ashtech

MB100™

Reference Manual

P/N 631650-01 C, October 2013.

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Chapter 1. Introduction

Preamble

With the new MB100, Ashtech introduces the only RTK board designed to address equally well L1 GPS+SBAS standard applications, L1/L2 GPS+SBAS and L1 GPS/GLONASS + SBAS applications. The board versatility is achieved while offering the smallest form factor and power consumption available today on the market.

In addition to these leading capabilities, the MB100 features two antenna input connectors, with automatic switching between the two antennas for specific applications such as handheld integration.

Embedded Z-Blade technology secures the best possible measurements from the GPS, GLONASS and SBAS constellations. Z-Blade perfectly mixes multiple observables without any compromise between quality and availability. This leads to an incredibly robust and dependable measurement processing resulting in optimized field productivity:

- Advanced multi-path mitigation and signal tracking for maximum data reliability
- Fast initialization and centimeter accuracy at long range in dual-frequency GPS mode
- Full benefit of any available GLONASS satellites to strengthen the GPS solution in single-frequency GPS+GLONASS mode
- The most compact differential/raw data protocol: Ashtech Optimized Messaging (ATOM).

MB100 supports standard and advanced RTK operations such as:

- RTK against a static base, with or without SBAS and GLONASS satellites
- Advanced RTK against an external moving base for relative positioning

- Network RTK using third-party network corrections: VRS, FKP, MAC
- Auto-calibrated, internal heading mode, possibly with the simultaneous computation of an RTK or DGPS position for one of the two antennas.
- Heading and pitch or roll determination with baseline length auto-calibration between two receivers.
- Up to 20 Hz fast RTK and raw data output.

This manual provides a technical description of the MB100 allowing you to integrate the board into your application. The manual is organized as follows:

- The present chapter (**Chapter 1**) deals with technical specifications, board layout and dimensions, I/O connector pinout, LED indications, communication ports, and the list of possible firmware options.
- **Chapter 2** briefly describes the evaluation kit and reviews all the required connections, including power, through which you can interface the board with your application. Chapter 2 also summarizes the most common configurations users will want to use in the board. All appropriate set commands are listed for these configurations.
- **Chapter 3** explains how to configure the board so it can meet the specific requirements of your applications. Chapter 3 includes an introduction to serial commands and reviews the different configuration steps: antenna & receiver parameters, position computation mode, heading function, managing data messages (differential data, raw data, NMEA and NMEA-like data). This chapter also provides in-depth information about differential data messages.
- **Chapters 4 and 5** provide an exhaustive description of all the set and query commands available for the board.
- **Chapter 6** provides a description of the raw data messages in Ashtech proprietary format.
- **Chapter 7** gathers different topics not addressed elsewhere in the manual, such as antenna issues, antenna height transformations, differential data transport modes and the list of predefined antennas.

MB100 Top and Bottom Views

Top view:

Bottom View:

If needed, shields may be mounted on the digital section to improve EMC. This should be done using the contact pads on the PCB. These pads form a thick dotted line around the digital section of the board (see pictures). The warranty after modification is on the user's own responsibility.

List of Items

The tables below provide an overview of the different items that may be delivered with an MB100 board. Depending on your purchase, only some of the listed items may have been shipped. Please refer to the packing list for an accurate description of the items that were ordered.

Ashtech reserves the right to make changes to the list below without prior notice.

Basic Supply

Item	Part No.	Pre-activated Firmware Options	Picture
MB100 board, in one of the following configurations: • L1 GPS • L1 GPS+GLONASS • L1/L2 GPS • L1 GLONASS	 990641-01 990641-03 990641-02 990641-04	 [Y] [L] [E] [C] [N] [G] [Y] [L] [E] [C] [N] [P] [S] [Y] [L] [E] [C] [N] [G] [L] [E] [Y] [C]	

All four configurations have in common the following firmware options pre-activated:

- [Y]: SBAS tracking
- [L]: 1PPS output
- [E]: External event input (photogrammetry)
- [C]: Advanced Multipath Mitigation

Unless the [T] or [W] option is installed, the default update rate for position and raw data output is 5 Hz (firmware option [5]).

Firmware & Hardware Options

Item	Part No.	Picture
ASH-660 L1 GNSS antenna, gain: 38 dB 5/8” mount	802133-INT	
ASH-661 L1/L2/L5 GNSS antenna, gain: 38 dB 5/8” mount	802135-INT	
AV59 Trimble antenna, L1/L2/L5 GNSS + Omnistar aviation/marine/machine, not TSO certified, 39 dB gain	C02992	

Item	Part No.	Picture
LV59 Trimble antenna, L1/L2/L5 GNSS + Omnistar aviation/marine/machine, not TSO certified, 5/8" mount, 39 dB gain	C03167	
AV34 Trimble antenna, L1/L2 GNSS compact aviation/marine/machine, 43 dB gain	86362	
AV33 Trimble antenna, L1 GNSS compact aviation/marine/machine, 43 dB gain	83553	
AV33/34 antenna bracket	84902	
LV59 Trimble antenna, L1/L2/L5 GNSS + Omnistar aviation/marine/machine, not TSO certified, 5/8" mount, 39 dB gain	C03167	
[G]: GLONASS (L1 GNSS Signal option)	680610	(firmware option)
[P]+[S]: L2 GPS option	680611	(firmware option)
[K]: RTK Base	680612	(firmware option)
RTK rover, includes: • [J]: RTK Rover • [V]: Moving base • [H]: Heading Mode	680613	(firmware option)
[I]: Ashtech proprietary RAIM	680614	(firmware option)
[T]: 10-Hz position/raw data update rate	680615	(firmware option)
[W]: 20 Hz position/raw data update rate	680616	(firmware option)
[N]: GPS L1 signal	680669	(firmware option)
[D]: Internal Heading	680671	(firmware option)
[F]: Flying RTK for MB100	680672	(firmware options)

Other Accessories

Item	Part No.	Picture
Evaluation kit, includes: • Evaluation PCBA with two Antenna Cable Adaptors (MMCX-RA / TNC-F) • Power supply (5 V DC) • Universal Input • Carrying case	990643	
10-meter TNC-TNC coaxial cable	700439	

Specifications

GNSS Characteristics

- 45 channels:
  - GPS and GLONASS L1 C/A
  - GPS L1/L2 P(Y)-code, L2C, L1/L2 full wavelength carrier
  - SBAS (WAAS/EGNOS/MSAS)
- Fully independent code and phase measurements
- Advanced multipath mitigation
- Ashtech Z-Blade™ technology for optimal performance

Features

- Up to 20 Hz real-time GPS, GLONASS, SBAS raw data (code and carrier) and position output
- Real-time GPS, GLONASS and SBAS subframes output
- Ephemeris and almanac for GPS, GLONASS and SBAS output
- Ionosphere data output
- NMEA 0183 message output (ALM, GBS, GGA, GLL, GRS, GSA, GST, GSV, RMC, VTG, ZDA)
- RTK base and rover modes usable simultaneously on the board
- Easy-to-use trouble ticket (ATL)

RTK Base

- RTCM 2.3 & RTCM-3.1

- CMR & CMR+ (1)
- DBEN & ATOM (Ashtech formats)
- Moving base operation.

RTK Rover

- Up to 20 Hz Fast RTK
- RTCM 2.3 & RTCM-3.1
- CMR & CMR+ (i)
- DBEN, LRK (TOPAZE) & ATOM (Ashtech formats)
- Networks: VRS, FKP, MAC
- NMEA 0183 messages output
- RTK with moving base operation.
- Heading and pitch or roll determination with auto-calibration (against another board or sensor).

Accuracy

All mentioned values are RMS. See (2)

SBAS

- Horizontal < 50 cm typical

DGPS

- Horizontal < 30 cm typical

Flying RTK™

- < 50 km: 5 cm + 1 ppm (3) (4)
- > 50 km: 20 cm + 1 ppm (ii) (5)

RTK

- Horizontal: 1 cm+ 1 ppm
- Vertical: 2 cm + 1 ppm

Heading, Pitch/Roll

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(1) CMR/CMR+ type 3 refers to GLONASS observations compatible with similar Leica/Topcon/Novatel messages described in the official Leica White Paper entitled “A GLONASS Observation Message Compatible With The Compact Measurement Record Format.”

(2) Accuracy and TTFF specifications may be affected by atmospheric conditions, signal multipath, satellite geometry and corrections quality and availability. Position accuracy specifications are for horizontal positioning. Vertical error is typically equal to twice the horizontal error.

(3) Performance values assume minimum of five satellites, following the procedures recommended in the product manual. High multi-path areas, high PDOP values and periods of severe atmospheric conditions may degrade performance.

(4) Steady state value for baselines < 50 km after sufficient convergence time.

(5) Typical values after 3 minutes of convergence for baselines > 50 km.

- Heading: 0.2 deg/baseline (m) (ii)(6)
- Pitch/roll: 0.4 deg/baseline (m) (ii)(v)

Velocity

- 95%: 0.1 knots (i)

RTK Initialization

Range

- 40 km and more in dual-frequency mode
- 10 km typical in single-frequency mode

Time to First Fix

See Note (1-7)

- Re-acquisition: 3 sec
- Hot start: 11 sec
- Warm start: 35 sec
- Cold start: 45 sec

Reliability

- 99.9% typical

I/O Interface

- SAMTEC 26-pin I/O connector (SAMTEC FTS-113-01-F-DV-A (pinout compatible with DG14)
- 1 RS232 port up to 921.6 kbits/sec (RXD, TXD, CTS and RTS signals)
- 1 RS232 port up to 460.8 kbits/sec (RXD and TXD signals)
- 1 USB Device 2.0 “Serial Port” up to 12 Mbits/sec
- 1 PPS output
- Event Marker input
- Radar-simulated pulse output on the I/O connector for accurate ground speed
- Onboard LED + output to drive external LED
- Two female MMCX straight connectors for two antenna inputs (7)

Physical Characteristics

- Size (WxHxD): 58 x 56 x 11 mm (2.3 x 2.2 x 0.4 in)
- Weight: 22 g (0.78 oz)

Power Characteristics

- Input voltage: +3.3 V DC -5%/+10%
- Power consumption:

(6) Typical values for properly installed antenna on vehicle body.
(7) For internal and external active antennas with automatic switch to external antenna when connected.

- – < 0.8 W in GPS L1
- – < 0.95 W in GPS L1/L2 or GPS+GLONASS L1

- Backup power: 2.6 to 3.3 V DC (8)
- External power requirement for LNA (one or two antennas): +5 V DC (±10%); DC current: 100 mA max.
  External antenna detected by MB100 for DC current greater than or equal to 5 mA.

Environmental Characteristics

- Operating temperature: -40° to +85°C (-40° to +185°F)
- Storage temperature: -40° to +85°C (-40° to +185°F)
- Humidity: 95%, non-condensing
- Shock: MIL-STD 810F, Fig 516.5-10 (40g, 11 ms, sawtooth)
- Vibration: MIL-STD-810F, Fig 514.5C-17

Recommended Antennas

- ASH-660 L1 GNSS antenna (gain: 38 dB)
- ASH-661 L1/L2/L5 GNSS antenna (gain: 38 dB)
- GNSS Machine/Marine Antenna (gain: 38 dB) (P/N 111407)

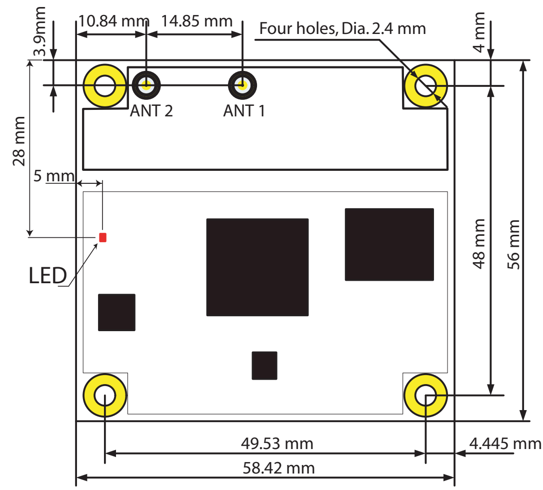
Configuration Tool

Ashtech Communicator is a GNSS utility for evaluating and configuring Ashtech boards and sensors. This utility offers the following functions:

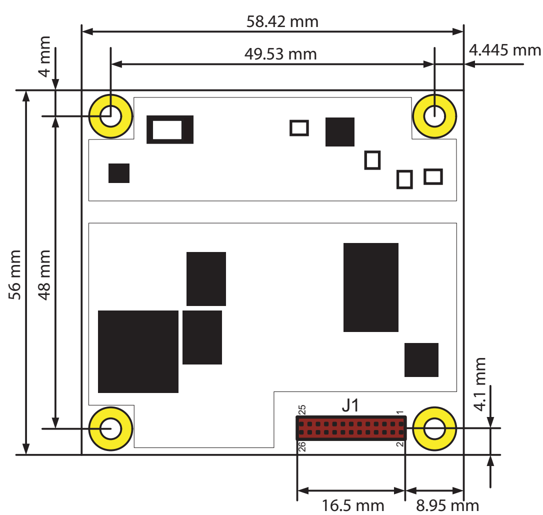
- Use of HTML pages makes board configuration easy
- Preset command scripts
- Real-time data logging
- Real-time data visualization

(8) Back-up battery may be used for RTC (Real Time Clock) to improve hot start TTFF performance. Because of the non-volatile memory used on the board, a back-up battery is not required to save the board configuration.

Board Layout and Dimensions



Top View



Bottom View

The board can be secured onto a chassis of your choice through 4 holes dia. 2.4 mm. The above diagram gives all the dimensions allowing you to perform this operation.

I/O Connector Pin Out

Pin	Name	Type	Description	Levels
1	GND	-	System Ground	-
2	CTSA	Input	Port A Clear to Send	Standard RS-232
3	TXDA	Output	Port A Transmit Data	Standard RS-232
4	RTSA	Output	Port A Request to Send	Standard RS-232
5	RXDA	Input	Port A Receive Data	Standard RS-232
6	USB D-	I/O	USB Device Data-	Standard USB Dev. 2.0
7	GND	-	System Ground	-
8	USB D+	I/O	USB Device Data+	Standard USB Dev. 2.0
9	TXDB	Output	Port B Transmit Data	Standard RS-232
10	TIOA1	Output	Programmable signal (see $PASHS,PIN command)	LV-TTL
11	RXDB	Input	Port B Receive Data	Standard RS-232
12	TIOB2	I/O	Programmable signal (see $PASHS,PIN command)	LV-TTL
13	+3.3 V	Input	Power Supply Voltage	+3.3 V DC, -5% / +10%
14	+3.3 V	Input	Power Supply Voltage	+3.3 V DC, -5% / +10%
15	BATT_IN	Input	+Battery Backup Voltage	+2.6 to 3.3 V
16	BOOT	Input	Boot Select signal	LV-TTL; “1” or not connected-internal; “0”-external code storage
17	RESET	Input	Reset signal	LV-TTL, “0”-active, t=1 to 20 ms
18	1PPS_OUT	Output	Pulse per Second signal	LV-TTL, “1”-active pulse width t=1 ms
19	GND	-	System Ground	-
20	GND	-	System Ground	-
21	LED_RED	Output	External Red LED signal	LV-TTL
22	LED_GREEN	Output	External Green LED signal	LV-TTL
23	EXT_LNA_PWR	Input	Antenna LNA Power Supply Voltage	+5 V DC±10%
24	GND	-	System Ground	-
25	EVT_IN	Input	External Event signal	LV-TTL, “0”-active, pulse width equal to or greater than 500 ns
26	GND	-	System Ground	-

Connector type: 26-pin SAMTEC FTS-113-01-F-DV-A

LED Indicator

A single LED indicator (see location on *page 10*) allows you to monitor both the power status and the constellations of satellites, based on the use of different colors, as explained in the table below.

Color	Meaning
Red	Power
Green	GNSS reception
Yellow	Delimiter between GPS/SBAS and GLONASS

The sequence of red, green and yellow flashes should be interpreted as follows:

1. One red flash: Means the board is powered properly.
2. Green flashes: The number of green flashes is equal to the number of GPS and SBAS satellites tracked and locked.
3. One yellow flash: Ends the first sequence of green flashes (GPS+SBAS).
4. Green flashes: The number of green flashes is equal to the number of GLONASS satellites tracked and locked.

   One red flash: Ends the second sequence of green flashes (GLONASS) and resumes the whole of the above sequence of flashes from the beginning.

If the board is powered and there is not a single satellite locked yet, the LED indicator will uniformly flash red then yellow until the first satellite is locked.

Communication Ports

Port	Type	Bit rate	Notes
A	RS-232	Up to 921 600 bits/s	Standard RS-232 levels
B	RS-232	Up to 460 800 bits/s	Standard RS-232 levels
C	USB Device	Up to 12 Mbits/s	Standard USB 2.0

Firmware Options

The list of possible firmware options is given below.

- {[5]: Default 5-Hz Position/Raw Data Update Rate}
- [C]: Advanced Multipath Mitigation
- [D]: Internal heading
- [E]: External Event input (Photogrammetry)
- [F]: Flying RTK
- [G]: GLONASS Tracking
- [H]: Heading function. Requires the [J] and [V] options to be installed as well.
- [I]: Ashtech proprietary RAIM
- [J]: RTK Rover
- [K]: RTK Base
- [L]: 1 PPS (Timing Pulse Output)
- [N]: GPS tracking
- [P]: GPS /GLONASS L2 frequency tracking
- [S]: GPS L2CS frequency tracking
- [T]: 10-Hz Position/Raw Data Update Rate
- [V]: RTK with Moving Base. Requires the [J] option to be installed as well.
- [W]: 20-Hz Position/Raw Data Update Rate
- [Y]: SBAS Tracking.

⚠ Some firmware options are interdependent (e.g. [L] and [E], or [J], [V] and [H]. See $PASHQ,RIO for more information.

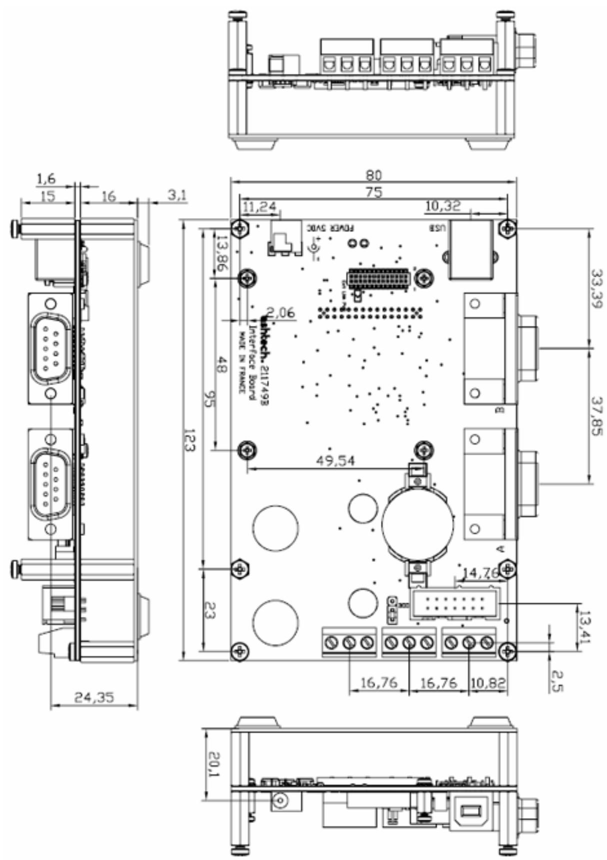
Chapter 2. First Steps

Using the Evaluation Kit

The evaluation kit can be used at the design stage of a given application to test the performance of the board within that application.

Board Layout

(All dimensions in mm)



Connector Pinout

RS232 ports A (J6) and B (J12) have the same pinout, which is as indicated in the table below. The connectors used are of the 9-pin SubD male type.

Pin	Signal
1	NC
2	RX to board
3	TX from board
4	Ground
5	Ground
6	NC
7	RTS from board
8	CTS to board
9	NC

The pinout of **Port 0 LVTTL** is provided in the table below. The connector used (J9) is of the HE10-14 male type. Only the board's port A is available on this connector.

Pin	Signal
1	Ground
2	RTS from board
3	Ground
4	CTS to board
5	Ground
6	RX to board
7	Ground
8	TX from board
9	Ground
10	1 PPS from board
11	Ground
12	EVT to board
13	Ground
14	Open=RS, close to ground=TTL

There are also three 3-pin screw terminal blocks with the following pinout:

- **EVT/1PPS**:

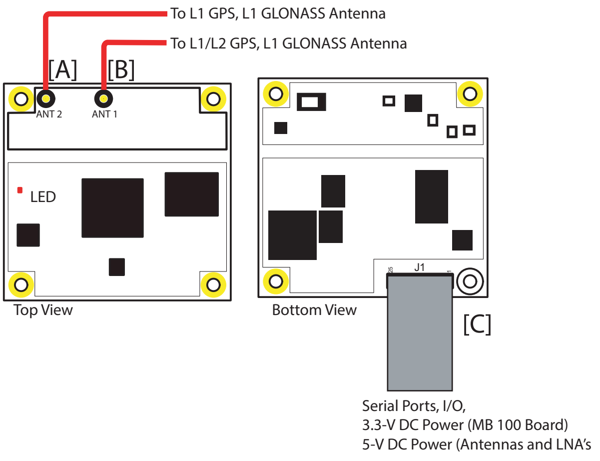
Pin	Signal
1	EVT (to board)
2	Ground
3	1 PPS (from board)

- **RST ON/OFF**:

Pin	Signal
1	Reset (active when low)
2	Ground
3	ON/OFF (OFF when low)

USB (J14): a standard USB2.0 connector.
5 VDC Power (J10): a standard jack connector.

Connecting MB100 to your Application



Perform the connections required between the MB100 and your application following the instructions below and referring to the above diagram.

- **[A]**, **[B]**: GNSS antenna inputs: Female MMCX straight connectors. For each input used, please use a coaxial cable fitted with a male MMCX connector to apply the antenna signal to the board.

  IMPORTANT! ANT 1 is an L1/L2 GPS and L1 GLONASS antenna input, while ANT 2 is only an L1 GPS and L1 GLONASS antenna input.

  Each antenna used should incorporate a built-in LNA (Low-Noise Amplifier). The gain of the LNA minus the signal loss in the coaxial cable connecting the LNA to the MB100 board should be in the range 20 to 30 dB.

An output voltage of 5 V DC ± 10% is delivered on the center conductor of each GNSS antenna input (corresponding to external DC power provided on pin 23, I/O connector, see **[C]** below). This DC voltage is used to power the antenna LNA when connecting the antenna to the board's GNSS antenna input. The DC output current is monitored internally from which the antenna status is deduced:

Out DC current	Antenna status
5-100 mA	Normal
>100 mA	Antenna shorted
<5 mA	No antenna connected

The DC output is also protected from high DC voltages (up to 12 V) that might unintentionally be applied to the GNSS antenna input via the antenna cable.

By default, ANT 1 is used in priority over ANT 2 when the board detects DC current flowing through this input. Typically, the ANT 1 input can be used for an external antenna (a high-grade antenna) and ANT 2 for an internal antenna (lower-grade antenna). See *ANT: Switching Antenna Inputs on page 52* for more information.

- **[C]**: I/O connector: A 26-contact connector (see page *10* for connector pinout and type as well as signal specifications). All non-RF connections are routed through this connector. Perform the connections you need for your application:
  - **Communication ports** (A, B, C). Choose the port, or ports, you need for applying serial commands and output the messages you need for your application.
  - **Main power supply**. Used to power the board.

    Input voltage range: + 3.3 V DC -5%/+10%

    Power consumption: 0.8 W (GPS L1); 0.95 W (GPS L1/L2 or GPS+GLONASS)

    Power ON/OFF command input available.
  - **Antenna power supply**: Used to power one or two of the antennas (and their associated LNAs) connected to the board (5 V DC)
  - **Backup power supply**. Used to power Real-Time Clock circuitry. Permanently applying a backup voltage allows the board to speed up its startup sequence.

    Input voltage range: 2.6 to 3.3 V DC

    Consumption: < 2 µA
  - External event signal input (Event Marker)

– PPS output
– Reset input
– Miscellaneous signals (External LED outputs, etc.).

GNSS Antenna Setup for Heading Measurements

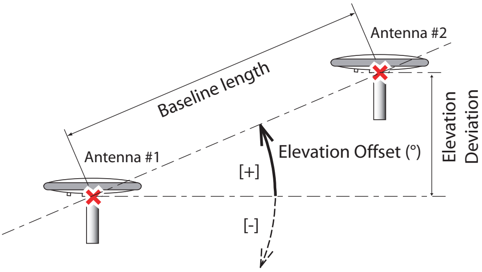
Choosing the Baseline Length

In theory, the baseline length (i.e. the horizontal distance between the phase centers of the two GNSS antennas used, also called antenna separation) can be set between 30 centimeters and 20 meters (or more).

In practice, you will choose the baseline length taking into account the level of expected accuracy as well as the various installation constraints in the vehicle.

Elevation Offset

Ideally, the two antennas should be installed at the same elevation. You may however be facing some installation constraints on your vehicle compelling you to install the antennas at different elevations. If that is the case, this is how you should calculate the elevation offset between the two antennas after measuring the elevation deviation and the baseline length. The sign of the elevation offset is also provided on the diagram below (elevation offset positive if Antenna #2 is higher than Antenna #1, negative if lower).



$$\left| Elevation\ Offset\ (°) \right| = \arcsin \frac{Elevation\ Deviation\ (m)}{Baseline\ Length\ (m)}$$

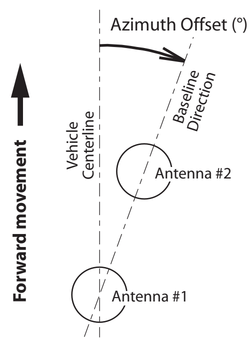
⚠ **The elevation offset should not be greater than 45 degrees (or less than -45 degrees)**, or the receiver will consider the antenna setup to be invalid and so will not deliver any heading, roll or pitch measurements.

Example: If Elevation Offset is +14°, then enter the elevation offset through one of the following commands (depending on which RTK engine is concerned):

$PASHS,CPD,ARR,OFS,0,14
or
$PASHS,CP2,ARR,OFS,0,14
(Azimuth offset assumed to be 0 in these two examples.)

Azimuth Offset

Ideally, the antennas should be installed to generate a baseline strictly parallel or perpendicular to the vehicle centerline. However, you may also be facing some installation constraints on your vehicle compelling you to install the antennas differently. The azimuth offset describes the non-alignment of the baseline with the vehicle centerline. When the baseline is strictly parallel to the centerline and the baseline is oriented in the direction of forward movement, the azimuth offset is zero. In all other cases, the offset is non-zero and should be measured as shown in the diagram below.



⚠ The non-alignment of the baseline with the vehicle centerline may be intentional (see explanations in the next section below).

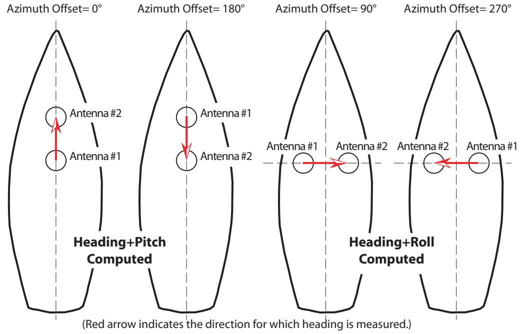
Example: If Azimuth Offset is +20°, then enter the azimuth offset through one of the following commands (depending on which RTK engine is concerned):

$PASHS,CPD,ARR,OFS,20,0
or
$PASHS,CP2,ARR,OFS,20,0
(Elevation offset assumed to be 0 in these two examples.)

Correlation Between Azimuth Offset, Antenna Setup & Measurements Made

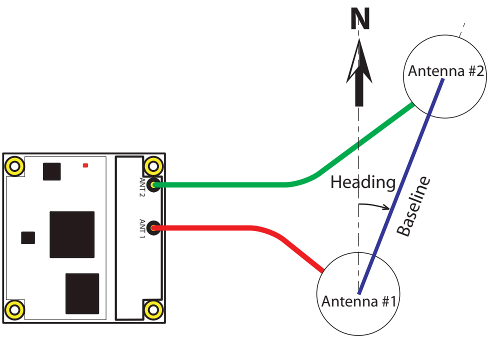
Consider the following four setups before installing your antennas. A ship is shown in the examples but this could be any other type of vehicle.

Depending on the type of measurements you wish the receiver to perform (heading + roll or heading + pitch) and the installation possibilities offered in the vehicle, you will choose the most appropriate setup and set the azimuth offset accordingly.



(Red arrow indicates the direction for which heading is measured.)

Internal Heading Mode Setup



Quick Start with MB100

This chapter describes the most popular setups to start with MB100. This includes:

- Getting RTK position from MB100
- Setting MB100 to deliver heading measurements
- Setting MB100 to output raw data

- Setting MB100 as RTK base.
- Setting MB100 as moving RTK base
- Configuring RTK rover operated with moving RTK base
- Configuring RTK rover to work in heading mode with moving RTK base
- Requesting trouble ticket (ATL)

The MB100 supports bidirectional communication through ports A, B and C.

In all the examples below, it is assumed that MB100 output data are requested through port A and incoming corrections are applied to port B. For more detailed setups, please read the relevant chapters in the present manual.

Getting RTK Position from MB100

1. Run the $PASHS,DIF,PRT,B command to choose port B as the port acquiring incoming differential corrections (the default port is A).
2. Feed the corrections stream (in RTCM 2, RTCM 3, ATOM, CMR, CMR+, DBEN or TOPAZE format) into the MB100 through port B.
3. Run the $PASHS,NME,GGA,A,ON command to enable the output of the position result on port A as a standard NMEA GGA message.

Setting MB100 to Deliver Heading & DGPS Position

(RTK firmware option not installed)

Once the two antennas have been set up and connected to the board (see also *Internal Heading Function on page 41*), run the series of commands below to let the board deliver heading measurements.

$PASHS,CFG,DUO
$PASHS,DIF,PRT,H
$PASHS,CPD,ARR,MOD,ON
$PASHS,CPD,ARR,LEN,0

You can set the following messages at an output rate of x seconds to output respectively heading measurements, vector measurements describing the baseline, DGPS position for the “rover” antenna (antenna #2) and attitude measurements:

$PASHS,NME,ATT,A,ON[,x]
$PASHS,NME,HDT,A,ON[,x]
$PASHS,NME,GGA,A,ON[,x] (antenna #2 position)
$PASHS,NME,POS,A,ON,[x] (antenna #2 position)

Setting MB100 to Deliver Heading & RTK Position

(RTK firmware option installed)

Once the two antennas have been set up and connected to the board (see also *Internal Heading Function on page 41*), run the series of commands below to let the board deliver heading measurements.

$PASHS,CFG,DUO
$PASHS,DI2,PRT,H
$PASHS,CP2,MOD,HED
$PASHS,CP2,ARR,MOD,ON
$PASHS,CP2,ARR,LEN,0
$PASHS,DIF,PRT,<Port_ID>
(<Port_ID>: Port receiving incoming corrections for RTK position computation)

You can set the following messages at an output rate of x seconds to output respectively heading measurements, vector measurements describing the baseline, RTK position for the "rover" antenna and attitude measurements:

$PASHS,NME,HDT,A,ON[,x]
$PASHS,NME,ATT,A,ON[,x]
(HDT/ATT data up to 10 Hz if Fast Rate option enabled)
$PASHS,NME,GGA,A,ON[,x] (antenna #2 position)

Setting MB100 to Output Raw Data

GNSS raw data can be output in different ways:

- Legacy Ashtech Raw messages (including DBEN)
- Ashtech proprietary ATOM messages
- Standardized RTCM 3 or 2.3 messages

The resulting files can then be converted into legacy Ashtech B- or E-files, and RINEX format.

A few typical scenarios of raw data output are given below.

Outputting Raw Data in Legacy Ashtech Format

Run the series of commands below to enable the output of raw data messages in the legacy Ashtech format. Output rates are given as examples:

(Output rate= 0.5 s for position information and C/A code measurements):
$PASHS,RAW,PBN,A,ON,0.5
$PASHS,RAW,MCA,A,ON,0.5

(Output rate= 5 s for ephemeris and ionosphere data):
$PASHS,RAW,SNV,A,ON,5
$PASHS,RAW,SNG,A,ON,5
$PASHS,RAW,SNW,A,ON,5
$PASHS,RAW,ION,A,ON,5

To disable all these messages, run the following command:

$PASHS,RAW,ALL,A,OFF

Outputting Raw Data in Ashtech Proprietary ATOM Format

Run the series of commands below to enable the output of raw data messages in the Ashtech proprietary ATOM format.

In these examples, raw data messages are all output at 1 second (default).

(Receiver observations, full presentation):
$PASHS,ATM,RNX,A,ON,1,&SCN,0
(Navigation data):
$PASHS,ATM,NAV,A,ON
(The default output rate is 300 seconds and a message is output immediately after this command has been run. You should therefore make sure you can acquire and store this message before sending the command, otherwise you would lose the first message and had to wait another 300 seconds before you can get a new one.)

(Additional data):
$PASHS,ATM,ATR,A,ON
(The default output rate is 30 seconds and a message is output immediately after this command has been run. You should therefore make sure you can acquire and store this message before sending the command, otherwise you would lose the first message and had to wait another 30 seconds before you can get a new one.)

For more information on the ATOM format and the possible output rates and content, refer to the *ATOM Reference Manual*.

To disable all these messages, run the following command:

$PASHS,ATM,ALL,A,OFF

Outputting Raw Data in Standardized RTCM 3 Format

Run the series of commands below to enable the output of raw data messages in standardized RTCM 3 format:

(Example of GPS+SBAS raw observations message output at 1 second):
$PASHS,RT3,1004,A,ON,1
(Example of ITRF coord. of reference position message output at 1 second):
$PASHS,RT3,1006,A,ON,1
(Example of GLONASS raw observations message output at 1 second):
$PASHS,RT3,1012,A,ON,1
(Example of system information message output at 31 s; recommended):
$PASHS,RT3,1013,A,ON,31
(Example of GPS ephemeris message output at 13 s; recommended):
$PASHS,RT3,1019,A,ON,13
(Example of GLONASS ephemeris message output at 13 s; recommended):
$PASHS,RT3,1020,A,ON,13
(Example of antenna/receiver names message output at 31 s; recommended):
$PASHS,RT3,1033,A,ON,31

To disable all these messages, run the following command:

$PASHS,RT3,ALL,A,OFF

Setting MB100 as RTK Base

First enter the receiver's known position using the $PASHS,POS command. For example, run this command if your position is lat 55°39.358908'N, lon 37°31.607218' E and height 268.26 m:

$PASHS,POS,5539.358908,N,3731.607218,E,268.26

Then the MB100 can be configured as:

- RTCM 2.3 base
- RTCM 3.1 base
- ATOM base
- DBEN base
- CMR base
- CMR+ base

Setting up the MB100 as an RTCM 2.3 Base

Run the series of commands below to enable the output of the required RTCM 2.3 messages on port A:

$PASHS,RT2,18,A,ON
$PASHS,RT2,19,A,ON
$PASHS,RT2,24,A,ON,13
$PASHS,RT2,23,A,ON,31

To disable all these messages, run the following command:

$PASHS,RT2,ALL,A,OFF

Setting up the MB100 as an RTCM 3.0 Base

Run the series of commands below to enable the output of the required RTCM 3.0 messages on port A:

$PASHS,RT3,1004,A,ON
$PASHS,RT3,1002,A,ON
$PASHS,RT3,1006,A,ON,13
$PASHS,RT3,1010,A,ON
$PASHS,RT3,1033,A,ON,31

To disable all these messages, run the following command:

$PASHS,RT3,ALL,A,OFF

Setting up the MB100 as an ATOM Base

Run the series of commands below to enable the output of the required ATOM messages on port A:

$PASHS,ATM,RNX,A,ON or **$PASHS,ATM,RNX,A,ON,&SCN,4**
$PASHS,ATM,ATR,A,ON

To disable all these messages, run the following command:

$PASHS,ATM,ALL,A,OFF

Setting up the MB100 as a DBEN Base

Run the series of commands below to enable the output of the required DBEN messages on port A at 10 seconds:

$PASHS,NME,BPS,A,ON,10
$PASHS,RAW,RPC,A,ON,10

To disable all these messages, run the following commands:

$PASHS,NME,BPS,A,OFF
$PASHS,RAW,RPC,A,OFF

Setting up the MB100 as a CMR Base

Run the series of commands below to enable the output of the required CMR messages on port A:

$PASHS,CMR,0,A,ON
$PASHS,CMR,3,A,ON
$PASHS,CMR,1,A,ON,13
$PASHS,CMR,2,A,ON,31

To disable all these messages, run the following command:

$PASHS,CMR,ALL,A,OFF

Setting up the MB100 as a CMR+ Base

Run the series of commands below to enable the output of the required CMR+ messages on port A:

$PASHS,CMP,0,A,ON
$PASHS,CMP,3,A,ON

To disable all these messages, run the following command:

$PASHS,CMP,ALL,A,OFF

Setting MB100 as Moving RTK Base

First, allow MB100 to use a moving position as the reference position. This is achieved using the following command:

$PASHS,POS,MOV

The MB100 can then be set in one of the following configurations:

- RTCM-2.3 moving base
- RTCM-3.1 moving base
- ATOM moving base
- CMR moving base

NOTE: CMR+ and DBEN are not recommended protocols for a moving base.

