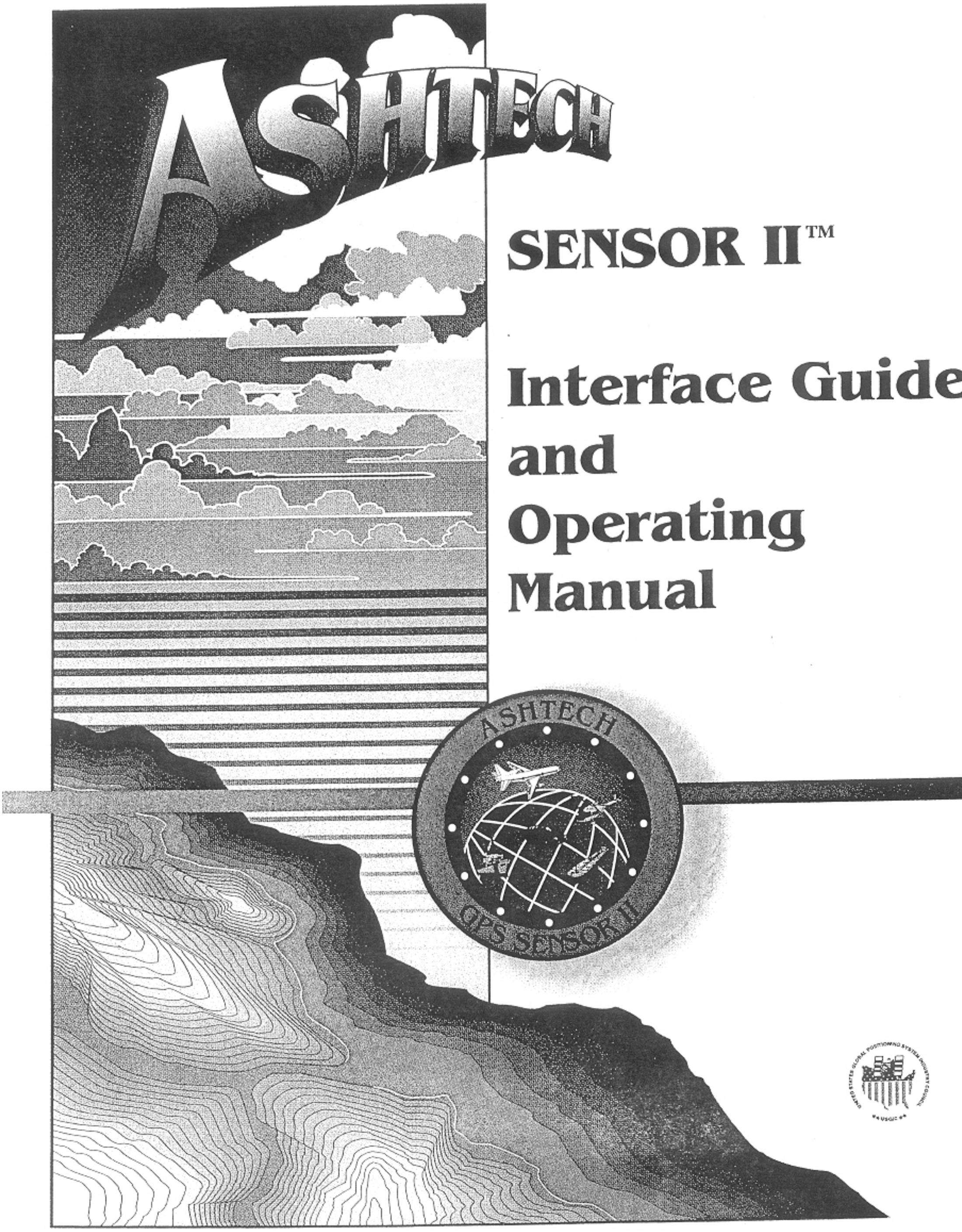

SENSOR II™

Interface Guide and Operating Manual

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INTRODUCTION

The Sensor II receiver module processes signals from the Global Positioning System (GPS) satellite constellation to provide real-time position, velocity, heading, and time measurements using twelve dedicated separate and parallel channels for Clear/Acquisition (C/A) code-phase or carrier phase measurement on the L1 (1575 Mhz) band. Sensor II receives satellite signals via an L-band antenna and low-noise amplifier (LNA). The standard Sensor II is designed for stand-alone range measurement applications, and also is suitable as a remote (rover) station to any GPS receiver equipped to act as a reference (base) station, that is, able to provide real-time differential GPS corrections in RTCM 104 version 2.0 format. The optimum reference station would also have 12-channel all-in-view capability, such as the Ashtech Model M-XII series.

This chapter comprises a functional and hardware description of Sensor II, characterizes the RF interface connector and the power/input/output connector, and lists power requirements and environmental specifications.

FUNCTIONAL DESCRIPTION

Upon application of power, Sensor II runs a built-in self test of its internal memory, and thereafter periodically selt-tests various functions during normal operation. Test results are stored for commanded output. After self test, Sensor II initializes volatile RAM. If non-volatile RAM fails self test (due to a low battery backup condition, for example), Sensor II clears and reports the loss of stored data, then initializes its 12 channels and begins searching for all satellites (SVs or Space Vehicles) within the field of view of the antenna.

Sensor II can track all Block I and Block II GPS SVs; all 32 PRN numbers as specified in *Navstar GPS Space Segment/Navigation User Interfaces*; ICD-GPS-200, Revision B are coded inside the receiver/processor card; the planned constellation will comprise 24 SVs. As it acquires (locks on to) each SV, Sensor II notes the time and then collects the ephemeris data about the orbit of that SV and almanac data about the orbits of all the SVs in the constellation. When tracking three SVs, Sensor II can compute and time tag the two-dimensional position and velocity of its antenna; no initial estimate is necessary. When it receives an appropriate command message from controller equipment through one of its serial communications ports, Sensor II sends the results of its computations to the commanded port. With four locked SVs,

Sensor II can determine three-dimensional position and velocity. Position accuracy is 16 meters rms or less SEP (when Position Dilution of Precision - PDOP is less than

4), subject to the US governmental policy of Selective Availability; velocity accuracy is one centimeter per second.

One independent measurement is determined per second with no interpolation or extrapolation from previous solutions. The position and velocity computations are performed using all the SVs in view simultaneously. Sensor II uses a sophisticated technique for computing velocity which does not require computations to be dependent upon the last position, and uses instantaneous doppler values from four SVs to compute dynamic speed. All computations are accomplished relative to the World Geodetic System WGS-84 reference ellipsoid.

Sensor II features 12-channel/12-SV All-In-View operation; each of up to 12 visible SVs can be assigned to a channel and then continuously tracked. Each SV broadcasts almanac and ephemeris information every 30 seconds, and Sensor II automatically records this information in its non-volatile memory.

HARDWARE DESCRIPTION

Sensor II is an unmounted card, shown in Figure 1.

It has two RS-232 input/output (I/O) ports and an L1-band radio-frequency (RF) port. Both serial ports are capable of two-way communication with external equipment.

Sensor II requires a DC input voltage of 5VDC (regulated ±5%); power consumption is less than 2.5 watts. With external power removed from the non-volatile part of the RAM, data storage may be maintained using an external 3-3½-volt battery. The RF circuitry receives satellite data from a GPS antenna and LNA via a coaxial cable, and can supply power to the antenna/LNA by means of that cable. No separate antenna power cable is required. Power consumption is less than 2.5 watts even when powering an LNA.

Sensor II includes a two-color LED; red indicates the power status, and green flashes for the number of SVs locked.

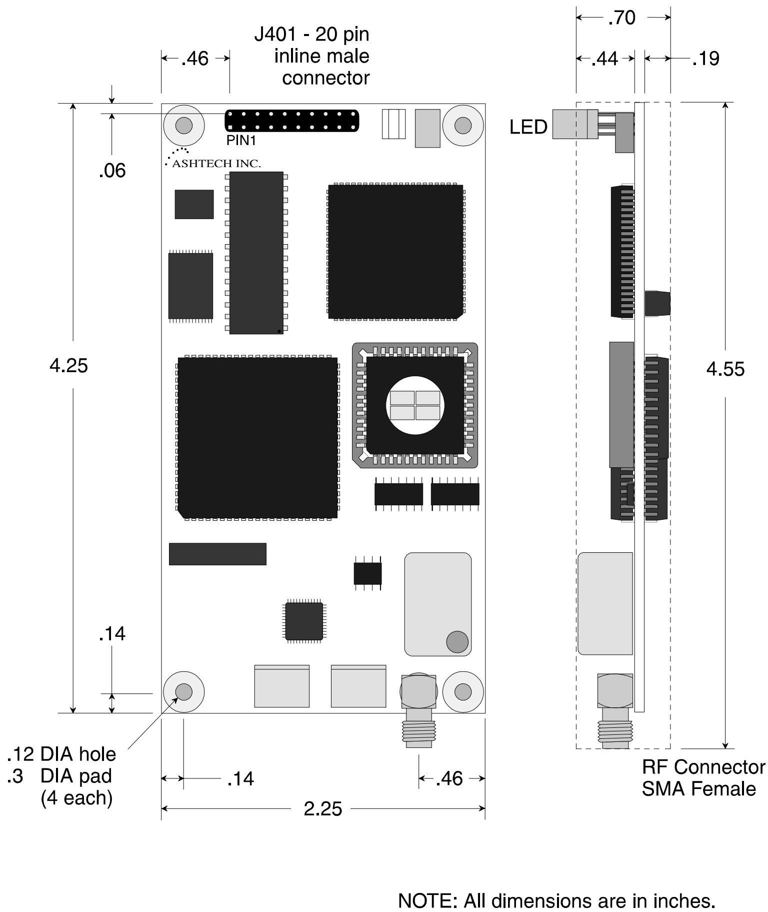

Figure 1 Sensor II Physical Layout

Rf Interface Connector

The RF connector is a standard SMA female receptacle wired for connection via 50-ohm coaxial cabling to a GPS antenna with integral LNA. The SMA connector shell is connected to GPS Sensor II common ground. The SMA center pin provides +4.8 VDC (to power the LNA) and accepts 1575 Mhz RF input from the antenna; the RF and DC signals share the same path.

CAUTION

Sensor II may be damaged if the SMA center pin is not isolated from DC ground. Provide a DC block between the center pin and ground with the following characteristics: VSWR 1.15 maximum (at 1575 MHz), insertion loss 0.2 db maximum, and main line maximum voltage 5 VDC.

Power/input/output Connector

Power input/output connector J401 is a 20-pin inline male plug. It provides the input power connection, the battery backup memory connection, a manual hardware reset input, the one-pulse-per-second TTL output, and the RS-232 I/O connection. Following is a diagram of the pin assignment for this connector.

CAUTION

To avoid damage to Sensor II, ensure that when connecting the cable to J401, pin 1 of your cable matches pin 1 of J401, as indicated in Figure 2 and Table 1.

