second.
float navtdot	4	Receiver clock drift in meters per second.
unsigned short PDOP	2	PDOP multiplied by 100.
checksum	2	Checksum is computed by breaking the structure into unsigned shorts, adding them together, and taking the least significant 16 bits of the result. The structure starts right after the header and continues up to the checksum. The PBN message has 16 unsigned shorts in the structure.
Total bytes	56	

MCA: MCA Message On/Off

$PASHS,NME,MCA

This command turns the MCA raw measurement message on or off. MCA is output only if the receiver is tracking three or more satellites. The command structure is

$PASHS,NME,MCA,c,s,d

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

If the command is set without a period, the AC12 uses the period set by the $PASHS,NME,PER command. If the $PASHS,NME,PER command is issued after this message period has been set, the period resets to the PER setting.

Example: Turn off MCA message at port A:

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

$PASHQ,MCA

The associated query command is **$PASHQ,MCA.** This command outputs the MCA message one time (i.e., not continuously).

$PASHR,MCA

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

The structure of the MCA response message is:

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

Table 7.2 defines the MCA response message parameters.

Table 7.2. $PASHR,MCA Data String

Field	Bytes	Content
unsigned short [sequence tag]	2	Sequence ID number in units of 50 ms, modulo 30 minutes
unsigned char [left]	1	Number of remaining MCA messages to be sent for current epoch. The AC12 outputs a separate MCA message for each satellite it is tracking.
unsigned char [svprn]	1	Satellite PRN number (1 - 56)

Table 7.2. $PASHR,MCA Data String (continued)

Field	Bytes	Content
unsigned char [elev]	1	Elevation angle (degrees) of the satellite referenced in [svprn]
unsigned char [azim]	1	Azimuth angle of the satellite referenced in [svprn] in increments of 2°
unsigned char [chnind]	1	Channel (1 - 12) assigned to the satellite referenced in [svprn]
Measurement data derived from the C/A code (29 bytes):		
unsigned char [warning]	1	See Table 7.3
unsigned char [goodbad]	1	Indicates the quality of the position measurement: •0 - Measurement not available; no additional data will be sent. •21 - The satellite is below the PEM elevation mask. •22 - Code and/or carrier phase has been measured. •23 - Code and/or carrier phase has been measured, and navigation message was obtained, but measurement(s) not used to compute position. •24 - Code and/or carrier phase measured, navigation message was obtained, and measurement(s) used to compute position
char [polarity_known]	1	This number is either zero or five: • 0 - the satellite has just been locked • 5 - meaning the first frame of the navigation message has been found
unsigned char [ireg]	1	Signal-to-noise measurement (db Hz) for the satellite referenced in [svprn]
unsigned char [qa_phase]	1	Not used; always zero
double [full phase]	8	Full carrier phase (measured in cycles) of the satellite referenced in [svprn].
double [raw_range]	8	Raw range (in seconds) to the satellite referenced in [svprn] using the following formula: receiver time - transmitted time = raw range (Note: There is an eleven second difference between GPS system time and GLONASS system time. If the time scale is set to GPS, the [raw_range] measurement for GLONASS satellites will contain an extra eleven-second integer. If the time scale is set to GLONASS, the [raw_range] measurement for GPS satellites will have an extra eleven-second integer
long [doppler]	4	Doppler measurement (10^{-4} Hz) for the satellite referenced in [svprn]

Table 7.2. $PASHR,MCA Data String (continued)

Field	Bytes	Content
long [smoothing]	4	Bits 31-24 represent the [smooth_count]. They are unsigned and normalized, and indicate the amount of smoothing: • 0 - Unsmoothed • 1 - Least smoothed • 100 - Most smoothed Bits 23-0 represent [smooth_corr]. Bit 23 (most significant bit) is the sign and bits 22 through 0 are the least significant bits representing the magnitude of the correction in centimeters
unsigned short [checksum]	1	The checksum is a bytewise exclusive OR (XOR) of all bytes from sequence_tag (just after header) to the last byte in [smoothing]
Total bytes	37	

The MCA message is output in binary format according to the setting chosen for the recording interval ($PASHS,NME,PER). One MCA message is output for each locked satellite with an elevation equal to or greater than the elevation mask ($PASHS,PEM).