Set Up MB100 as RTCM2.3 Base With 1-Hz Rate

To start data output, run the following commands:

$PASHS,RT2,18,A,ON,1
$PASHS,RT2,19,A,ON,1
$PASHS,RT2,24,A,ON,1
$PASHS,RT2,23,A,ON,31

To stop data output, run the following command:

$PASHS,RT2,ALL,A,OFF

Set Up MB100 as RTCM3.0 Base With 5-Hz Rate

To start data output, run the following commands:

$PASHS,RT3,1004,A,ON,0.2
$PASHS,RT3,1012,A,ON,0.2
$PASHS,RT3,1006,A,ON,0.2
$PASHS,RT3,1033,A,ON,31

To stop data output, run the following command:

$PASHS,RT3,ALL,A,OFF

Set Up MB100 as ATOM Base With 10-Hz Rate

To start data output, run the following commands:

$PASHS,ATM,RNX,A,ON,0.1,&SCN,204
$PASHS,ATM,ATR,A,ON

To stop data output, run the following command:

$PASHS,ATM,ALL,A,OFF

Set Up MB100 as CMR Base With 2-Hz Rate

To start data output, run the following commands:

$PASHS,CMR,0,A,ON,0.5
$PASHS,CMR,3,A,ON,0.5
$PASHS,CMR,1,A,ON,0.5
$PASHS,CMR,2,A,ON,31

To stop data output, run the following command:

$PASHS,CMR,ALL,A,OFF

Requesting ATL Data

The receiver can generate the so-called “trouble ticket” in the form of ATL messages (ATL for All To Log).

When experiencing problems with their receivers, users may run the ATL command in order to be able to provide the problem data files to the Ashtech Technical Support. ATL messages are generated using a proprietary format.

To enable the generation of ATL messages on a port (e.g. port A), run the following command:

$PASHS,ATL,A

To disable ATL messages, use this command:

$PASHS,ATL,OFF

Chapter 3. Configuring the MB100

Introduction to Serial Commands

Serial commands allow you to communicate directly with the receiver in its proprietary command language. Serial commands can be used for various purposes such as:

- Changing default settings
- Monitoring different receiver statuses (internal operation, constellations, etc.)
- Outputting messages on request

Serial commands fall into two categories:

- *Set* commands ($PASHS,...), used to set or modify the receiver's internal parameters.
- *Query* commands ($PASHQ,...), used to interrogate the receiver.

If you wish to change some internal settings in the receiver or modify the operating mode, then use the available set of $PASHS commands.

If you want to read the instant status of the receiver, use the set of $PASHQ commands. The receiver responds to $PASHQ commands by returning one of the following, depending on which $PASHQ command is sent:

- ASCII or binary formatted $PASHR sentences, for your reading or/and automatic parsing.
- Non-formatted responses, like for example ASCII tables, only for your reading (not intended for automatic parsing).

If you want to program the receiver so that it delivers its results at regular intervals, then you should also use the set of available $PASHS commands. The receiver will respond by delivering messages at the specified output rate. Messages fall into different groups:

- NME (standardized NMEA messages and NMEA-like Ashtech proprietary messages)
- RAW (Ashtech legacy binary data)
- ATM (Ashtech proprietary ATOM binary data)

- RT2 (Standardized RTCM-2 messages)
- RT3 (Standardized RTCM-3 messages)
- CMR (Widely used TRIMBLE CMR messages)
- CMP (Widely used TRIMBLE CMR+ messages)

A three-letter identifier is part of the $PASHS command header clearly identifying which group of data the command deals with. For example, “$PASHS,NME,GGA,A,ON,1” will enable the GGA NMEA message on port A at an output rate of 1 second.

Some $PASHS and $PASHQ commands can initiate the same $PASHR response. However, $PASHS will return $PASHR responses at regular intervals whereas $PASHQ will only return a single $PASHR response.

In general, all the messages of a given group are output inside a dedicated transport layer. For example, NMEA-like and RAW data are output using the Ashtech legacy $PASHR frame, whereas ATM and RT3 data are output using the standardized RTCM-3 transport protocol. For more convenience, using the $PASHS,ENC command, you can ask the receiver firmware to output all the groups via the same port and using the same frame (e.g. $PASHR).

Standard NMEA messages will all be output with the standard ASCII NMEA preamble (e.g. $GPGGA) and not with the “$PASHR..” preamble.

The few conventions used to describe the serial commands in this manual are summarized in the table below.

String or sign	Description
$PASHS	Header for set commands (Whole line shown in bold characters)
$PASHQ	Header for query commands (Whole line shown in bold characters)
$PASHR	Receiver response line, in normal characters.
GP	Header in standard NMEA output messages for results provided by GPS.
GL	Header in standard NMEA output messages for results provided by GLONASS.
GN	Header in standard NMEA output messages for results provided by GNSS (combination of several constellations).
$--	Header prefix for all standard NMEA messages delivered by the receiver.
[ ]	Optional field or parameter
,	Field delimiter
.	Decimal point (used in f-type fields)
c..	One-character string
d..	Integer
f..	Real number, with decimal places

String or sign	Description
h..	Parameter in hexadecimal notation
m..	Denotes specific data format used, such as angles (e.g. ddmm.mmm) or time (e.g. hhmmss.sss)
n	Used in the syntax of responses to query commands to indicate that a sequence of parameters will be repeated “n” times in the response. For example, n(f1,f2,f3) means the response will include the sequence “f1,f2,f3,f1,f2,f3,f1,f2,f3...”. The value of n is specific to each command.
s..	Character string
*cc	Checksum

In response to a well recognized and properly executed set command, the receiver will return the message:

$PASHR,ACK*3D

A set command is said to be “NAKed” when it is not accepted or acknowledged. The following message is then returned:

$PASHR,NAK*30

If this happens, check that the command has been typed correctly and the number and format of parameters are correct. In some cases, the execution of a set command may be contingent upon the prior activation of the corresponding firmware option.

Checksum Calculation: The checksum is computed by “exclusive-ORing” all of the bytes in the message between, but not including, the “$” and the “*”. The result is “*hh” where h is a hexadecimal character.

Special Warning

Some legacy **GPS only** receivers (like Ashtech DG14 or Trimble 5800) *cannot* process incoming corrections containing GPS+GLONASS data *inside some protocols*.

It is therefore highly recommended to run the $PASHS,GLO,OFF command in any MB100 base used by such GPS-only rovers.

Setting the Antenna & Receiver Parameters

Query or Set Command	Description
ANTENNA	
$PASHS,ANT/ANH	Antenna Reference Point With Respect to Ground Mark
$PASHS,ANT	Choosing Antenna Input Switching Mode
$PASHS,ANP,DEL	Deleting User-Defined Antenna
$PASHS,ANP,OUT	Enabling/Disabling Raw Data Reduction for a Specific Antenna
$PASHS,ANP,OWN/OW2	Naming Local and Antennas
$PASHS,ANP,PCO..	Entering Offset Values to User-Defined Antennas
$PASHS,ANP,REF	Naming the reference antenna
$PASHS,POS	Setting the Antenna Position
$PASHQ,ANP	Antenna Parameters
$PASHS,ANR	Antenna reduction mode
RECEIVER	
$PASHS,AGB	Adjusting GLONASS biases
$PASHS,CFG ($PASHS,GNS,CFG)	Selecting a GNSS mode
$PASHS,CRR	Code Correlator Mode
$PASHS,GLO	Enabling/disabling GLONASS Tracking
$PASHS,GPS	Enabling/disabling GPS Tracking
$PASHS,INI	Resetting Receiver to Preferences
$PASHS,PGS	Defining a primary GNSS system
$PASHS,POP	Setting Internal Update Rates for Measurement and PVT
$PASHS,RCP,DEL	Deleting User-Defined Receiver Name
$PASHS,RCP,GBx	GLONASS Carrier Phase Biases for User-Defined Receiver
$PASHS,RCP,OWN/REF	Naming Local and Reference Receivers
$PASHS,RST	Default Settings
$PASHS,SBA	Enabling/Disabling SBAS Tracking
$PASHS,SMI	Code Measurement Smoothing
$PASHS,ZDA	Setting Date & Time
$PASHQ,PAR	Receiver Parameters
$PASHQ,RID	Receiver Identification
$PASHQ,RIO	Receiver Options

Query or Set Command	Description
OBSERVATION & ELEVATION MASKS	
$PASHS,ELM	Setting Elevation Mask for Raw Data Output
$PASHS,SOM,CTT	Cumulative tracking time mask
$PASHS,SOM,NAV	Navigation data mask
$PASHS,SOM,SNR	Signal-to-noise ratio mask
$PASHS,SOM,WRN	Channel warnings mask
I/O SETTINGS	
$PASHS,CTS	Handshaking protocol
$PASHS,PHE	Setting Active Edge of Event Marker Pulse
$PASHS,PIN	Setting programmable pin on I/O connector
$PASHS,PPS	Setting PPS Pulse Properties
$PASHS,SPD	Setting Baud Rates for Ports A and B
$PASHQ,PRT	Baud Rate Settings
ALL OUTPUT MESSAGES	
$PASHS,OUT,ALL	Disabling all periodic messages on specified port
$PASHS,x,ON/OFF	Suspending/resuming all periodic messages on specified port
OTHER	
$PASHQ,CPD,REF	Querying rover for base position used
$PASHQ,DDM	Differential decoder message
$PASHQ,BPS	Base position message
$PASHS,ENC	Setting Transport Mode for Differential Data
$PASHS,MET	Entering meteo parameters
$PASHS,MSG	Entering User Data for Insertion into Standard Messages
$PASHS,NME,MSG	Requesting Rover to Output Differential Message from Base
$PASHS,SIT	Defining a Site Name

Setting the Position Computation Mode

Use the following set of commands to set the position computation mode used in the receiver.

Set Command	Description
$PASHS,CPD,AFP	Setting the Confidence Level of Ambiguity Fixing
$PASHS,CPD,BAS	Setting Static or Moving Base Mode
$PASHS,CPD,NET	Network Corrections
$PASHS,DIF,PRT	Choosing an Input Port for Differential Corrections
$PASHS,DYN	Receiver Dynamics
$PASHS,CPD,FST	Fast RTK Output Mode
$PASHS,CPD,RST	RTK Process Reset
$PASHS,CPD,VRS	VRS Assumption Mode
$PASHS,KPI	Known Point Initialization

Set Command	Description
$PASHS,LCS	Enabling/Disabling Use of Local Coord. System from Base
$PASHS,PEM	Setting the Position Elevation Mask
$PASHS,TOP	Type of Output Position
$PASHS,SVM	Setting the Maximum Number of Observations in the PVT
$PASHS,UTS	Synchronizing onto GPS Time
$PASHS,UDP	User-Defined Dynamic Model Parameters
$PASHS,VEC	Defining vector output mode
$PASHQ,BPS	Base position message
$PASHQ,CPD,REF	Querying Rover for Base Position Used

Setting Differential Data Messages

Differential Data Messages Generated by the MB100

The following messages can be generated by the MB100:

- RTCM-3.1 message types 1001-1013, 1019, 1020, 1029, 1033, 1071-1077, 1081-1087, 1091-1097
- RTCM-2.3 message types 1, 3, 9, 16, 18-24, 31, 32, 34, 36
- CMR message types 0, 1, 2, 3
- CMR+ message types 0, 3 (type “0” sometimes referred to as “10”)
- ATOM messages of types 1, 4, 5 and 7
- DBEN message types 0 (RPC) and 1 (BPS)

For each protocol, some default configuration can be recommended.

As a reminder, the content of some typical differential data messages are listed below:

- RTCM-3.1 message types 1001-1004 generate GPS and SBAS data.
- RTCM-3.1 message types 1009-1012 generate GLONASS data.
- RTCM-3.1 messages 1071-1077,1081-1087,1091-1097 generate GPS, GLONASS observables respectively
- RTCM-2.3 message types 18, 19, 20, 21 generate GPS and GLONASS data.
- CMR message types 0, 1, 2, 3 generate GPS observation, location, description and GLONASS observation data.
- CMR+ message type 0 (or 10) generates GPS observation, location and description data.
- CMR+ message type 3 generates GLONASS observation data.

- CMR/CMR+ message type 3 is compatible with similar Leica/Topcon messages described in the official Leica White Paper.
- ATOM messages contain GPS,GLONASS,SBAS observations (type 7), location (type 7), description (type 4), ephemeris (type 5) and supplementary (type 1) information.
- Depending on installed firmware options, ATOM messages can contain GPS,GLONASS,SBAS observation, location and description data.

Data Transport Modes

The data transport mode is controlled by the $PASHS,ENC command. The different data formats available can be output using the following transport modes:

- RTCM-3.1 messages can be output in native (RTCM-3 standard) or ASH transport mode.
- RTCM-2.3 messages can be output in native (RTCM-2 standard), RT3 or ASH transport mode.
- CMR messages can be output in native (CMR standard), RT3 or ASH transport mode.
- CMR+ messages can be output in native (CMP standard), RT3 or ASH transport mode.
- ATOM messages can be output in native (RT3) or ASH transport mode.

Setting ATOM Messages

Use the following set of commands to control the output of ATOM data messages.

Set Command	Description
$PASHS,ATM,VER	Choosing which version of ATOM messages the board will deliver.
$PASHS,ATM	Enabling/Disabling ATOM Messages
$PASHQ,PAR,ATM	ATOM Data Generation Settings
$PASHS,ATM,ALL	Disabling All ATOM Messages

For more information on the ATOM protocol and data, refer to the *ATOM Reference Manual*.

Setting RTCM Messages

Use the following set of commands to control the output of RTCM data messages.

Set Command	Description
$PASHS,RT2	Enabling/Disabling RTCM 2.3 Messages
$PASHS,RT2,ALL	Disabling All RTCM 2.3 Messages
$PASHS,RT3	Enabling/Disabling RTCM 3.1 Messages
$PASHS,RT3,ALL	Disabling All RTCM 3.1 Messages

Setting CMR and CMR+ Messages

Use the following set of commands to control the output of CMR or CMR+ data messages.

Set Command	Description
$PASHS,CMR	Enabling/Disabling CMR Messages
$PASHS,CMR,ALL	Disabling All CMR Messages
$PASHS,CMP	Enabling/Disabling CMR+ Messages
$PASHS,CMP,ALL	Disabling All CMR+ Messages

Understanding How MB100 Generates Differential Data Messages

All differential data messages may be output independently (if requested). The MB100 may support a different output rate for each message.

However, because some messages include some others, there is no need to output them all (e.g. message type 1002 may not be output if message type 1004 is, because all data in message type 1002 are also included in message type 1004).

The order in which messages are output cannot be changed. Regardless of the order in which these are requested, the MB100 will always keep the following order within each epoch:

1. Location messages (e.g. RTCM-3 1006)
2. Data messages (e.g. RTCM-3 1004,1012)
3. Description messages (e.g. RTCM-3 1033)

Location messages always go first for more effective support of the moving base RTK mode.

As recommended by the RTCM, for each epoch, GPS data go first (e.g. 1004), then GLONASS (e.g. 1012).

GPS and GLONASS data are output for the same physical time (the only exception can be for differential message types 1 and 31).

When the CMR or CMR+ format is used, GLONASS data always go first, owing to backward compatibility problems.

With L1/L2 GPS+GLONASS tracking, the board sends up to eight RTCM-2 observation messages per epoch. As the standard does not prescribe the order in which messages should be sent in this case, the following sequence is used when generating message types 18 & 19 (same for message types 20 & 21):

- 18, GPS, L1
- 18, GLO, L1
- 18, GPS, L2
- 18, GLO, L2
- 19, GPS, L1
- 19, GLO, L1

- 19, GPS, L2
- 19, GLO, L2

The intervals of time between messages cannot be chosen arbitrarily.

- For “fast” messages, only the following intervals are valid: 0.05, 0.1, 0.2, and 0.5 seconds.

  The phase of these messages is chosen in such a way that messages are output at an integer number of seconds of GPS time.
- For “slow” messages, time intervals of entire seconds are admissible. However, for data messages such as 1001-1004 or 1009-1012, only the following time intervals are recommended: 0.5, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60 seconds and an integer number of minutes.

  The phase of these messages is chosen in such a way that messages are output at an integer number of minutes of GPS week time.

These intervals and time shifts are recommended in the RTCM-2 standard and “kept in mind” in all the other standards. For “slow” location/description messages however, where exact time tagging is not important, any time interval with an integer number of seconds is permissible (e.g. a 31-second interval is recommended for message type 1033).

All messages (except ephemeris message types 1019 and 1020) are output on an “on-time” basis, i.e. they strictly comply with the requested time intervals. However, outputting these ephemeris messages follows the same philosophy as when outputting SNV and SNG messages, which means they are output independently and there can’t be more than one 1019 and one 1020 message for each epoch.

There can be three types of output requirements:

- *On new*: messages start to be output only after they’ve been requested.
- *On change*: messages are output only when their contents have changed (e.g. new IODE).
- *On time*: messages are output at regular intervals of time whether or not their contents are changing.

All differential data messages can serve two different receiver modes:

- *Base mode*, when data are generated to be sent to a remote receiver (rover).

- *Data collection mode*, when data are recorded for further post-processing.

While almost the same data are used in both receiver modes, some setup differences may exist:

- When the RTCM or CMR (CMR+) format is used in base mode, the reference position inserted in differential data messages is a stationary position entered externally (either by specifying the exact coordinates of this position or through $PASHS,POS,CUR). The message rate is typically 10 to 30 seconds. There is no need to generate ephemeris data, because this information is available on the rover side.
- When the RTCM or CMR (CMR+) format is used in data collection mode, the position inserted in differential data messages is the one currently computed for the receiver position (cf. $PASHS,POS,MOV). It is desirable to generate the messages with the same rate as the one used for observations.

  To use recorded data effectively in post-processing, there is a need to record ephemeris data if the format allows it (e.g. RTCM-3). Rough position and ephemeris are very desirable in this mode, because many of the messages (e.g. CMR Type 0) require that an integer value of milliseconds of ambiguity in pseudo-range and carrier data be restored.

Differential Data Messages Received by the MB100

The MB100 can receive the following reference data:

- RTCM-3.1 message types 1001-1017, 1019-1027, 1029-1035, 1037-1039, 1057-1058, 1071-1077, 1081-1087, 1091-1097
- RTCM-2.3 message types 1, 3, 9, 16, 18-24, 31, 32, 34, 36, 59.adv (FKP)
- CMR message types 0, 1, 2, 3, 20
- CMR+ message types 0 (or 10), 3, 20
- ATOM message types 4, 5 and 7
- DBEN message types 0 (GPS observations, or RPC) and 1 (location, or BPS)
- TOPAZE (LRK) message (GPS observations and location) (SBIN@R: single-frequency GPS/WAAS/EGNOS pseudo-ranges in satellite time; SBIN@R: dual-frequency GPS pseudo-ranges in satellite time).

RTCM-3.1 numbers 1021-1027 refer to coordinate transformation messages.

RTCM-3.1 numbers 1057-1068 refer to SSR messages (orbit, clock and bias corrections to GPS and GLONASS satellites).

RTCM-3.1 numbers 1014-1017 and 1037-1039 refer to GPS and GLONASS Network MAC messages. RTCM-3.1 numbers 1030-1031 refer to GPS and GLONASS Network residual messages. RTCM-3.1 numbers 1034-1035 refer to GPS and GLONASS Network FKP messages. RTCM-3.1 number 1032 refers to reference position of physical station.

CMR and CMR+ message type 20 refers to GLONASS L1/L2 observables, presented in proprietary (not open) TRIMBLE format. Message type 20 is the alternative to message type 3.

The $PASHS,DIF,PRT command can be used to specify the port dedicated to receiving the differential data stream (the differential decoder is then requested to "listen to" only one port).

To minimize decoder workload in the case of high-speed incoming data, the same command also allows you to specify the differential protocol used.

Differential decoders and processors do not make any *a priori* assumptions about the sequence of messages that follow and their intervals.

Why There is No Need for Specifying Base or Rover Mode

By default, the MB100 starts operating as a rover as soon as a differential data stream is detected according to the settings of the $PASHS,DIF,PRT command.

Operating the MB100 in base mode results from the simple fact that commands are executed in the MB100 that enable the generation of differential data messages.

So in no case does the base or rover mode in the MB100 result from a specific command that would be applied to the board.

All generated differential data messages can be used not only to support the RTK base mode, but also to allow their further post-processing (if they are also recorded). In that respect, all available differential data formats (ATOM, RTCM, CMR) are equivalent to legacy MPC (etc.) messages.

Setting Raw Data Messages

Use the following set of commands to control the output of raw data messages.

Set or Query Command	Description
$PASHS,RAW	Enabling/Disabling Raw Data Messages in Ashtech Format
$PASHS,RAW,ALL	Disabling All Raw Data Messages
$PASHQ,<message_name> Where <message_name>: DPC, , RPC, ION, MCA, MPC, PBN, SNV, SNG, SNW, SAL, SAG, SAW or SBD.	Asking for the Output of the Requested Raw Data Message

Setting the NMEA and NMEA-Like Data Messages

Use the following set of commands to control the output of NMEA and NMEA-like data messages.

Enable/Disable Commands:

Query Command	Description
$PASHS,NME	Enabling/Disabling NMEA and NMEA-like Messages
$PASHS,NME,ALL	Disabling All NMEA and NMEA-Like Messages

NMEA Messages:

Query Command	Description	Resulting NMEA Message
$PASHQ,ALM	Almanac Message	$GPALM
$PASHQ,GBS	GNSS Satellite Fault Detection	$-GBS, $GLGBS, $GPGBS or $GNGBS
$PASHQ,GGA	GNSS Position Message	$GPGGA
$PASHQ,GLL	Geographic Position - Latitude/ Longitude	$GPGLL
$PASHQ,GRS	GNSS Range Residuals	$GPGRS, $GLGRS or $GNGRS
$PASHQ,GSA	GNSS DOP and Active Satellites	$GPGSA, $GLGSA or $GNGSA
$PASHQ,GST	GNSS Pseudo-Range Error Statistics	$GPGST, $GLGST or $GNGST
$PASHQ,GSV	GNSS Satellites in View	$GPGSV or $GLGSV
$PASHQ,HDT	True Heading	$GPHDT
$PASHQ,RMC	Recommended Minimum Specific GNSS Data	$GPRMC

Query Command	Description	Resulting NMEA Message
$PASHQ,VTG	Course Over Ground and Ground Speed	$GPVTG
$PASHQ,ZDA	Time & Date	$GPZDA

NMEA-like Messages:

Query Command	Description	Resulting NMEA-Like Message
$PASHQ,ATT	Heading, Roll and Pitch	$PASHR,ATT
$PASHQ,LTN	Latency	$PASHR,LTN
$PASHQ,POS	Computed Position Data	$PASHR,POS
$PASHQ,PTT	PPS Time Tag	$PASHR,PTT
$PASHQ,SAT	Satellites Status	$PASHR,SAT
$PASHQ,VEC	Vector & Accuracy Data	$PASHR,VEC
(External Event Signal)	Event Marker	$PASHR,TTT

Internal Heading Function

Introduction

The Internal Heading function can be started in the board if the following conditions are met:

- The [D] firmware option has been installed and activated in the board.
- GNSS tracking has been to configured to operate in DUO mode, using the following command:

  $PASHS,CFG,DUO

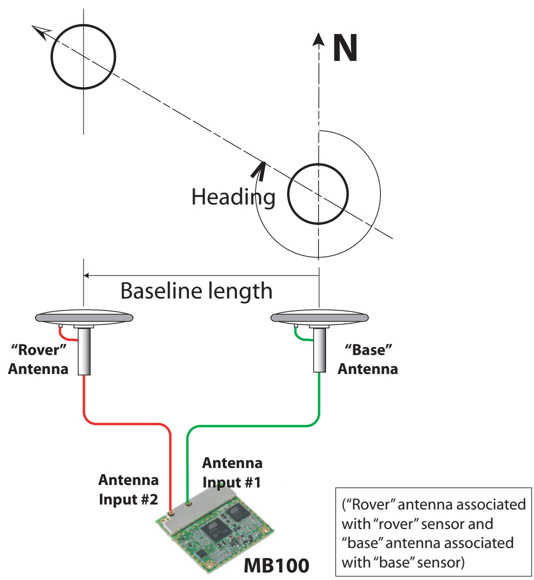
  Following the execution of this command, the board will be re-started.

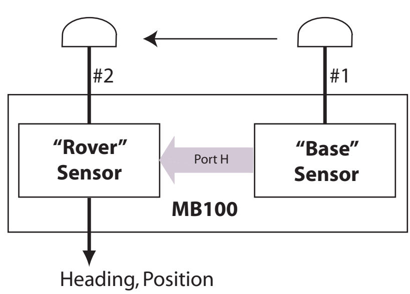
When used in DUO mode, the board in fact features two independent receivers (or sensors):

- “Rover” sensor connected to Antenna input #2 (initially defined as the board’s “internal antenna input”).
- “Base” sensor connected to Antenna input #1 (initially defined as the board’s “external antenna input”).

Once the DUO mode has been activated, the board can be configured in heading mode as if two independent sensors (e.g. a base and a rover) were used in the so-called *external* heading mode. But since in this case, the two sensors are physically in the same board, we will rename this operating mode as the *internal* heading mode. In this mode:

- The “rover” sensor (connected to Antenna input #2) will be able to deliver a position solution, up to SBAS Differential in terms of position accuracy.
- The same “rover” sensor will be able to deliver heading measurements for the baseline oriented from the “base” antenna to the “rover” antenna (see figure below).
- There is no particular need for configuring the “base” sensor as this is done implicitly when selecting the DUO mode.
- The “rover” sensor will be configured in the same way as in *external* heading mode.
- The board operates in L1 GPS only.





The performance of the internal Heading function is guaranteed if the following two conditions are met:

- **The baseline length between the base and rover antennas should not exceed 100 meters**. The cable length on either side can be any length as long as the sum of the two lengths does not exceed 100 meters. For example, if the rover cable is 10 meters long, then the base cable can be as long as 90 meters.
- **Signal levels at the two antenna inputs should not differ from each other by more than 15 dB**. Greater differences will induce negative effects resulting in degraded heading performance.

  This means you should take care when choosing your antennas, RF cables and additional equipment (such as splitters) to make sure this requirement will always be met.

Completing the Board Settings for Internal Heading

Use this command to state that the base data (from "base" sensor) will be routed to the "rover" sensor through internal port H:

$PASHS,DIF,PRT,H

NOTE: With the board still in DUO mode, you can change the input port for differential corrections. For example, you can select an external port, such as port A, using this command:

$PASHS,DIF,PRT,A

If you do that, the board will stop computing heading measurements (the "rover" sensor will stop acquiring data from port H), but the MB100 will still be able to work in RTK mode using base data received from external equipment via port A.

More About Port H

Port H is reserved for use in the internal heading function (GNSS tracking set to "DUO"). The following commands are not applicable when port H is used:

- $PASHS,CPD,BAS: When using port H, the "base" sensor is always supposed to be a moving base. You may however run this command knowing that the setting you will perform with this command will be effective only after you have selected another input port for differential corrections.

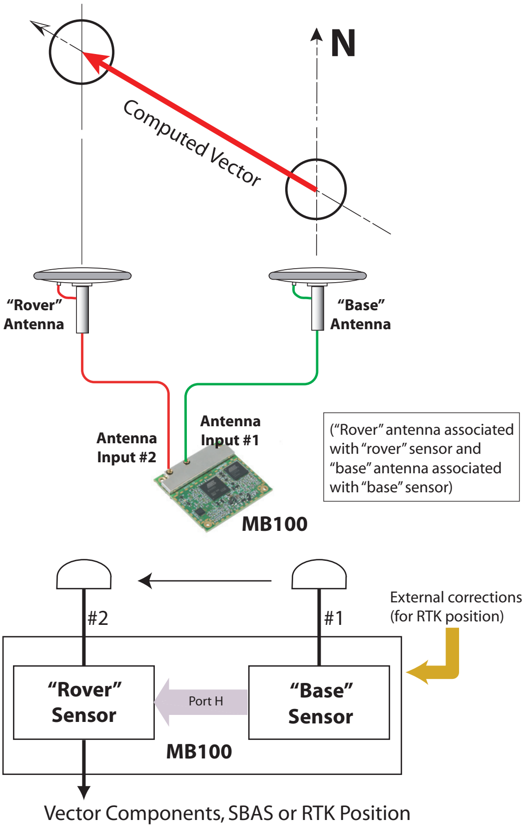
- $PASHS,TOP: When using port H, the best possible position solution can only be “SBA”. You may however run this command knowing that the setting you will perform with this command will be effective only after you have selected another input port for differential corrections.

Heading/Vector/ Position Output

- The heading information is delivered through NMEA messages ATT or HDT, and also in block HPR of ATOM message ATM,PVT.
- NMEA message VEC or block BLN in ATOM message ATM,PVT will refer to the baseline between the receiver antennas (oriented from Antenna #1 –”base”– to Antenna #2 –”rover”).
- The position delivered in each position message (NME, ATOM) is tagged to Antenna #2 (“rover”).
- Depending on $PASHS,VEC,TT/FST, the output vector and heading can either be time tagged –more accurate but available at a lower rate and with higher latency– or extrapolated –less accurate but available at a rate defined by POP, and with low latency.

Internal Relative Mode

The MB100 board can be used in the so-called "internal relative mode" in which the three components of the baseline vector are continuously computed. In this mode (DUO mode), the board operates in L1 GPS only.



Relative Mode + SBAS Configuration Commands:

$PASHS,CFG,DUO
$PASHS,CPD,BAS,1
$PASHS,DIF,PRT,H
$PASHS,TOP,SBA
$PASHS,CPD,ARR,MOD,OFF

Relative Mode + RTK Configuration Commands:

$PASHS,CFG,DUO
$PASHS,CP2,BAS,1

$PASHS,DI2,PRT,H
$PASHS,TOP,SBA
$PASHS,CP2,ARR,MOD,OFF
$PASHS,DIF,PRT,B
(last command for external RTK stream)

Setting the External Heading Function

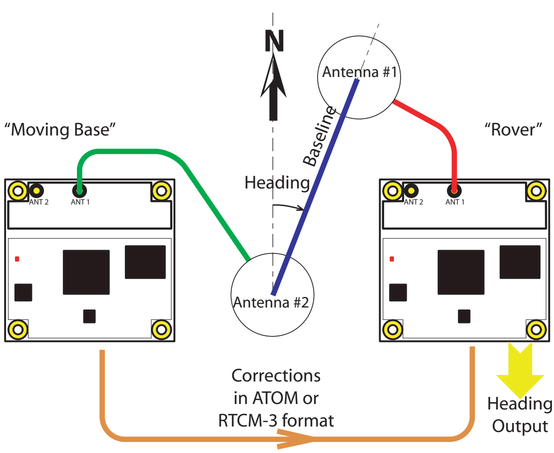
Use the following set of commands to set the external heading mode in the receiver.

Set Command	Description
$PASHS,CPD,ARR,LEN	Setting the Baseline Length in Heading Mode
$PASHS,CPD,ARR,MOD	Enabling/Disabling the Heading Mode
$PASHS,CPD,ARR,OFS	Setting Heading and Elevation Offsets
$PASHS,CPD,ARR,PAR	Setting Upper Limits in Heading Mode

(NOTE: “$PASHS,CPD...” for 1st RTK engine, “$PASHS, CP2” for 2nd RTK engine.)

Example of External Heading Setup With Two MB100 Boards

Below is a possible setup for calculating external heading, using two MB100 boards and their ANT1 inputs.



Configuration relevant to Antenna #1 ("rover"):

(External Heading + RTK)

L1/L2 GPS		L1 GPS/GLONASS
$PASHS,CFG,DSL		$PASHS,CFG,SSL
Wait for the board to return an ACK or a $PMGNGO		
$PASHS,ANT,EXT		$PASHS,ANT,EXT
$PASHS,CP2,BAS,1		$PASHS,GLO,ON
$PASHS,CP2,ARR,MOD,ON		$PASHS,CP2,BAS,1
$PASHS,CP2,MOD,HED		$PASHS,CP2,ARR,MOD,ON
$PASHS,CP2,ARR,LEN,0		$PASHS,CP2,MOD,HED
		$PASHS,CP2,ARR,LEN,0
$PASHS,DI2,PRT,A	(If corrections for heading processing received on port A)	$PASHS,DI2,PRT,A

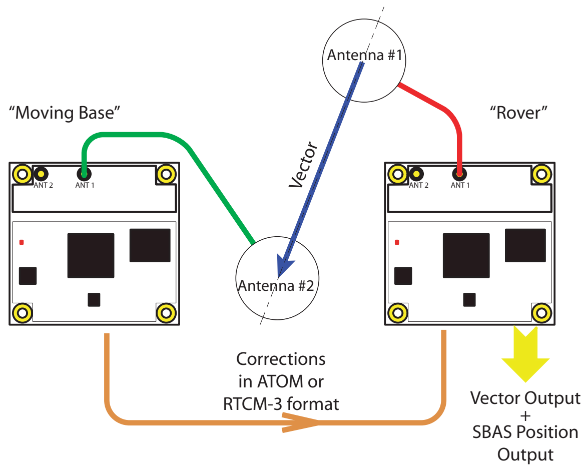
Configuration relevant to Antenna #2 ("moving base"):

(Corrections in ATOM format)

L1/L2 GPS	L1 GPS/GLONASS
$PASHS,CFG,DSL	$PASHS,CFG,SSL
Wait for the board to return an ACK or a $PMGNGO	
$PASHS,ANT,EXT	$PASHS,ANT,EXT
$PASHS,POS,MOV	$PASHS,GLO,ON
$PASHS,ATM,RNX,A,ON,1,&SCN,204	$PASHS,POS,MOV
$PASHS,ATM,ATR,A,ON	$PASHS,ATM,RNX,A,ON,1,&SCN,204
	$PASHS,ATM,ATR,A,ON

External Relative Mode With Two MB100 Boards

Below is a possible setup using two MB100 boards and their ANT1 inputs to operate in the so-called "external relative" mode.



Configuration relevant to Antenna #1 ("rover"):

(External Relative Mode + SBAS Position)

L1/L2 GPS	L1 GPS/GLONASS
$PASHS,CFG,DSL	$PASHS,CFG,SSL
Wait for the board to return an ACK or a $PMGNGO	
$PASHS,ANT,EXT	$PASHS,ANT,EXT
$PASHS,CPD,BAS,1	$PASHS,GLO,ON
$PASHS,DIF,PRT,B	$PASHS,CPD,BAS,1
$PASHS,TOP,SBA	$PASHS,DIF,PRT,B
	$PASHS,TOP,SBA

Configuration relevant to Antenna #2 ("moving base"):

(Corrections in ATOM format)

L1/L2 GPS	L1 GPS/GLONASS
$PASHS,CFG,DSL	$PASHS,CFG,SSL
Wait for the board to return an ACK or a $PMGNGO	
$PASHS,ANT,EXT	$PASHS,ANT,EXT
$PASHS,POS,MOV	$PASHS,GLO,ON
$PASHS,ATM,RNX,A,ON,1,&SCN,204	$PASHS,POS,MOV
$PASHS,ATM,ATR,A,ON	$PASHS,ATM,RNX,A,ON,1,&SCN,204
	$PASHS,ATM,ATR,A,ON

Chapter 4. Set Command Library

AGB: Enabling/Disabling GLONASS Bias Adjustments

Function

This command is used to enable or disable the adjustment of L1 & L2 GLONASS carrier biases in the receiver so that the GLONASS Double-Difference carrier residuals between the receiver and the *golden Ashtech receiver* are equal to zero (± noise errors).

MB 500 is considered as the golden Ashtech receiver.

After activating the adjustment function, the receiver name provided by any message supposed to deliver that name (e.g. RTCM-3 MT 1033) will appear in the form:

ASHTECH<space><name>

Where <space> is a space character between the two words and <name> is the receiver name entered through the $PASHS,RCP,OWN command.