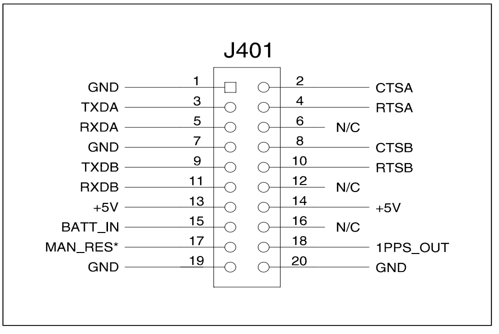

Figure 2 J401 Pinout

Table 1 J401 Signal Assignments

Pin	Code	Description
1	GND	Ground for serial Port A
2	CTSA	RS-232 port A clear to send
3	TXDA	RS-232 port A transmit data
4	RTSA	RS-232 port A request to send
5	RXDA	RS-232 port A receive data
6	N/C	Not used
7	GND	Ground for serial Port B
8	CTSB	RS-232 port B clear to send
9	TXDB	RS-232 port B transmit data
10	RTSB	RS-232 port B request to send
11	RXDB	RS-232 port B receive data
12	N/C	Not used
13	+5V	+5 volt
14	+5V	+5 volt
15	BATT_IN	3 -3½ volt lithium battery backup for memory
16	N/C	Not used
17	MAN_RES*	Connect to ground for manual hardware reset
18	1PPS_OUT	1 pps +/-1 usec TTL output synchronized to GPS time
19	GND	Sensor II chassis common ground
20	GND	Sensor II chassis common ground

NOTE

If pin 15 (BATT IN) is not used, it should be connected to ground (GND). If pin 17 (MAN_RES*) is not used it should be left open. If pin 17 (MAN_RES*) is used, it can be pulled to ground (GND) using a switch, or it can be driven with an open-collector gate.

INTERFACES TO EXTERNAL EQUIPMENT

Figure 3 shows suggested interfacing to external equipment such as a PC or radio.

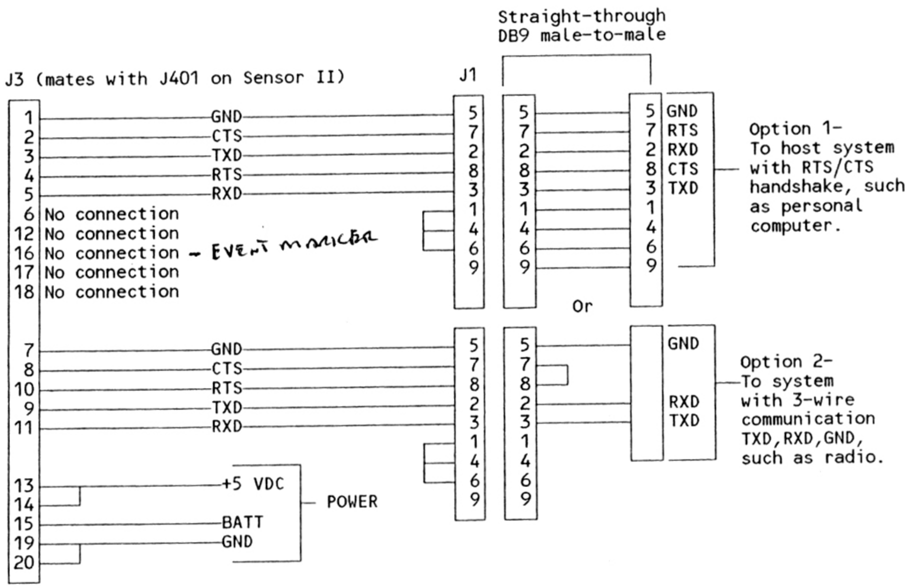

Figure 3 Interfaces to External Equipment

NOTES

1. **BATT is a control line normally connected to 3 VDC, or ground if not used.**
2. **J1 and J2 are female DB9 solder cup.**
3. **J3 is a 20-pin female ribbon connector, part number 111198.**
4. **Cable is flat ribbon 28 gauge 20-conductor Ashtech 100201, Ansley 171-20.**
5. **Straight-through DB9 male-to-male cable is standard commercial, obtain locally.**

Power Requirements

Table 2 lists power requirements.

Table 2 Power Requirements

Wattage	2.5 Watts
DC Voltage	5 Volts DC (regulated ± 5%)
External Wiring	at least 22-gauge wire

Environmental Specifications

The operating temperature range of Sensor II is -30°C to +70°C; storage range is -55°C to +100°C.

Radio Interference

Ashtech suggests that you verify that the broadcast frequencies of any handheld or mobile communications devices do not interfere with GPS receivers during operation.

CAUTION

Some radio transmitters and receivers, such as FM radios, can interfere with the operation of GPS receivers.

GETTING STARTED

Introduction

This chapter is intended to help you learn to use the Ashtech GPS Sensor II. For details, please refer to the sections on Operation and Command/Response Message Language Firmware Interface Requirements.

Briefly discussed in Getting Started are:

- Procedure for connecting Sensor II to power, the antenna, and your control and data logging equipment.
- Important default parameters.
- Instructions for establishing communications with Sensor II using typical communications software with an IBM-compatible PC.
- Procedure for sending common commands to Sensor II.

Connection Procedures

Power

CAUTION

To avoid damage to Sensor II, always connect the power wiring to 20-pin connector J401 before turning on the power supply.

Removing power from the power input pins on the Sensor II connector J401 stops Sensor II operation.

CAUTION

To avoid damage to Sensor II, always disconnect the power wiring from the power supply before disconnecting it from the J401 connector.

1. Connect the female plug on the power cable to the J401 male connector on Sensor II before applying power.
2. Connect the power cable to the power supply.
3. Applying power to Sensor II starts the unit. Once power is connected, the two-color LED on Sensor II card flashes red approximately every three seconds.
4. When you disconnect power, disconnect the power wiring from the power supply before disconnecting it from the J401 connector on Sensor II.

Antenna

Sensor II is designed to work with an antenna/preamplifier that only requires five volts and is isolated from DC ground. The gain of the antenna/preamplifier minus the loss of the cable should be between 20 and 30 dB.

CAUTION

Sensor II may be damaged if the SMA center pin is not isolated from DC ground. Provide a DC block between the center pin and ground with the following characteristics: VSWR 1.15 maximum (at 1575 MHz), insertion loss 0.2 db maximum, and main line maximum voltage 5 VDC.

Connect the antenna cable directly to the antenna SMA connector on Sensor II.

Once power is on and the antenna connected, Sensor II starts acquiring satellites (SVs or Space Vehicles) within the field of view of the antenna. As a channel in Sensor II locks on to an SV, the two-color led on Sensor II receiver/processor card flashes green between the red power flashes for every channel in use (i.e. SVs locked). Lock requires 28 dB, maintaining lock requires 25 dB.

Important Default Parameters

Communication Port Setup

The default communication parameters of Sensor II are:

Baud	Data Bits	Parity	Stop Bits
9600	Eight	None	One

When you first establish communications with Sensor II, your communications interface must use this protocol.

Data Output Options

All the default data output options are set to NO. Sensor II will not output any data until you send a message commanding it to do so.

Initial Operating Instructions

After you have Sensor II powered and running, you must send it command messages in order to receive data (such as antenna position). The following procedure describes how to send directives to and receive information from Sensor II using an IBM-compatible PC. Many communications software packages are available. The steps in this procedure apply specifically to the Procomm communications software.

Angle brackets <Key> indicate computer keys; <Key1-Key2> means the keys are held down together.

Run Communications Software

1. To start Procomm, at the PC DOS prompt, type PROCOMM and press the <Enter> key.
2. Set the communication protocol of the computer RS-232 port connected to Sensor II to the defaults: 9600 baud, 8 data bits, no parity, and 1 stop bit.

   a.In Procomm, press <Alt-P>; a "port setup" window displays possible communication setups.

   b. Choose the 9600,N,8,1 option and press <Enter>.

   c. Choose the "**save setup**" option and press <Enter>.

   d. Press <Esc> to leave the port setup window.
3. Set the software to half-duplex. In Procomm, press <Alt-E> and then press <Alt-S> to save this setup.
4. Set the software to chat mode.

   a. In Procomm, press <Alt-O>.

   b. The screen splits into two windows. The top window displays messages received from Sensor II, and the bottom window displays the commands you type for tranmission to Sensor II.

   c. At this stage you are ready to send commands to Sensor II.
5. To exit Procomm:

   a.Press <Esc> to exit chat mode.

   b. Press <Alt x>.

   c. A window asks you if you want to exit to DOS; press Y (yes).

Command The GPS Sensor Ii

You are now ready to send commands to GPS Sensor II. The letters in your command must be typed in ALL UPPER CASE and completed with <Enter>. If you have typed in and sent the command correctly, you should get a response in the top window. To become familiar with GPS Sensor II messages, send a few common commands to Sensor II and observe the responses. In the following steps command messages appear as COMMAND, and response messages appear as RESPONSE.

1. Type in capital letters: **$PASHQ,PRT** and press <Enter>. This command queries the communication setup of the port.
2. If communication with Sensor II has been established through serial port A, the top window displays: **$PASHR,PRT,A,5**. GPS Sensor II port A is using its default communications setup 5: 9600 baud, eight data bits, no parity, and one stop bit.
3. Type in capital letters: **$PASHQ,STA** and press <Enter>. This command queries which satellites are locked and their signal strength at the time the command is sent.
4. The top window typically might display:

   TIME: 18:38:31 UTC
   LOCKED:03 23 16
   COUNT :54 26 17

5. If communication with Sensor II has been established through serial port A, type in capital letters: $PASHS,NME,POS,A,ON and press <Enter>. This command tells Sensor II to return information on the position of the antenna at a set rate. The default rate for NME commands is once per second.
6. The top window displays once per second:

   $PASHR,POS,0,"......."

   where the "......." is your position information, if you have enough SVs locked to compute a position.

7. If communication with Sensor II has been established through serial port A, type in capital letters: $PASHS,NME,SAT,A,ON and press <Enter>. This command tells Sensor II to return locked satellite information at a set rate.
8. The top window displays once per second:

   $PASHR,SAT,"......."

   where the "......." is the number of SVs locked, and the elevation, azimuth, and signal strength for each locked SV.

9. For details on these commands and responses, as well as the rest of Sensor II's command and response repertoire, consult the following chapters in this guide.

Operation

This chapter discusses system setup, power-up, command format, serial port configuration, parameter settings and status, the satellite search algorithm, position modes, altitude hold definition, the ionospheric/tropospheric model, and differential operation.

System Setup

If other than Ashtech-supplied equipment is used, it must meet the hardware specifications described in Hardware Interface.

Applying power to the power input pins on the Sensor II J401 connector starts Sensor II operation. Before applying power connect any controller devices or data logging equipment to the input/output ports of Sensor II by way of the J401 connector.

CAUTION

> **To avoid damage to Sensor II, always connect the power wiring to 20-pin connector J401 before turning on the power supply.**

Removing power from the power input pins on Sensor II connector J401 stops Sensor II operation.

CAUTION

> **To avoid damage to Sensor II, always disconnect the power wiring from the power supply before disconnecting it from the J401 connector.**

Power-up

Upon power-up, the status LED lights red and then flashes briefly every three seconds (approximately). When Sensor II's automatic search results in an SV acquisition, the status LED flashes green between the red power status flashes. Every SV lock-on produces a GREEN flash; for example, if Sensor II is tracking eight SVs, the LED flashes green eight times between red power flashes.

MESSAGE FORMAT

The built-in command/response firmware allocates both RS-232 ports to receiving command messages from and sending response messages to a single external control device (such as a PC), and to output data to a separate data logging device, but only port B to receive differential corrections from a reference (base) station.

Input Messages to Sensor II

These comprise set command messages, query command messages, and general command messages complying with the NMEA 0183 standard to the following extent:

- NMEA 0183 ASCII byte strings following $ character.
- Headers are Ashtech proprietary.
- Message IDs are Ashtech proprietary.
- Data items are separated by commas.
- Checksum character delimiter and NMEA checksum bytes are recognized by Sensor II but are optional. The hexadecimal checksum is computed by exclusive-ORing 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>.