Table 7.3 defines the MCA warning flag message.

Table 7.3. MCA Warning Flag Format

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

SNV: SNV Message On/Off

$PASHS,NME,SNV

This command turns the SNV ephemeris message on or off. The structure is

$PASHS,NME,SNV,c,s,d

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

If the command is set without a period, the AC12 uses the period set by the $PASHS,NME,PER command. If the $PASHS,NME,PER command is issued after this message period has been set, the period resets to the PER setting.

Example: Turn on SNV message at port A:

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

$PASHQ,SNV

The associated query command is **$PASHQ,SNV.** This command outputs the SNV message one time (i.e., not continuously).

The periodicity of PBN, MCA, and SNV is controlled by the PER command (page 91).

$PASHR,SNV

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

The message is output in the format:

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

Table 7.4 defines the SNV response message parameters.

Table 7.4. SNV Data String

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

Table 7.4. SNV Data String (continued)

Field	Bytes	Content
float af1	4	Clock correction (sec/sec).
float af0	4	Clock correction (sec).
long aode	4	Orbit data issue.
float deltan	4	Mean anomaly correction (semicircles/sec).
double m0	8	Mean anomaly at reference time (semicircles).
double e	8	Eccentricity.
double roota	8	Square root of semi-major axis (meters 1/2).
long toe	4	Reference time for orbit (sec).
float cic	4	Harmonic correction term (radians).
float crc	4	Harmonic correction term (meters).
float cis	4	Harmonic correction term (radians).
float crs	4	Harmonic correction term (meters).
float cuc	4	Harmonic correction term (radians).
float cus	4	Harmonic correction term (radians).
double omega0	8	Longitude of ascending node (semicircles).
double omega	8	Argument of perigee (semicircles).
double i0	8	Inclination angle (semicircles).
float omegadot	4	Rate of right ascension (semicircles/sec).
float idot	4	Rate of inclination (semicircles/sec).
short accuracy	2	User range accuracy.
short health	2	Satellite health.
short fit	2	Curve fit interval.
char prnnum	1	Satellite PRN number minus 1 (0 to 31)
char res	1	Reserved character.
checksum	2	The checksum is computed by breaking the structure into 65 unsigned shorts, adding them together, and taking the least significant 16 bits of the result. The structure starts right after the header and continues up to the checksum.
Total bytes	132	

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Reference

Search Strategy & Position Algorithms

Satellite Selection

The search manager tracks the 12 satellites with the highest elevation. Only healthy satellites are tracked; unhealthy satellites are ignored. If fewer than 12 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 12 satellites with the highest elevation with known visibility. If fewer than 12 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 A12 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 of 12 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 A12 may operate in either of two modes to return a position computation. The $PASHS,PMD command 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, A12 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 as set by the user, the A12 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 A12 requires at least three locked satellites 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, A12 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.

Missile Technology Control Regime (MTCR)

Whenever the A12 has calculated a position and has determined that either the A12 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 A12 produces no valid position information.

Other Operational Characteristics

Conversions

The A12 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 A12 memory and verify the integrity of information saved in backup RAM. Invalid data are not used.

Watchdog Timer

The A12 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 A12 can save all current parameter settings using a $PASHS,SAV command such that during a power interruption these settings will be utilized when power is restored. A $PASHS,RST command can also be used to revert to default settings.

$PASHS,SAV,Y command is not required to save position, ephemeris, almanac, etc. This information is automatically saved by the receiver during power off and is used for faster acquisition when the unit is turned on.

Long-Term Operation

The A12 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)
- 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 69.

Detailed Performance Characteristics

Accuracy

A12 accuracy is defined in terms of horizontal 95% and circular error probable (CEP) as listed in Table 8.1. All measurements assume SA is off.