The command will be NAKed if the [G] option (GLONASS tracking) has not been installed yet.

Command Format

Syntax

$PASHS,AGB,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Enabling (ON) or disabling (OFF) adjustment of GLONASS biases	ON, OFF	OFF
*cc	Optional checksum	*00-*FF	

Example

Enabling adjustment of GLONASS biases:

$PASHS,AGB,ON*1C

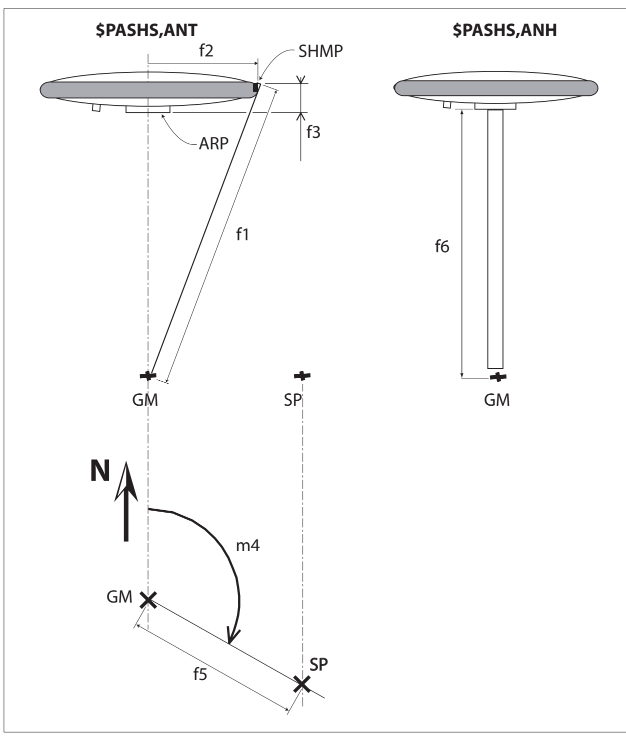
ANT & ANH: Antenna Reference Point With Respect to Ground Mark

Function

These two commands allow you to define the 3D location of the Antenna Reference Point (ARP) with respect to the survey point.

The offset parameters entered through ANT allow the receiver to deduce the position of the ARP from the entered reference position for the survey point (SP). The antenna offset parameters are never used to correct internally the computed receiver position, unless this position is generated as a reference position in differential protocols. The value entered for the vertical offset can also be included in some reference data messages.

When the antenna is placed just above the survey point and the vertical distance to the ARP is known, this distance can be entered through the more straightforward ANH command.



You will necessarily choose only one of these commands to define the ARP and discard the other. Whether the last command run is ANT or ANH, it will in any case supersede the settings made with the ANT or ANH command run previously.

Command Format

Syntax

$PASHS,ANT,f1,f2,f3,m4,f5[*cc]
or
$PASHS,ANH,f6[*cc]

Parameters

See also the above two diagrams for reference.

Parameter	Description	Range
f1	Slant height measurement, from ground mark (GM) to antenna edge (SHMP).	0-99.9999 m
f2	Antenna radius: horizontal distance from ARP to SHMP (antenna edge).	0-6.5535 m
f3	Vertical offset from ARP to SHMP, negative if SHMP is above ARP, positive otherwise. See also comments below.	-3.2768 to 3.2767 m
m4	Horizontal azimuth [dddmm.mm] for the horizontal line connecting the ground mark (GM) to the survey point (SP), measured with respect to WGS84 North.	0-35959.99 (from 0° to 359° 59.99”)
f5	Horizontal offset from the ground mark (GM) to the survey point (SP).	0-6.5535 m
*cc	Optional checksum	*00-*FF
f6	Antenna height from ARP to ground mark (GM).	0-99.9999 m
*cc	Optional checksum	*00-*FF

Example

Entering the vertical measurement (2 m) of a base antenna:

$PASHS,ANH,2.0000*02

Comments

- The $PASHS,ANH command sets the antenna height from ARP to GM. It is used when the ground mark coincides with the survey point.
- The MB100 being fitted with two antenna inputs, the $PASHS,ANT command needs to be used to describe each of the two antennas. It is therefore your responsibility to use this command accordingly when switching from one antenna input to the other (see also *ANT: Switching Antenna Inputs on page 52*).

- The vertical height from ARP to ground mark can also be entered through the ANT command, which in this case should be used as follows:
  - Set **f1** to “0.0”
  - Enter the antenna height from ARP to ground mark as **f3** (which in this case should be positive and equal to **f6**). Only when **f1**=0.0 can you define **f3** this way.

ANT: Switching Antenna Inputs

Function

This command is used to select the antenna connector that provides GNSS signals to the receiver input. The command is NAKed if $PASHS,CFG has been set to “DUO”.

Command Format

Syntax

$PASHS,ANT,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Choosing the active antenna input: • AUT: Automatic selection • EXT: ANT 1 is the antenna input (high-grade antenna) • INT: ANT 2 is the antenna input (low-grade antenna)	AUT, EXT, INT	AUT
*cc	Optional checksum	*00-*FF	

Example

Selecting antenna input 1 (ANT 1):

$PASHS,ANT,EXT*4B

ANP,DEL: Delete User-Defined Antenna

Function

This command allows you to delete the definition of a user-defined antenna.

Command Format

Syntax

$PASHS,ANP,DEL,s1[*cc]

Parameters

Parameter	Description	Range
s1	User-defined antenna name (case-sensitive)	31 characters max.
*cc	Optional checksum	*00-*FF

Example

Deleting RZ510A antenna definition:

$PASHS,ANP,DEL,RZ510A*1A

Relevant Query Command

$PASHQ,ANP

See Also

$PASHS,ANP,PCO
$PASHS,ANP,ED1
$PASHS,ANP,ED2

ANP,OUT: Defining a Virtual Antenna

Function

This command allows you to specify the name of an antenna that raw data will be adjusted to. By specifying the name of a virtual antenna, you ask the receiver to correct (“reduce”) the raw and differential data it generates from the received GNSS signals to make them available as if they had been received through *that* antenna.

Command Format

Syntax

$PASHS,ANP,OUT[,s1][*cc]

Parameters

Parameter	Description	Range
s1	Virtual antenna name (case-sensitive). Running this command with s1 omitted means that no virtual antenna is used (data reduction disabled).	31 characters max.
*cc	Optional checksum	*00-*FF

Examples

Setting the ADVNULLANTENNA as the virtual antenna:

$PASHS,ANP,OUT,ADVNULLANTENNA*73

Disabling the use of the virtual antenna:

$PASHS,ANP,OUT*48

Comments

- By default, the receiver observables are not corrected for the type of GNSS antenna used. It's only by providing separately the name of the GNSS antenna used (declared as the OWN antenna) that the antenna corrections can be performed when processing the receiver observables. Now precisely, the ANP,OUT command allows you to directly generate the raw and differential observables for the type of antenna you specify in the command (e.g. ADVNULLANTENNA).
- Be aware that the raw data reduction process is possible only if the name of the antenna physically used by the receiver has been specified through the $PASHS,ANP, OWN command and declared in the receiver's antenna database as one of the default or user-defined antennas. Otherwise, the command will be NAKed.
- Raw data reduction will not be performed on data from any satellite located below the elevation mask.
- When raw data reduction is effective, any antenna name messages generated by the receiver will include the name of the virtual antenna, and not the antenna serial number or the setup ID.
- If no reference position has been entered in the receiver, raw data reduction is performed in such a way that the location of the L1 phase center is left unchanged.
- Reduction is performed in such a way that this does not change the ARP. If the reference position was specified for the L1 phase center, and not for the ARP, then the receiver computes the ARP using the physical parameters of the antenna used, and then re-computes the L1 phase center position according to the OUT antenna parameters. This guarantees that the reported reference position, antenna name and observables remain consistent with each other.

See Also $PASHS,ANP,OWN

ANP,OWN - ANP,OW2: Naming Local Antennas

Function This command is used to enter the names of the antennas connected to the receiver (local antennas).

$PASHS,ANP,OWN refers to the name of the antenna that can potentially be connected to ANT 1 (primary antenna connector).

$PASHS,ANP,OW2 refers to the name of the antenna that can potentially be connected to ANT 2 (secondary antenna connector).

For more convenience, ANT 1 is associated with the "external" antenna and ANT 2 with the "internal" antenna. Note that the two inputs may not have the same reception capabilities. For example, ANT 1 can support L1/L2 signal reception while ANT 2 can support L1-only signal reception.

Command Format

Syntax

$PASHS,ANP,OWN,s1[,s2[,d3]][*cc]
or
$PASHS,ANP,OWN,s1,,d3[*cc]

$PASHS,ANP,OW2,s1[,s2[,d3]][*cc]
or
$PASHS,ANP,OW2,s1,,d3[*cc]

Parameters

Parameter	Description	Range
s1	User-defined antenna name (case-sensitive). There is no default name (s1 empty). The command will be "NAKed" if s1 consists of more than 31 characters.	31 characters max.
s2	Antenna serial number	31 characters max.
d3	Antenna setup ID	0-255
*cc	Optional checksum	*00-*FF

Comments

- Antenna names must be chosen to be consistent with the built-in antenna database, which is a hard-coded database. The firmware has the capability to extract numerical values from the parameters entered under a given antenna name.
- The active antenna input (whether ANT 1 or ANT 2) can be specified externally, or detected automatically. In both cases, the firmware is informed of the antenna input providing the GNSS signal and, as a result, of the name of the antenna providing the signal.
- Parameters s2 and d3 have little interest for a rover (that's why they are optional). If however they are specified, they should be inserted in such RTCM messages as type 1008 or 1033, in which room is reserved for these parameters.
- With the receiver used as an RTK base, the s1 parameter (and also the s2 and d3 parameters if available) are

inserted into antenna name messages (e.g. RTCM 23 or RTCM 1007, 1008 or 1033). If needed, the receiver performs the transformation of the entered base position from ARP to APC, or vice versa.

- With the receiver used as an RTK rover, the numerical values corresponding to the s1 parameter are used to appropriately correct the local antenna data.

Example

Entering “ASH111661” as the name of the receiver antenna connected to ANT 1:

$PASHS,ANP,OWN,ASH111661*26

ANP,PCO/EDx: Entering Offset Values to User-Defined Antennas

Function

These commands are used to enter offset values to the definition of a given user-defined antenna.

Up to 5 user-defined antennas can be added to the existing antenna list. Being kept in the Battery Backup Unit (BBU), the list is preserved after a usual power cycle but can however be deleted through a receiver cold reset ($PASHS,INI,1) or using the $PASHS,RST command.

Command Format

Syntax

$PASHS,ANP,PCO,s1,f2,f3,f4,f5,f6,f7[*cc]

$PASHS,ANP,ED1,s1,f2,f3,f4,... ,f20[*cc]

$PASHS,ANP,ED2,s1,f2,f3,f4,... ,f20[*cc]

Parameters

ANP,PCO

Parameter	Description	Range
Headers	ANP stands for Antenna Parameters PCO stands for Phase Center Offset	-
s1	User-defined antenna name (case-sensitive).	31 characters max.
f2, f3, f4	North/East/Up phase center offset for L1, in mm (with respect to Antenna Reference Point)	Full range of real variable allowed
f5, f6, f7	North/East/Up phase center offset for L2, in mm (with respect to Antenna Reference Point)	Full range of real variable allowed
*cc	Optional checksum	*00-*FF

ANP,ED1 and ANP,ED2

Parameter	Description	Range
Headers	ANP stands for Antenna Parameters ED1 (ED2) stands for Elevation Dependent for L1 (L2)	-
s1	User-defined antenna name (case-sensitive).	31 characters max.
f2 to f20	Elevation-dependent delays for L1 (L2) in mm. These parameters correspond to elevations from 90 degrees to 0 degrees in 5-degree steps.	Full range of real variable allowed
*cc	Optional checksum	*00-*FF

Comments

- Applying either of these commands to an existing antenna name causes the firmware to modify the corresponding parameters of this antenna accordingly and save them to backup memory. All other predefined parameters of the antenna not addressed by the command will be left unchanged.
- You may not apply the three commands necessarily for a given antenna name. The firmware will assume that the parameters corresponding to the non-applied commands will be all zero, if it's a newly created antenna name, or all as predefined if it's an already existing antenna name.

Example

Entering the parameters of the "TPSPG_A1" user-defined antenna:

$PASHS,ANP,PCO,TPSPG_A1,0.7,1.8,51.5,0.2,0.1,50.7
$PASHS,ANP,ED1,TPSPG_A1,0.0,1.4,2.5,3.5,4.3,4.9,5.4,5.9,6.2,6.2,6.2,5.8,5.1,4.1,2.6,0.5,-2.2,0.0,0.0
$PASHS,ANP,ED2,TPSPG_A1,0.0,0.1,0.5,1.3,2.2,3.1,3.9,4.5,4.8,4.8,4.5,3.8,2.8,1.6,0.2,-1.1,-2.5,0.0,0.0

(Use the link below to view the parameters of this antenna such as determined by the NGS:)

http://www.ngs.noaa.gov/cgi-bin/query_cal_antennas.prl?Model=TPS&Antenna=TPSPG_A1%20%20%20%20%20%20%20%20TPSD

ANP,REF: Naming Reference Antenna

Function

This command is used to enter the name of the antenna used by the reference station the receiver is working with.

Command Format

Syntax

$PASHS,ANP,REF,s1[,d2][*cc]

Parameters

Parameter	Description	Range
s1	User-defined antenna name (case-sensitive). There is no default name (s1 is empty)	31 characters max.
d2	Antenna name preference (see note below)	0 (default) or 1
*cc	Optional checksum	*00-*FF

Comments

- Antenna names must be chosen to be consistent with the built-in antenna database, which is a hard-coded database. The firmware has the capability to extract numerical values from the parameters entered under a given antenna name.
- With the receiver used as an RTK rover, the numerical values corresponding to the s1 parameter are used to correct the data from the reference antenna.
- When the receiver is used as an RTK rover and d2=0, the antenna name (s1) will be ignored if the incoming reference data contain the reference antenna name.

  Reciprocally, in the same context and with d2=1, the antenna name entered as s1 will be used, and the antenna name decoded from the incoming reference data will be ignored.
- Running this command with s1 left empty (“zero” length) amounts to deleting the previously entered antenna name from the backup memory. After this has happened, the antenna name will be extracted from the incoming base data, when available. The following sentences are therefore syntactically admissible:

  $PASHS,ANP,REF
  $PASHS,ANP,REF,,0
  $PASHS,ANP,REF,,1

Example

Entering “ASH802111” as the name of the reference antenna (ignored if messages from base include reference antenna name):

$PASHS,ANP,REF,ASH802111*2A

ANR: Antenna Reduction Mode

Function

This command is used to define the exact location for which the receiver (a base or rover) computes a position.

Command Format

Syntax

$PASHS,ANR,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Antenna reduction mode: • **OFF** or **PC1**: Position tagged to the L1 phase center. • **ON** or **SPT**: Position tagged to the survey point (ground mark). • **ARP**: Position tagged to the Antenna Reference Point.	OFF, ON, ARP	OFF
*cc	Optional checksum	*00-*FF	

Example

Setting the antenna reduction mode to ARP:

$PASHS,ANR,ARP*47

Comments

- Internally, the receiver will always compute a position tagged to the L1 phase center (PC1). Using this command, you may ask the firmware to make the necessary transformation so that the position delivered be tagged to another point:
  – The transformation from PC1 to ARP or ARP to PC1 relies on the parameters entered through the $PASHS,ANP,OWN command.
  – The transformation from ARP to SPT or SPT to ARP relies on the parameters entered through the $PASHS,ANT/ANH command.

Changes made “on-line” using the $PASHS,ANP,OWN or $PASHS,ANT/ANH commands will cause the position delivered to leap.

- The messages that are affected by this command are the following:
  - All NMEA messages
  - All NMEA-like messages
  - ATOM,PVT message. The MIS block in the ATM,PVT message will tell you the exact location the position is tagged to.
- The messages that are NOT affected by this command are the following:
  - ATM,RNX
  - PBN
  - All RTCM-2 position messages
  - All RTCM-3 position messages
  - CMR and CMR+ messages
  - TOPAZE reference position message
  - DBEN (BPS) reference position message
- The current setting of Antenna Reduction Mode can be read in the response to the $PASHQ,PAR command.
- Changing the antenna reduction mode setting (s1) “on-line” will NOT reset the PVT engine. You should therefore be aware that in this case, the position will jump noticeably, and most notably the altitude, which may jump by as much as a few meters.
- The above transformations only make sense for a properly installed antenna. You should be aware that the PL1-ARP transformations will become ambiguous if the antenna is not kept vertical while being moved. Also, many antennas feature OFF-ARP shifts in the horizontal plane, which cannot be accounted for unless the antenna heading is accurately known.

ATL: Debug Messages

Function This command allows you to enable or disable the output of the binary ATL message on the specified port.

After you have disabled the output of ATM messages, you should save all the messages collected by the connected device (e.g. AshCom running on a computer) as a file, typically named “atl.log”.

Normally you don’t have to enable this message but the Ashtech Technical Support may ask you to do so if a problem occurs in your receiver and Technical Support needs to analyze the resulting log file (atl.log) to fix the problem.

The content of the atl.log file can only be analyzed by Ashtech as the ATL message uses a proprietary, undisclosed data format, which in addition is subject to change without notice.

Command Format

Syntax

$PASHS,ATL,s1[f2][,SCN,d3][*cc]

Parameters

Parameter	Description	Range	Default
s1	ID of port on which the ATL message is output or “OFF” to disable data recording and close the file.	A, B, C, OFF	OFF
f2	Output interval, in seconds	0.05, 0.1, 0.2, 0.5, 1	1
d3	Configuration index	0, 1	0
*cc	Optional checksum	*00-*FF	

Example

Enabling the ATL message on port A:

$PASHS,ATL,A*41

Disabling the ATL message:

$PASHS,ATL,OFF*4F

Comments

- The ATL message is in binary format. Only the header (**$ATL**) of the message appears in plain format for easy recognition of the data stream.
- The ATL message can only be output on a single port at a time. If you need to change the output port (e.g. from A to B), then you should first stop the message on port A and re-enable the output on port B.
- The ATL setting is not affected by power cycles. If the output of ATL messages is enabled when the receiver is turned off, it will still be enabled when the receiver is turned back on (and reciprocally).
- The ATL message can be output on a given port without affecting the messages you have programmed on this port. This is because ATL uses a specific format, different from

the one used for all the other output messages. See however the recommendations below.

- Optionally, ATL data logging may be configured to allow higher output rate for some messages or/and to change the ATL default configuration. More choices for f2 and d3 will be supported in future firmware versions.
- Field d3=1 means a compact content will be generated for the atl.log file, which will only consist of raw and spied data. By contrast, d3=0 will result in a “full-content” atl.log file, also including a significant amount of receiver debug data.

Although normally ALT messages will not interfere with your own messages on the same port, here are a few recommendations for best use of the ATL command:

- Use the USB port for ATL messages whenever possible.
- The size of ATL messages may vary significantly, depending on internal receiver settings (CGF, POP, etc.) and the availability of corrections data (see throughput requirement estimates below). Ashtech recommends you set the port accordingly, in order to have sufficient data throughput assuring ATL data and your other messages to be output uncorrupted. It is therefore advisable to use the highest possible baud rate for the port delivering the ATL messages.
- You should ask for ATL messages only after the receiver has been set in the configuration that needs debugging, otherwise ATL messages will be of little help to Technical Support.

ATL messages should be enabled only when you think that the receiver is not operating as expected. With some heavy user configurations (e.g. 20 Hz RTK + 10 Hz heading, numerous data outputs enabled), enabling ATL messages may to some extent affect data output (corrupted data, missing epochs, increased latency), especially if they are output on the same port as user data.

On the other hand, ATL messages will have no impact whatsoever on the internal receiver algorithms.

Below are rough estimates of the data throughput requirements for some edge receiver modes in “CFG,4” with default ATL request. These are averaged figures. The instant figures may vary by as much as ±50% depending on the operating conditions (such as the number of tracked SVs).

Receiver Operating Mode	Data Throughput (bytes/second)
Standalone, POP,10	2,500
Standalone, POP,20	3,000
Fast RTK (10-Hz corrections input), POP,10	9,000
Fast RTK (10-Hz corrections input), POP,20	10,000

ATM: Enabling/Disabling ATOM Messages

Function

This command allows you to enable or disable ATOM messages on the specified port. For more details about the ATOM format, please refer to the *AshTech Optimized Messaging (ATOM) Reference Manual*.

Command Format

Syntax

$PASHS,ATM,s1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range
s1	ATOM message type	PVT, ATR, NAV, DAT, RNX, EVT, STA
c2	Port ID	A, B, C
s3	Enable (ON) or disable (OFF) this ATOM message type.	ON, OFF
f4	Output rate, in seconds.	See Comments below.
*cc	Optional checksum	*00-*FF

Examples

Enabling ATOM message type PVT on serial port A at a 1-second output rate:

$PASHS,ATM,PVT,A,ON,1*0E

Enabling ATOM message type RNX (4) on serial port A :

$PASHS,ATM,RNX,A,ON*05

Comments

Defining output rates for ATOM messages should follow the rules presented in *Understanding How MB100 Generates Differential Data Messages on page 36*.

ATM,ALL: Disabling All ATOM Messages

Function

This command disables all ATOM messages currently enabled on the specified port.

Command Format

Syntax

$PASHS,ATM,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all ATOM messages on port A:

$PASHS,ATM,ALL,A,OFF*4E

ATM,VER: Setting the Version of ATOM Messages

Function

This command is used to set the version in which the receiver will generate ATOM messages on all its ports. All ATOM messages are equally affected.

The receiver will return the currently used version of ATOM in response to $PASHQ,PAR,ATM.

You can find more information on the format of ATOM messages in the *ATOM Reference Manual*.

Command Format

Syntax

$PASHS,ATM,VER,d[*cc]

Parameters

Parameter	Description	Range	Default
d	Index of ATOM version: • 1: ATOM V1 • 2: ATOM V2	1, 2	2
*cc	Optional checksum	*00-*FF	-

Example

Setting to ATOM V2:

$PASHS,ATM,VER,2*5E

CFG: GNSS Tracking Configuration

Function

This command is used to set the GNSS tracking configuration in the receiver.

Command Format

Syntax

$PASHS,CFG,s1[*cc]

Parameters

Parameter	Description	Range
s1	GNSS tracking configuration: • SSL: Single-signal tracking • DSL: Dual-signal tracking • DUO: Internal Heading mode	SSL, DSL or DUO
*cc	Optional checksum	*00-*FF

The possible GNSS tracking configurations are detailed in the table below.

	Single Signal	Dual Signal	Internal Heading
GPS Tracking	14 GPS (similar to $PASHS,GNS,CFG, 0 or 1)	See $PASHS,GPS command	14 GPS on chip #1 12 GPS and 2 SBAS (ranging) on chip #2
GLON-ASS Tracking	14 GLO (L1 only)	N/A	NAK
SBAS Tracking	2 + SBAS	2 SBAS	2+ SABS on chip #0

Default Settings

They depend on the presence or not of firmware options ([P] option for L2). See table below (the $PASHS commands detailed in some of the cells below describe the resulting default settings, as if you had run these commands at start-up).

Firmware Option Status	Common Defaults
[P] Option Enabled	Default is DSL; GPS,ON,1C,2LW
No [P] Option	Default is SSL; $PASHS,CFG,DSL NAKed

Comments

- Changing the GNSS tracking configuration will automatically cause the receiver to re-start.
- The settings you make by running $PASHS,CFG have priority over those you make using $PASHS,GPS (for GPS), $PASHS,GLO (for GLONASS). After you have run $PASHS,CFG to change the GNSS tracking configuration, GNSS tracking is set to the appropriate defaults, depending on the installed firmware options.
- Using $PASHS,CFG to change the GNSS tracking mode does not affect the output of periodical messages as long as they are compatible with the selected mode. For example, if “SSL” is selected and a message is then programmed through $PASHS,NME,POS,A,ON, then changing the GNSS tracking mode to “DSL” will not affect the message at all.
- The L2C signal has priority over the L2P signal if both signals are available for a given satellite (2LW mode)
- Whenever $PASHS,CFG is run, appropriate defaults are restored, even if the signal remains unchanged.
- Without the [N] option installed, the possible GNSS tracking configurations are given in the table below:

	Single Signal	Dual Signal	Internal Heading
GPS Tracking	N/A	N/A	NAK
GLONASS Tracking	14+ GLO (L1 only)	N/A	NAK
SBAS Tracking	2+ SBAS	2 SBAS	NAK

Default tracking setting without the [N] option installed: SSL.

Example

Setting the receiver in dual-signal configuration:

$PASHS,CFG,DSL*40

CMR: Enabling/Disabling CMR Messages

Function This command is used to enable or disable the continuous output of CMR messages.

Command Format

Syntax

$PASHS,CMR,d1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range	Default
d1	Data message	See table below	-
c2	Port ID	A, B, C	-
s3	Enabling/disabling command	ON, OFF	OFF
f4	Output interval, in seconds	See table below.	1
*cc	Optional checksum	*00-*FF	-

The list of supported data messages is the following:

Data	Description	f4 Range
0	GPS observations	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. integer minutes, up to 960.
1	Reference WGS84 position (location) tagged to L1 phase center	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, etc. integer seconds, up to 999.
2	Reference site description (as entered through $PASHS,MSG)	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, etc. integer seconds, up to 999.
3	GLONASS observations	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. integer minutes, up to 960.

Example

Setting default CMR messages at a base:

$PASHS,POS,<coordinates of position>
or
$PASHS,POS,CUR*51
or
$PASHS,POS,AVG,<averaging interval>

$PASHS,CMR,0,A,ON,1*68
$PASHS,CMR,1,A,ON,13*5A
$PASHS,CMR,2,A,ON,31*59
$PASHS,CMR,3,A,ON,1*6B

Comments

Defining output rates for CMR messages should follow the rules presented in *Understanding How MB100 Generates Differential Data Messages on page 36*.

CMR,ALL: Disabling All CMR Messages

Function

This command is used to disable all the CMR messages currently enabled on the specified port.

Command Format

Syntax

$PASHS,CMR,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all CMR messages on port A:

$PASHS,CMR,ALL,A,OFF*4A

CMP: Enabling/Disabling CMR+ Messages

Function

This command is used to enable or disable the continuous output of CMR+ messages.

Command Format

Syntax

$PASHS,CMP,d1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range	Default
d1	Data message	See table below	-
c2	Port ID	A, B, C	-
s3	Enabling/disabling command	ON, OFF	OFF
f4	Output interval, in seconds	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 etc., integer minutes, up to 960	1
*cc	Optional checksum	*00-*FF	-

The list of supported data messages is the following:

Data	Description
0	GPS observations, location, description
3	GLONASS observations

Comments

- The output interval refers to the time interval between observations.
- Location and description data are spread over a number of consecutive observation epochs regardless of the output interval.
- The number of epochs required to output the complete message depends on the length of the description data. If there is no description data, then this number is 7 epochs, which means the complete location information has a fixed period of 7 epochs.

Example

Setting default CMR+ messages at a base:

$PASHS,POS,<coordinates of position>
or
$PASHS,POS,CUR*51
or
$PASHS,POS,AVG,<averaging interval>

$PASHS,CMP,0,A,ON,1*6A
$PASHS,CMP,3,A,ON,1*69

Comments

Defining output rates for CMP messages should follow the rules presented in *Understanding How MB100 Generates Differential Data Messages on page 36*.

CMP,ALL: Disabling All CMR+ Messages

Function

This command is used to disable all the CMR+ messages currently enabled on the specified port.

Command Format

Syntax

$PASHS,CMP,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all CMR+ messages on port A:

$PASHS,CMP,ALL,A,OFF*48

CPD,AFP - CP2,AFP: Setting the Confidence Level of Ambiguity Fixing

Function

This command is used to set the confidence level required of the ambiguity fixing process. The higher the confidence level, the more likely the ambiguities are fixed correctly, but the longer the time it takes to fix them.

Command Format

Syntax

For primary RTK engine:

$PASHS,CPD,AFP,f1[*cc]

For second RTK engine:

$PASHS,CP2,AFP,f1[*cc]

Parameters

Parameter	Description	Range	Default
f1	Confidence level, in percent, required of ambiguity fixing process. Choosing "0" means the receiver will not try to fix ambiguities but instead will stay indefinitely in Float mode.	0, 95.0, 99.0 or 99.9	99.0
*cc	Optional checksum	*00-*FF	-

Example

Setting the confidence level to 99.9% for primary RTK engine:

$PASHS,CPD,AFP,99.9*62

Comments

Changing the ambiguity fixing parameter "on-line" will not reset the primary RTK engine. This means sending $PASHS,CPD/CP2,AFP,0 while the position status is currently reported as "Fixed" will not affect this position status. If you want to switch to a float position status, you will have in addition to run the $PASHS,CPD/CP2,RST, then $PASHS,CPD/CP2, AFP,0 commands.

CPD,ARR,LEN - CP2,ARR,LEN: Setting the Baseline Length in Arrow Mode

Function

This command is used to set the baseline length between the base and the rover in arrow mode.

Command Format

Syntax

For the primary RTK engine:

$PASHS,CPD,ARR,LEN,f1[*cc]

For the second RTK engine:

$PASHS,CP2,ARR,LEN,f1[*cc]

Parameters

Parameter	Description	Range	Default
f1	Baseline length in meters. When setting f1 to"0" and the arrow mode is ON, the receiver switches to calibration mode. Once the baseline length is determined, the receiver automatically switches from calibration to arrow operating mode.	0 or 0.05 to 1000 m	0
*cc	Optional checksum	*00-*FF	-

Example

Setting the baseline length to 2.5 meters for the primary RTK engine:

$PASHS,CPD,ARR,LEN,2.5*21

CPD,ARR,MOD - CP2,ARR,MOD: Enabling/Disabling the Arrow Mode

Function

This command is used to enable or disable the arrow mode in the receiver. The arrow mode is defined as a special RTK mode primarily used when the receiver (whether a base or a rover) is mounted on a solid body (e.g. a vehicle) and the baseline length is constant, to determine the vehicle’s heading and pitch or roll.

Command Format

Syntax

In the primary RTK engine:

$PASHS,CPD,ARR,MOD,s1[*cc]

In the second RTK engine:

$PASHS,CP2,ARR,MOD,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Enabling/disabling command.	ON, OFF	OFF
*cc	Optional checksum	*00-*FF	-

Example

Turning on the arrow mode (first RTK engine):

$PASHS,CPD,ARR,MOD,ON*08

Comments

- Operating in heading mode requires that the baseline length should not be less than 0.05 meters.
- If the baseline length has not been set yet (using $PASHS,CPD/CP2,ARR,LEN) when the $PASHS,CPD/CP2, ARR,MOD command is run, the receiver automatically switches to the arrow calibration mode. Only after the baseline length has been determined (or entered through $PASHS,CPD/CP2,ARR,LEN) will the receiver switch to the arrow operating mode.
- Once the arrow mode is enabled, the respective baselines are processed with the assumption of a moving base, regardless of how you set up $PASHS,CPD/CP2,BAS.
- As the arrow mode uses an extra baseline constraint, the resulting solution is provided with higher availability and reliability.
- Since in most of the heading applications the base is moving, the $PASHS,CPD/CP2,BAS,1 command also needs to be run when enabling the arrow mode.

CPD,ARR,OFS - CP2,ARR,OFS: Setting Azimuth & Elevation Offsets

Function

This command is used to set the azimuth and elevation offsets from the vehicle centerline.

Command Format

Syntax

For the primary RTK engine:

$PASHS,CPD,ARR,OFS,f1[,f2][*cc]
or
$PASHS,CPD,ARR,OFS,,f2[*cc]

For the second RTK engine:

$PASHS,CP2,ARR,OFS,f1[,f2][*cc]
or
$PASHS,CP2,ARR,OFS,,f2[*cc]

Parameters

Parameter	Description	Range	Default
f1	Baseline azimuth offset angle.	0° to 359.99°	0°
f2	Baseline elevation offset angle	-45° to +45°	0°
*cc	Optional checksum	*00-*FF	-

Comments

- It is recommended to use a baseline elevation offset as close as possible to zero and a baseline azimuth offset as close as possible to n×90 degrees.
- If the azimuth offset is close to 0 or 180°, then the vehicle's pitch and heading will be estimated and output.
- If the azimuth offset is close to 90 or 270°, then the vehicle's roll and heading will be estimated and output.
- If the azimuth offset from either North, South, West or East exceeds 15 degrees, then the receiver delivers the heading component of attitude, but does not output pitch and roll.
- The specified values of offsets are used only when the rover is operating in arrow mode (including during the calibration process).
- Sending the command without f1 or f2 will not change the corresponding offset value currently used, which will stay either that entered previously through a valid CPD/CP2,ARR, OFS command, or 0° (default value) if no such command was run.

Example

Setting the baseline offsets to 90° azimuth and 2° elevation for the primary RTK engine:

$PASHS,CPD,ARR,OFS,90,2*02

CPD,ARR,PAR - CP2,ARR,PAR: Setting Upper Limits in Arrow Mode

Function

This command is used to set the upper limits of baseline elevation and expected maximum error in the entered baseline length.

Command Format

Syntax

For the primary RTK engine:

$PASHS,CPD,ARR,PAR,d1[,f2][*cc]
or
$PASHS,CPD,ARR,PAR,,f2[*cc]

For the second RTK engine:

$PASHS,CP2,ARR,PAR,d1[,f2][*cc]
or
$PASHS,CP2,ARR,PAR,,f2[*cc]

Parameters

Parameter	Description	Range	Default
d1	Maximum value of expected baseline elevation (absolute value), in degrees. Parameter d1 only affects the arrow operating mode and is not applied during baseline length auto-calibration.	0° to 90°	15
f2	Maximum value of tolerated baseline length error, in meters.	0.001 to 10.000	0.01
*cc	Optional checksum	*00-*FF	-

Comments

Sending the command without d1 or f2 will not change the corresponding limit currently used, which will stay either that entered previously through a valid CPD/CP2,ARR,PAR command, or the default value if no such command was run.

The default value for f2 is applicable only if the baseline length is user entered. It is not applicable if the baseline length results from a calibration process.

Example

Setting the limits to 10° for elevation and 0.02 m for baseline length error for the primary RTK engine:

$PASHS,CPD,ARR,PAR,10,0.02*3D

CPD,BAS - CP2,BAS: Setting Static or Moving Base Mode

Function

This command is used to set an RTK rover so that it operates either from a static or moving base.

Command Format

Syntax

Primary RTK engine:

$PASHS,CPD,BAS,d1[*cc]

Second RTK engine:

$PASHS,CP2,BAS,d1[*cc]

Parameters

Parameter	Description	Range	Default
d1	=0: Base is assumed to be static =1: Base is assumed to be moving	0, 1	0
*cc	Optional checksum	*00-*FF	-

Example

Setting the receiver to operate with a moving base (primary RTK engine):

$PASHS,CPD,BAS,1*43

Comments

- The [V] firmware option is required for this command to work.
- When setting the receiver to operate with a moving base (primary RTK engine), it is advisable to choose the time-tagged RTK mode, rather than the Fast RTK mode, using $PASHS,VEC,TT.

  In that mode (d1=1), the accuracy on the rover position is basically the same as the one you get for the base position, that is, a not very accurate position.

  However, in this mode (d1=1), it is the baseline orientation (i.e. the heading) that is of primary interest, and not the rover position.

  The rover position is obviously much more accurate with a static base (d1=0).
- Running $PASHS,CP2,BAS,1 is recommended when configuring the second RTK engine in Heading mode (see $PASHS,CP2,MOD,HED).

- Once the rover is set to work from a moving base, conventional DGNSS positions (i.e. those using RTCM-2 MT 1 & 31) will no longer be available.

CPD,FST: RTK Output Mode

Function

This command enables or disables the fast RTK output mode (Fast CPD mode).

Command Format

Syntax

$PASHS,CPD,FST,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Enables (ON) or disables (OFF) the fast RTK output mode	ON, OFF	ON
*cc	Optional checksum	*00-*FF	-

Example

Enabling the fast RTK output mode:

$PASHS,CPD,FST,ON

Comments

- With the fast RTK output mode disabled, the receiver will provide a position solution only for those epochs to which reference data (corrections) are tagged. In this mode, the most accurate position estimates are obtained, although possibly affected by data link delays or outages.
- With the fast RTK output mode enabled, the receiver will provide a position solution for each receiver epoch. In this mode, position estimates are of lesser quality, but available at regular intervals of time and with minimum latency.
- This command is applicable with a static base ($PASHS,CPD,BAS).
- This command only affects the position output. The baseline (vector) output is controlled using the $PASHS, VEC command.