All command messages (set, query or general) must be **ALL UPPER CASE** and completed by **<Enter>**. A valid set command causes Sensor II 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 Sensor II 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 are ignored.

Output Messages from Sensor II

These are messages Sensor II sends to the data logging device in response to a command message. They comprise Sensor II general status messages, command acknowledged/not acknowledged messages and GPS data messages. Sensor II general status messages have free-form Ashtech proprietary formats. The command acknowledged/not acknowledged messages and GPS data messages comply with NMEA 0183 as follows:

- NMEA ASCII byte strings following $-character.
- Headers are standard NMEA or Ashtech proprietary NMEA.
- Message IDs are standard NMEA or Ashtech proprietary NMEA
- 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 <Enter>, the standard NMEA message terminator characters.

Serial Port Configuration

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

On initial power-up or after use of the $PASHS,RST (reset) command, the Sensor II default is 9600 baud for both RS-232 serial ports A and B.

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

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

Parameter Settings And Status

On initial power-up or after use of the $PASHS,RST reset command, Sensor II reverts to its default parameter settings. To get the current status of these settings, there are two query commands available:

$PASHQ,PAR - general and differential parameters

$PASHQ,RAW - raw data paramters

$PASHQ,PAR Query Command

The response message for the default values of query command $PASHQ,PAR is:

```
SVS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
POS:1 UNH:N PDP:40 HDP:04 VDP:04 FIX:0 ION:N ELM:05 ALT:+00000
DIF:0 AUTO:N PREC:05 QA:100 MAX:0120 STID:0000 SAV:N
PER:001
NMEA:POS GLL GXP GGA VTG GSN MSG GSS SAT GRS RRE
PRTA: ON  OFF OFF OFF OFF OFF OFF  OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF  OFF OFF OFF OFF
```

Where:

SVS:Y...	SVs which Sensor II will attempt to acquire, default is all Y.
POS:1	Position mode for the minimum number of satellites required to compute a position fix. With default value 1, minimum of 3 SVs are needed to compute a position. With 3 SVs, the altitude is held (2-D), with 4 or more, the altitude is not held (3-D)
UNH:N	Use unhealthy satellites from position fix computation, default is N.
PDP:40	Position Dilution of Precision, default is 40.
HDP:04	Horizontal Dilution of Precision, default is 4.
VDP:04	Vertical Dilution of Precision, default is 4.
FIX:0	Altitude hold position fix mode for the altitude used when computing a 2-D position. With the default value (0), the most recent antenna altitude is used.
ION:N	Include the ionospheric model and the tropospheric model from the position fix computation, default is N.
ELM:05	Elevation mask below which the satellite is not used in a position computation, default is 5 degrees.
ALT:+00000	Entered altitude used in altitude hold position fix mode for 2-D position determination.
DIF:0	Differential mode setting, default is 0.
AUTO:N	Enable automatic differential mode, default is N.
PREC:05	Precision in meters when Sensor II is in differential mode, accepting Ashtech format, default is 5.

QA:100	Maximum number of received frames in RTCM differential mode above which the quality factor is reset to 100%, default is 100.
MAX:0120	Maximum age in seconds of an RTCM differential correction above which it will not be used. Default is 120.
STID:0000	user station identification (user stid) of the base site, default is 0000.
SAV:N	Save parameters in the battery-backed-up memory. With the default value (N), at the next power up default parameters are used.
PER:001	Send interval of the NMEA response messages in seconds, default is once per second.

For NMEA messages POS, GLL, GXP, GGA, VTG, GSN, MSG, GSS, GRS, RRE, and SAT, the default is OFF for all ports.

$PASHQ,RAW Query Command

The response message for the default values of query command $PASHQ,RAW is:

RCI: 010   MSV:3

RAW: MBN PBN SNV SAL

PRTA: OFF OFF OFF OFF

PRTB: OFF OFF OFF OFF

Where:

RCI:010	Send interval of the raw data outputs in seconds. Default is once every 10 seconds.
MSV:3	Minimum number of SVs mask for the raw data outputs. Default is 3.

For raw data output messages: MBN, PBN, SNV, and SAL, the default is OFF (disabled) for both ports.

If any of these parameters are changed by the corresponding set commands, send the query command $PASHQ,PAR or $PASHQ,RAW to get the current status. If changed parameter values are saved by the $PASHS,SAV,Y set command, after the next power-up, and if a backup battery is connected, the response message to $PASHQ,PAR or $PASHQ,RAW will display the saved quantities instead of the defaults. $PASHS,RST always reinstates the defaults.

Satellite Search Algorithm

When Sensor II is operated for the first time after receipt from Ashtech, the non-volatile memory must be cleared of factory acceptance test position, almanac and ephemeris data with the $PASHS,RST reset command. Initially, therefore, no almanac or ephemeris data is available. Sensor II always assigns the first 12 elements of a 32-element table of SV PRN numbers to its 12 channels. These first 12 SVs are chosen to be members of the current actual SV constellation. This reduces the SV acquisition time. Within six seconds after an SV is locked, the Sensor II time is set. If no ephemeris data is available in the memory or if the data is older than ten hours, between 30 to 60 seconds may be needed to collect data. After three or four SVs are locked and the almanac/ephemeris data is collected, Sensor II attempts to compute its first position fix using an estimated position based on SV locations. Sensor II continuously collects in its non-volatile memory the almanac and ephemeris data as well as the most recent position for calculations in the current session. The time to the first position fix, if no almanac/ephemeris data is available, is typically two minutes.

At the next power up, if the almanac/ephemeris data from non-volatile memory, Sensor II uses the almanac data to search only the visible SVs. The almanac data also allows the prediction of the doppler shift and the Sensor II clock offset to reduce the lock time considerably.

Position Modes

Sensor II performs a position fix computation in four modes:

In **mode 0** at least four SVs above the elevation mask are needed to compute a position. All three polar coordinates are computed in this mode.

In **mode 1** at least three SVs above the elevation mask are needed to compute a position. Only the latitude and the longitude are computed if three SVs are locked and the altitude is held. If more than three SVs are locked, this mode is similar to mode 0.

In **mode 2** at least three SVs above the elevation mask are needed to compute a position. Only the latitude and the longitude are computed, and the altitude is always held.

In **mode 3** at least three SVs above the elevation mask are needed to compute a position. Only the latitude and longitude are computed, and the altitude is held if only three SVs are locked. If more than three SVs are used and the HDOP is less than the specified HDOP mask, all three polar components are computed. If HDOP is higher than the specified HDOP mask, Sensor II automatically goes into the altitude hold mode.

Altitude Hold Definition

Two modes define what altitude is selected when Sensor II 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 set command or the one computed when four or more SVs are used in the solution, whichever is most recent. If the last altitude is the one computed with four or more SVs, it is used only if VDOP is less than the VDOP mask.

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

On initial power-up or after use of the $PASHS,RST set command, the most recent antenna altitude is zero.

Ionospheric/tropospheric Model

Sensor II can be set to use an ionospheric model and a tropospheric model in its position fix computation. Theionospheric model is based on the model defined in ICD-GPS-200, Revision B. The tropospheric model is based on the Bean and Dutton model.

NMEA Outputs

Sensor II allows you to output NMEA message format through serial ports A and B. Eleven different types of messages are available: POS, GLL, GXP, GGA, VTG, GSN, MSG, GSS, SAT, GRS, and RRE. All the NMEA messages are a string of ASCII characters defined by commas and that comply with NMEA 0183 Standards Version 2.0. Transmission protocol is 8 data bits, 1 stop bit, and no parity bit. Any combination of these messages can be output through any of the serial ports, and the same messages can be output through different ports at the same time. The output rate is determined by the $PASHS,NME,PER command, and can be set to any value between 1 and 999 seconds.

Raw Data Outputs

Sensor II has a feature that allows you to send real-time data out through serial ports A and B. Four different types of messages are available:

MBN messages which contain measurement data output

PBN messages which contain position data

SNV messages which contain ephemeris data

SAL messages which contain proprietary almanac data

All outputs are in binary format and the transmission protocol is 8 data bits, 1 stop bit, and no parity bit. Any combination of messages can be output through any of the serial ports, and the same messages can be output through different ports at the same time. The output rate is determined by the $PASHS,RCI setting. Information on the data structures for all the above messages can be found in the discussion of RAW DATA MESSAGES.

DIFFERENTIAL OPERATION

The reference (base) station receiver supplies to remote stations data for differential corrections. In remote mode, Sensor II operates as *user equipment* to the reference station. In this case, Sensor II obtains range corrections from the reference station which it uses to correct the position of its antenna.

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

General

Real-time differential positioning involves a reference (base) station (such as an Ashtech M-XII GPS receiver) computing the SV range corrections and transmitting them to the remote (rover) stations (such as GPS Sensors). The reference station transmits these corrections in real time to the remote receivers via a telemetry link. Remote receivers apply the corrections to their measured ranges; they use corrected ranges to compute their position.

The base receiver determines range correction by subtracting the *measured range* from the *true range*, computed by using the accurate position entered in the receiver. (This accurate position must have been previously surveyed using GPS or some other technique.) The remote receivers subtract the received corrections from their measured ranges and use the corrected ranges for position computation.

A stand-alone Sensor II can compute a position of around 25 meters with Selective Availability off and around 100 meters with SA on. Differential GPS can achieve 1-10 meters at the remote receivers even with SA on.

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 SV orbit estimation, SV clock estimation, ionosphere, troposphere, and receiver noise in measuring range. The first four are almost totally removed using differential GPS. Their residual error is in the order of one millimeter for every kilometer of separation between base and remote receivers.

Receiver noise is not correlated between the base and the remote receiver and is not canceled by differential GPS. However, in Ashtech XII receivers and in Sensor II, integrated doppler is used to smooth the range measurements and reduce the receiver noise.

At the instant an SV is locked, there is also rms noise affecting the range measurement. This rms noise is reduced with the square root of *n* where *n* is the number of measurements. For example, after 100 seconds of locking to an SV, the rms noise in range measurement is reduced by a factor of 10 (one meter of noise is reduced to 0.1 meter). The noise is further reduced over time.

If the lock to an SV is lost, the noise goes back to one meter and smoothing starts from the one-meter level. The loss of lock to an SV is rare. It typically happens only when the direct path to the SV is blocked by an object.

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.

GPS Sensor II Messages

Sensor II can accept both Ashtech and RTCM 104 version 2.0 differential formats. Sensor II is set to differential mode in port B with the $PASHS,DIF,MOD set command. Of RTCM message types 1 through 64, Sensor II processes only: types 3 and 16 for station location and special information; types 1, 2 and 9 for RTCM differential corrections; and null frame type 6. The differential corrections are automatically processed by Sensor II. RTCM message types 3 and 16 provide user information from the reference (base) station via the $PASHS,NME,MSG set command and the $PASHQ,MSG inquiry command. The reference station sends types 1, 2 and 9 continuously and may send either type 3 or type 16 individually.

On initial power-up or after use of the $PASHS,RST reset set command, the Sensor II default automatic differential mode is OFF, and the default is 120 seconds for the maximum age of an RTCM differential correction above which it will not be used. If the automatic mode is not enabled by the $PASHS,DIF,AUT set command and the differential correction data is older than the maximum age specified by the $PASHS,RTC,MAX set command, Sensor II will 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, Sensor II will return the uncorrected raw position.