Table 8.1: Accuracy Specifications

Mode	A12	Test Conditions
Autonomous CEP (50%)	3 m	Autonomous guidelines:
Autonomous horizontal 95%	5 m	Precision antenna
Autonomous vertical 95%	7.5 m	10° elevation angle
Autonomous speed	0.2 km/h	
Autonomous directional at 40 km/h	0.2 degree	
DGPS using SBAS Horizontal CEP (50%)	1 m	SBAS guidelines
DGPS using SBAS Horizontal (95%)	3 m	Precision antenna
DGPS using SBAS Vertical (95%)	4.5 m	10° elevation angle
DGPS CEP (50%)	0.8 m	DGPS guidelines
DGPS horizontal 95%	1.5 m	Precision antenna
DGPS vertical (95%)	2.25 m	10° elevation angle

Table 8.1: Accuracy Specifications (continued)

Mode	A12	Test Conditions
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 40 km/h.

4. Measure DGPS accuracy using a Magellan 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 8.2.

Table 8.2: 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	150

Reference

Table 8.2: TTFF and Reacquisition Performance (continued)

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)
Warm start TTFF	Receiver off over-night	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 A12 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 8.3.

Table 8.3: Reacquisition Times

Mode	Description	Typical Example	Average (50th Percentile)
Reacquisition (<20 sec blockage)	Temporary blockage	Under over-pass	1 to 2 sec
Reacquisition (<180 sec blockage)	Temporary blockage	In short tunnel	3 to 5 sec

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Troubleshooting

Listed below are some tests and fixes for common problems that you may encounter when installing and configuring the A12 GPS OEM board.

TTL-to-RS-232 Conversion

If you are using a TTL-to-RS-232 converter for your A12 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

For A12, verify the port A and B 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. For B12, default baud rate for port A is 9600 bps, and for port B is 4800 bps.

RTS/CTS

RTS/CTS are connected together in the A12 Sensor, but not in the A12 OEM board. If you do not have the A12 Sensor, your 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,RST or $PASHS,INI command, as described on page 66.

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 67. 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

Magellan cannot support logging data with unique PC application programs other than Magellan's Evaluate program. When writing software to read A12 messages, recommend parse on commas and not field sizes.

Using Third-Party Software

When using third-party software like Hyperterminal, ensure CR/LF outgoing is enabled. All set commands and queries end with CR/LF.

A

Supported Datums

Table B.1 lists the supported datums. To use a datum, enter the 3-character **Datum ID** in the $PASHS,DTM command (page 54).

Table B.1Supported Datums

Datum ID	Offset in meters dX	dY	dZ	Reference Ellipsoid	Datum Description
ADN	-162	-12	206	CLARKE 1880	Adindan (Ethiopia,Mali,Senegal,Sudan)
ARF	-143	-90	-294	CLARKE 1880	ARC 1950 (Botswana, Lesotho, Malawi, Swaziland, Zaire,Zambia, Zimbabwe)
ARS	-160	-8	-300	CLARKE 1880	ARC 1960 (Kenya,Tanzania)
AST	-104	-129	239	INTERNATIONAL 1924	Camp Area Astro (Antarctica)
AUA	-133	-48	148	AUSTRALIAN NATIONAL	Australian Geodetic Datum 1966 (Australia, Tasmania Island)
AUG	-134	-48	149	AUSTRALIAN NATIONAL	Australian Geodetic Datum 1984 (Australia, Tasmania Island)
BOO	307	304	-318	INTERNATIONAL 1924	Bogota Observatory (Columbia)
BUK	-384	664	-48	BESSEL 1841	Bukit Rimpah (Indonezia)
CAI	-148	136	90	INTERNATIONAL 1924	S. American Campo Inchauspe (Argentina)
CAP	-136	-108	-292	CLARKE 1880	Cape (South Africa)
CGE	-263	6	431	CLARKE 1880	Carthage (Tunisia)
CHI	175	-38	113	INTERNATIONAL 1924	Chatham 1971 (Chatham,New Zealand)
CHU	-134	229	-29	INTERNATIONAL 1924	S. American Chua Astro (Paraguay)
CNA	0	125	194	CLARKE 1866	N. American Central America
COA	-206	172	-6	INTERNATIONAL 1924	S. American Corrego Alegre (Brazil)
CRB	-7	152	178	CLARKE 1866	N. American Caribbean
DHD	583	40	399	BESSEL 1841	DHDN_

Table B.1Supported Datums (continued)