CP2,MOD: Operating Mode for Second RTK Engine

Function

This command is used to set the operating mode in the second RTK engine.

Command Format

Syntax

$PASHS,CP2,MOD,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Choice of operating mode for second RTK engine	HED, OFF; See table below.	OFF
*cc	Optional checksum	*00-*FF	

s1 parameter	Description
HED	Switches second RTK engine to heading mode.
OFF	Turns off second RTK engine.

Example

Enabling heading mode in second RTK engine:

$PASHS,CP2,MOD,HED

Comments

- Using s1=HED is possible when the receiver is fed with two independent corrections streams, entering the receiver through different physical or virtual ports.

  The primary stream usually comes from a remote static base at 1-Hz rate and should serve the conventional RTK function.

  The secondary stream typically comes from a nearby sensor (at a rate usually greater than 1 Hz) and should serve the heading function.

  In this mode, the position delivered by the receiver (through messages ATM,PVT or GGA, or other) will always originate from the primary RTK engine. The heading result, delivered by the second RTK engine, can be read via ATM,PVT (same as position ATM,PVT, or separate) and ATT, HDT or VEC NMEA messages. ATT messages should be preferred to VEC messages.

  Still in heading mode, the second RTK engine can provide a time-tagged solution, at an update rate of up to 10 Hz, matching the update rate of the incoming corrections, provided $PASHS,VEC has been set to “TT”. If it has been set to “FST”, then the second RTK engine can provide an extrapolated heading at a rate of up to 20 Hz.

Setting the second RTK engine to operate in heading mode affects the way the primary RK engine works: It can still provide Fast RTK solutions at up to 20 Hz, but can only provide time-tagged solutions at maximum 1 Hz.

Since in most heading applications the base is moving, then the following command should be run additionally when enabling the heading mode:

$PASHS,CP2,BAS,1

- If the base and rover are fixed on a solid body, i.e. the baseline length is fixed and constant in time, the second RTK engine can advantageously be set to Arrow mode. See CP2,ARR,MOD.

  In this case, different heading and elevation offsets can be introduced. See CP2,ARR,OFS.

  See also DIF,PRT and DI2,PRT.

CPD,NET - CP2,NET: Network Corrections

Function

This command sets the behavior of the receiver with relation to network corrections, i.e. RTK correction data delivered by a network. When using master base data (and only in this case), ignoring network corrections means ignoring MAC and FKP corrections as well as Network Residual Messages (NRM).

Command Format

Syntax

For first RTK engine:

$PASHS,CPD,NET,d1[,d2][*cc]

For second RTK engine:

$PASHS,CP2,NET,d1[,d2][*cc]

Parameters

Parameter	Description	Range	Default
d1	RTK network operating mode relative to GPS corrections: • 0: GPS corrections from network are not used. • 1: FKP/MAC GPS corrections from network are used when available and healthy, otherwise they are rejected.	0-1	1
d2	RTK network operating mode relative to GLONASS corrections: • 0: GLONASS corrections from network are not used. • 1: FKP/MAC GLONASS corrections from network are used when available and healthy, otherwise they are rejected.	0-1	1
*cc	Optional checksum	*00-*FF	

Example

Setting the receiver to process GPS and GLONASS network corrections (first RTK engine):

$PASHS,CPD,NET,1,1*51

Comments

This command is NAKed if the [J] firmware option is not installed.

ATOM STA messages will inform you of whether or not network corrections are used in RTK computations performed by the rover.

CPD,RST - CP2,RST: RTK Process Reset

Function

This command resets the RTK processing in the first (CPD) or second (CP2) RTK engine. This implies resetting the current estimates of single-difference (SD) carrier ambiguities for all the processed signals. Just after issuing this command, you shouldn’t be too surprised to observe position jumps, increased RMS values and transitions to Float status.

The $PASHS,CPD,RST command is automatically mapped to $PASHS,CP2,RST if $PASHS,CP2,MOD has been set to BKP (not true if set to HED).

$PASHS,CP2,RTS affects the second RTK engine in the same way as $PASHS,CPD,RST affects the first RTK engine.

Command Format

Syntax

In the primary RTK engine:

$PASHS,CPD,RST[*cc]

In the second RTK engine:

$PASHS,CP2,RST[*cc]

Parameters

None.

Example

Resetting the RTK processing in the primary RTK engine:

$PASHS,CPD,RST*5B

CPD,VRS - CP2,VRS: VRS Assumption Mode

Function

This command is used specifically to set the receiver (a rover) to operate in the so-called "compulsory VRS mode" through which it is forced to consider that the differential corrections it receives are always VRS corrections (this impacts the way corrections are processed internally).

When not operated in this mode, the receiver will automatically detect whether the received corrections are, or are not, VRS corrections (Automatic detection).

Command Format

Syntax

For first engine:

$PASHS,CPD,VRS,d[*cc]

For Second engine:

$PASHS,CP2,VRS,d[*cc]

Parameters

Parameter	Description	Range	Default
d	VRS assumption mode: • 0: Automatic detection • 1: Compulsory VRS mode • 2: Never switches to VRS mode	0, 1, 2	0
*cc	Optional checksum	*00-*FF	

Example

Enabling the compulsory VRS mode for first RTK engine:

$PASHS,CPD,VRS,1*44

CRR: Code Correlator Mode

Function

This command is used to select the type of code correlator used for multipath mitigation.

Command Format

Syntax

$PASHS,CRR,c1[*cc]

Parameters

Parameter	Description	Range	Default
c1	Code correlator type: • E: Edge correlator • S: Strobe correlator	E, S	See below
*cc	Optional checksum	*00-*FF	-

Example

Selecting the strobe correlator type:

$PASHS,CRR,S*49

Comments

- The [C] firmware option (Advanced Multipath Mitigation) is required for this command to work.
- The Ashtech multipath mitigation technique can generally reduce the code multipath error.
- The default setting depends on whether the [C] option is enabled or not:
  - "Edge correlator" is used if option [C] is disabled.
  - "Strobe correlator" is used if option [C] is enabled.

CTS: Handshaking

Function

This command enables or disables the RTS/CTS handshaking protocol for the specified port. If the specified port doesn't support the CTS/RTS protocol, then the command is NAKed.

Command Format

Syntax

$PASHS,CTS,c1,s2[*cc]

Parameters

Parameter	Description	Range	Default
c1	Port ID	A	
s2	RTS/CTS control	ON, OFF	OFF
*cc	Optional checksum	*00-*FF	

Example

Disabling RTS/CTS on port A:

$PASHS,CTS,A,OFF*3F

DIF,PRT - DI2,PRT: Choosing an Input Port for Differential Corrections

Function

This command is used to choose the input port (and protocol) of the incoming differential corrections, or disable all differential decoders.

Specifying the protocol, if known a priori, will improve the throughput of the differential decoder. The choice of a protocol, and implicitly of the corresponding differential decoder, will indeed result in disabling all the other differential decoders.

Command Format

Syntax

Primary PVT

General form:

$PASHS,DIF,PRT,c1[,s2][*cc]

Disabling all differential decoders in the primary PVT:

$PASHS,DIF,PRT,OFF[*27]

Primary PVT

General form:

$PASHS,DI2,PRT,c1[,s2][*cc]

Disabling all differential decoders in the second PVT:

$PASHS,DI2,PRT,OFF[*27]

Parameters

Parameter	Description	Range	Default
c1	Input port ID Physical port: A, B or C (Virtual port: V, W, X, Y or Z)	A, B, C, H (V, W, X, Y, Z)	A
s2	Protocol If s2 is omitted or set to ALL, then any of the possible differential protocols received on the specified port (c1) will be decoded.	ALL, ATM, CMR, DBN, RT2, RT3, TPZ	ALL
*cc	Optional checksum	*00-*FF	

Example

Choosing port A and protocol RT3 for the incoming differential corrections:

$PASHS,DIF,PRT,A,RT3*30

Comments

- Both the CMR and CMR+ protocols are detected if CMR is specified.
- Although using the same transport layer, ATM and RT3 data will be decoded successfully.
- The differential decoder will only “listen to” the specified port, only expecting the specified differential protocol on this port.
- When the requested differential protocol is received on the specified port and detected, the corresponding differential messages are decoded and, when requested, the $PASHR,DDM message showing the decoded data can be output.
- When the requested differential protocol is received on the specified port, the resulting corrections are fed to the RTK engine. These may be RTK corrections or DGPS corrections, in which case a code-differential position will be determined.
- Whatever differential stream is applied to another port, it will be ignored and so will not be fed to the primary RTK engine.
- Choosing a protocol on the specified port implies that any other protocol received on that port will be ignored.
- Letters V to Z refer to so-called “virtual” receiver ports. For more information on these ports, see *ATOM Reference Manual*.

- Letter H refers to the internal virtual port on the “slave” sensor when the CFG,DUO mode is used.
  $PASHS,DIF,PRT,H is the command to be used to initiate the internal Heading function. This runs the differential decoder/processor and the RTK engine to determine the baseline.
- $PASHS,DI2,PRT will be ACKed even in the case where the second RTK engine is disabled by the option mechanism.
- **The board used in DUO mode can support DGPS + Internal Heading mode. In this configuration, $PASHS,DIF,PRT,H is serving internal heading mode while $PASHS,DI2,PRT,<port_ID> specifies the port that external corrections come from (port ID: A, B or C).**

DSY: Daisy Chain

Function

This command is used to redirect all the characters flowing through a given serial port (source port) to another (destination port), without interpreting the flow of redirected data.

Once the daisy chain mode is on, only the command used to discontinue this mode can be interpreted on the source port.

Redirection can be in both directions, in which case two DSY commands, instead of one, are required to allow bidirectional data flow.

Command Format

Syntax

Redirecting data from a source port to a destination port:

$PASHS,DSY,c1,c2[,d3][*cc]

Discontinuing the daisy chain mode from a specified source port:

$PASHS,DSY,c1,OFF[*cc]

Discontinuing the daisy chain mode for all source ports:

$PASHS,DSY,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Source port ID	A, B, C

Parameter	Description	Range
c2	Destination port ID	A, B, C
d3	Mode: • 0: Raw (default). • 1: Block.	0,1
*cc	Optional checksum	*00-*FF

Examples

Redirecting port B to port A:

$PASHS,DSY,B,A*38

Redirecting port B to port A and port A to port B:

$PASHS,DSY,B,A*38
$PASHS,DSY,A,B*38
For a connection to the board through port A, enter $PASHS,DSY,B,A first.
For a connection to the board through port B, enter $PASHS,DSY,A,B first.

Discontinuing the daisy chain mode from port A:

$PASHS,DSY,A,OFF*35

Discontinuing the daisy chain mode from all source ports:

$PASHS,DSY,OFF*58

DYN: Receiver Dynamics

Function

This command allows you to define the receiver dynamics. The chosen number best represents the receiver motion.

Command Format

Syntax

$PASHS,DYN,d1[*cc]

Parameters

Parameter	Description	Range	Default
d1	Receiver dynamics: • 1: Static • 2: Quasi-static • 3: Walking • 4: Ship • 5: Automobile • 6: Aircraft • 7: Unlimited • 8: Adaptive • 9: User-defined (see also $PASHS,UDP)	1-9	8
*cc	Optional checksum	*00-*FF	

Example

Setting rover dynamics to “Walking”:

$PASHS,DYN,3*39

Comments

- If the receiver is set as an RTK rover using a moving base mode, it is recommended to use d1=8 (Adaptive).
- In the adaptive mode (8), the receiver analyzes its own motion and automatically chooses one of the dynamic models that is the most suitable. The possible dynamic models are those corresponding to the other choices in the command (i.e. 2 to 7, but not 1 or 9). Using the adaptive mode rejects the possible use of the user-defined dynamic model.

ELM: Setting the Elevation Mask for Raw Data Output

Function

This command is used to set the minimum satellite elevation for the output of raw and differential measurement data. The following data are impacted: MPC, MCA, RT2, RT3, CMR, CMR+, ATM regardless of their use (i.e. as input protocol for differential data or in raw data recording).

Command Format

Syntax

$PASHS,ELM,d1[*cc]

Parameters

Parameter	Description	Range	Default
d1	Elevation mask, in degrees.	0-90°	5
*cc	Optional checksum	*00-*FF	

Example

Setting the elevation mask to 10 degrees:

$PASHS,ELM,10*1C

ENC: Setting Transport Mode for Differential Data

Function

This command defines the transport mode used for every differential data message flowing through the specified physical port.

Command Format

Syntax

$PASHS,ENC,c1,s2[*cc]

Parameters

Parameter	Description	Range	Default
c1	Port ID.	A, B, C	-
s2	Transport identifier.	See table below	NTV
*cc	Optional checksum	*00-*FF	

The list of transport identifiers is the following:

Data	Description
ASH	$PASHR transport used for encapsulation of all non-Ashtech messages
RT3	Standardized RTCM-3 transport for encapsulation of all non-RT3 messages.
NTV	NaTiVe transport, i.e. no encapsulation for all output messages.

Example

Setting the data encapsulation mode to "NTV" for port A:

$PASHS,ENC,A,NTV*30

Comments

If a virtual port is created for a given physical port, then this command will also affect the data flowing through this virtual port.

GLO: GLONASS Tracking

Function

This command is used to enable or disable GLONASS tracking. Enabling GLONASS tracking will power on the corresponding part in the RF section, if not powered on yet. The command is valid only if the GLONASS option has been activated in the receiver. See also $PASHS,CFG.

Command Format

Syntax

$PASHS,GLO,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Enables (ON) or disables (OFF) GLONASS tracking.	ON, OFF	ON
*cc	Optional checksum	*00-*FF	

Example

Enabling GLONASS:

$PASHS,GLO,ON*1C

GNS,CFG: Selecting a GNSS Mode

Function

This command is maintained to support backward compatibility with former firmware versions. It allows you to select the GNSS mode that the receiver should use. The GNSS mode refers to the constellations and frequencies used.

$PASHS,GNS,CFG is now replaced with command $PASHS, CFG (refer to this command for more information).

Command Format

Syntax

$PASHS,GNS,CFG,d1[*cc]

Parameters

Parameter	Description	Range
d1	GNSS mode: • 0: GPS L1 • 1: GPS L1 & GLONASS L1 • 2: GPS L1/L2P • 3: GPS L1/L2C • 4: GPS L1/L2P & GLONASS L1/L2 • 5: GPS L1/L2C & GLONASS L1/L2	0, 1, 2, 3, 4, 5
*cc	Optional checksum	*00-*FF

Comments

- Default Setting: Depends on whether firmware option [G] has been installed or not (see $PASHS,CFG).
- Changing the GNSS mode setting may cause the receiver to re-start (see $PASHS,CFG for more details).
- The command will be NAKed if the firmware option corresponding to the requested change has not been activated.
  - Modes “1”, “4” and “5” will be NAKed as long as the [G] option (GLONASS) is kept inactive.
  - Modes “2”, “3”, “4” and “5” will be NAKed as long as the [P] option (L2) is kept inactive.
- The command will not affect the last settings performed through $PASHS,GPS and $PASHS,SBA but will set GLONASS tracking to its default setting, in agreement with the last $PASHS,CFG command run.
- The command will be NAKed if the [N] option is missing.

Example 1

The receiver is configured in DSL (Dual-signal tracking mode, see $PASHS,CFG for details). If you run this command:

$PASHS,GNS,CFG,0*5D

Then the resulting tracking mode will be changed from “DSL” to “SSL” (single-signal tracking), GLONASS tracking will be turned off and the board will be reset.

Example 2

The receiver is configured in DSL (Dual-signal tracking mode, see $PASHS,CFG for details). If you run this command:

$PASHS,GNS,CFG,2*5F

Then the resulting tracking mode will be kept unchanged (”DSL”), GLONASS tracking will be turned off and the type of GPS signals tracked will be changed to L2P. The board will not be reset because basically the tracking mode has not changed.

GPS: GPS Tracking

Function

This command is used to enable or disable GPS tracking (Default: ON).

Enabling GPS tracking will power on the corresponding part in the RF section, if not powered on yet.

Conversely, disabling GPS tracking will power off the corresponding part in the RF section, unless SBAS reception requires that this part be kept in use.

Important! Combined with $PASHS,CFG, this command makes command $PASHS,GNS,CFG obsolete.

Command Format

Syntax

$PASHS,GPS,ON[,s1[,s2]][*cc]
$PASHS,GPS,OFF[*52]

Parameters

Parameter	Description	Range
s1	First Signal: • 1C: Tracking GPS L1 C/A signal	1C
s2	Second Signal: • 2L: Tracking L2CS signal for all GPS SVs • 2W: Tracking L2P signal for all GPS SVs • 2LW: Tracking L2CS signal for L2CS-capable GPS SVs and L2P for others • “Blank”: No second signal to be tracked	2L, 2W, 2LW or “blank”
*cc	Optional checksum	*00-*FF

Remember the settings you make with $PASHS,CFG have priority over those made with $PASHS,GPS.

The table below summarizes the interaction between these two commands. Its content should be interpreted as follows:

– If you run one of the $PASHS,GPS,... commands mentioned in the left-hand column,

– and you earlier chose to enable the single, dual- or triple-signal tracking using $PASHS,CFG (headers of 2nd, 3rd, 4th columns),

– then the resulting tracking will be the one specified in the corresponding cell."NAK" means the command will be rejected (NAKed)

If You Run $PASHS,GPS,...:	Single Signal	Dual Signal
ON	14 GPS (Similar to $PASHS,GNS,CFG, 0 or 1)	See $PASHS,GPS command, **Common Defaults** table.
ON,1C	14 GPS (similar to $PASHS,GNS,CFG, 0 or 1)	Same as Single Signal; Second Signal not tracked.
ON,1C,2W	NAK	12 GPS (C/A+P) (Similar to $PASHS,GNS,CFG,2)
ON,1C,2L	NAK	12 GPS (C/A+L2CS) (Similar to $PASHS,GNS,CFG,3)
ON,1C,2LW	NAK	12 GPS (C/A+(P or L2CS))

Example

Enabling GPS reception:

$PASHS,GPS,ON,1C,2W*0B

INI: Resetting Receiver According to Your Preferences

Function

This command resets the receiver processor and memory according to the different options you choose.

Command Format

Syntax

$PASHS,INI,d3[*cc]

or (only for older firmware versions):

$PASHS,INI,d1,d2,d3[*cc]

(This second command line is still supported to avoid backward compatibility issues but is not recommended with the latest board firmware version.)

Parameters

Parameter	Description	Range
(d1)	(Port A baud rate code)	2-15 See “Baud Rate Codes“ table below.
(d2)	(Port B baud rate code)	2-11 See “Baud Rate Codes” table below
d3	Memory reset code: • 0: No memory reset • 1: Cold start • 4: No memory reset+ clears RTC time • 5: Warm start (ephemeris data cleared, but almanac and position/time data preserved)	0, 1, 4, 5 See Memory Reset Codes table below
*cc	Optional checksum	*00-*FF

Baud Rate Codes:

Code	Baud Rate	Code	Baud Rate	Code	Baud Rate	Code	Baud Rate
2	1 200	6	19 200	10	230 400	14	2 500 000
3	2 400	7	38 400	11	460 800	15	5 000 000
4	4 800	8	57 600	12	921 600		
5	9 600	9	115 200	13	1 428 571		

Memory Reset Codes:

Reset Code:	0	1	4	5
Clear receiver parameters in BBU		•		
Clear ephemeris data		•		•
Clear almanac data		•		
Clear latest position		•		
Clear RTC time		•	•	
Reset channels	•	•	•	•
Restart processor	•	•	•	•
Clear receiver parameters in RAM	•	•	•	•

Example

Asking for a cold start:

$PASHS,INI,1*26

KPI: Known Point Initialization

Function

This command is used to force the receiver to perform PVT initialization on a point with known coordinates. These known coordinates should be expressed in the default primary coordinate system (WGS-84 if GPS is the primary system, or PZ-90.02 if GLONASS is the primary system).

Command Format

Syntax

$PASHS,KPI,m1,c2,m3,c4,f5[,f6,f7,f8][,c9][*cc]

Parameters

Parameter	Description	Range	Default
m1	Latitude in degrees, decimal minutes (ddmm.mmmmmmm)	0-90	-
c2	North (N) or South (S)	N,S	-
m3	Longitudes in degrees, decimal minutes (dddmm.mmmmmmm)	0-180	-
c4	East (E) or West (W)	E,W	-
f5	Height in meters	±9999.9999	-
f6	Accuracy (rms) in lat direction	0-99.999 m	0.01
f7	Accuracy (rms) in lon direction	0-99.999 m	0.01
f8	Accuracy (rms) in alt direction	0-99.999 m	0.01
c9	Position attribute	PC1,ARP,SPT See table below	PC1
*cc	Optional checksum	*00-*FF	-

Position Attributes:

Parameter	Description
PC1	Position is referenced to L1 phase center.
ARP	Position is referenced to ARP.
SPT	Position is referenced to survey point.

Example

Forcing the receiver to initialize from lat 37°22.2912135' N, lon 121° 59.7998217' W, height 15.25 m:

$PASHS,KPI,3722.2912135,N,12159.7998217,W,15.25

Comments

- The KPI command should be used only for a static receiver occupying the specified point ($PASHS, DYN,1). The receiver can however start moving a few seconds after it has accepted the command. Another dynamic model may also be set from this time.

- On receiving the KPI command, the receiver performs automatic PVT reset and initialization against the specified point.
- Any attempt to assign a value less than “0.001 m” to f6, f7 or f8 will be rejected. The firmware will automatically assign the value “0.001” instead.
- To prevent the receiver from bad initialization, it is your responsibility to provide the exact coordinates of the point where initialization takes place, and also to make a sensible assessment of the accuracy figures you provide in the command.

  In fact, when the KPI command is executed, an internal watchdog routine protects the receiver from obviously wrong initialization. The routine checks that:
  - An internally computed receiver position is available.
  - The difference between internal receiver position and KPI position is less than 100 meters for each component.

  If at least one of the two conditions above is not met, then the KPI command is NAKed.

LCS: Enabling/Disabling Use of Local Coordinate System

Function

This command is used to enable or disable the use of the local coordinate system in the receiver. Having the receiver using a local coordinate system requires that it receives RTCM 3.1 message type 1021-1027 from the base.

Command Format

Syntax

$PASHS,LCS,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	ON: Local coordinate system used if RTCM 3.1 messages received. OFF: Coordinate system used is WGS84.	ON, OFF	OFF
*cc	Optional checksum	*00-*FF	-

Example

Enabling the use of the local coordinate system in the receiver:

$PASHS,LCS,ON*04

Comments

When this command is set to ON, the board is allowed to decode RTCM-3 MT 1021 to 1027 and further process MT 1021 to 1023, which are currently generated by some SAPOS networks. The processing of message types 1024 to 1027 is currently not supported.

All legacy position messages (e.g. GGA, POS, PBN, or ATM,PVT,COO) are not affected by coordinate transformation messages. When this command is set to ON, local coordinates are delivered in extra-block ATM,PVT,LDP.

“LDP” stands for Local Datum Position. The extra-block is output only if the receiver considers that the transformation parameters are valid and match the ATM,PVT,COO position.

Positions in ATM,PVT,COO and ATM,PVT,LDP always refer to the same position, but are expressed in a different datum. The LDP block also provides information on the name of the local datum.

MET,OWN - MET,REF: Entering Meteorological Parameters

Function

These two commands are used to enter the current values of three meteorological parameters respectively for the local receiver or for the reference receiver the local receiver is working with.

Command Format

Syntax

$PASHS,MET,OWN,f1,f2,f3[*cc]
or
$PASHS,MET,REF,f1,f2,f3[,d4][*cc]

Parameters

Parameter	Description	Range	Default
f1	Local temperature, in degrees Celsius.	±100	
f2	Local pressure, in mBar	±1300	
f3	Local relative humidity, in percent	±100	
d4	Preference	0, 1	0
*cc	Optional checksum	*00-*FF	

Comments

- As an RTK base, the receiver will insert its own f1 to f3 parameters into a meteo message such as ATM,ATR,MET
- As an RTK rover, the receiver can use the meteo parameters corresponding to the local (OWN) and reference (REF) receivers to adjust troposphere models.
- As an RTK rover, the receiver will use or ignore the meteo data entered locally for the reference receiver (REF), depending on the value given to d4 when running the $PASHS,MET,REF command:
  - d4=0: Meteo data entered locally for REF will be ignored if incoming reference data contain such data.
  - d4=1: Always used, regardless of what's decoded from the incoming reference data.

Example

Entering meteo values for the local receiver:

$PASHS,MET,OWN,+21,+1200,+51*50

MSG: Defining a User Message

Function

This command is used to define a user message to be generated "as is" or for insertion into one or more of the following standard messages:

- ATOM,ATR,UEM, if requested
- RTCM-2 message type 16 or 36
- RTCM-3 message type 1029
- CMR type 2
- CMR+ type 0

Any new MSG command you send to the receiver overwrites the user message previously defined through the same command.

Command Format

Syntax

$PASHS,MSG,[c1],s2[*cc]

Parameters

Parameter	Description	Range	Default
c1	Message interpreter (provision for future uses): • 0: ASCII message generated periodically. If c1 is omitted, this is interpreted as c1=0	0	0
s2	User message	100 characters max.	"MB500" (receiver name)
*cc	Optional checksum	*00-*FF	

Example

Sending ASCII message "going to stop at 11pm" periodically:

$PASHS,MSG,0,going to stop at 11pm*5F

Comments

Warning! Only the first 90 characters from the user message will actually be transferred through RTCM-2 message types 16 and 36.

NME: Enabling/Disabling NMEA Messages

Function

This command is used to enable or disable NMEA messages and NMEA-like messages.

Command Format

Syntax

$PASHS,NME,s1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range
s1	Data message type	See tables below
c2	Port ID	A, B, C
s3	Enables (ON) or disables (OFF) the message OFF by default.	ON, OFF
f4	Output rate, in seconds. Default is 1 second.	See tables below
*cc	Optional checksum	*00-*FF

NMEA messages:

Data	Description	f4 Range
ALM	GPS almanac data	1, 2, 3, 4, 5, etc. any integer second up to 999

Data	Description	f4 Range
GBS	GNSS Satellite Fault Detection	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 s, etc. any integer minute up to 960 s (16 min).
GGA	GPS fix data	
GLL	Geographic position - Latitude / Longitude	
GRS	GNSS range residual	
GSA	GNSS DOP and active satellites	
GST	GNSS pseudo-range error statistics	
GSV	GNSS satellites in view	
HDT	True heading	
RMC	Recommended minimum specific GNSS data	
RRE	Satellite residual and position error	
VTG	Course over ground and ground speed	
ZDA	Time and date	

NMEA-like messages:

Data	Description	f4 range
ATT	Heading, roll and pitch	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. (integer minutes up to 960)
BPS	Base position	1, 2, 3, 4, 5, etc. (integer seconds up to 999). Default: 30 seconds
DDM	Differential decoder message	Not Applicable
LTN	Latency	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. (integer minutes up to 960)
POS	Position	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. (integer minutes up to 960)
PTT	1 PPS time tag	Not Applicable
SAT	Satellite status	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. (integer minutes up to 960)
TTT	Event marker	Not Applicable
VEC	Baseline vector	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120, etc. (integer minutes up to 960)
GIS	Geodetic information	

Example

Setting GGA message on USB port at 1-second output rate:

$PASHS,NME,GGA,C,ON,1*01

Comments

- For ALM messages, the f4 parameter can only take an integer value of seconds (by default 3600) and refers to the interval between messages related to the same satellite and with the same content.
- For a given satellite, the ALM messages are therefore renewed every “x” seconds (x=f4), or following a change in the message content (“on change”), whichever occurs first.
- ALM messages cannot be output more than once over a given period of 1 second.

NME,ALL: Disabling All NMEA and NMEA-Like Messages

Function

This command is used to disable all NMEA messages and NMEA-like messages currently enabled on the specified port.

Command Format

Syntax

$PASHS,NME,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all NMEA and NMEA-like messages on port A:

$PASHS,NME,ALL,A,OFF*50

NME,MSG: Requesting Rover to Output Differential Message from Base

Function

This command is used in a rover to output the incoming differential stream as a user-readable message. The message is available on the specified port at the same output rate.

The incoming differential stream may enter the rover through any of its ports but the resulting output message can only be the one defined through DIF,PRT.

Command Format

Syntax

Activating message output:

$PASHS,NME,MSG,c1,ON[,f1][*cc]

Deactivating message output:

$PASHS,NME,MSG,c1,OFF[,f1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
f1	For future use	
*cc	Optional checksum	*00-*FF

Example

Enabling message on port A:

$PASHS,NME,MSG,A,ON*06

Response Format

The message delivered on the specified port is in the form:

$PASHR,MSG,message[*cc]

Where “message” can be one of the following decoded data:

- RTCM3 MT 1029
- RTCM2 MT 16 or 36
- ATOM,ATR MT UEM

Example:

$PASHR,MSG,ProMark500

See Also

$PASHQ,DDM

This command can be used to read all the differential streams, and not only the one defined by DIF,PRT.

OUT,ALL: Disabling All Periodic Messages

Function

This command is used to disable all the periodic messages programmed to be output on the specified port. Periodic messages are all those programmed using $PASHS commands.

Command Format

Syntax

$PASHS,OUT,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all periodic messages on port A:

$PASHS,OUT,ALL,A,OFF*58

OUT,x,ON/OFF: Suspending/Resuming Message Output

Function

This command is used to suspend or resume the output of the requested periodic messages (those requested using $PASHS commands) on the specified port.

Command Format

Syntax

Suspending the output of all periodic messages:
$PASHS,OUT,c1,OFF[*cc]
Resuming the output of all periodic messages:
$PASHS,OUT,c1,ON[*cc]

Parameters

Parameter	Description	Range
c1	ID of port on which to suspend or resume the output of periodic messages.	A, B, C
*cc	Optional checksum	*00-*FF

Comments

- Suspending all periodic messages on a given port implies that the receiver “keeps in mind” all the settings of these messages. When later you apply the “ON” command, the receiver will resume the output of these messages as if nothing had happened in the meantime.

- With all the periodic messages suspended on a given port, you are still allowed to modify the settings of these suspended messages, or even add new ones.
- With all the periodic messages suspended on a given port, you are still allowed to apply $PASHQ commands on this port to get $PASHR responses from the receiver through the same port.

Example

Suspending all messages on port A:

$PASHS,OUT,A,OFF*35

PEM: Setting the Position Elevation Mask

Function

This command is used to set the elevation mask used in the position processing.

Command Format

Syntax

$PASHS,PEM,d1[*cc]

Parameters

Parameter	Description	Range	Default
d1	Elevation mask angle, in degrees	0-90°	5
*cc	Optional checksum	*00-*FF	

Example

Setting the elevation mask for position processing to 15 degrees:

$PASHS,PEM,15*05

Relevant Query Command

$PASHQ,PEM

See also

$PASHS,ELM

PGS: Defining the Primary GNSS System

Function

This command is used to define GPS or GLONASS as the primary GNSS system used in the receiver.

Command Format

Syntax

$PASHS,PGS,c1[*cc]

Parameters

Parameter	Description	Range	Default
c1	Desired primary GNSS system: • “GPS”: GPS system • “GLO”: GLONASS system	GPS,GLO	GPS
*cc	Optional checksum	*00-*FF	

Comments

- The choice of a primary system impacts the following:
  - Time tagging of some messages (ATM,RNX - ATM,PVT - $PASHR,PBN
  - Use of a default position datum (e.g. WGS-84 for GPS, PZ-90.02 for GLONASS)
  - Reference time scale for reported clock estimate. More information on this point in the *ATOM Reference Manual*).
- On the other hand, the choice of a primary GNSS system has no impact whatsoever on the internal algorithms used by the receiver. For example, the way channels are assigned for satellite tracking or the way observables from different systems are weighted in the PVT solution are not impacted by this choice. NMEA time tags are not affected either as they always refer to UTC time.
- The choice of a primary system is an “absolute” setting. That choice is indeed totally independent of the receiver configuration parameters. It remains valid even when the chosen primary system is NOT currently tracked. In this case however, you may expect some approximations due to the use of a priori information about time/datum differences between the different GNSS’s.

  For example, GPS can be designated as the primary system, but may be disabled for tracking using the $PASHS,GPS,OFF command. In this case, the reported values of time tag and clock offset parameters will only use a priori information about GPS-GLONASS differences.
- Changing the primary GNSS system causes the board to be unconditionally restarted. The restart condition is similar to running the $PASHS,INI,0 command.
- When GLONASS is used as the primary system, the following differential protocols should not be used:

- DBEN and TOPAZE (these protocols do not support GLONASS)
- CMR+ (does not support equally GPS and GLONASS)

- When specifying the position of the receiver through external means (i.e. by using the $PASHS,POS or $PASHS,KPI command), you should always keep in mind that it should be in agreement with the currently selected primary system (i.e. expressed on the same datum).
- GPS is the default primary GNSS system. That's why running $PASHS,PGS,GLO is recommended when the GPS option is not installed, otherwise raw data cannot be generated (because of unknown GPS time).

Example

Choosing GLONASS as the primary GNSS system:

$PASHS,PGS,GLO*59

PHE: Setting the Active Edge of the Event Marker Pulse

Function

This command is used to set the active edge (rising or falling) of the event marker pulse used in photogrammetry time-tagging. The Event Marker firmware option [E] must be installed for this command to work.

Command Format

Syntax

$PASHS,PHE,c1[*cc]

Parameters

Parameter	Description	Range	Default
c1	Active edge code: • "R" for rising edge • "F" for falling edge	R, F	R
*cc	Optional checksum	*00-*FF	

Example

Making the falling edge active:

$PASHS,PHE,F*42

PIN: Assigning Function to Programmable Pin on I/O Connector

Function

This command is used to assign a specific function to the programmable pin on the board's I/O connector.

Command Format

Syntax

$PASHS,PIN,d1,s2,d3[*cc]

Parameters

Parameter	Description	Range	Default
d1	Programmable pin ID: • 0: TIOA1 • 1: TIOB2	0 or 1	-
s2	Function: • OFF: no function assigned • PAV: Position available (see comment 1) • RSP: Radar simulated pulse (see comment 2) • LED: LED signal output	OFF, PAV, RSP or LED	OFF
d3	Depends on s2 value: • s2=OFF: d3 should be omitted • s2= PAV: d3 is the number of consecutive seconds while position is not computed that causes the signal on the pin to switch to low level. • s2= RSP: d3 should be set to "1" to make Radar Simulated Pulse output available on the pin. • d3=LED: Defines the LED used. "1" for red LED; "2" for green LED.	Omitted 1-3600 1 1 or 2	-
*cc	Optional checksum	*00-*FF	

Example

Assigning the PAV function to the programmable pin and asking for a low-level signal on that pin after 60 seconds of position unavailability:

$PASHS,PIN,0,PAV,60*7F

Comment

1. By default, the programmable pin provides a high-level signal. When the PAV function is assigned to the pin, a low level will occur on the pin in the following cases:

- Immediately after the $PASHS,PIN,d1,PAV command has been executed and the position has not been computed yet at that time.
- If for any reason, the position has not been computed for more than the time specified as d3.
- After running the $PASHS,INI,x,y,0 or $PASHS,INI,x,y,5 command.
- After running the POP and GNS,CFG commands following a re-start of the board.

High level is restored on the pin right after the board has re-started computing the position.

2. By default, the programmable pin is at a high level.

   After the $PASHS,PIN,d1,RSP,1 command has been accepted, and if the ground speed is within the range 0.8 to 322 km/hr, an LV-TTL pulse signal with a 50% duty cycle is made available on the pin. The frequency conversion is then 94 Hz/(m/s).

   If the ground speed is out of the range 0.8 to 322 km/hr, the pin level is kept at a high level.

POP: Setting Internal Update Rates for Measurement and PVT

Function

This command allows you to set the updates rates used internally in the measurement and position processing.

Command Format

Syntax

$PASHS,POP,f1[*cc]

Parameters

Parameter	Description	Range	Default
f1	Internal update rate, in Hz, for measurement.	1, 2, 5, 10, 20	Firmware option dependent (see below)
*cc	Optional checksum	*00-*FF	

Example

Setting both update rates to 20 Hz:

$PASHS,POP,20*14

Comments

- Changing the POP setting causes all the update rates of the output messages to be reset to their default values. It is therefore recommended to set these update rates only after having run the $PASHS,POP command.

- The default POP setting depends on which firmware option has been installed:
  – Default is “10 Hz” with the [T] option
  – Default is “20 Hz” with the [W] option

POS: Setting the Antenna Position

Function

This command is used to enter the position of the receiver (the position should be expressed on the same datum as the one corresponding to the primary system used, i.e. WGS-84 if GPS is primary, or PZ-90.02 if GLONASS is primary).