Ashtech Format

Sensor II acting as a remote receiver needs to know the smooth count of the range corrections. *Smooth count* is the number of measurements used to compute the current smoothing correction on a given data point. Therefore, the smooth count for each range correction is also transmitted from base to remote receiver. A range correction with a smooth count of 100 has a noise level of 0.1 meter, while a range correction with a smooth count of 25 has a noise level of 0.2 meter.

In using a range correction, the remote receiver considers its smooth count to determine whether or not to use it. The decision is based on the precision that was specified by the $PASHS,DIF,REM set command.

If the precision was specified as 1 meter, the remote receiver will not use the received range corrections that have a smooth count less than 25. This means that after locking to an SV, the first 25 measurements for position computation are ignored and used only for smoothing. Then, after this initial 25 seconds, the range measurements from the given SV are used in every second of position computation.

The required smooth count is determined by the remote receiver, using the equation:

$$\textbf{smooth count} = \mathbf{1 + 25/p^2}$$

where p is the required precision (in meters) specified by the $PASHS,DIF,REM set command.

RTCM 104 Format, Version 2.0

When a receiver such as the Ashtech M-XII is used as a reference station and the RTCM option is enabled, the receiver computes differential corrections for up to12 SVs, converts those corrections to RTCM format, and transmits the converted messages via its serial ports. The receiver can generate message types 1, 2, 3, 6, and 16 (Table 3).

Table 3 RTCM Message Types

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

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

When Sensor II is used as remote equipment and the RTCM option is enabled, Sensor II can accept any type of RTCM message. However it decodes only types 1, 2, 3, 6, 9, and 16 and uses only types 1, 2, and 9 for differential corrections. For radio communication, Sensor II in remote mode can recover bit slippage.

ONE-PULSE-PER-SECOND OPERATION

A one-pulse-per-second (PPS) output function is available in Sensor II. The signal is synchronized with GPS time and has a 1-second period. The precision of the 1PPS signal is within 1 μsec, and a position needs to be computed for this precision to be valid.

The PPS signal is a TTL signal into a 75-ohm impedance.

The signal is normally low and goes high 1 to 2 ms before the falling edge. The rising edge is synchronized with GPS time (Figure 4).

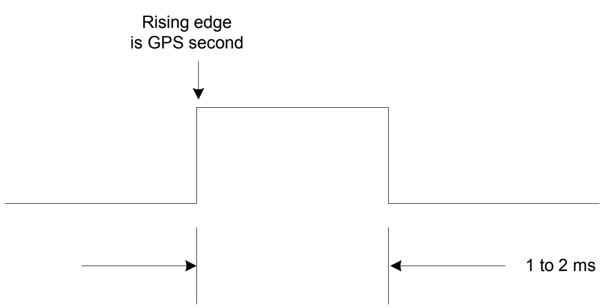

Figure 4 PPS Signal

COMMAND/RESPONSE MESSAGE LANGUAGE

Firmware Interface Requirements

This section defines in detail the requirements for establishing a communications interface between the Ashtech GPS Sensor II and interfacing data equipment.

Introduction

Sensor II includes command/response message language firmware enabling it to receive command messages and to send data messages when so commanded through either of the serial ports. With the use of the differential mode option, Sensor II acting as a remote GPS receiver can receive differential corrections from any GPS receiver equipped to act as a reference station through port B. Sensor II receives command messages in Ashtech format or NMEA format, and optional differential correction messages in Ashtech format or RTCM 104 version 2.0 format. Sensor II responds with messages indicating the acceptance or rejection of commands and providing data on its internal status, antenna position, and status for all SVs currently being tracked. The input messages to Sensor II consist of set command messages, query command messages, general command messages, and differential correction message capability. Output messages from Sensor II are composed of command acknowledged/not acknowledged messages, general status messages, and NMEA-format data messages.

Set Command Messages

Set command messages are accepted by both serial ports. When Sensor II receives a set command message it returns an "acknowledged" messag if it accepts the command; Sensor II returns a "not acknowledged" message if it rejects the command, except for the RST, reset command.

The set command message format is:

$PASHS,xxx,<data items>*cc<Enter>

Where:

$	NMEA message start character
PASHS	proprietary Ashtech set message header
xxx	proprietary message ID for message command
<data items>	data field dependent upon message ID

*	Checksum character delimiter - optional
cc	NMEA checksum bytes - optional

NOTE

All message items between the $ and the * including data items are separated by commas; if any of these message items is not available, it will be omitted.

The acknowledged message is: $PASHR,ACK*3D<Enter>.

The not-acknowledged message is: $PASHR,NAK*30<Enter>.

The items between $ and * are Ashtech proprietary, and 3D and 30 are the respective NMEA checksums computed by Sensor II for your optional use.

Examples:

1. Set message $PASHS,UNH,Y<Enter> instructs Sensor II to include unhealthy satellites in position fix computation; Sensor II returns $PASHR,ACK*3D<Enter>.
2. 2)Set message $PASHS,UNH lacks the data (Y or N), therefore Sensor II returns $PASHR,NAK*30.

NOTE

To get the current status of quantities adjusted by the set commands, send the query command $PASHQ,PAR.

Speed of Serial Port

$PASHS,SPD,x,s<Enter>

Set the baud rate s of Sensor II serial port x, where x is either A or B, and s is a number between 0 and 7 specifying the baud rate as shown in Table 4. (Default is 9600 baud).

Table 4 Baud Rate Codes

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

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

Examples:

$PASHS,SPD,A,5 - port A at 9600 baud (default)

$PASHS,SPD,B,7 - port B at 38400 baud

Reset Sensor II

$PASHS,RST<Enter>

Reset Sensor II and clear all memory. All parameters are reset to the defaults, and all almanac data is cleared. Sensor II does not return an acknowledged message.

Save Parameters Enable/Disable

$PASHS,SAV,N<Enter>

Do not save parameters in the battery backed up memory; at the next power up default parameters are used (default).

$PASHS,SAV,Y<Enter>

Save ALL parameters in the battery backed up memory. Note that the external backup battery should be connected.

Unhealthy SV Select Group

$PASHS,UNH,N<Enter>

Omit unhealthy SVs from position fix computation (default).

$PASHS,UNH,Y<Enter>

Include unhealthy SVs in position fix computation.

SV Enable/Disable

$PASHS,SVS,xxx...x<Enter>

Set the SVs which Sensor II will attempt to acquire, where x indicates if an SV must be used in the automatic search algorithm.

x = Y, SV is used (default).

x = N, SV is not used.

NOTE

Up to 32 SVs may be selected. They are entered in order of PRN number. If fewer than 32 are specified the rest are set to N; entry of any character except Y is interpreted as N.

Examples:

$PASHS,SVS,YYY - PRN 1, 2 and 3 are used; PRN 4 through 32 are not used

$PASHS,SVS,NYYY - PRN 2, 3 and 4 are used; PRN 1 and PRN 5 through 32 are not used

$PASHS,SVS,YYYYYYYYYYNNYY - PRN 1 through 10 and 13 and 14 are used; PRN 11, 12, and 15 through 32 are not used

$PASHS,SVS,NNNNNNNNNNNNNNNNYNNNNNNNNNNNNNYY- only PRN 17, 31 and 32 are used

Elevation Mask

$PASHS,ELM,x<Enter>

Set the value of the elevation mask below which the satellite is not used in a position computation, where x is a number between 0 and 90 (default = 5 degrees).

Example:

$PASHS,ELM,21

Recording Interval

$PASHS,RCI,x<Enter>

Set the value of the interval at which raw data (MBN, PBN), when enabled, will be output through the serial ports, where x is a number between 1 and 999 in seconds. Default is 10.

Example:

$PASHS,RCI,5

Minimum Satellites

$PASHS,MSV,x<Enter>

Set the minimum number of satellites below which no MBN raw data will be output, where x is a number between 1 and 9. Default is 3.

Example:

$PASHS,MSV,4

Position Mode

$PASHS,POS,x<Enter>

Set position mode for minimum number of SVs required to compute a position fix, where x = 0, 1, 2 or 3.

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

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

x = 2, minimum of 3 SVs needed; altitude is always held (always 2-D)

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

Example:

$PASHS,POS,0

Fix, Altitude Hold Position

$PASHS,FIX,x<Enter>

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

x = 0 (default), the most receitude is taken from either the one entered by the $PASHS,ALT command or the last one computed when VDOP is less than VDOP mask.

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

NOTE

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

Example:

$PASHS,FIX,1

Altitude, Altitude Hold Position Fix

$PASHS,ALT,sx<Enter>

Set the altitude data used in an altitude hold position fix computation, where s = + or -, and x = 0 to 30000. The data range (above WGS-84 reference ellipsoid) is -30000 meters to +30000 meters. Sensor II uses this data in the position calculation for 2-D position fixes.

Examples:

$PASHS,ALT,+24756

$PASHS,ALT,-30

Dilution of Precision Group

$PASHS,HDP,x<Enter>

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

Example:

$PASHS,HDP,6

$PASHS,PDP,x<Enter>

Set the value of the PDOP mask to x, where x is a number between 0 and 99. Position will not be computed if the PDOP exceeds the PDOP mask. Default is 40.

Examples:

$PASHS,PDP,20

$PASHS,VDP,x<Enter>

Set the value of the VDOP mask (default = 4), where x is 0 to 99.

Example:

$PASHS,VDP,6

Ionospheric Model/Tropospheric Model

$PASHS,ION,N<Enter>

Exclude the ionospheric model and the tropospheric model from the position fix computation (default).

$PASHS,ION,Y<Enter>

Include the ionospheric model and the tropospheric model in the position fix computation.

NMEA Response Message Group

$PASHS,NME,str,x,ON<Enter>

Enable NMEA message type str on port x, where x is either A or B, and str is one of the following three-character strings:

POS, GLL, GXP, GGA, VTG, GSN, MSG, GSS, SAT, GRS, RRE

NOTE

After one of the NMEA set commands enables the corresponding NMEA response message type, Sensor II periodically returns that response message at the frequency selected by the PASHS,NME,PER set command (default once per second).

Examples:

$PASHS,NME,POS,A,ON

$PASHS,NME,str,x,OFF<Enter>

Disable NMEA message type str on port x, where x is either A or B, and str is one of the following three-character strings:

POS, GLL, GXP, GGA, VTG, GSN, MSG, GSS, SAT, GRS, RRE, ALL

NOTE

The default is NMEA message disabled. After one or more of the NMEA set commands enables the corresponding NMEA response message type, the ALL command stops return of all response messages.

Example:

$PASHS,NME,POS,A,OFF

$PASHS,NME,POS,x,ON/OFF<Enter>

Enable/disable NMEA position response message on port x, where x is either A or B. The default is NMEA message disabled.

Examples:

$PASHS,NME,POS,A,ON

$PASHS,NME,POS,B,OFF

NOTE

The $PASHR,POS data response message contains information on the most recently computed position, updated at the rate defined by the $PASHS,NME,PER set command (default once per second). If it receives the $PASHS,NME,POS set command message, Sensor II always returns the position response message, whether it is currently computing a position fix or not.

$PASHS,NME,GLL,x,ON/OFF<Enter>

Enable/disable NMEA latitude/longitude response message on port x, where x is either A or B. The default is NMEA message disabled. This message is not output unless position is computed.