Datum ID	Offset in meters dX	dY	dZ	Reference Ellipsoid	Datum Description
DJK	-377	681	-50	BESSEL 1841	Djacarta (Indonesia)
EUA	-87	-96	-120	INTERNATIONAL 1924	European 1950 (Western Europe: Austria,Denmark,France,F.R. of Germany, Netherlands, Switzerland)
EUE	-104	-101	-140	INTERNATIONAL 1924	European 1950 (Cyprus)
EUF	-130	-117	-151	INTERNATIONAL 1924	European 1950 (Egypt)
EUH	-117	-132	-164	INTERNATIONAL 1924	European 1950 (Iran)
EUJ	-97	-88	-135	INTERNATIONAL 1924	European 1950 (Sicily)
EUM	-87	-98	-121	INTERNATIONAL 1924	European 1950 mean
EUS	-86	-98	-119	INTERNATIONAL 1924	European 1979 (Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland)
FAH	-346	-1	224	CLARKE 1880	Oman
FRE	-168	-60	320	CLARKE 1880 IGN	FRENC_
GAA	-133	-321	50	INTERNATIONAL 1924	Gandajika Base (Rep. of Maldives)
GEO	84	-22	209	INTERNATIONAL 1924	Geodetic Datum 1949 (New Zealand)
GHA	0	0	0	GHANA	GHANA_
GUA	-100	-248	259	CLARKE 1866	Guam 1963 (Guam Island)
GUG	-403	684	41	BESSEL 1841	GUNSG_
GUR	0	0	0	BESSEL 1841	GUNSR_
HAW	89	-279	-183	INTERNATIONAL 1924	Hawaiian Hawaii (Old)
HJO	-73	46	-86	INTERNATIONAL 1924	Hjorsey 1955 (Iceland)
HNK	-156	-271	-189	INTERNATIONAL 1924	Hong Kong 1963
HRN	-333	-222	114	INTERNATIONAL 1924	Herat North (Afghanistan)
HTS	-634	-549	-201	INTERNATIONAL 1924	Hu-Tzu-Shan (Taiwan)
INA	214	836	303	EVEREST INDIA 1830	Indian (Thailand, Vietnam)
IND	295	736	257	INDIAN2	INDM2_

Table B.1Supported Datums (continued)

Datum ID	Offset in meters dX	dY	dZ	Reference Ellipsoid	Datum Description
INM	289	734	257	EVEREST INDIA 1830	Indian (India,Nepal,Bangladesh)
IRL	506	-122	611	MODIFIED AIRY	Ireland 1965
KAA	190	-230	-341	INTERNATIONAL 1924	KAUAI_
KAN	-97	787	86	EVEREST INDIA 1830	Kandawala (Sri Lanka)
KAU	45	-290	-172	INTERNATIONAL 1924	Hawaiian Kauai (Old)
KEA	-11	851	5	EVEREST WEST MALAY-SIA and SINGAPORE 1948	Kertau 1948 (West Malayzia,Singapore)
KKJ	-78	-231	-97	INTERNATIONAL 1924	KKJ_
LIB	-90	40	88	CLARKE 1880	Liberia 1964
LUZ	133	77	51	CLARKE 1866	Luzon (Philippines excluding Mindanoa Is.)
MAI	210	-230	-357	INTERNATIONAL 1924	MAUI_
MAS	639	405	60	BESSEL 1841	Massawa (Eritrea,Ethiopia)
MAU	65	-290	-190	INTERNATIONAL 1924	Hawaiian Maui (Old)
MER	31	146	47	CLARKE 1880	Merchich (Morocco)
MIN	-92	-93	122	CLARKE 1880	Minna (Nigeria)
MND	-133	-79	-72	CLARKE 1866	Mindanao Island
MON	0	0	0	BESSEL 1841	MONTJ_
MXC	-12	130	190	CLARKE 1866	N. American Mexico
NAC	-8	160	176	CLARKE 1866	N. American CONUS 1927 (North America)
NAD	-5	135	172	CLARKE 1866	N. American Alaska 1927 (Alaska)
NAE	-10	158	187	CLARKE 1866	N. American Canada 1927 (Canada incl. Newfoundland Island)
NAH	-231	-196	482	CLARKE 1880	Nahrwan (Saudi Arabia)
NAN	-6	127	192	CLARKE 1866	Central America (Belize,Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Mexico)