The command is either used in a rover to speed up the receiver start-up, in which case the entered position may be very approximate (to within a few kilometers), or on the contrary, it is used to enter the accurate coordinates of a base, coordinates that will be inserted in all ATM, RTCM or CMR data messages.

Command Format

Syntax

To set receiver’s position (estimate in a rover, reference position in a base):
$PASHS,POS,m1,c2,m3,c4,f5[,s6][*cc]
or, to set the computed position as a reference position:
$PASHS,POS,s7[*cc]

Parameters

Parameter	Description	Range
m1	Latitude in degrees and minutes with 7 decimal places (ddmm.mmmmmmm)	0-90
c2	North (N) or South (S)	N, S
m3	Longitude in degrees, minutes with 7 decimal places (ddmm.mmmmmmm)	0-180
c4	West (W) or East (E)	W, E
f5	Height in meters	±0-9999.9999
s6	Position attribute (see table below)	PC1, ARP, SPT
*cc	Optional checksum	*00-*FF
s7	=CUR: Position is equal to the currently computed position at the moment the command is issued. After this, the reference position is kept constant. =MOV: Position is always equal to the receiver's computed position and can change arbitrarily as the receiver moves. This computed position may be standalone or DGPS position, but never RTK position.	CUR, MOV
*cc	Optional checksum	*00-*FF

Position Attributes:

Parameter	Description
PC1	Position is referenced to L1 phase center (default).
ARP	Position is referenced to ARP.
SPT	Position is referenced to survey point.

Examples

Setting the antenna position to 37°22.2912135'N, 121°59.7998217'W and 15.25 m:

$PASHS,POS,3722.2912135,N,12159.7998217,W,15.25*1F

Defining the computed position as the reference position:

$PASHS,POS,CUR*51

Comments

- The position you enter through $PASHS,POS will be NAKed if it differs from the autonomous one computed internally by more than a certain threshold (dependent on hardware, antenna type and firmware version). If however, the internally computed position is not available at the time you run the $PASHS,POS command, then the entered position will be accepted whatever it is.
- The reference position inserted in RTCM, CMR or ATM messages is either the position you entered manually, or a

position resulting from $PASHS,POS,CUR or $PASHS,POS,MOV, whichever was issued last.

- If no position was entered manually and no $PASHS,POS, CUR is applied, then the receiver operates as if $PASHS,POS,MOV had been applied. The RTCM, CMR or ATM messages will be generated accordingly.
- The reference position generated in ATM,RNX messages using scenario SCN 1, 2, 3, 4, 100 or 101 should be entered either manually or through $PASHS,POS,CUR, whichever occurs last.

  If no such command has been issued, or the last position has been specified as a “MOV” not a “CUR” position, then the moving position will be used for these messages.

  Please note, that ATOM super-compact is designed for static reference receivers only. It is therefore the user’s responsibility to ensure that a correct position is entered. The reference position generated in ATM,RNX messages SCN 0, 201, 202, 203, 204 and 300 is always a “MOV” position.
- When working as a rover in RTK or differential mode, the receiver can mix corrected and uncorrected data. This is reflected accordingly in the weight matrix. Differentiating corrected and uncorrected data is based on the assumption that incoming corrections are computed in relation to an accurate reference position. If the reference position was not accurate enough (e.g. 10 meters or more distant from the true position), then the performance of the RTK rover would be degraded, resulting in false outlier detection or even the inability to deliver a position at all.

POS,AVG: Averaged Reference Position

Function

This command is used to allow the receiver to compute an averaged position of its location over a specified interval of time. Typically, this command is used for a base receiver installed at some unknown location.

Command Format

Syntax

$PASHS,POS,AVG[,d1][*cc]

Parameters

Parameter	Description	Range
d1	Averaging interval, in seconds	< 86400 sec
*cc	Optional checksum	*00-*FF

Comments

- Once the command is applied, the position engine starts working in static mode, as if $PASHS,DYN,1 had been run. The resulting averaged position is the computed PVT position at the moment the requested time interval expires. The position engines is then automatically switched back to the DYN mode it was in just before you ran the POS,AVG command.
- If for some reason, the PVT engine is reset during the averaging process, the resulting averaged position will be the position corresponding to the longest interval of continuous averaging within the requested time interval. In other words, an averaged position will always be available at the end of the requested time interval, but the exact duration of averaging may be less than the requested time interval (d1).
- While all requested correction and observation data will actually be generated during the averaging process, the reference position message (e.g. MT 1006) on the other hand will not be generated until the averaging process is complete. That means the reference data stream is not 100% usable on rover side.

  Once the averaging process is over and the averaged position has been saved in receiver memory, the reference position message will be generated with the averaged position included.

  The status of the reference position is reported in the $PASHQ,PAR response.
- The averaged position saved in memory is automatically available after a receiver power cycle.
- Any new $PASHS,POS command run after an averaging process is complete will clear the averaged position saved in memory.
- Running $PASHS,POS,AVG,0 is equivalent to running $PASHS,POS,CUR.

Example

Letting the receiver determine an averaged position of its location over 100 seconds and then store the result as the base position:

$PASHS,POS,AVG,100*58

In reply to this command, the receiver will instantly return a start receipt, which looks like this:

$PASHR,RECEIPT,POS,AVG,STARTED,INTERVAL,100,114502.56,
28.12.2011*52

Once the averaged position has been determined (here after 100 seconds) and stored as the base position, the receiver will deliver a finish receipt, which looks like this:

$PASHR,RECEIPT,POS,AVG,100,FINISHED,114642.81,28.12.2011,5542.51
78481,N,03739.2954994,E,176.334,OK,CONTINUOUS,100.20*09

If the receiver is unable to determine a valid position after the required time interval, the returned receipt will look like this:

$PASHR,RECEIPT,POS,AVG,100,FINISHED,124628.01,28.12.2011,ERR*67

PPS: Setting PPS Pulse Properties

Function

This command is used to set the period, offset and GPS synchronized edge (rising or falling) of the PPS pulse with an accuracy of ± 50 nanoseconds.

Command Format

Syntax

$PASHS,PPS,f1,f2,c3[*cc]

Parameters

Parameter	Description	Range	Default
f1	PPS time period, a multiple or fraction of 1 second. • 0: 1 PPS disabled	0 to 1, with 0.1-sec increments 1 to 60, with 1-sec increments	0
f2	Time offset in milliseconds.	± 999.9999	0
c3	GPS-synchronized edge code: • "R" for rising edge • "F" for falling edge	R, F	R
*cc	Optional checksum	*00-*FF	

Example

Setting the PPS signal to a period of 2 seconds, with an offset of 500 ms and a GPS-synchronized rising edge:

$PASHS,PPS,2,+500,R*74

Comment

- The PPS time period (f1) cannot be less than the internal update rate (see firmware options T and W).
- The 1PPS sifgnal is not output until the receiver time scale is corrected to GPS time.

PWR,OFF: Powering Off the Receiver

Function

This command is used to prepare the board before it is turned off. Using this command allows all the settings and parameters to be saved in the non-volatile memory. This command DOES NOT switch off the on-board power supply.

Command Format

Syntax

$PASHS,PWR,OFF[*cc]

Parameters

None.

Comments

Whenever you run a $PASHS command (set command), you must be aware that the resulting change is not saved to backup memory instantly, but only after a certain delay, which is estimated to be not greater than 120 seconds. There is a requirement behind this operating mode, which is to extend the chip's life cycle as much as possible by reducing the number of write operations in the memory chip.

Because the $PASHS commands causing the receiver to restart (i.e. INI, RTS, CFG, POP, PWR, etc.) are also part of the "delayed" commands (seen from the backup memory), it is therefore recommended that you run $PASHS,PWR,OFF about 2 to 3 seconds before you initiate a power cycle or reset through one of these commands.

Example

Preparing the board to be turned off:

$PASHS,PWR,OFF*43

RAW: Enabling/Disabling Raw Data Messages in Legacy Ashtech Format

Function

This command is used to enable or disable the standard, continuous output of raw data in legacy Ashtech format.

Command Format

Syntax

$PASHS,RAW,s1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range	Default
s1	Raw data message type	See table below	
c2	Port ID	A, B, C	-
s3	Enables (ON) or disables (OFF) the raw data message	ON, OFF	OFF
f4	Output rate in seconds.	See table below	1
*cc	Optional checksum	*00-*FF	

Raw data message types:

Data	Description	f4 range
MCA	GPS/GLONASS/SBAS C/A code measurements	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 sec., etc.(integer minutes up to 960 sec.)
MPC	GPS/GLONASS/SBAS raw data	
DPC	Compact GPS raw data	
RPC	DBEN messages	
PBN	Position information	

Data	Description	f4 range
SNV	GPS ephemeris data	1, 2, 3, 4, 5, etc. (integer seconds up to 999 sec.)
SNG	GLONASS ephemeris data	
SNW	SBAS ephemeris data	
SAL	GPS almanac data	
SAG	GLONASS almanac data	
SAW	SBAS almanac data	
ION	Ionospheric parameters	
SBD	SBAS data message	Not applicable

Examples

Enabling output of MPC message type on port A to 1 second:

$PASHS,RAW,MPC,A,ON,1*1E

Enabling output of SNV message type on port A to 300 seconds:

$PASHS,RAW,SNV,A,ON,300*09

Comments

- For each of the SNV, SNG, SNW, SAL, SAG, SAW and ION messages, the f4 parameter can only take an integer value of seconds and refers to the interval between messages related to the same satellite and with the same content.

  For a given satellite, each of these messages is therefore renewed every x seconds (where x=f4), or following a change in the message content ("on change"), whichever occurs first.

  Each of these messages cannot be output more than once over a given period of 1 second.
- By default, f4 is set as follows:

Output message	f4 Default Value
SNV, SNG, ION	900
SAL, SAG	3600
SNW	120
SAW	300

- The SBD message output rate is always 1 second (as decoded). Parameter f4 is ignored.

QZS: Enabling/Disabling QZSS Tracking

Function

This command is used to enable or disable QZSS tracking. The QZSS constellation tracking function is off by default.

Command Format

Syntax

$PASHS,QZS,s[*cc]

Parameters

Parameter	Description	Range	Default
s	Programmable pin ID: • ON: QZSS satellites tracked and used • OFF: QZSS satellites not tracked	ON or OFF	OFF
*cc	Optional checksum	*00-*FF	

Example

Enabling QZSS tracking:

$PASHS,QZS,ON

Relevant Query Command

$PASHQ,QZS
$PASHQ,PAR

See Also

$PASHS,CFG
$PASHS,SBA
$PASHS,GPS
$PASHS,GLO

RAW,ALL: Disabling All Raw Data Messages

Function

This command is used to disable all the currently active raw data messages on the specified port.

Command Format

Syntax

$PASHS,RAW,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all raw data messages on port A:

$PASHS,RAW,ALL,A,OFF*52

RCP,DEL: Deleting User-Defined Receiver Name

Function

This command is used to delete a user-defined receiver name.

Command Format

Syntax

$PASHS,RCP,DEL,s1[*cc]

Parameters

Parameter	Description	Range
s1	Receiver name you want to delete (case sensitive)	31 characters max.
*cc	Optional checksum	*00-*FF

Example

Deleting receiver name “MyReceiver”:

$PASHS,RCP,DEL,MyReceiver*74

Relevant Query Command

$PASHQ,RCP

See Also

$PASHS,RCP,GB1
$PASHS,RCP,GB2

RCP,GBx: GLONASS Carrier Phase Biases for User-Defined Receiver

Function

This set of two commands is used to define GLONASS carrier phase biases for a given receiver. One command deals with the GLONASS L1 band and the other with the GLONASS L2 band.

Command Format

Syntax

For the L1 band:

$PASHS,RCP,GB1,s1,f2,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f13,f14,f15,f16,f17[*cc]

For the L2 band:

$PASHS,RCP,GB2,s1,f2,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f13,f14,f15,f16,f17[*cc]

Parameters

Parameter	Description	Range
s1	Name of user-defined receiver for which GLONASS biases must be defined (case sensitive)(12 characters max. recommended)	31 characters max.
f2	When a linear pattern is assumed for GLONASS biases, f2 represents the delta bias between two adjacent GLONASS frequency numbers (cycle of local L1 [or L2] frequency).	Full range of Real variables allowed
f3-f16	When an arbitrary pattern is assumed for GLONASS biases, f3-f16 represent biases for GLONASS frequency numbers from -7 to 6 (cycle of local L1 [or L2] frequency)	Full range of Real variables allowed
f17	Mean pseudo-range bias (in meters) between L1 [or L2] GPS and L1 [or L2] GLONASS constellations.	
*cc	Optional checksum	*00-*FF

Comments

- **Only fractional parts of GLONASS carrier phase biases are of practical importance**. Only these parts are saved to backup memory. For example, assuming some bias is set to 23.517 cycles using $PASHS,RCP,GBx, then $PASHQ,RCP will return the value "0.517" for this bias.
- Phase biases are always stored and output as positive values. For example, if you enter a bias value of "-0.2", then the query command will return "0.8" for this bias. Likewise, an entered value of "-1.48" will be returned as

"0.52" by the query command. Beyond the sign conversion, what really matters here is the fractional part.

- Running one of these commands on a receiver already stored in the list of user-defined receivers will save all the submitted parameters to backup memory and keep all the others unchanged.
- You may not run the two commands (GB1 and GB2) for a given user-defined receiver. If you run just one of them, then the parameters corresponding to the other command will all be assumed to be invalid (i.e unknown). All user-defined receivers created from this receiver will also inherit these invalid parameters.
- The board will interpret any missing parameter in a command as a parameter for which there is currently no known valid value for this parameter.
- These commands will be NAKed if the [G] option (GLONASS tracking) has not been installed yet.

RCP,OWN and RCP,REF: Naming Local and Reference Receivers

Function

These commands are used to enter the receiver's own name as well as the reference receiver name.

Command Format

Syntax

$PASHS,RCP,OWN,s1[,s2[,s3]][*cc]
or
$PASHS,RCP,OWN,s1,,s3[*cc]

$PASHS,RCP,REF,s1[,d2][*cc]

Parameters

Parameter	Description	Range	Default
s1	Receiver name (case-sensitive).	31 characters max.	"MB100" for local receiver, Empty field for reference receiver
s2	Receiver firmware version	31 characters max.	
s3	Receiver serial number	31 characters max.	
d2	Receiver name preference	0 or 1	0
*cc	Optional checksum	*00-*FF	

Comments

- With the receiver used as an RTK base, the s1 parameter is inserted into receiver name messages (e.g. RTCM-1033).
- When the receiver is used as an RTK rover, it will use the bias values corresponding to the entered local and receiver names to correct the local and reference data accordingly.
- When the receiver is used as an RTK rover and d2=0, the receiver name (s1) will be ignored if the incoming reference data contain the base receiver name.

  Reciprocally, in the same context and with d2=1, the receiver name entered as s1 will be used, and the receiver name decoded from the incoming reference data will be ignored.
- Because the RINEX format reserves only 20 characters for receiver names, including the 8 characters used when the $PASHS,AGB command is set to "ON", Ashtech recommends you specify receiver names in 12 characters max. so that they can be converted to RINEX format without being truncated.
- $PASHS,RCP,REF will be NAKed if the [G] option (GLONASS tracking) has not been installed yet. $PASHS,OWN can always be run whether the [G] option is installed or not.
- Running either of these commands with s1 left empty ("zero" length) amounts to deleting the previously entered receiver name from the backup memory. After this has happened, the receiver name will be extracted from the incoming base data, when available. The following sentences are therefore syntactically admissible:

  $PASHS,RCP,REF

$PASHS,RCP,REF,,0
$PASHS,RCP,REF,,1

Example

Entering "Unknown" as the name of the local receiver:

$PASHS,RCP,OWN,UNKNOWN*2A

RST: Default Settings

Function

This command is used to reset the receiver parameters to their default values. All parameters are reset except:

- Ephemeris data
- Almanac data
- Position
- GPS time

Command Format

Syntax

$PASHS,RST[*cc]

Parameters

None.

Example

Resetting the receiver:

$PASHS,RST*20

RT2: Enabling/Disabling RTCM 2.3 Messages

Function

This command is used to individually enable or disable RTCM 2.3 message types on the specified port.

Command Format

Syntax

$PASHS,RT2,s1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range	Default
s1	RTCM 2.3 message type	See table below	-
c2	Port ID	A, B, C	-
s3	Enables (ON) or disables (OFF) RTCM 2.3 message type	ON, OFF	OFF
f4	Output rate in seconds	See table below	1
*cc	Optional checksum	*00-*FF	-

Supported Data Messages:

Data	Description	f4 range
1, 9	GPS corrections	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999
24	Geographical coordinates (ITRF) tagged to ARP for reference position	
3, 22	Geographical coordinates (ITRF) tagged to L1 phase center for reference position	
23	Antenna name	
18, 19	GPS and GLONASS raw observations	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 sec., etc. (integer minutes up to 960 sec.)
20, 21	GPS and GLONASS RTK corrections	
16, 36	User messages (those entered through $PASHS,MSG)	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999 sec.)
31, 34	GLO corrections	
32	Reference GLONASS PZ 90 position	

Example

Setting the default RTCM 2.3 configuration in a base:

$PASHS,POS,<position coordinates> or $PASHS,POS,CUR*51
$PASHS,RT2,18,A,ON,1*39
$PASHS,RT2,19,A,ON,1*38
$PASHS,RT2,24,A,ON,13*05
$PASHS,RT2,23,A,ON,31*02
[$PASHS,RT2,16,A,ON,59*0A]

Comments

- With RTCM 2.3, the last command (bracketed) in the above example is the only way a rover can be informed of the base receiver name (provided the corresponding $PASHS,MSG is used on the base). However, the RTCM 2 standard only allows message type 16 to be used for viewing purposes, and not in further automatic processing steps.
- Defining output rates for RTCM 2.3 messages should follow the rules presented in *Understanding How MB100 Generates Differential Data Messages on page 36*.

- **About DGNSS corrections**: Ashtech receivers generate the same content in messages 3 and 32, which is coordinates entered by the $PASHS,POS command. To transform the original geodetic position ($PASHS,POS) into a Cartesian position (types 3 and 32), the WGS-84 or PZ-90.02 ellipsoid is used depending on which primary GNSS system is used (PGS).

  Ashtech receivers generate DGNSS corrections (type 1 for GPS and type 31 for GLO) against reference position “type 3” (=32), using all GNSS satellites coordinates expressed either in WGS-84 or PZ.90.02, depending on the primary GNSS system used.

  Ashtech rovers ignore the content of message type 32. Ashtech rovers need the “type 3” reference position to apply “type 1” and/or “type 31” corrections in DGNSS positions.

RT2,ALL: Disabling All RTCM 2.3 Messages

Function

This command is used to disable all the currently active RTCM 2.3 data messages on the specified port.

Command Format

Syntax

$PASHS,RT2,ALL,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all RTCM 2.3 messages on port A:

$PASHS,RT2,ALL,A,OFF*22

RT3: Enabling/Disabling RTCM 3.1 Messages

Function

This command is used to individually enable or disable RTCM 3.1 message types on the specified port.

Command Format

Syntax

$PASHS,RT3,s1,c2,s3[,f4][*cc]

Parameters

Parameter	Description	Range	Default
s1	RTCM 3.1 message type	See table below	-
c2	Port ID	A, B, C	-
s3	Enables (ON) or disables (OFF) RTCM 3.1 message type	ON, OFF	OFF
f4	Output rate in seconds	See table below	1
*cc	Optional checksum	*00-*FF	-

Supported Data Messages:

Data	Description	f4 range
1001-1004	GPS+SBAS raw observations	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 sec, etc. (integer minutes up to 960 sec.)
1005-1006	ITRF coordinates of reference position, tagged to ARP	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999 sec.)
1007-1008	Antenna name	
1009-1012	GLONASS raw observations	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 sec., etc. (integer minutes up to 960 sec.)
1013	System information	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999 sec.)
1019	GPS ephemeris data	1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999 sec.)
1020	GLONASS ephemeris data	
1029	User unicode message (as entered through $PASHS,MSG)	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999 sec.)
1033	Antenna and receiver names	
1071-1077	GPS MSM messages	0.05, 0.1, 0.2, 0.5, 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, 60, 120 sec., etc. (integer minutes up to 960 sec.)
1081-1087	GLONASS MSM messages	
1230	GLONASS code bias message	1, 2, 3, 4, 5 sec., etc. (integer seconds up to 999 sec.)

Examples

Setting the default RTCM 3.1 configuration to serve the base mode:

$PASHS,POS,<position coordinates> or $PASHS,POS,CUR*51

```
$PASHS,RT3,1004,A,ON,1*34
$PASHS,RT3,1012,A,ON,1*33
$PASHS,RT3,1006,A,ON,13*05
$PASHS,RT3,1033,A,ON,31*03
```

Setting the default RTCM 3.1 configuration to serve the raw data collection mode:

```
$PASHS,POS,MOV*41
$PASHS,RT3,1004,A,ON,1*3
$PASHS,RT3,1012,A,ON,1*33
$PASHS,RT3,1006,A,ON,1*36
$PASHS,RT3,1013,A,ON,61*04
$PASHS,RT3,1033,A,ON,300*32
$PASHS,RT3,1019,A,ON,600*3F
$PASHS,RT3,1020,A,ON,600*35
```

Comments

Defining output rates for RTCM 3.1 messages should follow the rules presented in *Understanding How MB100 Generates Differential Data Messages on page 36*.

RT3,ALL: Disabling All RTCM 3.1 Messages

Function

This command is used to disable all the currently active RTCM 3.1 data messages on the specified port.

Command Format

Syntax

```
$PASHS,RT3,ALL,c1,OFF[*cc]
```

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Example

Disabling all RTCM 3.1 messages on port A:

```
$PASHS,RT3,ALL,A,OFF*23
```

SBA: Enabling/Disabling SBAS Tracking

Function

This command may be used for one of the following:

- Power on the part in the RF section that deals with SBAS tracking (unless already ON) and in all cases enable SBAS tracking.
- Or power off this part in the RF section (unless required for GPS tracking) and in all cases disable SBAS tracking.

Command Format

Syntax

$PASHS,SBA,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Enables (ON) or disables (OFF) SBAS tracking	ON, OFF	ON
*cc	Optional checksum	*00-*FF	

Example

Enabling SBAS tracking:

$PASHS,SBA,ON*08

SBA,MAN: Manual Selection of SBAS Satellites

Function

This command is used to select the two SBAS satellites the receiver is only allowed to work with.

You may use $PASHQ,PAR to view the current selection of SBAS satellites.

Command Format

Syntax

Choosing two SBAS satellites:
$PASHS,SBA,MAN,d1,d2[*cc]

Returning to automatic selection of SBAS satellites:
$PASHS,SBA,AUT[*cc

Parameters

Parameter	Description	Range
d1	PRN of first SBAS satellite	33-51
d2	PRN of second SBAS satellite	33-51
*cc	Optional checksum	*00-*FF

Comments

The command syntax is valid only if d1 and d2 are different and both specified.

The PRN of a satellite is simply obtained by subtracting “87” to its satellite number. For example, for sat number “120”, the PRN is: 120 - 87= 33.

Example

Choosing SBAS satellites PRN#33 and PRN#37:

$PASHS,SBA,MAN,33,37*4F

SIT: Defining a Site Name

Function

This command is used to define the site name occupied by the receiver.

Command Format

Syntax

$PASHS,SIT,s1[*cc]

Parameters

Parameter	Description	Range
s1	Site name, a 4-character string where alphanumeric symbols are allowed.	See tables below
*cc	Optional checksum	*00-*FF

Example

Defining site name “1001”:

$PASHS,SIT,1001

Comments

- In rover mode, the site name can be set “on line” in the field to name occupation points. The site name appears in the PBN raw data message, and in the ATM,PVT message, and probably in some other messages. Historically, “????” refers to an unknown site name or a kinematic sequence in progress.
- In base mode, the site name refers to the reference station ID. The table below lists the permitted range of values for the reference station ID, depending on the message format used to route this information.

Message format	Permitted range of reference station ID
CMR/CMR+	0000-0031
RTCM 2	0000-1023
RTCM 3	0000-4095

The resulting reference station ID may be different from s1 if s1 does not fall within the permitted range. The table below lists the resulting values of the reference station ID, depending on which s1 value was entered through $PASHS,SIT, and depending on the message format carrying the reference station ID information.

s1 value set to:	RTCM 3	RTCM 2	CMR/ CMR+	ATOM 2, 4, 5, 6, 7, 14	ATOM 3 PBN
Default (not set)	31	31	31	31	????
0017	17	17	17	17	0017
0123	123	123	31	123	0123
1666	1666	31	31	1666	1666
5000	31	31	31	31	5000
A5CD	31	31	31	31	A5CD

SMI: Code Measurement Smoothing

Function

This command is used to set the smoothing interval in code measurements.

Command Format

Syntax

$PASHS,SMI,d1[,d2[,d3]][*cc]
or
$PASHS,SMI,d1,,d3[*cc]
or
$PASHS,SMI,,,d3[*cc]

Parameters

Parameter	Description	Range	Default
d1	Time constant in seconds for the simplest first-order smoothing, when there is no L1-L2 smoothing applied. "0" means no smoothing applied.	0-100	100
d2	Time constant in seconds for the second-order smoothing, when there is no L1-L2 smoothing applied. "0" means no 2nd-order smoothing applied.	0 100-600	600
d3	Time constant in seconds for the first-order L1-L2 smoothing. "0" means no L1-L2 smoothing applied.	0-3600	1800
*cc	Optional checksum	*00-*FF	-

Example

Setting code measurement smoothing to 100 seconds:

$PASHS,SMI,100

Comments

- The smoothing correction is provided in the MCA/MPC raw data message along with the smoothing count. If the internal smoothing count is greater than 255, then the smoothing count in the MCA/MPC message is set to 255.
- Sending the command without d1, d2 or d3 will not change the corresponding value currently used, which will stay either that entered previously through a valid SMI command, or the default value if no such command was run.

SOM,CTT: Cumulative Tracking Time Mask

Function

This command is used to mask the signal observations that do not meet the minimum continuous tracking time you specify. This means that only the observations meeting this requirement will be output (all the others will be rejected).

Command Format

Syntax

$PASHS,SOM,CTT,d1[,d2][*cc]

Parameters

Parameter	Description	Range	Default
d1	Minimum continuous tracking time for differential data, in seconds. “0” means no mask.	0-255	10
d2	Minimum continuous tracking time for raw data, in seconds. If d2 is omitted, then the receiver will assume d2=d1. “0” means no mask.	0-255	10
*cc	Optional checksum	*00-*FF	

Raw Data Masked by d2	Differential Data Masked by d1
MCA MPC DPC ATM,RNX,SCN,0	All other messages

Comments

- “Continuous” tracking means tracking “without cycle slips”.
- This command can only mask some particular signal data. If however at the same time the L1CA data are disabled, then ALL the satellite observations, and not only the masked ones, will be rejected.
- This command equally affects all GNSS and their signals.

Examples

Setting CTT masks for differential and raw data to 20 s:

$PASHS,SOM,CTT,20*65

Enabling all signal observations to be output regardless of the continuous tracking time requirement (no CTT mask):

$PASHS,SOM,CTT,0*57

SOM,NAV: Navigation Data Mask

Function

This command is used to mask the signal observations that are not consistent with the relevant navigation data. This means that only the observations meeting this requirement will be output (all the others will be rejected).

Command Format

Syntax

$PASHS,SOM,NAV,s1[,s2][*cc]

Parameters

Parameter	Description	Range	Default
s1	Differential data mask	ON, OFF	ON
s2	Raw data mask. If s2 is omitted, then the receiver will assume s2=s1	ON, OFF	OFF
*cc	Optional checksum	*00-*FF	

Raw Data Masked by s2	Differential Data Masked by s1
MCA MPC DPC ATM,RNX,SCN,0	All other messages

Comments

- Stating that signal observations are consistent with the corresponding navigation data means the following:
  - GNSS time, receiver position and receiver clock offsets are available and valid.
  - L1CA pseudo-range for a given satellite is measured and valid.
  - The corresponding satellite navigation data are available and valid.
  - The L1CA pseudo-range and computed range are in agreement with each other.
  - Elevation and azimuth angles are available and valid.

If at least one of the above requirements is not met, then signal observations are found to be not consistent with navigation data.

- The $PASHS,SOM,NAV command will mask all signals (all observables) corresponding to a given satellite, even if some other pseudo-ranges (e.g. L2C) can be consistent with the navigation data.
- The $PASHS,SOM,NAV command equally affects all GNSS systems.

Examples

Setting NAV masks for both differential and raw data:

$PASHS,SOM,NAV,ON*7C

Enabling all signal observations to be output regardless of whether they are consistent with navigation data or not (no NAV mask):

$PASHS,SOM,NAV,OFF*32

SOM,SNR: Signal-to-Noise Ratio Mask

Function

This command is used to mask the signal observations that do not meet the minimum signal-to-noise ratio you specify. This means that only the observations meeting this requirement will be output (all the others will be rejected).

Command Format

Syntax

$PASHS,SOM,SNR,f1[,f2][*cc]

Parameters

Parameter	Description	Range	Default
f1	Differential data mask. “0” means no mask.	0-60 dBHz	28
f2	Raw data mask. If s2 is omitted, then the receiver will assume s2=s1. “0” means no mask.	0-60 dBHz	28
*cc	Optional checksum	*00-*FF	

Raw Data Masked by f2	Differential Data Masked by f1
MCA MPC DPC ATM,RNX,SCN,0	All other messages

Comments

- The $PASHS,SOM,SNR command can only mask particular signal data for which the SNR does not meet your requirement. If however at the same time the L1CA data are disabled, then all the satellite observations will also be masked.
- The $PASHS,SOM,SNR command equally affects all GNSS systems and their signals, except GPS L1P(Y) and L2P(Y). For these two signals, a hard-coded SNR threshold is applied.

Examples

Setting SNR masks for both differential and raw data to 30 dBHz:

$PASHS,SOM,SNR,30*68

Enabling all signal observations to be output regardless of the signal-to-noise ratio:

$PASHS,SOM,SNR,0*5B

SOM,WRN: Channel Warnings Mask

Function

This command is used to mask the signal observations for those signals flagged with channel warnings (MPC/MCA warning bits are counted from 1 to 8). This means that only the observations from non-flagged signals will be output (all the others will be rejected).

Command Format

Syntax

$PASHS,SOM,WRN,s1[,s2][*cc]

Parameters

Parameter	Description	Range	Default
s1	Differential data mask	ON, OFF	ON
s2	Raw data mask. If s2 is omitted, then the receiver will assume s2=s1	ON, OFF	OFF
*cc	Optional checksum	*00-*FF	

Raw Data Masked by s2	Differential Data Masked by s1
MCA MPC DPC ATM,RNX,SCN,0	All other messages

Comments

- A signal is considered as flagged in at least one of the following cases:
  - Carrier phase tracking is not stable (Bit 3 of MPC/MCA warning is set).
  - Pseudo-range data quality is bad (Bit 5 of MPC/MCA warning is set).
  - Polarity is not resolved (MPC/MCA Phase Tracking Polarity flag is set to 0).
- The $PASHS,SOM,WRN command will mask only some particular signal data (e.g. L1CA or L2P) corresponding to a given satellite. If at the same time the L1CA data are disabled, then ALL the satellite observations, and not only those masked, will be rejected.
- The $PASHS,SOM,WRN command equally affects all GNSS systems.

Examples

Setting WRN masks for both differential and raw data:

$PASHS,SOM,WRN,ON*6E

Enabling all signal observations to be output regardless of whether some signals are flagged or not (no WRN mask):

$PASHS,SOM,WRN,OFF*20

SPD: Setting Baud Rates for Serial Ports

Function

This command is used to set the baud rate of each serial port individually.

Command Format

Syntax

$PASHS,SPD,c1,d2[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
d2	Baud rate code	2-15 (ports A and C) (Default: 9) 2-11 (port B) (Default: 9) See Baud Rate Codes in table below
*cc	Optional checksum	*00-*FF

Baud Rate Codes:

Code	Baud Rate	Code	Baud Rate	Code	Baud Rate	Code	Baud Rate
2	1 200	6	19 200	10	230 400	14	2 500 000
3	2 400	7	38 400	11	460 800	15	5 000 000
4	4 800	8	57 600	12	921 600		
5	9 600	**9**	**115 200**	13	1 428 571		

Example

Setting port A and B to 19 200 Bd:

$PASHS,SPD,A,6*45

Comments

- If the baud rate chosen for a port is too slow to meet the volume of data output requested on this port, then the following message is output on the port, after the board has detected that data messages were skipped:

  $PASHR,SKP*3C

- Port C is a virtual serial port serving as a bridge from USB to COM. Although you may use $PASHS,SPD to set the baud rate for port C and check this setting in the $PASHR,SPD response, in fact it does not make sense to set a baud rate for this port and so this setting is simply ignored.

SVM: Setting the Maximum Number of Observations in the PVT

Function:

This function is used to set the maximum number of code and doppler observations used in the PVT calculation.

Command Format

Syntax

$PASHS,SVM,d1[*cc]

Parameters

Parameter	Description	Range	Default
d1	Maximum number of observations	0-26	14
*cc	Optional checksum	*00-*FF	-

Example

Setting the number of observations to 25:

$PASHS,SVM,25*16

Comments

This setting affects all the positioning modes, except for the time-tagged RTK mode for which this limit is hardware coded and set to 14 satellites.

Relevant Query Command

$PASHQ,SVM
$PASHQ,PAR

TOP: Defining the Type of Output Position

Function

This command is used to define the best position solution the receiver is allowed to output through NMEA and ATM,PVT messages.

Command Format

Syntax

$PASHS,TOP,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Position type: • "RTK": Up to RTK • "DIF": Up to RTCM differential • "SBA": Up to SBAS differential • "ALO": Only standalone	RTK, DIF, SBA, ALO	RTK
*cc	Optional checksum	*00-*FF	

Comments

- The receiver can compute several types of position solutions simultaneously. By default, the receiver will provide the best position solution computed (up to RTK). In some cases however, you may prefer to get a position solution of lesser quality because you think it is more robust. That's exactly what this command allows you to do.
- Although "ACKed" even when the selected type of output position is other than "RTK", $PASHS,FST,ON and $PASHS,FST,OFF will in no case affect the output position.
- Choosing a type of output position does not mean this type of position will always be output. If you choose RTK and the conditions to get this type of position status are not met (no corrections available, or computed position does

not meet the quality criteria), then only a position of lesser quality will be provided.

- When the internal Heading mode is used and differential data are received via port H, the output position will never be of the RTK or DIF type (even if one of these types has been selected through $PASHS,TOP).This is because the reference position is known to be a priori not of better quality than the receiver position (SBA or ALO)
- Whatever your choice of the output position type, the content of the VEC (baseline) and ATT (attitude) messages will never be affected by this choice.

Example

Choosing RTCM differential as the best position solution to output:

$PASHS,TOP,DIF*59

UDP: User-Defined Dynamic Model Parameters

Function

This command is used to set the upper limits of the dynamic model (velocity, acceleration).

Command Format

Syntax

$PASHS,UDP,f1,f2,f3,f4[*cc]

Parameters

Parameter	Description	Range	Default
f1	Maximum expected horizontal velocity in m/s.	0-100 000	100 000
f2	Maximum expected horizontal acceleration in m/s/s.	0-100	100
f3	Maximum expected vertical velocity in m/s.	0-100 000	100 000
f4	Maximum expected vertical acceleration in m/s/s.	0-100	100
*cc	Optional checksum	*00-*FF	-

Example

Setting the dynamic model:

$PASHS,UDP,10,1,2,0.5*1D

Comments

The user-defined dynamic model is activated by the $PASHS,DYN,9 command. Note that when the adaptive dynamic mode (DYN,8) is selected, the user-defined model is automatically excluded from the possible models that could best describe the current receiver dynamics.

Relevant Query Command $PASHQ,UDP

See Also $PASHS,DYN

USE: Enabling or Disabling the Tracking of a GNSS Satellite

Function: This function is used to enable or disable the tracking of a particular GNSS satellite.

Command Format

Syntax

$PASHS,s1,USE,[d2],s3[*cc]

Parameters

Parameter	Description	Range	Default
s1	GNSS type: • GPS: GPS • GLO: GLONASS • SBA: SBAS • QZS: QZSS	GPS, GLO, SBA, QZS	-
d2	Satellite PRN: • For GPS: 1-32 • For GLONASS: 1-24 • For SBAS: 1-19 • For QZSS: 1-5 d2 omitted in the command line combined with s3=ON: Re-enables all the satellites you previously disabled.	1-32	-
s3	Tracking status	ON,OFF	ON
*cc	Optional checksum	*00-*FF	-

Comments

- Use the command as many times as the number of satellites you want to disable from tracking.