Examples:

$PASHS,NME,GLL,A,ON

$PASHS,NME,GLL,B,OFF

$PASHS,NME,GXP,x,ON/OFF<Enter>

Enable/disable NMEA position fix response message on port x, where x is either A or B. The default is NMEA message disabled. This message is not output unless position is computed.

Examples:

$PASHS,NME,GXP,A,ON

$PASHS,NME,GXP,B,OFF

$PASHS,NME,GGA,x,ON/OFF<Enter>

Enable/disable NMEA GPS position response message on port x, where x is either A or B. The default is NMEA message disabled. This message is not output unless position is computed.

Examples:

$PASHS,NME,GGA,A,ON

$PASHS,NME,GGA,B,OFF

$PASHS,NME,VTG,x,ON/OFF<Enter>

Enable/disable NMEA velocity/course response message on port x, where x is either A or B. The default is NMEA message disabled. This message is not output unless position is computed.

Examples:

$PASHS,NME,VTG,A,ON

$PASHS,NME,VTG,B,OFF

$PASHS,NME,GSN,x,ON/OFF<Enter>

Enable/disable NMEA signal strength/satellite number response message on port x, where x is either A or B. The default is NMEA message disabled. This message is output whether a position is computed or not.

Examples:

$PASHS,NME,GSN,A,ON

$PASHS,NME,GSN,B,OFF

$PASHS,NME,MSG,x,ON/OFF<Enter>

Enable/disable NMEA response message containing RTCM reference (base) station message types 03 and 16 on port x, where x is either A or B. The default is NMEA message disabled.

NOTE

Unless Sensor II is receiving differential corrections from a reference (base) station, this command is ignored.

Examples:

$PASHS,NME,MSG,A,ON

$PASHS,NME,MSG,B,OFF

$PASHS,NME,GSS,x,ON/OFF<Enter>

Enable/disable NMEA SVs-used response message on port x, where x is either A or B. The default is NMEA message disabled. This message is output regardless of whether a position is computed.

Examples:

$PASHS,NME,GSS,A,ON

$PASHS,NME,GSS,B,OFF

$PASHS,NME,SAT,x,ON/OFF<Enter>

Enable/disable NMEA satellite status response message on port x, where x is either A or B. The default is NMEA message disabled.

NOTE

The $PASHR,SAT response message contains satellite status information on all satellites currently being tracked. If this message is sent to Sensor II, Sensor II always returns the satellite status response message, whether or not it is currently computing a position.

Examples:

$PASHS,NME,SAT,A,ON

$PASHS,NME,SAT,B,OFF

$PASHS,NME,GRS,x,ON/OFF<Enter>

Enable/disable NMEA satellite range residual response message to port x, where x is either A or B. The default is NMEA message disabled. This message is not output unless a position is computed.

Example:

$PASHS,NME,GRS,A,ON

$PASHS,NME,GRS,B,OFF

$PASHS,NME,RRE,x,ON/OFF<Enter>

Enable/disable NMEA satellite residual and position error response message to port x, where x is either A or B. The default is NMEA message disabled. This message is not output unless a position is computed.

Example:

$PASHS,NME,RRE,A,ON

$PASHS,NME,RRE,B,OFF

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

Disable ALL NMEA message types on port x, where x is either A or B.

NOTE

The default is NMEA message disabled. After one or more of the NMEA set commands enables the corresponding NMEA response message type, the ALL command stops return of all response messages.

Examples:

$PASHS,NME,ALL,A,OFF

$PASHS,NME,ALL,B,OFF

$PASHS,NME,PER,x<Enter>

Set the send interval of the NMEA response messages in seconds, where x is a number between 1 and 999 (default once per second).

Example:

$PASHS,NME,PER,10

Raw Data Response Message Group

$PASHS,NME,str,x,ON<Enter>

Enable raw data message type str on port x, where x is either A or B, and str is one of the following character strings: MBN, PBN, SNV, SAL. Raw data messages are output in binary format.

NOTE

MBN and PBN messages will be output at each recording interval (set with command $PASHS,RCI,x). SNV and SAL will be output one satellite at each recording interval, once every hour, including when first requested. SNV is output once every hour or each time the IODE changes, whichever comes first.

Example:

$PASHS,NME,SNV,B,ON

$PASHS,NME,str,x,OFF<Enter>

Disables raw data messages type str on port x, where x is either A or B and str is one of the following character strings: MBN, PBN, SNV, SAL, ALL.

NOTE

The ALL str disables all raw data and NMEA messages through port x.

Example:

$PASHS,NME,SNV,OFF

$PASHS,NME,MBN,x,ON/OFF<Enter>

Enable/disable measurement data (MBN) messages on port x, where x is A or B.

NOTE

No MBN data will be output if minimum satellite mask (MSV) is bigger than number of locked SVs. No MBN data will be output for those satellites with elevation below the elevation mask (ELM).

Example:

$PASHS,NME,MBN,A,ON

$PASHS,NME,PBN,x,ON/OFF<Enter>

Enable/disable position data (PBN) messages on port x, where x is A or B.

Example:

$PASHS,NME,PBN,B,ON

$PASHS,NME,SNV,x,ON/OFF<Enter>

Enable/disable ephemeris data (SNV) messages on port x, where x is A or B.

Example:

$PASHS,NME,SNV,A,OFF

$PASHS,NME,SAL,x,ON/OFF<Enter>

Enable/disable almanac data (SAL) messages on port x, where x is A or B.

Example:

$PASHS,NME,SAL,B,OFF

Differential Mode Group

$PASHS,DIF,MOD,x<Enter>

Choose differential/non-differential mode, where x = 0, 1, or 2.

Examples:

$PASHS,DIF,MOD,0

x = 0, non-differential mode (default)

$PASHS,DIF,MOD,1

x =1, differential mode Ashtech format

$PASHS,DIF,MOD,2

x = 2, differential mode RTCM format

NOTE

When Port B is assigned to receive differential corrections, it can not be used to communicate with Sensor II.

$PASHS,DIF,AUT,X <Enter>

Enable or disable automatic differential mode, where x is N (default) or Y. If set to Y, the receiver automatically switches position computation from differential to stand-alone mode when differential corrections are not received, and from stand-alone to differential when corrections are resumed.

$PASHS,DIF,REM,x <Enter>

Set the precision in meters when Sensor II is in differential mode, accepting Ashtech format, where x is a number between 0 and 99 (default 5).

Example:

$PASHS,DIF,REM,9

RTCM Response Message Group

$PASHS,RTC,MAX,x<Enter>

Set the maximum age in seconds of an RTCM differential correction above which it will not be used, where x is any number between 1 and 1199. Default is 120.

Example:

$PASHS,RTC,MAX,100

$PASHS,RTC,QAF,x<Enter>

Set the maximum number of received frames in RTCM differential mode above which the quality factor is reset to 100%, where x is any number between 0 and 999. This parameter allows you to evaluate the communication quality between the base and remote stations. Default is 100.

Example:

$PASHS,RTC,QAF,50

$PASHS,RTC,STI,xxxx<Enter>

Set the user station identification (user STID). In RTCM differential mode, the corrections will not be applied if the station ID between base and remote are different, unless the remote is set to zero. If the user STID of the remote is set to zero, Sensor II will attempt to use all RTCM differential corrections it receives, regardless of the station ID of the base. xxxx can be any number between 0000 (the default) and 1023.

Example:

$PASHS,RTC,STI,0001<Enter>

QUERY COMMAND MESSAGES

The query command messages are used to request the current GPS port baud rate setting, parameter setting, position information and tracking status in the Sensor II. Query command messages can be sent to Sensor II through RS-232 serial port A or B, and some also can direct that Sensor II respond through either port A or port B. Sensor II acknowledges a valid query command message by sending the requested response message through the specified port. The information requested is sent once each time the command is issued and is not repeated.

The query command message format is:

$PASHQ,xxx,<data items>*cc<Enter>

Where:

$	NMEA message start character
PASHQ	proprietary Ashtech query message header
xxx	proprietary message ID for message command
<data items>	data field dependent upon message ID
*	Checksum character delimiter - optional
cc	NMEA checksum bytes - optional.

NOTE

All message items between the $ and the * including data items are separated by commas; if any of these message items are omitted, the command is ignored by Sensor II.

Port Baud Rate Query

$PASHQ,PRT<Enter>

Get baud rate in effect for Sensor II RS-232 port. The response message format is:

$PASHR,PRT,x,s

Where

x =	communication port (A or B)
s =	communication speed according to the table on page 25.

Example:

$PASHQ,PRT

$PASHR,PRT,A,5

Receiver ID

$PASHQ,RID<Enter>

Show the receiver ID for Sensor II: firmware version and installed options. The response message format is:

$PASHR,RID,SE,vvvv,ooooooo*cc<Enter>

Where

SE =	GPS Sensor II
vvvv =	firmware version
ooooooo =	installed options

Options installed are:

D =	differential remote option
R=	raw data output option
P=	photogrammetry option
- =	options not available
L=	Sensor II
P=	carrier phase option

Example:

$PASHR,RID,1E13,DRP--LP*6C

NOTE

A dash (-) in any of the option slots indicates that the option is not installed or is not available.

Parameter Settings

$PASHQ,PAR<Enter>

Show current settings of Sensor II parameters.

Example:

```
$PASHQ,PAR
SVS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
POS:1 UNH:N PDP:40 HDP:04 VDP:04 FIX:0 ION:N ELM:05 ALT:+00000
DIF:0 AUTO:N PREC:05 QA:100 MAX:0120 STID:0000 SAV:N
NMEA:POS GLL GXP GGA VTG GSN MSG GSS SAT GRS RRE
PRTA:ON   OFF OFF  OFF OFF  OFF OFF  OFF OFF OFF OFF
PRTB:OFF  OFF OFF  OFF OFF  OFF OFF   OFF OFF OFF OFF
PER: 001
```

Status of SVs

$PASHQ,STA<Enter>

Show the status of SVs currently locked: present time, the PRN number, and the signal strength (count).

Example:

$PASHQ,STA

TIME: 18:38:31 UTC
LOCKED: 03 23 16
COUNT : 54 26 17

Raw Data Parameter Setting

$PASHQ,RAW<Enter>

Show current settings of raw data parameters.

Example:

```
$PASHQ,RAW
RCI:010  MSV:3
RAW: MBN PBN SNV SAL
PRTA:OFF  OFF OFF OFF
PRTB:OFF  OFF OFF OFF
```

RTCM Tracking Status

$PASHQ,RTC<Enter>

Show the RTCM tracking status of Sensor II.

Example:

$PASHQ,RTC

SYNC:* STID:0122 STHE:0 QA:100%AGE:+014

Where:

SYNC	Indicates with an * that synchronization between base and remote has been established.
STID	Displays the station ID set in the base station.
STHE	Displays the station health set in the base station.
QA	Displays the communication quality factor between the base and remote, defined as **# of good measurements × 100 ÷ total # of messages**
AGE	Displays the age of the received messages in seconds

Memory Test Status

$PASHQ,MEM<Enter>

Show the result of the last memory test of Sensor II.

Example:

$PASH Q,MEM

FFF0 0000 FFFF 0000 0000

First field: FFF0	Volatile memory test result. It should always be FFF0.
Second field:0000	Non-volatile memory checksum result. Non-zero means checksum failed, and this part of memory will be initialized and tested. In that case the third field will show the result of this memory test. The first time the receiver is used and each time that the RST command is issued this field will be non-zero.