Table B.1Supported Datums (continued)

Datum ID	Offset in meters dX	dY	dZ	Reference Ellipsoid	Datum Description
NAR	0	0	0	GEODETIC REFERENCE SYSTEM 1980	Noth American 1983
OAH	56	-284	-181	INTERNATIONAL 1924	Hawaiian Oahu (Old)
OAU	201	-224	-349	INTERNATIONAL 1924	OAHU_
OEG	-130	110	-13	HELMERT 1906	Old Egyptian
OGB	375	-111	431	AIRY 1830	Ordnance Survey of Great Britain 1936 (England,Isle of Man,Scotland, Shetland Islands, Wales)
OHA	61	-285	-181	CLARKE 1866	Old Hawaiian
OHH	89	-279	-183	CLARKE 1866	OH_HAW_
OHK	45	-290	-172	CLARKE 1866	OH_KAU_
OHM	65	-290	-190	CLARKE 1866	OH_MAU_
OHO	56	-284	181	CLARKE 1866	OH_OAH_
PIT	185	165	42	INTERNATIONAL 1924	Pitcairn Astro 1967 (Pitcairn Island)
PRO	-288	175	-375	INTERNATIONAL 1924	PROVI_
PRV	-288	175	-376	INTERNATIONAL 1924	S. American (Provisional 1956)
PUE	11	72	-101	CLARKE 1866	Puerto Rico and Virgin Islands
QAT	-128	-283	22	INTERNATIONAL 1924	Qatar National (Qatar)
QUO	164	138	-189	NTERNATIONAL 1924	Qornoq (South Greenland)
SAM	-57	1	-41	AUSTRALIAN NATIONAL	SAM69_
SAN	-57	1	-41	SOUTH AMERICAN 1969	S. American 1969 (Argentina,Bolivia, Brazil,Chile,Colombia,Ecuador,Guyana, Paraguay,Peru,Venezuela,Trinidad,Tobago)
SCH	616	97	-251	BESSEL 1841	SCHWA_
SCK	616	97	-251	BESSEL 1841NAMIBIA	Schwarzeck (Namibia)
SDI	173	750	264	EVEREST INDIA 1830	SDIND_
SDL	-133	-77	-54	CLARKE_1866	SDLUZ_
SDW	0	0	0	WGS_1984	SDWGS_

Table B.1Supported Datums (continued)

Datum ID	Offset in meters dX	dY	dZ	Reference Ellipsoid	Datum Description
SEG	-403	684	41	INTERNATIONAL 1924	Gunung Segara (Kalimantan-Indonesia)
SIE	0	0	0	CLARKE 1880	SIERR_
SRD	-225	-65	9	INTERNATIONAL 1924	Rome 1940 Sardinia Island
SWI	674	15	405	BESSEL 1841	SWISS_
TAN	-189	-242	-91	INTERNATIONAL 1924	Tanarive Observatory 1925 (Madagascar)
TIL	-689	691	-46	EVEREST INDIA 1830	Timbalai 1948 (Brunei,East Malaysia, Sarawak,Sabah)
TOY	-128	481	664	BESSEL 1841	Tokyo (Japan,Korea,Okinawa)
TRI	-632	438	-609	INTERNATIONAL 1924	Tristan Astro 1968 (Tristan du Cunha)
VIT	51	391	-36	CLARKE 1880	Viti Levu 1916 (Fiji Islands)
VOI	0	0	0	CLARKE 1880	VOIRO_
W72	0	0	4.5	WGS 1972	Word geodeic system 1972
W84	0	0	0	WGS 1984	World Geodetic System - 84
YAC	-155	171	37	INTERNATIONAL 1924	S. American Yacare (Uruguay)
ZAN	-265	120	-358	INTERNATIONAL 1924	Zanderij (Surinam)

Glossary

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.

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).

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 (CEP)
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 autonomous GPS 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 - b2/a2)-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 - e2) 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.
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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.

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 Ll 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 electro-magnetic 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, POP 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.

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
Magellan'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

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 a 13 second offset between GPS time and UTC since 1999. 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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A12™, B12™ & AC12™

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