- The tracking of a given satellite is suspended immediately after disabling it. The satellite is also excluded from the list of searched/tracked satellites.
- Conversely, re-enabling a previously disabled satellite consists of re-inserting it into the list of searched/tracked satellites.
- Be aware that re-enabling the tracking of a satellite shortly after having disabled it does not mean that the receiver will be able to quickly restore the tracking of this satellite.

Examples

Disabling GLONASS satellite PRN 5:

$PASHS,GLO,USE,5,OFF

Disabling all GLONASS satellites:

$PASHS,GLO,USE,,OFF

Enabling all GPS satellites:

$PASHS,GPS,USE,,ON

UTS: Synchronizing Onto GNSS Time

Function: This function is used to enable or disable a clock steering mechanism that synchronizes measurements and coordinates with the GPS system time (default) or the GLONASS system time (see $PASHS,PGS) rather than with the local (receiver) clock.

Command Format

Syntax

$PASHS,UTS,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Enabling (ON) or disabling (OFF) synchronization with GNSS time	ON, OFF	ON
*cc	Optional checksum	*00-*FF	-

Example

Enabling synchronization:

$PASHS,UTS,ON*0A

Comments

- All output data, except for legacy MPC, MCA, DPC and RPC, are always clock steered.
- Legacy MPC, MCA, DPC and RPC data appear as steered or not steered depending on the last $PASHS,UTS command run.
- The PBN message contains internal clock and clock drift estimates when UTS is OFF and reports zeros for these estimates when UTS is ON.
- The ATOM,RNX message with scenario 0 contains original clock and clock drift estimates that can be used on decoding side to restore the original (not steered) observables, if needed.
- The receiver clock estimate used in the steering procedure can internally be expressed with respect to GPS or GLONASS time whichever is selected as the primary system. The same clock estimate is used to correct both GPS and GLONASS observables.

VEC: Vector Output Mode

Function

This command is used to define the output mode for vector (baseline) estimates. Changing this parameter will affect all the messages providing baseline-related information, but not those providing position information such as POS and GGA (the output of which is controlled by the CPD,FST command).

Command Format

Syntax

$PASHS,VEC,s1[*cc]

Parameters

Parameter	Description	Range	Default
s1	Output mode for baseline parameters: • TT: Time-tagged • FST: Fast	TT, FST	TT
*cc	Optional checksum	*00-*FF	-

Comments

- With Fast output mode selected (s1=FST), the rover receiver can provide a baseline solution at every receiver epoch. Usually, this mode delivers estimates of lesser quality compared to TT. However, they are available at regular intervals of time and with minimum latency.

- With time-tagged output mode selected (s1=TT), the rover receiver can provide a baseline solution only at epochs to which incoming reference (corrections) data are tagged. This mode delivers the best possible estimates in terms of accuracy. Estimates may however be affected if the data link experiences delays or outages.

Example

Enabling Fast output mode:

$PASHS,VEC,FST*48

VIP: Defining a Virtual Port

Function

This command is used to define a virtual port. Using a virtual port is possible only after it has been associated with a physical port. It is indeed through the physical port that the virtual port can be accessed.

Command Format

Syntax

$PASHS,VIP,c1,c2[*cc]
$PASHS,VIP,c1,OFF[*cc]

Parameters

Parameter	Description	Range
c1	Virtual port	Z
c2	Physical port	A, B, C
*cc	Optional checksum	*00-*FF

Comments

- To date, only virtual port “Z” can be defined. Port Z may be associated with any of the existing physical ports. By default, the virtual port is OFF.
- The transport layer used to create a virtual port is the ATM,DAT,EXT message (see *ATOM Reference Manual*). The frame of this message always includes a single, complete, original receiver message (any of those described in this manual).
- In theory, any type of data can be transmitted via a virtual port. In 99% of the user cases however, only a physical port is used for raw data recording (messages ATM,RNX;

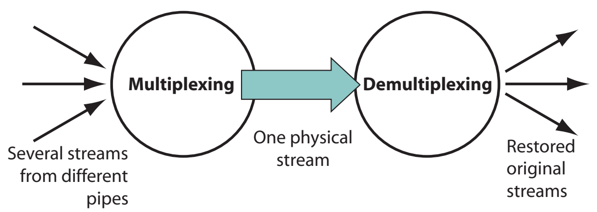
ATM,NAV and ATM,ATR) while the same port is also used to transmit ATM,RNX as differential stream.

- **Encapsulation (ENC) vs. Virtual Port (VIP) technique**: The encapsulation technique (ENC,ASH/RT3) is used to wrap up each of the requested messages into one high-level transport layer. Wrapping each of the messages is done independently:

  $PASHR,RT3,<original_RT3_message>
  $PASHR,CMR,<original_CMR_message>
  $PASHR,ATM,<original_ATM_message>

  Using the encapsulation technique facilitates and speeds up reception and data decoding on reception side.

  In contrast, the virtual port technique makes sense when you need to merge different input streams coming from different ports or pipes into one physical stream occupying one physical port. As shown on the diagram below, the virtual port technique therefore consists in multiplexing and then demultiplexing the different streams.



  Both techniques (encapsulation and virtual port) use RT3 transport, but each has its own message structure. ENC,RT3/ASH does not use ATM,DAT,EXT to encapsulate data, while VIP does. In general, the solutions that are applicable to ENC are not suitable for VIP, and the other round. In conclusion each of these two techniques have their own use area, each fulfilling distinct tasks.

Example

Delivering simultaneously both corrections and raw data on port A:

- Delivering corrections on physical port A:

  $PASHS,ATM,RNX,A,ON,0.1,&SCN,204*48

- Delivering raw data on virtual port Z associated with physical port A:

  $PASHS,VIP,Z,A*21

$PASHS,ATM,RNX,Z,ON,0.1,&SCN,204*53

Turning off virtual port Z:

$PASHS,VIP,Z,OFF*2F

ZDA: Setting Date & Time

Function

This command is used to set the date and time in the receiver.

Command Format

Syntax

$PASHS,ZDA,m1,d2,d3,d4[*cc]

Parameters

Parameter	Description	Range
m1	UTC time (hhmmss.ss)	000000.00-235959.99
d2	Current day	01-31
d3	Current month	01-12
d4	Current year	0000-9999
*cc	Optional checksum	*00-*FF

Example

$PASHS,ZDA,151145.00,13,03,2008*0A

Relevant Query Command

$PASHQ,ZDA

See also

$PASHS,LTZ

Chapter 5. Query Command Library

ALM: Almanac Message

Function

This command allows you to output the latest GPS almanac data on the specified port, or on the port on which the query is made if no port is specified. Each response line describes the almanac data from a given GPS satellite.

Command Format

Syntax

$PASHQ,ALM[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPALM,d1,d2,d3,d4,h5,h6,h7,h8,h9,h10,h11,h12,h13,h14,h15*cc

Parameters

Parameter	Description	Range
d1	Total number of messages	01-32
d2	Number of this message	01-32
d3	Satellite PRN number	01-32
d4	GPS week	4 digits
h5	SV health (in ASCII hex)	2 bytes
h6	e: Excentricity (in ASCII hex)	4 bytes
h7	toe: Almanac reference time, in seconds (ASCII hex)	2 bytes
h8	Io: Inclination angle, in semicircles (ASCII hex)	4 bytes
h9	OMEGADOT: Rate of ascension, in semicircles/second (ASCII hex)	4 bytes
h10	A1/2: Square root of semi-major axis, in meters 1/2 (ASCII hex)	6 bytes
h11	OMEGA: Argument of perigee, in semicircles (ASCII hex)	6 bytes

Parameter	Description	Range
h12	OMEGA0: Longitude of ascension mode, in semicircles (ASCII hex)	6 bytes
h13	Mo: Mean anomaly, in semi-circles (ASCII hex)	6 bytes
h14	af0: Clock parameter, in seconds (ASCII hex)	3 bytes
h15	af1: Clock parameter, in seconds/second (ASCII hex)	3 bytes
*cc	Checksum	*00-*FF

Example

$PASHQ,ALM
$GPALM,31,1,01,65535,00,39A8,4E,1FEA,FD65,A10C8C,B777FE,935A86,C994BE,0C6,001*73
$GPALM,31,2,02,65535,00,4830,4E,00D9,FD49,A10D24,64A66D,3B6857,E6F2A3,0BA,001*7A
$GPALM,31,3,03,65535,00,552B,4E,F572,FD3B,A10CE1,20E624,0CD7E1,D10C32,0CA,001*0D
$GPALM,31,4,04,65535,00,4298,4E,0069,FD46,A10D5C,0EE3DC,3C2E3E,51DDF9,FF0,FFF*0A
...

Automatic Output of ALM Messages

This is a reminder on how to output ALM messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,ALM,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output ALM messages on port A at a rate of 15 seconds:

$PASHS,NME,ALM,A,ON,15

ANP: Antenna Parameters

Function

This command allows you to read the antenna parameters of the specified antenna name, or of the complete antenna database if no antenna name is specified.

Command Format

Syntax

$PASHQ,ANP[,s1][,c2][*cc]

Parameters

Parameter	Description	Range
s1	Antenna name (case sensitive)	31 characters max.
c2	ID of the port through which the receiver provides the reply line. If no port ID is specified, the reply is sent to the port routing the query command.	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Example

$PASHQ,ANP,ProMark500
BEGIN ANTENNA
ProMark500
L1 N: -000.80 E: -001.40 U: +101.8
L1 PAE:+000.0 +000.9 +001.9 +002.8 +003.7 +004.7 +005.4 +006.0 +006.4 +006.5 +006.3 +005.8 +004.8 +003.2 +001.1 -001.6 -005.1 +000.0 +000.0
L2 N: +000.80 E: -001.10 U: +086.20
L2 PAE:+000.0 -000.9 -001.1 -000.6 +000.2 +001.1 +002.0 +002.7 +003.0 +003.0 +002.6 +001.7 +000.5 -001.1 -003.0 -004.9 -006.8 +000.0 +000.0
END ANTENNA

ATT: Heading, Roll and Pitch

Function

This command allows you to output the heading, roll and pitch message on the specified port, or on the port routing the query command if no output port is specified.

Command Format

Syntax

$PASHQ,ATT[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,ATT,f1,f2,f3,f4,f5,f6,d7*cc

Parameters

Parameter	Description	Range
f1	Week time in seconds.	000000.00-604799.99
f2	True heading angle in degrees.	000.00-359.99
f3	Pitch angle in degrees.	±90.00
f4	Roll angle in degrees.	±90.00
f5	Carrier measurement RMS error, in meters.	Full range of real variables
f6	Baseline RMS error, in meters.	Full range of real variables
d7	Integer ambiguity is “Fixed” or “Float”: • 0: Fixed • >0: Float	0, >0
*cc	Optional checksum	*00-*FF

Comments

- When baseline parameters are output in time-tagged mode ($PASHS,VEC,TT), the ATT message is generated only for those epochs for which reference data are available. In fast mode ($PASHS,VEC,FST), the ATT message will be generated for each receiver epoch using additional extrapolation algorithms.
- d7=0 does not necessarily mean that the corresponding position message (e.g. POS) includes a “fixed” RTK position solution. When d7>0, the reported attitude is not necessarily wrong. This is because even a float solution over long baselines can achieve sub-degree accuracy for attitude.

Example

Querying the heading and roll/pitch message on the current port:

$PASHQ,ATT
$PASHR,ATT,310080.0,248.57,+04.22,,0.0027,0.0000,0*2B

Automatic Output of ATT Messages

This is a reminder on how to output ATT messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,ATT,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output ATT messages on port A at a rate of 0.5 second:

$PASHS,NME,ATT,A,ON,0.5

BPS: Base Position Message

Function

This command returns the base position message on the specified port, or on the port routing the query command if no output port is specified. The command will be “NAKed” if the RTK Base option [K] is not installed.

Command Format

Syntax

$PASHQ,BPS[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

The base station position message is transmitted along with the DBEN RPC message.

This message contains the base station’s coordinates, always tagged to the L1 phase center of the antenna. When generating the response to this command, the receiver always ignores the optional tagging parameter set in $PASHS,POS and the antenna offset parameters (between f5 and s11) are all unconditionally set to zero.

The BPS response message is in the form below

$PASHR,BPS,m1,c2,m3,c4,f5,0.0000,0.0000,00.0000,00000.00,00.0000,s11*cc

Parameters

Parameter	Description	Range
m1	Latitude, in degrees and decimal minutes	0-90° 00-59.9999999’
c2	Direction of latitude	N, S
m3	Longitude, in degrees and decimal minutes	0-180° 00-59.9999999’
c4	Direction of longitude	E, W
f5	Altitude, in meters	±99999.9999
s11	Status byte in hexadecimal notation	See table below
*cc	Checksum	*00-*FF

Bit	Description
1 (LSB)	Coordinates of base station not entered
2	Not used
3	Base station is not computing position from raw pseudo-ranges
4	Entered coordinates for base are more than 500 meters away (in each direction) from the computed position, based on raw pseudo-ranges.
5	Base station is not tracking satellites properly
6, 7, 8	Not used

Comment The BPS message is not supported in moving base mode. All fields are set to zero in this case.

Example

$PASHQ,BPS

$PASHR,BPS,5539.3790930,N,03731.5553470,E,+00268.4450,0.0000,0.0000,00.0000,00000.00,00.0000,00*0E

Automatic Output of BPS Messages This is a reminder on how to output BPS messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,BPS,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output BPS messages on port A at a rate of 30 seconds:

$PASHS,NME,BPS,A,ON,30

CPD,REF: Querying Rover for Base Position Used

Function This command returns the base position, as available from a rover that uses it or will use it when possible. The reply is returned on the specified port, or on the port routing the query command if no output port is specified.

The base position can be returned “as is” or tagged to some specified point (L1 phase center or ARP) if the rover knows about the antenna used at the base (through the antenna name).

If the base antenna name is unknown, then no coordinate transformation will be possible and the receiver will assume the L1 phase center and the ARP of the base antenna are physically the same point in space.

Command Format

Syntax

$PASHQ,CPD,REF[,s1][,c2][*cc]

Parameters

Parameter	Description	Range
s1	Requested base position: • ORG: Original base position (as originally presented in decoded differential message) • PC1: Base position tagged to L1 phase center • ARP: Base position tagged to ARP Omitting s1 is equivalent to using ORG for this parameter.	ORG, PC1, ARP
c2	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,CPD,REF,f1,f2,f3,m4,c5,m6,c7,f8,s9,s10,s11*cc

Parameters

Parameter	Description	Range
f1	X component, in meters	±99999999.9999
f2	Y component, in meters	±99999999.9999
f3	Z component, in meters	±99999999.9999
m4	Latitude in degrees, decimal minutes (ddmm.mmmmmmm)	0-90
c5	North (N) or South (S)	N, S
m6	Longitude in degrees, decimal minutes (dddmm.mmmmmmm)	0-180
c7	East (E) or West (W)	E, W
f8	Ellipsoidal height, in meters	±9999.9999
s9	Position attribute: • PC1: Reference position tagged to L1 phase center • ARP: Reference position tagged to ARP	PC1, ARP, SPT
s10	Position source: • REC: Received via a differential message. May be referenced to a local datum, depending on the differential data provider. • ENT: As entered in the rover. Refers to the current ITRF. • CPT: As computed by the rover. May refer to the current ITRF.	REC, ENT, CPT

Parameter	Description	Range
s11	Reference base station ID	
*cc	Checksum	*00-*FF

Comments

- The coordinates refer to the original datum on which the reference position of the base is expressed.

  In response to the CPD,REF command, and although most often providers only send cartesian coordinates expressed on an unknown local datum, the receiver will return both the cartesian and geographical coordinates of the reference position. The IGS05 realization (WGS-84 ellipsoid model) will be used in the receiver to transform the cartesian coordinates into geographical coordinates.
- In most cases, the reference position of the base is that decoded from the incoming differential data (REC), e.g. from RTCM-3 MT 1006. But with **further firmware versions**, using the s10 parameter, there will be a possibility to either enter base coordinates on the rover (ENT), or compute approximate base coordinates (CPT) directly from the received base observations. If the three types of base positions are available from the rover, then the command will only return the one with the highest internal priority (i.e. the one currently used or the one that will be used when this is possible).
- If there is no reference base position available from a rover, then the command will only return empty fields.
- Most of the known differential protocols (RTCM-2, RTCM-3, CMR/CMR+) generate reference position tagged either to the ARP or to the L1 phase center (PC1).

  Some proprietary protocols, such as Ashtech DBEN, transmit reference coordinates tagged to some survey point (SVP) that differ from the ARP in both the vertical and horizontal directions.

  Usually these protocols contain internally offset values allowing the original SVP position to be transformed into ARP.

  Since only PC1 tagging and ARP tagging are currently supported, for such proprietary protocols, the command will automatically return the ARP position when the s1 parameter is omitted or the ORG position is implicitly requested.

Example **$PASHQ,CPD,REF,ARP*32**

$PASHR,CPD,REF,2860347.6069,2196947.3233,5243149.9374,5539.35890
84,N,03731.6072193,E,268.158,ARP,REC,0031*64

CTS: Handshaking

Function

This command allows you to query the handshaking (RTS/CTS) protocol status. If no port is specified in the command, the response message is sent back to the port that issued the query command.

Command Format

Syntax

$PASHQ,CTS[,s1][*cc]

Response Format

Syntax

$PASHR,CTS,s1,s2*cc

Parameters

Parameter	Description	Range
s1	Queried port	
s2	Current status of RTS/CTS handshaking protocol	ON, OFF
*cc	Checksum	*00-*FF

Comment

If the queried port does not support the CTS/RTS protocol, it is always reported as “OFF” for this port.

Example

$PASHQ,CTS

$PASHR,CTS,ON*1D

DDM: Differential Decoder Message

Function

This command returns a report about the decoded differential messages on the specified port, or on the port routing the query command if no output port is specified.

The report may refer to several types of differential messages that the built-in Differential Decoder gets from different receiver ports.

If the second RTK engine is enabled, the DD2 message is output as well.

Command Format

Syntax

$PASHQ,DDM[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,DDM,c1,s2,s3,d4,s5,f6,f7,s8*cc

If the second RTK engine is enabled, the response also includes the following:

$PASHR,DD2,c1,s2,s3,d4,s5,f6,f7,s8*cc

Parameters

Parameter	Description	Range
c1	Port receiving corrections	A, B, C
s2	Message transport	RT2, RT3, CMR, CMP, DBN, TPZ or ATM
s3	Message number/identifier	e.g. 1004 for RT3, RNX for ATM, etc.
d4	Counter of decoded messages	0-9999
s5	Base ID (empty if Base ID not available)	
f6	Time tag, in seconds, as read from the decoded message	
f7	Age of corrections, in seconds	
s8	Attribute	60 characters max.
*cc	Checksum	*00-*FF

Comments

- Corrections can come from more than one receiver port.
- Parameter d4 counts the number of decoded messages modulo 10000. It is incremented by one each time a new message is decoded.

  Each receiver port has its own counter. All counters are initialized to 0 after the $PASHS,RST or $PASHS,INI command has been issued. Counters are very useful to check if some DDM messages are lost at the output.
- Parameter f6 is the time tag, in seconds, as read from the decoded message. Regardless of its original presentation,

the time tag provided in the DDM message is always expressed in GPS time, within the GPS week.

For example the time tag from message RTCM-3 MT 1012 (referring to GLONASS time) will be transformed to a GPS time tag in the DDM message.

Another example is the time tag from message RTCM-2 MT 18. It is originally presented modulo 3600 seconds, but appears as a complete time tag in the DDM message.

If the decoded message does not contain any time tag (e.g. RT3 1005), the f6 field is empty.

- The age of corrections is defined as the difference, in seconds, between the receiver time at the end of the decoding process and the time tag read from the decoded message. If no tag time is provided in the message (e.g. RT3 1005), the f7 field is empty.
- Parameter s8 holds some vital attributes from the decoded message. It contains a number of parameters delimited by “slash” characters (/). It may also be empty.
- Although controlled by the $PASHS,NME,DDM command, the DDM message is independent of the NMEA period. It is output every time a new differential message is decoded.

Example

Eanbling the receiver to output the DDM message on port A:

$PASHS,NME,DDM,A,ON*12

Generating the differential decoder message on port A:

$PASHQ,DDM,A*57

$PASHR,DDM,A,RT2,18,6832,0000,461334.0,0.5,G:1/S:8/L:0/M:1*5A

GBS: GNSS Satellite Fault Detection

Function

This command returns the GBS message supporting RAIM (Receiver Autonomous Integrity Monitoring) on the specified port, or on the port routing the query command if no output port is specified.

Command Format

Syntax

$PASHQ,GBS[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

The response complies with the *Standard for Interactive Marine Electronic Devices – NMEA 0183 3.00*.The message header is in the form:

$--GBS

If only GPS satellites are used in the position solution, the message header is:

$GLGBS

If only GLONASS satellites are used in the position solution, the message header is:

$GPGBS

If several types of satellites are used in the position solution, the message header is:

$GNGBS

While the receiver is operated in RTK mode, the delivered GBS messages will only consist of empty fields.

Syntax

$--GBS,m1,f2,f3,f4,d5,f6,f7,f8*cc

Parameters

Parameter	Description	Range
m1	UTC time of the GGA or GNS fix associated with this message (hhmmss.ss)	000000.00-235959.99
f2	Expected error in latitude, in meters, due to bias, with noise= 0	-
f3	Expected error in longitude, in meters, due to bias, with noise= 0	-
f4	Expected error in altitude, in meters, due to bias, with noise= 0	-
d5	ID number of most likely failed satellite	1-32 for GPS 33-64 for SBAS 65-96 for GLON-ASS
f6	Probability of missed detection for most likely failed satellite	-
f7	Estimate of bias, in meters, on most likely failed satellite	-

Parameter	Description	Range
f8	Standard deviation of bias estimate	-
*cc	Checksum	*00-*FF

Automatic Output of GBS Messages

This is a reminder on how to output GBS messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GBS,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GBS messages on port A at a rate of 120 seconds:

$PASHS,NME,GBS,A,ON,120

GGA: GNSS Position Message

Function

This command is used to output a GGA message containing the last computed position on the specified port, or on the port on which the query is made if no port is specified. If no position is computed, the message will be output anyway, but with some blank fields.

Command Format

Syntax

$PASHQ,GGA[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPGGA,m1,m2,c3,m4,c5,d6,d7,f8,f9,M,f10,M,f11,d12*cc

Parameters

Parameter	Description	Range
m1	Current UTC time of position (hhmmss.ss)	000000.00-235959.99
m2	Latitude of position (ddmm.mmmmmm)	0-90 0-59.999999
c3	Direction of latitude	N, S

Parameter	Description	Range
m4	Longitude of position (dddmm.mmmmmm)	0-180 0-59.999999
c5	Direction of longitude	E,W
d6	Position type: • 0: Position not available or invalid • 1: Autonomous position • 2: RTCM Differential (or SBAS Differential) • 3: Not used • 4: RTK fixed • 5: RTK float • 9: SBAS Differential. See comment.	0-5, 9
d7	Number of GNSS Satellites being used in the position computation	0-26
f8	HDOP	0-99.9
f9,M	Altitude, in meters, above mean seal level. “M” for meters	± 99999.999,M
f10,M	Geoidal separation in meters. “M” for meters. Based on the official NATO's standard mean-sea-level algorithm (5-degree grid of height).	± 999.999,M
f11	Age of differential corrections, in seconds	0-600
d12	Base station ID (RTCM only)	0-4095
*cc	Checksum	*00-*FF

Example

$PASHQ,GGA

$GPGGA,131745.00,4717.960847,N,00130.499476,W,4,10,0.8,35.655,M,
47.290,M,3.0,1000*61

Comment

The code allotted to a position solution of the SBAS differential type is either “2” or “9”, depending on the last $PASHS,NPT command run.

Automatic Output of GGA Messages

This is a reminder on how to output GGA messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GGA,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GGA messages on port A at a rate of 0.5 second:

$PASHS,NME,GGA,A,ON,0.5

GLL: Geographic Position - Latitude/Longitude

Function

This command is used to output a GLL message containing the last computed position. The message is output on the specified port, or on the port on which the query is made if no port is specified. If no position is computed, the message will be output anyway, but all position-related fields will be blank.

Command Format

Syntax

$PASHQ,GLL[*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPGLL,m1,c2,m3,c4,m5,c6,c7*cc

Parameters

Parameter	Description	Range
m1	Latitude of position (ddmm.mmmmmm)	0-90 0-59.999999
c2	Direction of latitude	N, S
m3	Longitude of position (dddmm.mmmmmm)	0-180 0-59.999999
c4	Direction of longitude	E,W
m5	Current UTC time of position (hhmmss.ss)	000000.00- 235959.99
c6	Status • A: Data valid • V: Data not valid	A, V
c7	Mode indicator: • A: Autonomous mode • D: Differential mode • N: Data not valid	A, D, N
*cc	Checksum	*00-*FF

Example

$PASHQ,GLL
$GPGLL,4717.960853,N,00130.499473,W,132331.00,A,D*7D

Automatic Output of GLL Messages

This is a reminder on how to output GLL messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GLL,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GLL messages on port A at a rate of 0.5 second:

$PASHS,NME,GLL,A,ON,0.5

GRS: GNSS Range Residuals

Function

This command is used to output a GRS message containing the satellite range residuals. The message is output on the specified port, or on the port on which the query is made if no port is specified. No message will be output until a position is computed.

Command Format

Syntax

$PASHQ,GRS[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$--GRS,m1,d2,n(f3)*cc

Parameters

Parameter	Description	Range
“$--GRS” Header	$GPGRS: Only GPS satellites are used. $GLGRS: Only GLONASS satellites are used. $GNGRS: Several constellations (GPS, SBAS, GLONASS) are used.	$GPGRS, $GLGRS, $GNGRS
m1	Current UTC time of position (hhmmss.ss)	000000.00-235959.99
d2	Mode used to compute range residuals	Always “1”
f3	Range residual for satellite used in position computation (repeated “n” times, where n is the number of satellites used in position computation). Residuals are listed in the same order as the satellites in the GSA message so that each residual provided can easily be associated with the right satellite.	±999.999
*cc	Checksum	*00-*FF

Example

$PASHQ,GRS
$GNGRS,141003.50,1,1.14,-0.48,0.26,0.20,-0.94,-0.28,-1.18*61
$GNGRS,141003.50,1,-0.20*4F

Automatic Output of GRS Messages

This is a reminder on how to output GRS messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GRS,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GRS messages on port A at a rate of 0.5 second:

$PASHS,NME,GRS,A,ON,0.5

GSA: GNSS DOP and Active Satellites

Function

This command is used to output a GSA message containing data related to DOP values and satellites used in the position solution. The message is output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,GSA[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$--GSA,c1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,d14,f15,f16,f17*cc

Parameters

Parameter	Description	Range
"$--GSA" Header	$GPGSA: Only GPS satellites are used. $GLGSA: Only GLONASS sats are used. $GNGSA: Several constellations (GPS, SBAS, GLONASS) are used.	$GPGSA, $GLGSA, $GNGSA
c1	Output mode: • M: Manual • A: Automatic	M, A
d2	Position indicator: • 1: No position available • 2: 2D position • 3: 3D position	1-3
d3-d14	Satellites used in the position solution (blank fields for unused channels)	GPS: 1-32 GLONASS: 65-96 SBAS: 33-64 QZSS: 193-197
f15	PDOP	0-9.9
f16	HDOP	0-9.9
f17	VDOP	0-9.9
*cc	Checksum	*00-*FF

Example

$PASHQ,GSA
$GNGSA,A,3,20,11,13,23,17,04,31,,,,,,1.6,0.9,1.3*21
$GNGSA,A,3,81,83,68,,,,,,,,,1.6,0.9,1.3*2C

Automatic Output of GSA Messages

This is a reminder on how to output GSA messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GSA,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GSA messages on port A at a rate of 0.5 second:

$PASHS,NME,GSA,A,ON,0.5

GST: GNSS Pseudo-Range Error Statistics

Function

This command is used to output a GST message containing standard deviations relevant to the position solution. The message is output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,GST[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$--GST,m1,f2,f3,f4,f5,f6,f7,f8*cc

Parameters

Parameter	Description	Range
"$--GST" Header	$GPGST: Only GPS satellites are used. $GLGST: Only GLONASS satellites are used. $GNGST: Several constellations (GPS, SBAS, GLONASS) are used.	$GPGST, $GLGST, $GNGST
m1	Current UTC time of position (hhmmss.ss)	000000.00-235959.99
f2	RMS value of standard deviation of range inputs (DGNSS corrections included), in meters	0.000-99.999
f3	Standard deviation of semi-major axis of error ellipse, in meters	0.000-99.999
f4	Standard deviation of semi-minor axis of error ellipse, in meters	0.000-99.999
f5	Orientation of semi-major axis of error ellipse, in degrees from true North	0.000-99.999
f6	Standard deviation of latitude error, in meters	0.000-99.999
f7	Standard deviation of longitude error, in meters	0.000-99.999
f8	Standard deviation of altitude error, in meters	0.000-99.999
*cc	Checksum	*00-*FF

Example

$PASHQ,GST
$GNGST,154013.80,0.642,1.746,1.303,27.197,1.663,1.407,2.456*79

Automatic Output of GST Messages

This is a reminder on how to output GST messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GST,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GST messages on port A at a rate of 0.5 second:

$PASHS,NME,GST,A,ON,0.5

GSV: GNSS Satellites in View

Function

This command is used to output a GSV message containing information on the satellites in view. The message is output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,GSV[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$--GSV,d1,d2,d3,n(d4,d5,d6,f7)*cc

The set of parameters (d4,d5,d6,f7) can be repeated up to 4 times in a single response line, corresponding to the description of 4 different satellites. The number of response lines is therefore dependent on the number of satellites in view (e.g. three response lines if between 9 and 12 satellites are visible).

Parameters

Parameter	Description	Range
"$--GSV" Header	$GPGSV: GPS and SBAS satellites. $GLGSV: GLONASS satellites	$GPGSV, $GLGSV
d1	Total number of messages	1-4
d2	Message number	1-4
d3	Total number of satellites in view	1-15
d4	Satellite PRN	GPS: 1-32 GLONASS: 65-96 SBAS: 33-64 QZSS: 193-197
d5	Elevation in degrees	0-90
d6	Azimuth in degrees	0-359
f7	SNR in dB.Hz	30.0-60.0
*cc	Checksum	*00-*FF

GPS PRN number is d4
SBAS PRN number is d4+87
GLONASS slot number is d4-64

Example

$PASHQ,GSV
$GPGSV,2,1,07,20,61,066,50,11,30,146,36,13,41,200,50,23,73,134,52*7C
$GPGSV,2,2,07,33,34,198,42,17,40,242,50,04,37,304,48*47
$GLGSV,1,1,04,77,29,098,46,84,19,332,46,83,49,276,52,68,57,300,52*67

Automatic Output of GSV Messages

This is a reminder on how to output GSV messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,GSV,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output GSV messages on port A at a rate of 10 seconds:

$PASHS,NME,GSV,A,ON,10

HDT: True Heading

Function

This command is used to output an HDT message (last computed true heading in degrees) on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,HDT[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPHDT,f1,T*cc
$GPTHS,f1,T*cc

Parameters

Parameter	Description	Range
f1,T	Last computed heading value, in degrees “T” for “True”.	0-359.9°
*cc	Checksum	*00-*FF

Comments

- When baseline parameters are output in time-tagged mode ($PASHS,VEC,TT), the HDT message is generated only for those epochs for which reference data are available. In fast mode ($PASHS,VEC,FST), the HDT message will be generated for each receiver epoch using additional extrapolation algorithms.

Example

$PASHQ,HDT
$GPHDT,121.2,T*35

Automatic Output of HDT Messages

This is a reminder on how to output HDT messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,HDT,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output HDT messages on port A at a rate of 1 second:

$PASHS,NME,HDT,A,ON,1

LTN: Latency

Function

This command returns the current value of latency on the specified port, or on the port routing the query command if no output port is specified.

Command Format

Syntax

$PASHQ,LTN[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,LTN,d1*cc

Parameters

Parameter	Description	Range
d1	Latency in milliseconds.	Typically less than 100 ms in FAST RTK mode
*cc	Optional checksum	*00-*FF

Example

Querying the value of latency:

$PASHQ,LTN
$PASHR,LTN,60*08

Comments

Latency refers to the time it takes for the receiver to compute a position from the measurement time tag and prepare data to be transmitted through the serial port. The value of latency depends on the number of locked satellites.

In time-tagged mode, the value of latency also includes the time required for the correction stream to go through the data communication link before arriving at the receiver.

Automatic Output of LTN Messages

This is a reminder on how to output LTN messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,LTN,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output LTN messages on port A at a rate of 10 seconds:

$PASHS,NME,LTN,A,ON,10

PAR: Receiver Parameters

Function

This command lists the currently used parameters for the specified type of receiver settings. The response is returned through the specified port, or on the port routing the query command if no output port is specified.

Command Format

Syntax

$PASHQ,PAR[,[s1][,c2]][*cc]

Parameters

Parameter	Description	Range
s1	Type of receiver settings. If s1 is omitted, the response lists the parameters for all types of settings.	See table below.
c2	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Type	Description
INP	Input information.
OUT	Output information.
RCV	Receiver settings.
RTK	RTK settings.
STA	Status information.

Response Format

Example

Querying receiver parameters for output information settings:

$PASHQ,PAR,OUT

```
==============================+================================
 OUTPUT INFORMATION          |
-----------------------------|
PORTS: A:9,NTV B:9,NTV C:9,NTV D:9,NTV
VIRTUAL PORTS: Z:OFF
ATL:OFF
NME:
   LTN ZDA GLL GGA RMC VTG GST GBS GSA GSV GRS RRE ALM GMP MSG HDT THS POS GIS SAT BPS ATT VEC TTT PTT DDM
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
ATM:
   PVT ANG DAT RNX MES SUP TT1 TT2 ATR NAV STA EVT ALR
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
RT3:
   1005 1006 1001 1002 1003 1004 1007 1008 1033 1029 1019 1013
A:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
B:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
C:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
D:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
RT2:
   3   22  24  18  19  20  21  1   9   23  16
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
CMR:
   1   0   2
A:  OFF OFF OFF
B:  OFF OFF OFF
C:  OFF OFF OFF
D:  OFF OFF OFF
CMP:
   0
A:  OFF
B:  OFF
C:  OFF
D:  OFF
RAW:
   MCA MPC DPC RPC PBN SNV SAL ION SBD SNW SAW
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
==============================+================================
```

etc.

NOTE: When running the $PASHQ,PAR,OUT command, the returned parameters should be interpreted as follows:

- “OFF” means the message is currently not output.
- “ON” means it is currently output with the default output rate.
- A specified output rate means this rate was user-set through the appropriate command.

Querying receiver parameters for input information settings:

$PASHQ,PAR,INP

```
==============================+================================
 INPUT INFORMATION           |
-----------------------------|
 RTK1 CORR SOURCE            | H,ALL
 RTK2 CORR SOURCE            | OFF
 PORTS SPEED              | A:9 B:9 C:9 D:9
==============================+================================
Log File End at 18-11-13 14:04 COM1 MB100
```

Omitting s1 in the command is equivalent to asking for all receiver parameters, one type after the other. A typical response is given below.