Third field: FFFF	If the second field is non-zero, meaning the checksum of the non-volatile memory has failed, this field will show the result of the test on that part of memory. This result must be 8000 if memory passes the test. If the second field is zero this field has no meaning.
Fourth field: 0000	Must always be zero.
Fifth field : 0000	ROM checksum. Zero means checksum passed.

Raw and NMEA Message Query Group

$PASHQ,str,x<Enter>

Get the type str raw or NMEA message through port x once, where x is either A or B, and str is one of the following three-character strings:

POS, GLL, GXP, GGA, VTG, GSN, MSG, GSS, SAT, GRS, RRE, MBN, PBN, SNV, ALM

$PASHQ,POS,x<Enter>

Get NMEA position response message on port x, where x is either A or B. The PASHR,POS data response message contains information on the most recently computed position, updated once per second. If Sensor II receives the query message, it always returns the position response message whether it is currently computing a position fix or not.

Example:

$PASHQ,POS,A

$PASHR,POS,0,07,014308,3722.3705,N,12159.8406,W,+00014,,25 6,001,
-007,02,01,01,01,1E12*75

$PASHQ,GLL,x<Enter>

Get NMEA latitude/longitude response message on port x, where x is either A or B. This message is not output unless position is computed.

Example:

$PASHQ,GLL,B

$GPGLL,3722.3622,N,12159.8274,W,180236,A*7F

$PASHQ,GXP,x<Enter>

Get NMEA basic GPS position fix response message on port x, where x is either A or B. This message is not output unless position is computed.

Example:

$PASHQ,GXP,B

$GPGXP,183805,3722.3622,N,12159.8274,W*5C

$PASHQ,GGA,x<Enter>

Get NMEA GPS position response message on port x, where x is either A or B. This message is not output unless position is computed.

Example:

$PASHQ,GGA,B

$GPGGA,014919,3732.3754,N,12159.8456,W,1,08,01.2,+00028,M, ,M,,,*79

$PASHQ,VTG,x<Enter>

Get NMEA GPS velocity/course response message on port x, where x is either A or B. This message is not output unless position is computed.

Example:

$PASHQ,VTG,B

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

$PASHQ,GSS,x<Enter>

Get NMEA SVs used in position fix response message on port x, where x is either A or B. This message is output regardless of whether or not a position is computed.

Example:

$PASHQ,GSS,B

$GPGSS,0,3,08,20,09,12,24,04,05,02,07,01.7*49

$PASHQ,SAT,x<Enter>

Get NMEA satellite status for SVs currently being tracked; response message on port x, where x is either A or B. This message is output whether or not a position is computed.

Example:

$PASHQ,SAT,B

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

$PASHQ,GSN,x<Enter>

Get NMEA signal strength/SVs locked response message on port x, where x is either A or B. This message is output regardless of whether a position is computed.

Example:

$PASHQ,GSN,B

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

$PASHQ,MSG,x<Enter>

Get response message containing RTCM reference (base) station message types 03 and 16 on port x, where x is either A or B.

NOTE

Unless Sensor II is receiving differential corrections from a reference (base) station, this command is ignored.

Example:

$PASHQ,MSG,B

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

$GPMSG,16,0000,1209.6,5,0,038,231958,THIS IS A MESSAGE SENT FROM BASE*5C

$PASHQ,GRS,x<Enter>

Get NMEA satellite range residual response message on port x, where x is either A or B. This message is not output unless a position is computed.

Example:

$PASHQ,GRS,A<Enter>

$GPGRS,015803,1,-00.5,+07.3,+16.5,-28.0,+13.1,-08.4,+05.2*69

$PASHQ,RRE,x<Enter>

Get NMEA satellite residual and position error response message on port x, where x is either A or B. This message is not output unless a position is computed.

Example:

$PASHQ,RRE,A<Enter>

$GPRRE,08,20,+000.6,09,+007.9,12,-013.5,24,+037.3,04,-025.4,05,
-005.0,02,+010.1,07,+013.9,+0060.8,+0058.8*72

$PASHQ,MBN,x<Enter>

Get the MBN measurement data response message on port x, where x is either A or B. This message is output for those SVs with elevation equal to or greater than the elevation mask (ELV), and only if the number of locked SVs is equal to or greater than minimum satellite mask (MSV). Data is output in binary format. See section entitled *Raw Data Messages* for output format.

Example:

$PASHQ,MBN,A

$PASHQ,PBN,x<Enter>

Get the PBN position measurement data response message on port x, where x is either A or B. This message is output in binary format. See section entitled *Raw Data Messages* for output format.

Example:

$PASHQ,PBN,B

$PASHQ,SNV,x<Enter>

Get the SNV ephemeris data response message on port x, where x is either A or B. This message is output in binary format. See section entitled *Raw Data Messages* for output format.

Example:

$PASHQ,SNV,B

$PASHQ,SAL,x<Enter>

Get the SAL almanac data response message on port x, where x is either A or B. This message is output in binary format. See section entitled *Raw Data Messages* for output format.

Example:

$PASHQ,SAL,A

NMEA DATA MESSAGES

In response to a set command message or a query command message through the RS-232 serial port, Sensor II returns an NMEA data message (also called an NMEA sentence) through either port A or port B (as commanded). Set commands instruct Sensor II to return a continuous stream of NMEA data messages at a specified rate (default is once per second). The NMEA data response message is returned once each time a query command is issued and is not repeated.

The standard NMEA response message format is:

$<header>,<data items>*cc<Enter>

Where:

$	NMEA message start character
<header>	standard response message header
<data items>	data field dependent upon header
*	checksum character delimiter
cc	NMEA checksum computed by Sensor II for your optional use.

NOTE

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

Figure 5 is an example of an NMEA sentence.

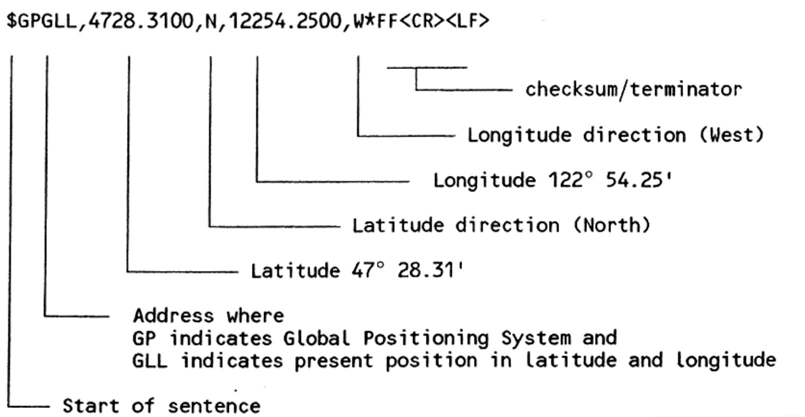

Figure 5 Example NMEA Sentence

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

The Ashtech proprietary NMEA response message format applies to the position and satellite data messages; the format is:

$PASHR,xxx,<data items>*cc<Enter>

replacing the standard header with an Ashtech proprietary header and adding Ashtech proprietary message IDs, POSition or SATellite.

The following paragraphs describe the various fields in each response message for typical cases. Data items within the italic data field are numbered from left to right.

GPS Position Data, Summary

$PASHR,POS,n,qq,hhmmss,ddmm.mmmm,s,dddmm.mmmm,s,
saaaaa,seeeee,ttt,ggg,svvv,pp,hh,vv,tt,vvvv,*cc<Enter>

NOTE

The $PASHR,POS data response message contains information on the most recently computed position, updated once per second, as described in Table 5. If Sensor II receives the $PASHQ,POS query message, it always returns the position response message, whether or not it is currently computing a position fix.

Table 5 POS Message Structure

Ittem	Significance
1	Raw/differential position, n n = 0 - Raw; position is not differentially corrected n = 1 - position is differentially corrected
2	qq = number of SVs used in position fix
3	Current GPS time, hhmmss, of position fix in hours, minutes and seconds
4	Latitude component of position, ddmm.mmmm, in degrees, minutes and fraction of minutes
5	Latitude sector, s = N(North), s = S(South)
6	Longitude component of position, dddmm.mmmm, in degrees, minutes and fraction of minutes
7	Longitude sector, s = E(East), s = W(West)
8	Sensor-computed altitude, saaaaa s = "+" or "-" aaaaa = Altitude 00000 to 30000 meters above WGS-84 reference ellipsoid For 2-D position fix this item contains the altitude used to compute the position fix.
9	Altitude of external encoder, seeeee s = "+" or "-" eeeee = Altitude 00000 to 30000 meters This item reports, for five seconds, the data received through Sensor II port B from an external altitude encoder and then replaces data with null characters (,,). If a new altitude is entered through port B, its value fills this item for five seconds. The encoder can be a reference (base) station.
10	True track/true course over ground in degrees, ttt = 000 to 359 degrees
11	Speed over ground, ggg = 000 to 999 knots
12	Vertical velocity, svvv s = "+" or "-" vvv = 000 to 999 decimeters per second
13	PDOP(position dilution of precision), pp = 00 to 99
14	HDOP(horizontal dilution of precision), hh = 00 to 99
15	VDOP(vertical dilution of precision), vv = 00 to 99
16	TDOP(time dilution of precision), tt = 00 to 99
17	Sensor II firmware version ID in ASCII, vvvv.

Example 1:

$PASHQ,POS,A [or] $PASHS,NME,POS,B,ON

$PASHR,POS,0,03,183805,3722.3622,N,12159.8274,W,

+00016,,179,021,+039,06,04,03,01,1C00*45

Table 6 Typical POS Response

Field	Significance
$PASHR,POS	Header
0	Position is not differentially corrected
03	Number of SVs used in position fix
18305	Time of position fix
3722.3622	Latitude
N	North
12159.8274	Longitude
W	West
+00016	Altitude in meters
Empty field	More than two seconds since last data
179	Course over ground in degrees (True)
021	Speed over ground in knots
+039	Vertical velocity in decimeters per second
06	PDOP
04	HDOP
03	VDOP
01	TDOP
1C00	Version number
45	Message checksum in hexadecimal

Example 2:

$PASHQ,POS,A[or}$PASHS,NME,POS,B,ON

$PASHR,POS,0,,,,,,,,,,,,,,,,1B03*1A

NOTE

If no position is computed, POS message will be output but fields 2 to 16 will be empty.