$PASHQ,PAR

```
Log File Start at 18-11-13 14:03 COM1 MB100
$PASHQ,PAR
==============================+=================================
 STATUS INFORMATION          |
------------------------------|
 STORED POSITION             | 4717.940292,N,00130.533338,W,077.509 COMPUTED
 DATE (dd.mm.yyyy)           | 18.11.2013
 UTC TIME (hhmmss.ms)        | 130313.30
 GPS TIME SCALE              | 1767(5):133409300(8)
 GLO TIME SCALE              | 6531(4):57793300(5)
 SVS TRACKED                 | 13 (GPS:11 SBA:2 GLO:0 QZS:0)
 SVS USED                    | 11 (GPS:11 SBA:0 GLO:0 QZS:0)
 SOLUTION STATUS             | 1
 EXTERNAL ANTENNA STATUS     | CONNECTED
==============================+=================================
==============================+=================================
 COMMON SETTINGS:            |
------------------------------|
 INTERNAL RECEIVER NAME      | MB100
 FIRMWARE VERSION            | Hm26
 REFERENCE CLOCK             | INTERNAL
 ANTENNA MODE                | AUTO(INTERNAL)
 GNSS CONFIGURATION          | DUO
 GPS ALLOWED TO TRACK        | ON,1C YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
 GLO ALLOWED TO TRACK        | OFF YYYYYYYYYYYYYYYYYYYYYYYY
 SBA ALLOWED TO TRACK        | ON YYYYYYYYYYYYYYYYYYY
 QZS ALLOWED TO TRACK        | OFF YYYYY
 PRIMARY GNSS SYSTEM         | GPS
 INTERNAL UPDATE PERIOD [msec]| 50
 CHANNELS-SVS ASSIGNMENT     | AUT
 DYNAMIC                     | ADAPTIVE
 USER DYNAMIC PARAMETERS     | 100000.0,100.0,100000.0,100.0
 CLOCK STEERING              | ON
 OUTPUT ADJUSTMENT TO ANTENNA |
 ANTENNA REDUCTION (TO)      | L1 PHASE CENTER (NO REDUCTION)
 CODE CORRELATOR MODE        | STROBE CORRELATOR
 CODE SMOOTHING INTERVAL [sec]| 100,600,1800
 ADJUST GLONASS BIASES       | OFF
 POSITION ELEVATION MASK [deg]| 05
 MAX SVS IN PVT              | 14
 OUTPUT POSITION TYPE (UP TO) | RTK
 VECTOR DATA OUTPUT MODE     | FAST
 PPS PERIOD [sec]            | 0.00
 PPS OFFSET [msec]           | 0
 PPS SYNCHRONIZED EDGE       | RISING
 EVENT MARKER EDGE           | RISING
------------------------------+--------------------------------
 DIFF GENERATOR SETTINGS:    |
------------------------------|
 CUR ANTENNA NAME            |
 OWN ANTENNA NAME            |
 OW2 ANTENNA NAME            |
 OWN RECEIVER NAME           | MB100
 SITE NAME                   | ????
 TEXT MESSAGE                | MB100
 REFERENCE POSITION TYPE     | MOVING
 ANTENNA SLANT [m]           | 0.000
 ANTENNA RADIUS [m]          | 0.000
 ANTENNA VERTICAL OFFSET [m] | 0.000
 ANTENNA HEIGHT [m]          | 0.000
 ANTENNA HORIZ. AZIMUTH [deg] | 0.000
 ANTENNA HORIZ. OFFSET [m]   | 0.000
 TEMPERATURE [degree]        | ????
 PRESSURE [mBar]             | ????
 RELATIVE HUMIDITY [%]       | ????
------------------------------+--------------------------------
 OBSERVATION OUTPUT MASKING  |
------------------------------|
 BY ELEVATION [deg]          | 5,5/05,05
 BY SNR [dBHz]               | 28,28/00,00
 BY TRACKING TIME [sec]      | 10,10/00,00
 BY NAVIGATION DATA          | ON,OFF/OFF,OFF
 BY CHANNEL WARNINGS         | ON,OFF/OFF,OFF
==============================+=================================
==============================+=================================
 RTK1 SETTINGS:              |
------------------------------|
 OPERATION MODE              | HEADING
 AMB. FIXING RELIABILITY     | 99.0
 PROTOCOLS ALLOWED           | ALL
 BASELINE LEN LIMITATION     | NO LIMITATION
 NETWORK USAGE GPS:GLO       | 1:1
 VRS ASSUMPTION              | 0
 FAST RTK MODE               | ON
 MOVING BASE MODE            | 1
 STREAM ID                   | H (INTERNAL HEADING)
 REFERENCE ANTENNA NAME      |
 REFERENCE RECEIVER NAME     |
```

```
------------------------------+--------------------------------
 ARROW1 SETTINGS:             |
------------------------------|
 ARROW MODE                   | ON
 ARROW BASELINE LENGTH [m]    | 0.998 CALIBRATED
 ARROW HEADING OFFSET [deg]   | 0.000
 ARROW ELEVATION OFFSET [deg] | 0.000
 ARROW MAX ELEVATION [deg]    | 15
 ARROW BASELINE LEN SIGMA [m] | 0.001
==============================+================================
==============================+================================
 RTK2 SETTINGS:               |
------------------------------|
 OPERATION MODE               | OFF
 AMB. FIXING RELIABILITY      | 99.0
 PROTOCOLS ALLOWED            | ALL
 BASELINE LEN LIMITATION      | NO LIMITATION
 NETWORK USAGE GPS:GLO        | 1:1
 VRS ASSUMPTION               | 0
 MOVING BASE MODE             | 0
 STREAM ID                    |
 REFERENCE ANTENNA NAME       |
 REFERENCE RECEIVER NAME      |
------------------------------+--------------------------------
 ARROW2 SETTINGS:             |
------------------------------|
 ARROW MODE                   | OFF
 ARROW BASELINE LENGTH [m]    | 0.000
 ARROW HEADING OFFSET [deg]   | 0.000
 ARROW ELEVATION OFFSET [deg] | 0.000
 ARROW MAX ELEVATION [deg]    | 15
 ARROW BASELINE LEN SIGMA [m] | 0.010
==============================+================================
==============================+================================
 INPUT INFORMATION            |
------------------------------|
 RTK1 CORR SOURCE             | H,ALL
 RTK2 CORR SOURCE             | OFF
 PORTS SPEED                  | A:9 B:9 C:9 D:9
==============================+================================
==============================+================================
 OUTPUT INFORMATION           |
------------------------------|
PORTS: A:9,NTV B:9,NTV C:9,NTV D:9,NTV
VIRTUAL PORTS: Z:OFF
ATL:OFF
NME:
   LTN ZDA GLL GGA RMC VTG GST GBS GSA GSV GRS RRE ALM GMP MSG HDT THS POS GIS SAT BPS ATT VEC TTT PTT DDM
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
ATM:
   PVT ANG DAT RNX MES SUP TT1 TT2 ATR NAV STA EVT ALR
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
RT3:
   1005 1006 1001 1002 1003 1004 1007 1008 1033 1029 1019 1013
A:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
B:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
C:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
D:  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF  OFF
RT2:
   3  22  24  18  19  20  21  1   9   23  16
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
CMR:
   1  0  2
A:  OFF OFF OFF
B:  OFF OFF OFF
C:  OFF OFF OFF
D:  OFF OFF OFF
CMP:
   0
A:  OFF
B:  OFF
C:  OFF
D:  OFF
RAW:
   MCA MPC DPC RPC PBN SNV SAL ION SBD SNW SAW
A:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
B:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
C:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
D:  OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
==============================+================================
Log File End at 18-11-13 14:04 COM1 MB100
```

PAR,ATM: ATOM Data Generation Settings

Function This command lists the currently used settings to generate ATOM messages. The response is returned through the specified port, or on the port routing the query command if no output port is specified.

Command Format

Syntax

$PASHQ,PAR,ATM[,[s1][,c2]][*cc]

Parameters

Parameter	Description	Range
s1	ATOM message type. If s1 is omitted, the response lists the settings for all the ATOM messages.	PVT, ATR, NAV, DAT, RNX, EVT, STA
c2	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Data	Description
PVT	Settings for generating ATOM, PVT messages (best RTK)
ATR	Settings for generating ATOM, ATR messages
NAV	Settings for generating ATOM, NAV messages
DAT	Settings for generating ATOM, DAT messages
RNX	Settings for generating ATOM, RNX messages
EVT	Settings for generating ATOM, EVT messages
STA	Settings for generating ATOM, STA messages
ANG	Settings for generating ATOM, ANG messages
SUP	Settings for generating ATOM, SUP messages
ALR	Settings for generating ATOM, ALR messages

Response Format

The response is in a user-readable format. See *ATOM Reference Manual*.

PIN: Programmable Pin

Function

This command returns the current settings of the specified programmable pin on the I/O connector. The response is returned on the port routing the query command.

Command Format

Syntax

$PASHQ,PIN[,d1][*cc]

Parameters

Parameter	Description	Range
d1	Identification of the programmable pin ID. If d1 is not specified, the response will include information about all the available programmable pins.	0
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,PIN,d1,s2[,d3]*cc

Parameters

Parameter	Description	Range
d1	Programmable pin ID recalled in this field • 0: TIOA1 • 1: TIOB2	0, 1
s2	Pin function status: • OFF: no function assigned • PAV: Position available • RSP: Radar simulated pulse • LED: LED signal output	OFF, PAV, RSP or LED
d3	If s2=PAV, d3 is the number of consecutive seconds while position is not computed that causes the signal on the pin to switch to low level. If s2=RSP, d3 has been set to “1” to make Radar Simulated Pulse output available on the pin. if s2=OFF, d3 has been omitted If s2=LED, “1” means red LED is used, and “2”, green LED is used.	1-3600 1 or 2
*cc	Optional checksum	*00-*FF

Example

$PASHQ,PIN
$PASHR,PIN,0,LED,2*40
(TIOA1 is green LED output)
or
$PASHR,PIN,0,LED,1*42
(TIOB2 is red LED output)

POS: Computed Position Data

Function

This command allows you to query the computed position. The message is output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,POS[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,POS,d1,d2,m3,m4,c5,m6,c7,f8,f9,f10,f11,f12,f13,f14,f15,f16,s17*cc

Parameters

Parameter	Description	Range
d1	Position mode: • 0: Autonomous • 1: RTCM code differential • 2: RTK float • 3: RTK fixed • 5: Extrapolated	0-3 or 5
d2	Count of satellites used in position computation	0-26
m3	Current UTC time of position (hhmmss.ss)	000000.00- 235959.99
m4	Latitude of position (ddmm.mmmmmm)	0-90° 00-59.999999 minutes
c5	North (N) or South (S)	N, S
m6	Longitude of position (ddmm.mmmmmm)	0-180° 00--59.999999 minutes
c7	East (E) or West (W)	E, W
f8	Altitude above the WGS84 ellipsoid	±9999.000
f9	Age of Differential data, in seconds	0.0-600.0
f10	True Track/Course Over Ground, in degrees	0.0-359.9
f11	Speed Over Ground, in knots	0.0-999.9
f12	Vertical velocity in dm/s	±999.9
f13	PDOP	0-99.9
f14	HDOP	0-99.9
f15	VDOP	0-99.9

Parameter	Description	Range
f16	TDOP	0-99.9
s17	Firmware version ID	4-char. string
*cc	Checksum	*00-*FF

Example

$PASHQ,POS

$PASHR,POS,3,10,151858.00,4717.960848,N,00130.499487,W,82.972,,0.0,
0.0,-0.0,2.0,1.1,1.7,1.3,G010*49

Automatic Output of POS Messages

This is a reminder on how to output POS messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,POS,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output POS messages on port A at a rate of 0.2 second:

$PASHS,NME,POS,A,ON,0.2

PRT: Baud Rate Settings

Function

This command is used to query the baud rate setting for port A, B or C. The message is output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,PRT[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,PRT,c1,d2*cc

Parameters

Parameter	Description	Range
c1	Queried port ID	A, B, C
d2	Baud rate code	2-15 for port A or C 2-11 for port B (see table below) (See table below)
*cc	Checksum	*00-*FF

Code	Baud Rate	Code	Baud Rate	Code	Baud Rate	Code	Baud Rate
2	1 200	6	19200	10	230400	14	2500000
3	2 400	7	38400	11	460800	15	5000000
4	4 800	8	57600	12	921600		
5	9 600	9	115200	13	1428571		

Example

$PASHQ,PRT,A

$PASHR,PRT,A,6*55

PTT: PPS Time Tag

Function

This command asks for the PPS time tag message to be output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,PTT[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,PTT,d1,m2*cc

Parameters

Parameter	Description	Range
d1	Day of week: • 1: Sunday • 7: Saturday	1-7
m2	GPS time tag in hours, minutes, seconds	0-23:59:59.9999999
*cc	Checksum	*00-*FF

Example

Enabling the receiver to output the PTT message on port A:

$PASHS,NME,PTT,A,ON

Generating the PPS time tag message on port A:

$PASHQ,PTT,A
$PASHR,PTT,6,20:41:02.0000000*2D

Comments

- The response to this command will be sent out once, right after the next PPS pulse is generated.
- The response contains the GPS time at which the PPS pulse was sent, including the offset if an offset was set when the PPS pulse was enabled.
- This message is not output unless the PPS pulse is enabled and the PPS option [L] is activated in the receiver. Being set to a periodical output by the $PASHS,NME,PTT command, this message is independent of the NMEA period. It is only linked to the PPS period.

Asking for the Output of a Raw Data Message

Function

This command is used to output a particular type of raw data message in the old Ashtech proprietary format. Each query will result in only one message delivered via the specified port, or on the port on which the query is made if no port is specified.

To output raw data at regular intervals of time, refer to command $PASHS,RAW,MCA, etc.

Command Format

Syntax

$PASHQ,s1[,c2][*cc]

Parameters

Parameter	Description	Range
s1	Ashtech Raw data message identification	See table below
c2	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Data	Description
MCA	GPS/GLONASS/SBAS L1 CA data
MPC	GPS/GLONASS/SBAS measurements
PBN	Position information
SNV	GPS ephemeris data
SNG	GLONASS ephemeris data
SNW	SBAS ephemeris data
SAL	GPS almanac data
SAG	GLONASS almanac data
SAW	SBAS almanac data
ION	Ionospheric parameters
SBD	SBAS data message
RPC	CPD carrier phase (DBEN)

Response Format

See detailed description of each of these messages in the chapter *Raw Data Messages in Ashtech Proprietary Format on page 193*.

RCP: Receiver Parameters

Function

This command returns the parameters of the receiver whose case-sensitive name is specified in the command. The response is returned through the specified port, or on the port routing the query command if no output port is specified.

Command Format

Syntax

$PASHQ,RCP[,[s1][,c2]][*cc]

Parameters

Parameter	Description	Range
s1	Name of the receiver (case sensitive). If s1 is omitted, the parameters for all the receivers described in the database are listed.	31 characters max.
c2	ID of the port returning the response	A, B, C
*cc	Checksum	*00-*FF

Response Format

The response is in user-readable form. Only fractional parts of the GLONASS carrier phase biases are of practical importance.

Below is an example of a response to this command:

```
$PASHQ,RCP,MyReceiver
PREDEFINED RECEIVER LIST (1):
BEGIN RECEIVER
MyReceiver:
L1 BIAS: +0.059,+0.613 +0.671 +0.729 +0.786 +0.829 +0.898 +0.949
         +0.000 +0.059 +0.112 +0.182 +0.253 +0.312 +0.373
L2 BIAS: +0.049,+0.667 +0.714 +0.761 +0.808 +0.849 +0.893 +0.947
         +0.000 +0.044 +0.102 +0.153 +0.201 +0.254 +0.292
MEAN CODE BIASES L1,L2: +40.40, -12.20
END RECEIVER
```

For pre-defined receivers, only receiver names are provided. For user-defined receivers, all bias parameters, except for code bias values, are provided as well. Examples:

```
$PASHQ,RCP
PREDEFINED RECEIVER LIST (17):
BEGIN RECEIVER
ASHTECH:
END RECEIVER
BEGIN RECEIVER
ProMark500:
END RECEIVER
BEGIN RECEIVER
ProFlex500:
END RECEIVER
BEGIN RECEIVER
MB500:
END RECEIVER
BEGIN RECEIVER
ProMark800:
END RECEIVER
BEGIN RECEIVER
MMapper100:
END RECEIVER
BEGIN RECEIVER
ProMark100:
END RECEIVER
```

```
BEGIN RECEIVER
ProMark200:
END RECEIVER
BEGIN RECEIVER
MB100:
END RECEIVER
BEGIN RECEIVER
NOVATEL:
END RECEIVER
BEGIN RECEIVER
TRIMBLE:
END RECEIVER
BEGIN RECEIVER
SEPTENTRIO:
END RECEIVER
BEGIN RECEIVER
TOPCON:
END RECEIVER
BEGIN RECEIVER
JAVAD:
END RECEIVER
BEGIN RECEIVER
MyReceiver:
L1 BIAS: +0.059,+0.613 +0.671 +0.729 +0.786 +0.829 +0.898 +0.949
         +0.000 +0.059 +0.112 +0.182 +0.253 +0.312 +0.373
L2 BIAS: +0.049,+0.667 +0.714 +0.761 +0.808 +0.849 +0.893 +0.947
         +0.000 +0.044 +0.102 +0.153 +0.201 +0.254 +0.292
MEAN CODE BIASES L1,L2: +40.40, -12.20
END RECEIVER
```

RID: Receiver Identification

Function

This command allows you to read the receiver identification parameters. The message is sent through the specified port, or through the port where the query is made if no port is specified.

Command Format

Syntax

$PASHQ,RID[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,RID,s1,s2*cc

Parameters

Parameter	Description	Range
s1	Receiver type	GNSS
s2	GNSS board firmware version. The firmware version contains one letter to identify the type of firmware and 3 characters for the version number (e.g. V1.00=G100)	Gxxx (4 characters)
*cc	Checksum	*00-*FF

Example

$PASHQ,RID*28

$PASHR,RID,GNSS,Kxxx*xx

RIO: Receiver Options

Function

This command returns the receiver identification and options on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,RIO[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

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

Parameters

Parameter	Description	Range
s1	Receiver type (i.e. “GNSS”)	4 characters
s2	GNSS board firmware version: Gxxx	4 characters
s3	Reserved field (can take arbitrary value)	16 characters
s4	Options list (see table below)	19 characters
s5	Receiver serial number	16 characters
*cc	Optional checksum	*00-*FF

Firmware Options List (always listed in the order given below):

Option	Description	If Not Installed
[T] [W] [5] [2]	Position/raw data update rate: [T]: 10 Hz [W]: 20 Hz [5]: 5 Hz [2]: 2 Hz	All programmed messages should use an update rate complying with the installed options otherwise they will each be NAKed. $PASHQ,POP should also be run to check the current internal update rate setting.
[J]	RTK rover	See 4. below.
[K]	RTK base	Requests for setting RTCM, CMR, PBC, BPS and DPC messages will all be NAKed. Exception for RTCM-2 message types 1, 3, 9, 16, 31, 32, 34 and 36.
[L]	Timing Pulse Output (PPS)	The following commands will be NAKed: $PASHS,PPS - $PASHQ,PPS - $PASHQ,PTT- $PASHS,NME,PTT - $PASHS,PHE - $PASHQ,PHE - $PASHS,NME,TTT
[E]	Photogrammetry event marker	See 2. below.
[Y]	SBAS tracking	The following commands will be NAKed: $PASHS,SBA $PASHS,RAW,..: requests for SNW, SAW, SBD messages.
[G]	GLONASS tracking	The following commands will be NAKed: $PASHS,GLO Requests for SNG, SAG and CMR/CMR+ message type 3 $PASHS,GNS,CFG set to “1”, “4” or “5”.
[S]	GPS L2CS tracking	See 1. below
[V]	RTK with moving base	See 3. below.
[H]	Heading function	See 3. below
[C]	Advanced multipath mitigation	$PASHS,CRR NAKed

Option	Description	If Not Installed
[P]	GPS L2 frequency tracking	The following commands will be NAKed: $PASHS,GNS,CFG set to “2”, “3”, “4” or “5” $PASHS,CFG in some cases (see this command)
[I]	RAIM	The following commands will be NAKed: $PASHS,NME,GBS $PASHQ,GBS
[F]	Flying RTK	See 4. below.
[D]	Internal heading	$PASHS,CFG,DUO NAKed. See also 5. below.
[N]	GPS tracking	The following commands will be NAKed: $PASHS,GPS $PASHS,GNS,CFG $PASHS,RAW,..: requests for SNV, SAL, ION, DPC, RPC messages
*cc	Optional checksum	

1. This option is obsolete. It cannot be bought and set separately. [S] is strongly linked with option [P] (L2 tracking). If option [P] is installed, then [S] is activated automatically (at firmware level). If [P] is not installed, [S] is disabled.

   Acceptable combination: [P] is installed and [S] is activated automatically:

   $PASHR,RIO,GNSS,Kq25,....,-------S---P------,..... *cc

   Acceptable combination: [P] is not installed and [S] is deactivated automatically:

   $PASHR,RIO,GNSS,Kq25,....,-----------------,..... *cc

   Unacceptable combination: Option [S] cannot be set without the [P] option installed:

   $PASHR,RIO,GNSS,Kq25,....,-------S----------,..... *cc

2. This option is obsolete. It cannot be bought and set separately. [E] is strongly linked with option [L]. If option [L] is installed, then [E] is activated automatically (at firmware level). If [L] is not installed, [E] is disabled.
3. These options are obsolete. They cannot be bought and set separately. [V] and [H] are strongly linked with option [J] (RTK Rover). If option [J] is installed, then [V] and [H]

are activated automatically (at firmware level). If [J] is not installed, [V] and [H] are disabled.

4. If both [J] and [F] are NOT installed, all CPD commands are NAKed. Requests for VEC, HDT and ATT are NAKed as well.

   The RTCM decoder will still be working, but there is no RTK engine running.

   [J] installed and [F] not installed **is a prohibited combination**. Once [J] is installed, [F] is activated automatically.

   If [F] is installed but not [J], the following commands will be ACKed: $PASHS,CPD,FST,ON/OFF - $PASHS,CPD,NET - $PASHS,CPD,RST - $PASHS,CPD,VRS.

   And the following commands will be NAKed: $PASHS,CPD,AFP,0/95/99/99.9 - $PASHS,CPD,BAS,0/1 - all the commands from the $PASHS,CPD,ARR group (MOD, LEN, OFS, PAR).

5. Option D has two main functions:
   – Validating the use of command $PASHS,CFG, DUO, used to configure the receiver in dual-sensor mode so it can collect raw data from two sensors.
   – Enabling the use of the internal heading function, using $PASHS,DIF,PRT,H. This command will run both the differential decoder/processor and the Z-Blade engine to determine the baseline between the two sensors.

   User Tip: The receiver also offers conventional RTK in DUO mode if the [D] option is installed. With the receiver switched to DUO mode, you can get GPS-only, L1-only RTK using either an internal or external source of corrections (internal source: port H; external source: port A, B or C). So with only the [D] option installed, the receiver operates as if it had the [J] option installed as well, but only if operating in DUO mode.

Example

$PASHQ,RIO
$PASHR,RIO,GNSS,Kq25,42DCBD134697BA8D,WJKLEYGSVHCPI----DN,7021000100740001*35

Comments

- Each option is represented by a letter. The presence of a given option is indicated by the presence of the

corresponding letter. A dash ("-") indicates that the option is not installed.
- Options are always listed in the same order (see table above).

RMC: Recommended Minimum Specific GNSS Data

Function

This command is used to output an RMC message containing the last computed position as well as navigation-related data. The message is output on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,RMC[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPRMC,m1,c2,m3,c4,m5,c6,f7,f8,d9,f10,c11,c12*cc

Parameters

Parameter	Description	Range
m1	Current UTC time of position (hhmmss.ss)	000000.00- 235959.99
c2	Status • A: Data valid • V: Data not valid	A, V
m3	Latitude of position (ddmm.mmmmmm)	0-90 0-59.999999
c4	Direction of latitude	N, S
m5	Longitude of position (dddmm.mmmmmm)	0-180 0-59.999999
c6	Direction of longitude	E,W
f7	Speed Over Ground, in knots	000.0-999.9
f8	Course Over Ground, in degrees (true)	000.0-359.9
d9	Date (ddmmyy)	010100-311299
f10	Magnetic variation, in degrees	0.00-99.9
c11	Direction of variation	E, W

Parameter	Description	Range
c12	Mode indicator: • A: Autonomous mode • D: Differential mode • N: Data not valid	A, D, N
*cc	Checksum	*00-*FF

Example

$PASHQ,RMC
$GPRMC,160324.50,A,4717.959275,N,00130.500805,W,0.0,0.0,250208,1.9,W,A*3D

Automatic Output of RMC Messages

This is a reminder on how to output RMC messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,RMC,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output RMC messages on port A at a rate of 0.5 second:

$PASHS,NME,RMC,A,ON,0.5

SAT: Satellites Status

Function

This command allows you to read the status of the different satellite constellations used. The message is output through the specified port, or through the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,SAT[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,SAT,d1,n(d2,d3,d4,f5,c6)*cc

Parameters

Parameter	Description	Range
d1	Number of satellites locked	0-26
d2	SV PRN number	1-32: GPS 33-51: SBAS 65-88: GLONASS 193-197: QZSS
d3	SV azimuth, in degrees	0-359
d4	SV elevation angle, in degrees	0-90
f5	SV signal-noise ratio, in dB.Hz	30.0-60.0
c6	SV used in computation or not • U: SV used • Any other character: SV not used	U, other character
*cc	Checksum	*00-*FF

Example

$PASHQ,SAT

$PASHR,SAT,13,20,092,32,44.0,U,13,206,78,50.0,U,23,056,55,48.0,U,33,198,34,44.0,-,17,218,13,42.0,U,25,152,34,38.0,U,04,276,65,50.0,U,02,308,31,48.0,U,77,052,37,48.0,U,84,294,33,48.0,U,83,234,23,48.0,U,78,124,42,46.0,U,68,034,65,48.0,U*35

Automatic Output of SAT Messages

This is a reminder on how to output SAT messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,SAT,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SAT messages on port A at a rate of 60 seconds:

$PASHS,NME,SAT,A,ON,60

TTT: Event Marker

Function

This message provides the GPS time of the external event. The time is provided with an accuracy of ± 50 nanoseconds.

Response Format

Syntax

$PASHR,TTT,d1,m2*cc

Parameters

Parameter	Description	Range
d1	Day of week: • 1: Sunday • 7: Saturday	1-7
m2	GPS time tag in hours, minutes, seconds	0-23:59:59.9999999
*cc	Optional checksum	*00-*FF

Example

$PASHR,TTT,3,18:01:33.1200417*AC

Comments

- Issuing this output message is tied to the prior execution of the appropriate $PASHS,NME,TTT command (see *NME: Enabling/Disabling NMEA Messages on page 97*), the detection of a signal at the board's external event input and the activation of the [E] event marker firmware option. There is no query command associated with the output of the TTT message.
- This message is independent of the NMEA period. It can be output faster or slower than the NMEA period, depending on the period of the event.

VEC: Vector & Accuracy Data

Function

This command is used to ask the receiver to return vector and accuracy data on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,VEC[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,VEC,m1,d2,d3,d4,d5,d6,d7,d8,f9,d10,f11,d12,f13,f14,f15,f16,f17, f18,f19,f20,f21*cc

Parameters

Parameter	Description	Range
m1	UTC time (hhmmss.ss)	000000.00-235959.99
d2	Source of base coordinates: • 0: No base • 1: Computed base • 2: Received base • 3: Entered base (WARNING: Field currently hard coded to “2”)	0-3
d3	Type of baseline estimate: • 0: No baseline • 1: Time-tagged RTK estimate • 2: FAST RTK estimate	0-2
d4	Baseline reset flag: • 0: Updated • >0: Initialized	0, >0
d5	Internal RTK ambiguity flag: • 0: Float • 1: Fixed	0-1

Parameter	Description	Range
d6	Number of SVs ready for use in the RTK processing (L1 portion) on rover side.	0-26
d7	Number of SVs received from the base.	0-26
d8	Number of SVs used in the baseline computation (L1 portion). With $PASHS,VEC set to “FST”, this field refers to the last time-tagged epoch. Its content may be different from the one reported in the POS message.	0-26
f9	Age of last received base data, in seconds.	Real number (no limit)
d10	Overall baseline estimate latency, in milliseconds.	Integer, no limit
f11	Interval of base L1 carrier data interpolation to rover time tag.	Real number (no limit)
d12	Coordinate frame flag defining the meaning of the next six fields: • 1: ENU centered on rover.	1
f13	First (East) component of baseline, in meters.	Real number (no limit)
f14	Second (North) component of baseline, in meters.	Real number (no limit)
f15	Third (Up) component of baseline, in m	Real number (no limit)
f16	RMS error for x1 component, in m.	Real number (no limit)

Parameter	Description	Range
f17	RMS error for x2 component, in m.	Real number (no limit)
f18	RMS error for x3 component, in m.	Real number (no limit)
f19	Scaled norm of L1 carrier residuals, in meters(0 if carriers were not processed).	Real number (no limit)
f20	Scaled norm of L1 code residuals, in meters(0 if codes were not processed).	Real number (no limit)
f21	Internal ambiguity ratio (0 if the ambiguity search is not called).	Real number (no limit)
*cc	Optional checksum	*00-*FF

Example

$PASHQ,VEC

$PASHR,VEC,140746.00,2,1,0,1,,,05,,,0,1,-68.467,-26.867,5.428,
0.011,0.010,0.020,0.003 ,0.390,0.000,*25

Comment

- When baseline parameters are output in time-tagged mode ($PASHS,VEC,TT), the VEC message is generated only for those epochs for which reference data are available. In fast mode ($PASHS,VEC,FST), the VEC message will be generated for each receiver epoch using additional extrapolation algorithms.

Automatic Output of VEC Messages

This is a reminder on how to output VEC messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,VEC,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output VEC messages on port A at a rate of 0.2 second:

$PASHS,NME,VEC,A,ON,0.2

VER: Firmware Component Versions

Function

This command queries the receiver for all firmware component versions. The response is provided on the specified port, or on the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,VER[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$PASHR,VER,GNS,f1,s2[*cc]
$PASHR,VER,PFL,s3[*cc]
$PASHR,VER,MFT,s4[*cc]
$PASHR,VER,CHK,s6,d7,d8[*cc]

Parameters

Parameter	Description	Range
f1	Receiver firmware platform number	x.xx
s2	GNSS board firmware version. Contains one letter to identify the type of firmware and 3 characters for the version number.	4 characters
s3	PFL version	4 characters
s4	Manufacturing tests firmware version	4 characters
s6	Firmware image checksum (includes all stored GNSS firmware images for all CPUs and modes as well as Mfg. test images for all CPUs)	2 characters
d7	Not used	-
d8	Not used	-
*cc	Checksum	*00-*FF

VTG: Course Over Ground and Ground Speed

Function

This command is used to output a VTG message. The message is output through the specified port, or through the port on which the query is made if no port is specified. The message is output with blank fields until a valid position is computed.

Command Format

Syntax

$PASHQ,VTG[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPVTG,f1,T,f2,M,f3,N,f4,K,c5*cc

Parameters

Parameter	Description	Range
f1,T	COG (with respect to True North) T for "True" North: COG orientation	000.00-359.99
f2,M	COG (with respect to Magnetic North) M for "Magnetic" North: COG orientation	000.00-359.99
f3,N	SOG (Speed Over Ground) N for "knots": SOG unit	000.00-999.99
f4,K	SOG (Speed Over Ground) K for "km/hr": SOG unit	000.00-999-99
c5	Mode indicator: • A: Autonomous mode • D: Differential mode • N: Data not valid	A, D, N
*cc	Checksum	*00-*FF

Comments

The magnetic table used is the WMM-2005 (published Dec 2004), which is the standard model of the US Department of Defense (WMM for "World Magnetic Model").

Example

$PASHQ,VTG
$GPVTG,128.00,T,129.92,M,0.17,N,0.31,K,A*2D

Automatic Output of VTG Messages

This is a reminder on how to output VTG messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,VTG,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output VTG messages on port A at a rate of 0.5 second:

$PASHS,NME,VTG,A,ON,0.5

ZDA: Time & Date

Function

This command returns the receiver date & time. The message is output through the specified port, or through the port on which the query is made if no port is specified.

Command Format

Syntax

$PASHQ,ZDA[,c1][*cc]

Parameters

Parameter	Description	Range
c1	Port ID	A, B, C
*cc	Optional checksum	*00-*FF

Response Format

Syntax

$GPZDA,ZDA,m1,d2,d3,d4,d5,d6*cc

Parameters

Parameter	Description	Range
m1	UTC time (hhmmss.ss)	000000.00-235959.99
d2	Current day	01-31
d3	Current month	01-12
d4	Current year	0000-9999
d5	Local zone offset from UTC time (hour)	-13 to +13
d6	Local zone offset from UTC time (minutes)	00-59
*cc	Checksum	*00-*FF

Example

$PASHQ,ZDA
$GPZDA,162256.27,25,02,2008,+00,00*43

NOTE: The time offset is always reported as null (d5= d6= 0).

Automatic Output of ZDA Messages

This is a reminder on how to output ZDA messages at regular intervals of time: Use the $PASHS,NME command with the syntax below:

$PASHS,NME,ZDA,<port_ID>,ON,<Rate>

For more details on the $PASHS,NME command, refer to the *Set Command Library* Chapter.

As an example, the command below will output ZDA messages on port A at a rate of 60 seconds:

$PASHS,NME,ZDA,A,ON,60

Chapter 6. Raw Data Messages in Ashtech Proprietary Format

Output Order

In most cases, the order in which messages are output by the receiver is the same as that in which they are listed in the response to $PASHQ,PAR,OUT, i.e. from left to right and top to bottom.

For example, LTN comes first in the NME group while RNX, in the ATM group, comes earlier than MCA (in the RAW group). Still in the tabular response to the $PASHQ, PAR,OUT command, the output rate for each enabled message is provided. When this parameter is set to OFF, this means the message is disabled.

Within each group, the receiver relies on the following concept to organize the data output:

- Position first,
- Then observables,
- And finally attributes.

There are however exceptions:

- Messages generated according to the “on change” or “on event” principle (such as SNV and TTT respectively) cannot be tagged exactly to an epoch. That is why in somes cases they will appear at different locations in the output stream.
- LTN and ZDA come earlier than GLL and GGA in the NME group. This is because of the highest importance of latency and time-tagging information in some applications.
- PBN is not of prime importance in the RAW group. It is there for legacy reasons. GPS or GLONASS time-tagging for the MCA and MPC message observations is in the PBN message following their output.
- TT1 or TT2 comes after RNX or MES. This is because TT1 and TT2 messages contain time-tagged RTK results that

are not synchronized with the current receiver time tag. Also, when the receiver is configured in time-tagged RTK mode, the output of some messages may present unusual behavior, due to local delays in the data link used.

Coordinate Transformations: The receiver is not designed to perform internally coordinate transformations. So all the positions the receiver delivers refer to a “default” datum. This requires some clarifications.

The cartesian coordinates the receiver delivers (for example through the PBN message) are expressed on the following datum:

- Current ITRF realization used in broadcast ephemeris data (to date IGS05)
- Datum of reference position (applicable only for DGNSS and RTK modes)

A priori and generally speaking, the receiver does not know anything about the datum used by the local corrections provider to express the reference position it receives from that provider. As a result, the standalone position the receiver determines is tagged to the IGS05 and the differential position is the sum of the reference position (on whichever datum it is expressed) and the baseline estimate (on the IGS05 datum).

For internal transformations from cartesian (e.g. PBN) to geographical (e.g. POS) coordinates, the receiver uses the IGS05 (WGS-84 ellipsoid model).

The board firmware uses the geoid model referred to as the “NATO STANAG 4294 Navstar Global Positioning System (GPS) System Characteristics-ED 2”. This model is used to determine the height above the geoid in GGA messages (or similar).

The board firmware applies the Magnetic table corresponding to model WMM-2005 (published 12/2004). This model is used in position/velocity transformations required by some NMEA messages.

When no other models (e.g. SBAS) are available, the board firmware uses the default ionosphere model, as extracted from the GPS navigation stream (Klobuchar model).

The board firmware uses proprietary troposphere models.

User positions reported in all messages are tagged to the antenna L1 phase center. There may be an exception however for reference positions generated inside correcting data streams: These can be tagged to either the L1 phase center or the ARP, according to the standard they have to comply with.

The receiver can internally compute different positions at the same time. The reported user positions are always the “best” positions, depending on the currently available corrections data. The only exception is for PBN messages, in which only a standalone, SBAS or DGNSS position can be reported. In no case can PBN messages deliver RTK positions.

Being all centimeter-level accurate, RTK positions are very sensitive to the slightest change in the parameters used. They can for example skip by a few centimeters if you change the antenna names. Changing the local and reference antenna names will indeed result in the use of new PCO parameters (antenna offset values).

If the receiver clock steering procedure is applied (UTS set to ON), this affects not only the appearance of some receiver raw data (RAW group) but also the reported position in the case of high receiver dynamics, when this position is extrapolated forward or backward for periods of time of up to 1 ms.

DPC: Compact GPS Measurements

This message contains the L1/L2 measurements from all tracked GPS satellites for one epoch.

The message is as follows:

$PASHR,DPC,<structure>

The message's binary structure is described in the table below.