GPS Latitude/Longitude

$GPGLL,ddmm.mmmm,s,dddmm.mmmm,s,hhmmss,A*cc<Enter>

Table 7 GLL Message Structure

Item	Significance
1	Latitude component of position, ddmm.mmmm, in degrees, minutes and fraction of minutes
2	Latitude sector, s = N(North), s = S(South)
3	Longitude component of position, dddmm.mmmm, in degrees, minutes and fraction of minutes.
4	Longitude sector, s = E(East), s = W(West)
5	UTC of position in hours, minutes, and seconds
6	Status, A = valid, V = invalid

Example:

$PASHQ,GLL,B [or] $PASHS,NME,GLL,A,ON

$GPGLL,3722.3622,N,12159.8274,W,180236,A*7F

Table 8 Typical GLL Message

Field	Significance
$GPGLL	Header
3722.3622	Latitude
N	North
12159.8274	Longitude
W	West
180236	Time of position fix
A	Valid
7F	Message checksum in hexadecimal

GPS Basic Position Fix

$GPGXP,hhmmss,ddmm.mmmm,s,dddmm.mmmm,s*cc<Enter>

Table 9 GXP Message Structure

Item	Significance
1	Current GPS time, hhmmss,of position fix in hours, minutes and seconds
2	Latitude component of position, ddmm.mmmm, in degrees, minutes and fraction of minutes
3	Latitude sector, s = N(North), s = S(South)
4	Longitude component of position, dddmm.mmmm, in degrees, minutes and fraction of minutes
5	Longitude sector, s = E(East), s = W(West)

Example:

$PASHQ,GXP,B [or] $PASHS,NME,GXP,A,ON

$GPGXP,183805,3722.3622,N,12159.8274,W*5C

Table 10 Typical GXP Response Message

Field	Significance
$GPGXP	Header
183805	Time of position fix
3722.3622	Latitude
N	North
12159.8274	Longitude
W	West
5q	Message checksum in hexadecimal

GPS Expanded Position Fix/Geoid/Ellipsoid

$GPGGA,hhmmss,ddmm.mmmm,s,dddmm.mmmm,s,n,qq,pp.p,saaaaa,
u,sggggg,u,sss,aaaa *cc<Enter>

Table 11 GGA Message Structure

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

Example:

$PASHQ,GGA,B [or] $PASHS,NME,GGA,A,ON

$GPGGA,183805,3722.3622,N,12159.8274,W,2,03,02.8,+00016,M,,
M,005,0001*6F

M,,M,005,0001*6F

Table 12 Typical GGA Response Message

Field	Significance
$GPGGA	Header
183805	Time of position fix
3722.3622	Latitude

Table 12 Typical GGA Response Message (continued)

Field	Significance
N	North
12159.8274	Longitude
W	West
2	Differential mode
03	Number of SVs used in position fix
02.8	HDOP
+00016	Altitude
M	Meters. Units of altitude
Empty field	Geoidal separation not available
M	Meters. Units of the geoidal separation
005	Age of differential corrections
Base station ID	Base station ID
6F	Message checksum in hexadecimal

GPS Velocity/Heading

$GPVTG,ttt,c,ttt,c,ggg.gg,u,ggg.gg,u*cc<Enter>

Table 13 VTG Message Structure

Item	Significance
1	True track/true course over ground, ttt = 000 to 359 degrees
2	True course over ground marker, c = always T (true course)
3	Magnetic track/magnetic course over ground, ttt = 000 to 359 degrees
4	Magnetic course over ground marker, c = always M (magnetic course)
5	Speed over ground, ggg.gg = 000 to 999.99 knots
6	Speed over ground units, u = N (nautical miles per hour), default is knots
7	Speed over ground, ggg.gg = 000 to 999.99 kilometers per hour
8	Speed over ground units, u = K (kilometers per hour)

Example:

$PASHQ,VTG,B [or] $PASHS,NME,VTG,A,ON

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

Table 14 Typical VTG Response Message

Field	Significance
$GPVTG	Header
179	Course over ground in degrees
T	True
Empty field	Magnetic course over ground (not available)
Empty field	Magnetic course over ground marker (not available)
000.11	Speed over ground in knots
N	Knots
000.20	Speed over ground in kilometers/hour
K	Kilometers/hour
3E	Message checksum in hexadecimal

GPS Position Fix Solution/Variables

$GPGSS,0,s,qq,ss,ss,ss,......,pp.p*cc<Enter>

SVs used in position fix and position dilution of precision (PDOP).

NOTE

The first data item is always zero. qq indicates the number of SVs used to compute the position fix solution, and ss lists the PRN of these SVs.

Table 15 GSS Message Structure

Item	Significance
1	Position fix solution, s s = 2, altitude hold position fix (2-D) solution s = 3, altitude not held (3-D) solution
2	Number of SVs used, number of SVs in message, qq
3	First SV PRN number, ss = 1 to 32
4	Second SV PRN number, ss = 1 to 32
5	Third SV PRN number, ss = 1 to 32
6	PDOP - position dilution of precision to the nearest tenth; pp.p = 00.0 to 99.9

Example:

$PASHQ,GSS,B

$GPGSS,0,2,04,03,23,16,31,02.8*5C

Table 16 Typical GSS Response Message

Field	Significance
$GPGSS	Header
0	Always 0
2	Altitude hold position fix solution
04	Number of SVs used in position fix
03	PRN number of the first satellite
23	PRN number of the second satellite
16	PRN number of the third satellite
31	PRN number of the fourth satellite
02.8	PDOP
5Q	Message checksum in HEX

Satellite Status Message

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

NOTE

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

Table 17 SAT Message Structure

Item	Significance
1	Number of SVS locked, number of SVs in message, qq
2	SV PRN number, pp = 1 to 32
3	SV azimuth angle, aaa = 000 to 359 degrees
4	SV elevation angle, ee = 00 to 90 degrees
5	SV signal strength/signal-to-noise ratio, ss = 00 to 99
6	SV used/not used, h = U (SV used in position fix solution), h = - (SV not used)

Example 1:

$PASHQ,SAT,B

$PASHR,SAT,0*7D

Table 18 Typical SAT Response Message - 1

Field	Significance
$PASHR,SAT	Header
0	No SVs locked
7D	Message checksum in hexadecimal

Example 2:

$PASHQ,SAT,B

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

Table 19 Typical SAT Response Message - 2

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

GPS Signal Strength/SVs Locked

$GPGSN,qq,pp,ss,pp,ss,.....ttt*cc<Enter>

NOTE

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

Table 20 GSN Message Structure

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

Example:

$PASHQ,GSN,B [or] $PASHS,NME,GSN,A,ON

$GPGSN,03,03,060,23,039,16,021,084*4D

Table 21 Typical GSN Response Message

Field	Significance
$GPGSN	Header
03	Number of SVs locked
03	PRN number of the first SV
060	Signal strength of the first SV
23	PRN number of the second SV
039	Signal strength of the second SV
16	PRN number of the third SV
021	Signal strength of the third SV
084	RTCM age
4D	Message checksum in HEX

RTCM Reference (Base) Station Locator/Special Message

$GPMSG,rr,ssss,zzzz.z,s,h,ccc,hhmmss,(sxxxxxxx.xx,syyyyyyy.yy,szz zzzzz.zz) [or] (text),*cc<Enter>

NOTE

Of RTCM message types 1 through 64, Sensor II processes only types 3 and 16 for the $GPMSG response message. This message is receivable only if Sensor II is receiving RTCM format differential corrections from a reference (base) station. The reference station determines the sending rate. Either type 3 or type 16 may be sent individually.

Table 22 MSG Message Structure

Item	Significance
1	RTCM type, rr rr = 03, reference station locator parameters rr = 16, reference station special message text
2	Station identifier, ssss = 0000 to 1023
3	Z count in seconds and tenths, zzzz.z = 0000.0 to 3600.0
4	Sequence number, s = 0 to 7
5	Station health, h = 0 to 7
6	Total number of characters after the time item, ccc = 000 to 999
7	Current GPS time, hhmmss, of position fix in hours, minutes and seconds
8	Station X component, sxxxxxxx.xx (for message type 3 only) s = "+" or "-" xxxxxxx.xx = metric X-distance from geocenter
9	Station Y component, syyyyyyy.yy (for message type 3 only) s = "+" or "-" yyyyyyy.yy = metric Y-distance from geocenter
10	Station Z component, szzzzzzz.zz (for message type 3 only) s = "+" or "-" zzzzzzz.zz = metric Z-distance from geocenter
11	Message content is determined by the sending reference station (for message type 16 only)

Example 1:

$PASHQ,MSG,B

$GPMSG,03,0000,1200.0,7,0,041,231958,-2691561.37,

-4301271.02,+3851650.89*6C

Table 23 Typical MSG Response Message

Field	Significance
$GPMSG	Header
03	RTCM type
0000	Station ID
1200.0	Z count in seconds and tenths
7	Sequence number
0	Station health
041	Total number of characters after the time item
231958	Current time in hours, minutes and seconds
-2691561.37	Station X component
-4301271.02	Station Y component
+3851650.89	Station Z component
6C	Message checksum in hexadecimal

Example 2:

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

Table 24 Typical MSG Response Message

Field	Significance
$GPMSG	Header
16	RTCM type
0000	Station ID
1209.6	Z count in seconds and tenths
5	Sequence number
0	Station health
038	Total number of characters after the time item
232008	Current time in hours, minutes and seconds
Texr	Message content
5C	Message checksum in hexadecimal

GPS Satellite Range Residuals

$GPGRS,hhmmss,m,sxx.x,sxx.x,sxx.x,....*cc<Enter>

NOTE

Range residuals are recomputed after the GGA position was computed. Therefore the mode m is always 1. There will be a range residual sxx.x for each satellite used in position computation, and the order of the residuals matches the order of the satellites in the GSS message.

Table 25 GRS Message Structure

Item	Significance
1	Current UTC time, hhmmss.ss, of GGA position fix in hours, minutes, and seconds
2	Mode, m, used to compute range residuals 0 - Residuals were used to calculate the position given in the matching GGA line 1 - residuals were recomputed after the GGA position was computed
3	Range residuals (sign s = + or -, and magnitude xx.x) for each satellite used in position computation. The order of the residuals matches the order of the satellites in the GSS message.

Example:

$PASHQ,GRS,A or $PASHS,NME,GRS,A,ON

$GPGRS,180257,1,+00.3,-00.4,+00.2,+00.5,+00.7,-00.8*64

Table 26 Typical GRS Response Message

Field	Significance
$GPGRS	Header
180257	Time of position fix
1	Mode
+00.3	Range residual for first SV in GSS message
-00.4	Range residual for second SV in GSS message
+00.2	Range residual for third SV in GSS message
+00.5	Range residual for fourth SV in GSS message
+00.7	Range residual for fifth SV in GSS message
00.8	Range residual for sixth SV in GSS message
64	Message checksum in hexadecimal

GPS Satellite Range Residuals and Position Errors

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

There will be a range residual (sxxx.x) computed for each satellite used in position computation. There will be a horizontal (hhhh.h) and a vertical (vvvv.v) position error computed. Residuals and position errors will not be computed unless there are at least 5 satellites used in position computation.

Table 27 RRE Message Structure

Item	Significance
1	Number of satellites, qq, used to compute position.
2	PRN number, ss, for each of the satellites used in position computation.
3	Range residuals magnitude (sxxx.x) for each satellite used in position computation, where s is sign (+ or -).
Last 2 fields	Horizontal hhhh.h, and vertical vvvv.v position errors, respectively.

Example:

$PASHQ,RRE,A or $PASHS,NME,RRE,A,ON

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

Table 28 Typical RRE Response Message

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

RAW DATA MESSAGES

In response to a set command message or query command message through serial port A or B, Sensor II returns a raw data message through the commanded port. Four different types of raw data binary messages are available, and for a particular RCI, if configured to be output, they will be output in the following order: MBN, PBN, SNV, and SAL.

MBN

Binary measurement data output on every recording interval (RCI) for all locked satellites with elevation equal to or greater that the elevation mask, if the number of locked SVs is equal to or greater than minimum satellite mask (MSV). The binary format is as follows.

$PASHR,MBN,measurement structure <Enter>

where the measurement structure is as defined in Table 29.

Table 29 MBN Measurement Structure

Field	Char	Content
char datatype	1	Is always equal to 1.
char count	1	Number of measurement structures to follow after this one.
char svprn	1	Satellite PRN number
char chnind	1	Channel number (between 1 and 12
long lost_lock_ctr	4	Continuous counts since satellite is locked. This number is incremented about 500 per second.
char polarity	1	This number is either 4 or 5, 4 meaning satellite is just locked, and 5 meaning the beginning of the first subframe has been found.
char goodbad	1	This number is either 22 or 24, 22 meaning the satellite is not usable, 24 meaning the satellite is usable for position fix.
char warning	1	Is always equal to 0.
char ireg	1	The satellite signal strength.
double codetxmt	8	The fractional part of the satellite transmit time in seconds. The integer part of this number must be ignored.
long doppler	4	The satellite doppler in units of 0.0001 Hz.
double intdoppler	8	The integrated doppler in Hz if carrier phase option is not installed; full phase if carrier phase option is installed.
short carphase1	2	Empty item.
short carphase2	2	Empty item.
short elevation	2	The satellite elevation in units of 0.01 degrees.

Table 29 MBN Measurement Structure (continued)

Field	Char	Content
short azimuth	2	The satellite elevation in degrees.
checksum	2	The checksum is computed by breaking the structure into 20 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	42	

PBN

Binary position data output on every recording interval (RCI). The binary format is:

$PASHR,PBN,position structure <Enter>

where the position structure is as defined in Table 30.

Table 30 PBN Position Structure - Binary

Field	Char	Content
long rcvtime	4	Signal received time in milliseconds of week of GPS time. This is the time tag for all measurements and position data.
char sitename	4	Set to ????.
double navx	8	Antenna position ECEF x coordinate in meters.
double navy	8	Antenna position ECEF y coordinate in meters.
double navz	8	Antenna position ECED z coordinate in meters.
float navt	4	Receiver clock offset in meters.
float navxdot	4	The antenna x velocity in meters per second.
float navydot	4	The antenna y velocity in meters per second.
float navzdot	4	The antenna z velocity in meters per second.
float navtdot	4	The receiver clock drift in meters per second.
unsigned short PDOP	2	PDOP multiplied by 100.
checksum	2	The checksum is computed by breaking the structure into 27 unsigned shorts, adding, and taking least significant 16 bits of result
total characters	56	

SNV

Ephemeris data for all locked satellites output once every hour or each time the IODE changes, whichever comes first, with one satellite output at each recording interval (RCI). The binary format is

$PASHR,SNV,ephemeris structure <Enter>

where the structure is as defined in Table 31.

Table 31 SNV Structure

Field	Char	Content
short wn	2	GPS week number
long tow	4	Second of GPS week.
float tgd	4	Group delay (seconds).
long aodc	4	Clock data issue.
long toc	4	sec
float af2	4	Clock correction (sec/sec^2).
float af1	4	Clock correction (sec/sec).
float af0	4	Clock correction (sec).
long aode	4	Orbit data issue.
float	4	deltan4Mean 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	4	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.

Table 31 SNV Structure (continued)

Field	Char	Content
short fit	2	Curve fit interval.
char prnnum	1	Satellite PRN number-1.
char res	1	Reserved character
checksum	2	The checksum is computed by breaking the structure into 65 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
total characters	132	

SAL

Almanac data for all locked satellites output once every hour with one satellite output at each recording interval (RCI). The binary format is:

$PASHR,SAL,almanac structure <Enter>

where the almanac structure is as defined in Table 32.

Table 32 SAL Structure - Binary

Field	Char	Content
short prn	2	Satellite PRN number -1.
short health	2	Satellite health.
float e	4	Eccentricity
long toa	4	Reference time for orbit (sec).
float i0	4	Inclination angle (semicircles).
float omegadot	4	Rate of right ascension (semicircles/sec).
double roota	4	Square root of semi-major axis (meters 1/2).
double omega0	8	Longitude of ascending node (semicircles).
double omega	8	Argument of perigee (semicircles).
double m0	8	Mean anomaly at reference time (semicircles).
float af0	4	Clock correction (sec).
float af1	4	Clock correction (sec/sec).
short wna	2	Contains the 8 least-significant bits of the almanac week number
short wn	2	Ephemeris week number.
long tow	4	Seconds of GPS week.
checksum	2	2The checksum is computed by breaking the structure into 34 unsigned shorts, adding them togehter, and taking the least significant 16 bits of the result.
total characters	70	

NOTE

To determine the value of the almanac week number the following computation needs to be done:

Almanac week number = (wn and FF00) or wna

WARNINGS

Following is a list of considerations the user should take into account when operating the Sensor II to avoid incorrect operation or damage.

1. To avoid damage to Sensor II, always connect or disconnect the power wiring to 20-pin connector J401 with the power supply turned off.
2. To avoid damage to Sensor II, ensure that when connecting the cable to power/input/output connector J401, pin 1 is per drawing on page 11.
3. To avoid possible unstable performance of Sensor II, if pin 15 (BATT_IN) is not used it should be tied to ground, and if pin 17 (MAN_RES) is not used it should be left open.
4. Sensor II may be damaged if the SMA center pin of the antenna connector is not isolated from DC ground. Provide a DC block between the center pin and ground with the following characteristics:

   VSWR 1.15 maximum at 1575 MHz

   Insertion loss 0.2 dB maximum

   Main line voltage 5 VDC maximum
5. To save user parameters, the external battery should be connected to the corresponding input pins of the 20-pin connector J401, and the SAV field should be set to Y.
6. Command $PASHS,DIF,MOD,x will enable differential mode through port B; differential mode can not be enabled through port A. When differential mode is enabled, communication through port B will be limited only to accept differential corrections or output NMEA or raw data, so all interface with the Sensor II should be done through serial port A.

CUSTOMER SUPPORT

If you have any problems or need further help, the Ashtech customer support team can be reached by telephone. Before you call, please refer to the documentation that came with your system (both receiver and software manuals). Many common problems are identified within the documentation and suggestions are offered for solving them.

_Check cables and power supplies. Many hardware problems are related to these simple problems.

_If the problem seems to be with your computer, reboot it to clear the system's RAM memory.

_If you are experiencing receiver problems, reset the receiver as documented in the set commands section of this manual. Note that the reset command clears receiver memory and resets operating parameters to factory default values.

If none of these suggestions solves the problem, contact the Ashtech customer support team. Have the following information at hand:

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

Then contact someone on the customer support team at the Sunnyvale installation at the following numbers:

800 Hot Line: 1-800-229-2400

Local Voice Line: (408) 524-1600

FAX Line: (408) 524-1500

WARRANTY

Ashtech Inc. warrants, to the original buyer only, that the GPS receiver (a) conforms to Ashtech's published specifications, and (b) is free from defects in material or workmanship. The duration of this warranty is one year from date of delivery. If Ashtech is unable to repair the receiver to conform to the warranty after a reasonable number of attempts, Ashtech will provide, at its option, one of the following: (a) a replacement receiver or (b) full refund of the purchase price. These remedies are the buyer's exclusive remedies for breach of warranty.

Ashtech does not warrant (a) against any product, components or parts not manufactured by Ashtech, (b) defects caused by failure to provide a suitable installation environment for the receiver, (c) damage caused by disasters such as fire, flood, wind, and lightning, (e) damage caused by unauthorized attachments or modification, (f) damage during shipment, (g) any other abuse or misuse by the buyer, or (h) that the receiver will be free from any claim for infringement of any patent, trademark, copyright or other proprietary right, including trade secrets.

The foregoing warranties are in lieu of all other warranties, express or implied, including but not limited to the implied warranties or merchantability and fitness for a particular purpose.

In no case shall Ashtech be liable for any special, incidental, or consequential damages arising directly or indirectly out of the ownership, use or operation of the receiver regardless of whether such damages are predicated based upon breach of warranty, breach of contract, negligence, strict tort, or any other legal theory. Such damages include, but are not limited to, loss of profits, loss of savings or revenue, loss of use of the receiver or any associated equipment, cost of capital, cost of any substitute equipment, facilities or services, the claims of third parties, including customers, and injury to property. This limitation does not apply to claims for personal injury.

Note: To the extent the foregoing provisions differ from the terms of the sales contract between the buyer and Ashtech, the sales contract will take precedence. The sales contract contains procedural qualifications and other contractual terms relating to the foregoing provisions.

Table 33 Common GPS Acronyms

ALT	Altitude
AFT	After
AGE	Age of Data
ALM	Almanac
ANT	Antenna
ASCII	American Standard Code for Information Interchange
AZM	Azimuth
BEF	Before
BIN	Binary Index (file)
BM	Bench Mark
BP	Barometric Pressure
C/A	Coarse/Acquisition
COG	Course Over Ground
CTD	Course To Destination
DGPS	Differential GPS
DIFF	Differential
DMS	Degrees, Minutes, Seconds
DOP	Dilution Of Precision
DOS	Disk Operating System
DTD	Distance To Destination
EDOP	Elevation Dilution Of Precision
ELEV	Elevation
ELIP	Ellipsoid
ELLIP	Ellipsoid
ELP	Ellipsoid
ELV	Elevation
EMI	Electromagnetic Interference
ENU	East, North, Up
EPHM	Ephemeris
FCC	Federal Communications Commission
FREQ	Frequency
GH	Geoid Height
GLL	Latitude/Longitude for Position

Table 33 Common GPS Acronyms

ALT	Altitude
GMST	Greenwich Mean Sidereal Time
GMT	Greenwich Mean Time
GPPS	GPS Post-Processing Software
GPS	Global Positioning System
GPSIC	GPS Information Center
HDOP	Horizontal Dilution Of Position
HEL	Health
HI	Height of Instrument
HTDOP	Horizontal/Time Dilution Of Precision
ID	Integrated Doppler
LAT	Latitude
LCD	Liquid Crystal Display
LNA	Low-Noise Amplifier
LNG	Longitude
LON	Longitude
MMDD	Date format - Month, Date
MSG	RTCM Message
MSL	Mean Sea Level
N	Geodetic Undulation
NAD	North American Datum
NMEA	National Marine Electronics Association
NV	Non-Volatile
PDOP	Posititon Dilution of Precision
PE	Precise Ephemeris
POS	Position
RAM	Random-Access Memory
RF	Radio Frequency
RFI	Radio Frequency Interference
RH	Relative Humidity
RMS	Root Meas Square
RTCM	Radio Technical Commission for Maritime Services P.O. Box 19087 Washington DC 20036-9087
SE	Site Editor Standard Error
SES	Session

Table 33 Common GPS Acronyms

ALT	Altitude
SOG	Speed Over Ground
SS	Static Survey
SV	Space Vehicle (satellite) Satellite Visibility
TDOP	Time Dilution Of Precision
T-DRY	Temperature - Dry (Celsius
T-WET	Temperature - Wet (Celsius
UT	Universal Time
UTC	Universal Time Coordinated
VDC	Volts Direct Current
VDOP	Vertical Dilution Of Precision
WGS	World Geodetic System
WGS-84	Reference Ellipsoid
WP	Waypoint

REFERENCE DOCUMENTS

Some excellent reference books on GPS theory are:

Wells: *Guide to GPS Positioning* ISBN 0-920-114-73-3

King, Masters, Rizos, Stolz, Collins: *Surveying with GPS* ISBN 0-85839-042-6

Leick: *GPS Satellite Surveying* ISBN 0-471-81990-5

Smith: *Basic Geodesy - An Introduction to the History and Concepts of Modern Geodesy without Mathematics* ISBN 0-910845-33-6

RECOMMENDED READING

Navstar GPS Space Segment/Navigation User Interfaces; ICD-GPS-200, Revision B ,Rockwell International

NMEA Standard 0183: Standard for Interfacing Marine Electronic Navigational Devices; National Marine Electronics Association,

Recommendations of Special Committee 104, differential NAVSTAR/GPS service, Radio Technical Commission for Maritime Service

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Symbols