Type*	Size in bits	Resolution	Contents
Unsigned short	16		Message length. Number of bytes in the <packed data> section.
PACKED DATA			
Double	32	1 msec	Receiver time in GPS milliseconds of week
Char[4]	32		Receiver's four-character ID
Unsigned long	32		Mask representing satellites that are contributors to the message content. This is a bitwise indication: Starting from the least significant bit, bit1 corresponds to SV PRN#1, bit2 corresponds to SV PRN#2, and so on. Bit value "1" for a given SV PRN means the corresponding satellite is a data contributor to this message, "0" otherwise.
The data that follow are repeated for each satellite presented in the satellite mask			
Unsigned char	1		Satellite health ("0" means Sat is unhealthy)
Unsigned char	7	1 degree	Satellite elevation
Unsigned char	1		RAIM status (always zero)
Unsigned char	7	1 dBHz	SNR of L1CA observation
#L1 Data Block (L1CA in all cases)			
Double	31	0.1 nsec	Raw range in 0.1 nsec (range is smoothed by carrier). "0" means bad raw range data.
Unsigned char	1		Warning flag ("1" means bad carrier phase with possible cycle slips)
Unsigned char	1		Sign of total carrier phase ("1": negative; "0":positive)
Double	28	1 cycle	Integer part of total carrier phase in cycles
Double	11	0.0005 cycles	Fractional part of phase in 0.0005 cycles
Double	24	0.002 Hz	Doppler in units of 0.002 Hz
#L2 Data Block (L2P for CFG,2&4 and L2C for CFG,3&5) Content and data packing scheme is the same as for L1 Data			
CHECKSUM			
Unsigned short	16		Cumulative unsigned short sum of the <packed data>, after <message length> and before <checksum>

The data in this message are packed in bits rather than bytes. So the presented types of fields are just for the sake of giving a meaningful description of the original data packing.

NOTES:

- Most of the fields found in the DPC and DBEN data outputs are similar.

- DPC will not be generated if the [K] option (RTK Base) is missing.
- DPC data are affected by the last $PASHS,UTS command run. By default, this command is set to “ON”.
- DPC data are affected by the last $PASHS,ANP,OUT command run.
- DPC data can be made available on several ports simultaneously.
- DPC data can be output at a rate of up to 20 Hz, but the throughput compared to RTCM-3, CMR and ATOM may be quite higher.
- DPC pseudo-ranges are smoothed by L1 & L2 carriers.
- L2 data are always L2P(Y) data (RINEX code W). To output complete DPC data, the receiver must be configured accordingly (see $PASHS,GPS).

Reminder on How to Output DPC Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,DPC,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output DPC messages on port A at a rate of 1 second:

$PASHS,RAW,DPC,A,ON,1

ION: Ionosphere Parameters

This message contains the ionosphere and GPS-to-UTC data conversion parameters.

The message is as follows:

$PASHR,ION,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
Float	a0	4	Ionospheric parameter (seconds)
Float	a1	4	Ionospheric parameter (seconds/semi-circle)
Float	a2	4	Ionospheric parameter (seconds/semi-circle)
Float	a3	4	Ionospheric parameter (seconds/semi-circle)
Float	b0	4	Ionospheric parameter (seconds)
Float	b1	4	Ionospheric parameter (seconds/semi-circle)
Float	b2	4	Ionospheric parameter (seconds/semi-circle)
Float	b3	4	Ionospheric parameter (seconds/semi-circle)
Double	A1	8	First order terms of polynomial
Double	A0	8	Constant terms of polynomial
Unsigned long	Tot	4	Reference time for UTC data
Short	Wnt	4	UTC reference week number
Short	DtLS	2	GPS-UTC differences at reference time
Short	WnLSF	2	Week number when leap second became effective
Short	DN	2	Day number when leap second became effective
Short	DtLSF	2	Delta time between GPS and UTC after correction
Short	Wn	2	GPS week number
Unsigned long	Tow	4	Time of the week (in seconds)
Short	bulwn	2	GPS week number when message was read
Unsigned long	bultow	4	Time of the week when message was read
Unsigned short	Check-sum	2	The checksum is computed by breaking the structure into 37 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		76	

The GPS broadcast ionosphere model (Klobuchar) is used.

Reminder on How to Output ION Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,ION,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output ION messages on port A at a rate of 5 seconds:

$PASHS,RAW,ION,A,ON,5

MCA: C/A Code Measurements

This message contains the GPS/GLONASS/SBAS L1 C/A data of one satellite for one epoch.

The message is as follows:

$PASHR,MCA,<structure>

The message's binary structure is described in the table below.

Type	Size	Contents
Unsigned short	2	Sequence tag (unit: 50 ms) modulo 30 minutes. See NOTE below.
Unsigned char	1	Number of remaining MCA messages to be sent for current epoch
Unsigned char	1	Satellite index number GPS: 1-32 SBAS: 33-51 GLONASS: 65-88
Unsigned char	1	Satellite elevation angle (degree)
Unsigned char	1	Satellite azimuth angle (2-degree increments)
Unsigned char	1	Channel ID not duplicated for the current epoch
	29	**C/A code data** block (29 bytes)
Unsigned char	1	Warning flag Bit1, Bit2: 0,0: Code and/or carrier phase measured, but measurement was not used to compute position. 1,0: Code and/or carrier phase measured, navigation message was obtained and measurement was used to compute position, but position wasn't finally computed. 0,1: Code and/or carrier phase measured, navigation message was obtained, measurement was used to compute position and position was computed successfully. Bit3: Carrier phase questionable Bit4: Code phase (range) questionable Bit5: Range not precise (code phase loop not settled) Bit6: Z tracking mode Bit7: Possible cycle slip Bit8: Loss of lock since last epoch

Type	Size	Contents
Unsigned char	1	Indicates quality of the position measurement (good/bad) 0: Measurement not available and no additional data will be sent 23: Code and/or carrier phase measured, navigation message was obtained and measurement was used to compute position but position wasn't finally computed. 24: Code and/or carrier phase measured, navigation message was obtained, measurement was used to compute position and position was computed successfully. Other state: measurement was not used to compute position.
Unsigned char	1	Polarity of the phase tracking 0: Polarity unknown 5: Polarity known
Unsigned char	1	Signal-to-noise ratio for satellite observation (db.Hz)
Unsigned char	1	Always 0. Not used.
Double	8	Full carrier phase measurements in cycles
Double	8	Raw range to SV (in seconds), i.e. receive time - raw range = transit time. See NOTE below.
Long	4	Doppler (10^{-4} Hz)
Long	4	Smoothing Bits 0-22: magnitude of smooth correction in centimeters Bit 23: sign of smooth correction Bits 24-31: smooth count, unsigned, as follows: 0=unsmoothed 1=least smoothed 255=most smoothed
Unsigned char	1	Checksum, a bytewise exclusive OR (XOR)
Total of bytes	37	

NOTE: The specifics of the MCA message content in relation to $PASHS,PGS are detailed in the table below.

	PGS,GPS	PGS,GLO
Sequence Tag	Refers to GPS time for GPS satellites and GLONASS time for GLONASSS satellites, in spite of the setting you make with $PASHS,PGS.	
Raw Range for GPS Satellites	Actual pseudo-range	Actual pseudo-range – UTC offset
Raw Range for GLONASS Satellites	Actual pseudo-range + UTC offset	Actual pseudo-range

Reminder on How to Output MCA Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,MCA,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output MCA messages on port A at a rate of 1 second:

$PASHS,RAW,MCA,A,ON,1

MPC: GNSS Measurements

This message contains the GPS/GLONASS/SBAS L1 C/A, L2P data of one satellite for one epoch.

The message is as follows:

$PASHR,MPC,<structure>

The message's binary structure is described in the table below.

Type	Size	Contents
Unsigned short	2	Sequence tag (unit: 50 ms) modulo 30 minutes. See NOTE 1 below.
Unsigned char	1	Number of remaining structure to be sent for current epoch
Unsigned char	1	Satellite index number GPS: 1-32 SBAS: 33-51 GLONASS: 65-88
Unsigned char	1	Satellite elevation angle (degree)
Unsigned char	1	Satellite azimuth angle (2-degree increments)
Unsigned char	1	Channel ID not duplicated for the current epoch
	29	**C/A code data** block (29 bytes)
Unsigned char	1	Warning flag Bit1, Bit2: 0,0: Code and/or carrier phase measured but measurement was not used to compute position. 1,0: Code and/or carrier phase measured, navigation message was obtained and measurement was used to compute position but position wasn't finally computed. 0,1: Code and/or carrier phase measured, navigation message was obtained, measurement was used to compute position and position was computed successfully. Bit3: Carrier phase questionable Bit4: Code phase (range) questionable Bit5: Range not precise (code phase loop not settled) Bit6: Z tracking mode Bit7: Possible cycle slip Bit8: Loss of lock since last epoch
Unsigned char	1	Indicates quality of the position measurement (good/bad) 0: Measurement not available and no additional data will be sent.

Type	Size	Contents
		23: Code and/or carrier phase measured, navigation message was obtained and measurement was used to compute position but position wasn't finally computed. 24: Code and/or carrier phase measured, navigation message was obtained, measurement was used to compute position and position was computed successfully. Other state: measurement was not used to compute position.
Unsigned char	1	Polarity of the phase tracking 0: Polarity unknown 5: Polarity known
Unsigned char	1	Signal-to-noise ratio for satellite observation (db.Hz)
Unsigned char	1	Always 0. Not used.
Double	8	Full carrier phase measurements in cycles
Double	8	Raw range to SV (in seconds), i.e. receive time - raw range = transit time See NOTE 1 below.
Long	4	Doppler (10^{-4} Hz)
Long	4	Smoothing Bits 0-22: magnitude of smooth correction in centimeters Bit 23: sign of smooth correction Bits 24-31: smooth count, unsigned, as follows: 0=unsmoothed 1=least smoothed 255=most smoothed
	29	**L1 block**, same format as C/A code data block (see NOTE 2 below)
	29	**L2 block**, same format as C/A code data block (see NOTE 3 below)
Unsigned char	1	Checksum, a bytewise exclusive OR (XOR)
Total of bytes	95	

NOTES:

1. The specifics of the MPC message content in relation to $PASHS,PGS are detailed in the table below.

	PGS,GPS	PGS,GLO
Sequence Tag	Refers to GPS time for GPS satellites and GLONASS time for GLONASSS satellites, in spite of the setting you make with $PASHS,PGS.	
Raw Range for GPS Satellites	Actual pseudo-range	Actual pseudo-range – UTC offset
Raw Range for GLONASS Satellites	Actual pseudo-range + UTC offset	Actual pseudo-range

2. In case of GPS L1/L2P tracking mode, the **L1 block** contains L1P data. In case of GPS L2CS tracking mode, the **L1 block** contains zero data. In case of GLONASS-M satellites, the **L1 block** contains zero data.
3. In case of GPS L1/L2P, the **L2 block** contains L2P data. In case of GPS L2CS tracking mode, the **L2 block** contains L2CS data. In case of GLONASS-M satellites, the **L2 block** contains C/A data on the L2 frequency.

Reminder on How to Output MPC Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,MPC,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output MPC messages on port A at a rate of 1 second:

$PASHS,RAW,MPC,A,ON,1

PBN: Position Information

This message contains position information in binary format.

The message is as follows:

$PASHR,PBN,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
Long	pbentime	4	GPS or GLONASS time when data was received (ms of week). See NOTE below.
Char	sitename	4	Site name
Double	navx	8	Station position: ECEF-X (m)
Double	navy	8	Station position: ECEF-Y (m)
Double	navz	8	Station position: ECEF-Z (m)
Float	navt	4	Clock offset (m)
Float	navxdot	4	Velocity in ECEF-X (m/s)
Float	navydot	4	Velocity in ECEF-Y (m/s)
Float	navzdot	4	Velocity in ECEF-Z (m/s)
Float	navtdot	4	Clock drift (m/s)
Unsigned short	pdop	2	PDOP multiplied by 100
Unsigned short	checksum	2	The checksum is computed by breaking the structure into 27 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total of bytes		56	

When for example after a cold start, the receiver has no correct time tag, the PBN message is output with a fixed "zero" time tag.

Unlike all the other position messages, the position provided in a PBN message *cannot* be an RTK position. It can only be a standalone, SBAS or DGNSS position.

NOTE: GPS time is used when GPS is defined as the primary system, and GLONASS time is used when GLONASS is defined as the primary system.

Reminder on How to Output PBN Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,PBN,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output PBN messages on port A at a rate of 1 second:

$PASHS,RAW,PBN,A,ON,1

RPC: DBEN Messages

This message contains the L1/L2 measurements from all tracked GPS satellites for one epoch. The data are tagged to the location of the antenna L1 phase center, as reported by $PASHQ,BPS.

The message is as follows:

$PASHR,RPC,<structure>

The binary structure consists of the following:

<structure> = <message length><packed data><checksum>

The message's binary structure is described in the table below.

Type*	Size in bits	Resolution	Contents
Unsigned short	16		Message length. Number of bytes in the <packed data> section.
PACKED DATA			
Double	30	1 msec	Receiver time in GPS milliseconds of week
Char[4]	32		Receiver's four-character ID (as entered using $PASHS,SIT)
Unsigned long	32		Satellite Mask. Mask representing satellites that are contributors to the message content. This is a bitwise indication: Starting from the least significant bit, bit1 corresponds to SV PRN#1, bit2 corresponds to SV PRN#2, and so on. Bit value "1" for a given SV PRN means the corresponding satellite is a data contributor to this message, "0" otherwise.
The data that follow are repeated for each satellite presented in the satellite mask			
#L1 Data Block (L1CA in all cases)			
Double	31	0.1 nsec	Raw range in 0.1 nsec (range is smoothed by carrier). "0" means bad raw range data.
Unsigned char	1		Warning flag ("1" means bad carrier phase with possible cycle slips)
Unsigned char	1		Sign of total carrier phase ("1": negative; "0":positive)
Double	28	1 cycle	Integer part of total carrier phase, in cycles
Double	11	0.0005 cycles	Fractional part of phase, in 0.0005 cycles
#L2 Data Block (L2P for CFG,2&4 and L2C for CFG,3&5) Content and data packing scheme is the same as for L1 Data			
CHECKSUM			
Unsigned short	16		Cumulative unsigned short sum of the <packed data>, after <message length> and before <checksum>

The data in this message are packed in bits rather than bytes. So the presented types of fields are just for the sake of giving a meaningful description of the original data packing.

NOTES:
- RPC data are affected by the last $PASHS,UTS command run. By default, this command is set to “ON”.
- RPC data are affected by the last $PASHS,ANP,OUT command run.
- RPC data can be made available on several ports simultaneously.
- Regardless of the entered station ID on base side (using $PASHS,SIT), the base ID in messages generated by a rover (e.g. GGA - DDM - CPD,REF) is always reported to be “1010”.
- L2 data are always L2P(Y) data (RINEX code W). To output complete DBEN data, the receiver must be configured accordingly (see $PASHS,GPS).

Reminder on How to Output RPC Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,RPC,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output RPC messages on port A at a rate of 1 second:

$PASHS,RAW,RPC,A,ON,1

SAG: GLONASS Almanac Data

This message contains almanac data for one GLONASS satellite.

The message is as follows:

$PASHR,SAG,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
Short	prn	2	Satellite number 1-24
Short	frq	2	Satellite GLONASS frequency number [-7,...,6]
Short	health	2	Satellite health 0=bad, 1=good
Float	e	4	Eccentricity
Long		4	Reference day number (days in range 1 to 1461)
Float		4	Correction to inclination (semicircles)
Float	w0	4	Longitude of first ascending node (semicircles)
Float		4	Reference time of longitude of first node (seconds)
w	Float	4	Argument of perigee (semicircles)
Float	Af0	4	Correction to mean value (43200 s) of Draconic period
Float	Af1	4	Af1=d(Af0)/dt(sec/sec)
Float		4	Satellite clock offset (seconds)
Unsigned short	Checksum	2	The checksum is computed by breaking the structure into 21 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		44	

Reminder on How to Output SAG Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,SAG,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SAG messages on port A at a rate of 15 seconds:

$PASHS,RAW,SAG,A,ON,15

SAL: GPS Almanac Data

This message contains almanac data for one GPS satellite. The message is as follows:

$PASHR,SAL,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
Short	prn	2	Satellite PRN number minus 1 (0-31)
Short	health	2	Satellite health
Float	e	4	Eccentricity
Long	toe	4	Reference time for orbit (sec)
Float	i0	4	Inclination angle at reference time (semi-circles)
Float	w dot	4	Rate of right ascension (semi-circles/sec)
Double	A1/2	8	Square root of semi-major axis (meters1/2)
Double	w0	8	Longitude of ascending node (semicircles)
Double	w	8	Argument of perigee (semicircles)
Double	M0	8	Mean anomaly at reference time (semi-circle)
Float	Af0	4	Clock correction (sec)
Float	Af1	4	Clock correction (sec/sec)
Short	wna	2	Almanac week number
Short	wn	2	GPS week number
Long		4	Seconds of GPS week
Unsigned short	Check-sum	2	The checksum is computed by breaking the structure into 34 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		70	

Reminder on How to Output SAL Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,SAL,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SAL messages on port A at a rate of 15 seconds:

$PASHS,RAW,SAL,A,ON,15

SAW: SBAS Almanac Data

This message contains almanac data for one SBAS satellite. The message is as follows:

$PASHR,SAW,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
char	Id	1	Data ID
char	Health	1	Satellite Health&Status bitwise meaning is: Bit0 – Ranging On(0), Off(1) Bit1 – Corrections On(0), Off(1) Bit2 – Broadcast Integrity On(0), Off(1) Bit3 – Reserved Bit4-7 – SBAS provider ID (0-15): 0 – WAAS, 1 – EGNOS, 2 – MSAS, 3-13 – Not assigned yet, 14-15 – Reserved
long	T0	4	Almanac data reference time within the day expressed in the SBAS time scale (seconds)
float		3*4	Satellite ECEF X,Y,Z coordinates (meters)
float		3*4	Satellite ECEF velocity X', Y', Z' coordinates (m/s)
long	Tow	4	Time within week in GPS time scale when SBAS almanac was received
char	Wn	1	Week number in GPS time scale modulo 256 when SBAS almanac was received
char	Prn	1	Satellite number (33 to 51)
Unsigned short	Check-sum	2	The checksum is computed by breaking the structure into 18 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		38	

Reminder on How to Output SAW Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,SAW,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SAW messages on port A at a rate of 15 seconds:

$PASHS,RAW,SAW,A,ON,15

SBA,DAT: SBAS Data Message

Provided the command below has been run beforehand,

$PASHS,RAW,SBD,<port_ID>,ON

... the SBA,DAT message is output in response to:

$PASHQ,SBD, <port_ID>

...and is in the form:

$PASHR,SBA,DAT,d1,m2,d3,d4,s5*cc

Where:

Parameter	Description	Range
d1	SBAS SV ID number	33-51
m2	Time tag: hhmmss.hh The SBA,DAT message contains the time tag of the beginning of WAAS message transmission (WAAS message transmission time is 1 second)	000000.00-235959.99
d3	RTCA message ID	0-63
d4	Error flags (in HEX): bit0-preamble error, bit1-parity error	0-2
s5	RTCA message: 250 bit in 63 HEX numbers. The data lie from left to right and from high-order to low-order bits. The two low-order bits in the 63rd number are not used.	
*cc	Checksum, computed by "exclusive-ORing" all of the bytes in the message between, but not including, the "$" and the "*". The result is "*cc" where c is a hexadecimal character.	*00-*FF

SNG: GLONASS Ephemeris Data

This message contains the GLONASS ephemeris data for one satellite.

The message is as follows:

$PASHR,SNG,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
Long		4	Start time of 30-second frame in satellite time scale tk from which the ephemeris data is derived; time modulo one day (seconds)
Short		2	Day number of 30-second frame; modulo four-year period counting from beginning of last leap year, which corresponds to parameter tb (tb is set within this day number). This parameter varies within the range 1 to 1461. If day number=0, the day number is unknown (absent in navigation frame)
Long		4	Ephemeris data reference time within the day expressed in GLONASS system time scale = UTC + 3 hours (seconds)
Float		4	Frequency offset gh of the on-board frequency standard at tb (dimensionless)
Float		4	Bias tn between satellite time scale and GLONASS system time scale at tb (seconds)
Double		3*8	Satellite ECEF (PZ-90) X, Y, Z coordinates (km)
Float		3*4	Satellite ECEF (PZ-90) velocity X', Y', Z' (km/sec)
Float		3*4	Satellite perturbation acceleration X", Y", Z" due to moon and sun (km/sec/sec).
Double		8	Bias between GLONASS system time scale and UTC + 3 hours time scale tc (seconds)
Char		1	Age of ephemeris parameter En (interval from moment when ephemeris data was last uploaded to tb)
Char		1	Combined 3-bit flag (contains Ï1, Ï 2, Ï 3)
Char		1	Satellite health status flag (0=good, 1=bad)
Char		1	Satellite frequency channel number [-7,…,6]
Short		2	Satellite system number (satellite number [1,…,24])

Type	Name	Size	Contents
Unsigned short	Check-sum	2	The checksum is computed by breaking the structure into 40 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		82	

Reminder on How to Output SNG Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,SNG,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SNG messages on port A at a rate of 15 seconds:

$PASHS,RAW,SNG,A,ON,15

SNV: GPS Ephemeris Data

This message contains the GPS ephemeris data for one satellite.

The message is as follows:

$PASHR,SNV,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
Short	Wn	2	GPS week number
Long	Two	4	Seconds in GPS week
Float	Tgd	4	Group delay (sec)
Long	Aodc	4	Clock data issue
Long	Toc	4	Clock data reference time (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	Dn	4	Mean anomaly correction (semicircles/sec)
Double	M0	8	Mean anomaly at reference time (semicircles)
Double	e	8	Eccentricity
Double	$A^{1/2}$	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 (meters)
Double	omega0	8	Longitude of ascending node (semicircles)
Double	omega	8	Argument of perigee (semicircles)
Double	i0	8	Inclination angle (semicircles)
Float	omega dot	4	Rate of right ascension (semicircles/sec)
Float	I dot	4	Rate of inclination (semicircles/sec)
Short	Accuracy	2	User range accuracy
Short	Health	2	Satellite health
Short	fit	2	Curve fit interval
Char	prn	1	Satellite PRN number minus 1 (0-31)
Char		1	Reserved byte
Unsigned short	Checksum	2	The checksum is computed by breaking the structure into 37 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		76	

Reminder on How to Output SNV Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,SNV,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SNV messages on port A at a rate of 15 seconds:

$PASHS,RAW,SNV,A,ON,15

SNW: SBAS Ephemeris Data

This message contains the SBAS ephemeris data for one satellite.

The message is as follows:

$PASHR,SNW,<structure>

The message's binary structure is described in the table below.

Type	Name	Size	Contents
char	-	1	Spare field
char	accuracy	1	Accuracy
long	T0	4	Ephemeris data reference time within the day expressed in the SBAS time scale (seconds)
double		3*8	Satellite ECEF X,Y,Z coordinates (meters)
float		3*4	Satellite ECEF velocity X', Y', Z' coordinates (m/s)
float		3*4	Satellite ECEF acceleration X",Y",Z" (m/s2)
float	aGf0	4	Time offset between satellite time scale and SBAS system time scale (seconds)
float	aGf1	4	Time drift between satellite time scale and SBAS system time scale (seconds)
long	tow	4	Time within week in GPS time scale when SBAS ephemeris was received
char	wn	1	Week number in GPS time scale when SBAS ephemeris was received
char	prn	1	Satellite number (33 to 51)
Unsigned short	Checksum	2	The checksum is computed by breaking the structure into 34 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total		70	

Reminder on How to Output SNW Messages

Use the $PASHS,RAW command with the syntax below:

$PASHS,RAW,SNW,<port_ID>,ON,<Rate>

For more details on the $PASHS,RAW command, refer to the *Set Command Library* Chapter.

As an example, the command below will output SNW messages on port A at a rate of 15 seconds:

$PASHS,RAW,SNW,A,ON,15

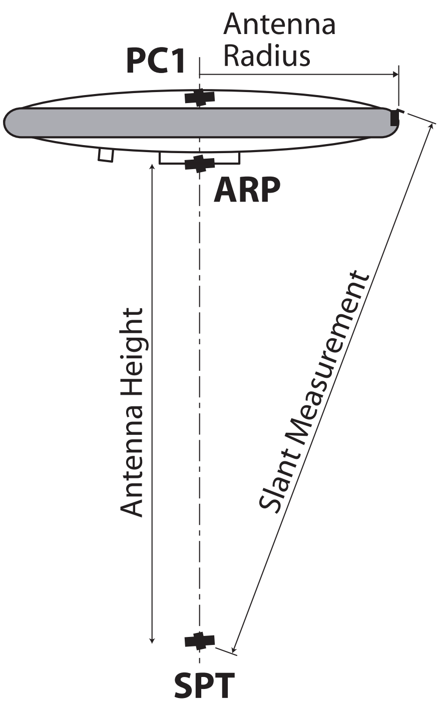
Chapter 7. Appendices

Base Antenna Issues

The firmware has to deal internally with positions tagged to different points on the antenna:

- The L1 Phase Center (PC1)
- The Antenna Reference Point (ARP)
- The ground mark, or Survey PoinT (SPT)

By default, the software assumes that PC1, ARP and SPT are the same point.



Through the $PASHS,POS command, you can enter the exact position of the base and tell the firmware if it is tagged to PC1, ARP or SPT. The position you enter through this command is the one that will be transmitted to rovers, along with RTK differential messages.

To allow the firmware to determine the position of the other two points, starting from the one you enter, antenna phase offset parameters are required. These parameters include antenna height, slant measurement and radius for SPT.

ARP and SPT are related to each other through commands $PASHS,ANH and $PASHS,ANP.

PC1 and ARP are related to each other via the Phase Center Offset table (PCO table), referring to the specified antenna name.

Whenever a position is entered using $PASHS,POS, the firmware re-calculates the positions of the other two points, using the current antenna name, as entered using the $PASHS,ANP,OWN command. If the antenna name is unknown (the antenna name field has been left blank), then the firmware assumes that the three points (PC1, ARP, SPT) are physically the same point in space.

Whenever you change the antenna name, using $PASHS,ANP,OWN, or antenna parameters, using *$PASHS,ANP,<name>,<parameters>*, the firmware re-calculates the other two points, keeping the user-entered position unchanged. For example, if the position entered through $PASHS,POS is that of PC1, then ARP will be re-calculated. Conversely, PC1 will be re-calculated if the entered position is that of the ARP.

Depending on the protocol and message set used, the transmitted reference position will be tagged to a specific point. See table below.

Message Type	PC1	ARP	SPT
RTCM2.3 messages 3+22	•		
RTCM2.3 message 24		•	
RTCM3.1 messages 1005 or 1006		•	
CMR	•		
ATOM,RNX		•	
DBEN			•
TOPAZE	•		

All the raw and differential data the firmware generates are always fully consistent with the reference position, the antenna name and, for DBEN, with the antenna offset parameters.

Rover Antenna Issues

Antenna information is vital for RTK operation, because not only does it contain the information for PC1-ARP transformation, but also the PC2 offset (PC2= L2 Phase Center) and the PCV (Elevation Dependent Phase Center Variations). Not making this information available to the rover may lead to a noticeable degradation of the position determination or the inability to reliably fix the ambiguities.

Since both rover and base data are involved in RTK operation, in which single-differencing is performed (i.e. subtracting base correction from rover data), it is essential that the parameters of both the reference antenna (REF) used at the base and the rover antenna (OWN) be known to the rover.

As the internal RTK engine always works on the PC1 position, any position received by the differential processor will be transformed to PC1, using base antenna parameters. Base antenna parameters are retrieved from hard-coded or user-defined antenna lists, using the antenna name decoded from the differential stream.

Unfortunately, only a few protocols provide the antenna name. These are listed below:

- RTCM2.3 message type 23
- RTCM3.1 message types 1007, 1008 and 1033
- Set of ATOM ATR messages

If the name of the antenna used at the base (reference antenna) is not available in the differential stream, you should use the $PASHS,ANP,REF command in the rover to specify that name. Since this command does not carry a default reference antenna name (by default, the corresponding field is empty), the rover will assume that PC1, PC2 and ARP at the base are all the same point in space, and the elevation-dependent biases are all zero. Besides, the rover will use either the entered or received reference antenna name, whichever is available last.

Even if the differential stream conveys a PC1-tagged position, which is needed for RTK, the antenna name remains a fundamental parameter, especially if the reference antenna has a noticeable L1-L2 phase center offset and/or a noticeable PCV.

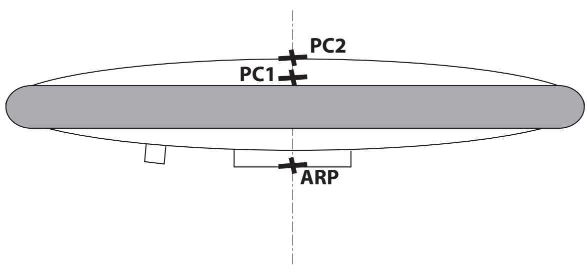
“Virtual Antenna” Concept

Experience has shown that a lot of rovers from other manufacturers do not know the PCO parameters of the antennas used by Ashtech base receivers (PCO= Phase Center Offset). As a result, these rovers cannot fully benefit from the streams of reference data delivered by Ashtech bases.

However, as there are a few antennas the names of which are well known to most vendors (e.g. ADVNULLANTENNA), Ashtech has implemented a special feature in its firmware allowing the owner of an Ashtech base to modify the complete flow of raw and differential data, as if they had been collected by a well known antenna, rather than the one actually used. This summarizes the concept of “virtual antenna”.

To enable this feature in a base, you should specify an antenna name for the truly used reference antenna (OWN), as well as a virtual antenna name (OUT) using the $PASHS, ANP,OUT command. Looking up the antenna name in the hard-coded or user-defined list of antennas, the base will then be able to make the following corrections:

- Virtual ARP coordinates= True ARP coordinates.
- Virtual PC1 coordinates: Deduced from the true ARP coordinates and the antenna parameters retrieved from the virtual (OUT) antenna name.
- Raw data: Adjusted to match the virtual antenna, i.e. L1 data will be centered on virtual PC1 and L2 data on virtual PC2. The adjusted raw data include both code and carrier L1 and L2, GPS and GLONASS.



Every time you modify any vital parameter through $PASHS,POS or $PASHS,ANP, the firmware will do the following automatically:

- Re-calculating the true ARP and/or the true PC1, using the data from the POS and OWN antenna names

- Calculating virtual PC1, using the true ARP and the data from the antenna name
- Adjusting raw data using data from the OWN and OUT antenna names

This mechanism guarantees the consistency of the position, observables/corrections and antenna name transmitted, regardless of the differential protocol and message set used.

This leads to a rover being able to calculate a correct RTK position, provided it has been able to decode the antenna name provided in the differential stream (or use the antenna name entered through the $PASHS,ANP,REF command) and retrieve the parameters of this antenna from its list of antenna names.

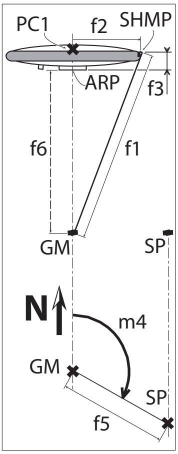
Antenna Height Transformations

The entered reference position may be defined as:

- The position of the surveyed point (SP),
- The position of the Antenna Reference Point (ARP).
- The position of the antenna L1 Phase Center (PC1).

The ground mark is defined as the vertical projection of the ARP to the ground.

The board firmware must be able to convert the originally entered position, first into ARP position, and then into L1 phase center position. To determine the ARP position, the firmware uses the data entered through either the ANT or ANH command, whichever was run last, to perform the required conversions.



- If the ANH command was the last run, the firmware will deduce that SP and GM are the same point. Then the firmware will use the entered antenna height (**f6**) to determine the ARP position, expressed in local ENU coordinates:

$$ARP(North) = GM(North) = SP(North)$$
$$ARP(East) = GM(East) = SP(East)$$
$$ARP(Up) = GM(Up) = f6$$

- If the ANT command was the last run, the firmware will use the entered parameters (**f1**, **f2**, **f3**, **m4** and **f5**) to determine the ARP position, expressed in local ENU coordinates:

$$GM(North) = SP(North) - f5 \times cos(m4)$$
$$GM(East) = SP(East) - f5 \times sin(m4)$$
$$GM(Up) = SP(Up)$$

$$ARP(North) = GM(North)$$
$$ARP(East) = GM(East)$$
$$ARP(Up) = GM(Up) + [\sqrt{f1^2 - f2^2}] + f3$$

Remember the vertical offset (**f3**) is entered as a negative value if the SHMP is above the ARP. It is otherwise positive.

With a known antenna name, the APC (Antenna Phase Center) positions for both L1 and L2 may be deduced from the ARP, using L1 and L2 3D offsets available from the hard-coded IGS antenna table:

$$APC(North)_{L1} = ARP(North) + L1Offset(North)$$
$$APC(East)_{L1} = ARP(East) + L1Offset(East)$$
$$APC(Up)_{L1} = ARP(Up) + L1Offset(Up)$$

$$APC(North)_{L2} = ARP(North) + L2Offset(North)$$
$$APC(East)_{L2} = ARP(East) + L2Offset(East)$$
$$APC(Up)_{L2} = ARP(Up) + L2Offset(Up)$$

How a Rover Reacts Dynamically to a Change of Base ID or Antenna Name

- Whenever the rover decodes a new base ID in the differential stream, all base-dependent parameters are reset to their default state in the rover. Through this reset, the default antenna name is made unknown (the corresponding field is made empty). This way, no previously received antenna name or reference position can be used.
- While the base ID is kept unchanged, a change of protocol will not cause any reset. The new position received through the new protocol will be processed normally, just as a new message including the reference position.
- Whenever a rover decodes a new antenna name, or a new antenna name is entered through the appropriate $PASH command, PC1 is re-calculated (if position received is tagged to ARP). The antenna parameters are also retrieved from the list of antennas for use in the processing run by the RTK engine.
- With a base declared as “static”, any change in the coordinates of the reference position provided by the differential stream will be interpreted by the rover as a true change in the base installation, or a change in the base setup.

  If however the difference between the new and old coordinates are greater than 10 km, the RTK engine is reset (similar to a base ID change). If the difference is between 1 km and 10 km, only the baseline estimate is reset. The baseline is otherwise simply adjusted, without any RTK reset.
- With the RTCM2.3 protocol, the reference position can be provided either in message type 3+22 or message type 24. This means the reference position received is either tagged to PC1 or ARP. Usually the positions provided by message types 3+22 and 24 refer to the same antenna and their relationship is as described in the antenna PCO table.

  If both messages are received, message type 3+22 (PC1-tagged position) has the priority. If message type 24 is received after message type 3+22, it will therefore be rejected, unless the difference between the two positions is greater than 25 meters.

Relationship Between WGS-84 and PZ-90.02

Each GNSS system is associated with a default datum.

Depending on which system is defined as the primary one (see $PASHS,PGS), the receiver will output and interpret all positions as being expressed in the "default" datum attached to this system. For all positions delivered by Ashtech receivers, you can convert them from one "default" datum to the other using the information below.

According to the official Russian document ref. 51794-2008 the following transformation parameters should be used for Helmert transformation, linear expression (OGP 2.4.3.2.2 Coordinate Frame Rotation, EPSG dataset coordinate operation method code 9607):

dX=-0.36 m; Rx=0;
dY=+0.08 m; Ry=0;
dZ=+0.18 m; Rz=0;
dS=0;

So the transformation from PZ90.02 to WGS-84 (G1150) is the following:

X(WGS84(G1150))=X(PZ90.02)-0.36;
Y(WGS84(G1150))=Y(PZ90.02)+0.08;
Z(WGS84(G1150))=Z(PZ90.02)+0.18;

Reciprocally, the transformation from WGS-84 (G1150) to PZ90.02 is the following:

X(PZ90.02)=X(WGS84(G1150))+0.36;
Y(PZ90.02)=Y(WGS84(G1150))-0.08;
Z(PZ90.02)=Z(WGS84(G1150))-0.18;

The ellipsoid used in PZ90.02 is named "PZ90" and is defined as follows:

A=6378137 m
1/f=298.25784

The ellipsoid used in WGS-84 (G1150) is named "WGS84" and is defined as follows:

A=6378137 m
1/f=298.257223563

All of the above parameters are used in Ashtech firmware, office/field software and tools.

The table below provides the deviations between WGS84 (GPS) and PZ90.02 (GLONASS) coordinates for several geodetic positions located far apart.

Location	LatGLO-LatGPS, m	LonGLO-LatGPS, m	AltGLO-AltGPS, m
Moscow	-0.340216104	-0.281950784	0.9518
London	-0.439712952	-0.078894086	1.0542
New-York	-0.29846832	0.322960782	0.9959
San-Francisco	-0.111497808	0.345720731	0.7728
Beijing	-0.036158447	-0.286006684	0.6873
Sydney	-0.303368712	-0.10296882	0.7916
Cape-town	0.071183472	-0.189164349	1.3481
Buenos-Aires	0.042136704	0.26386231	1.2984

NOTE: G1150 is the third update to the realization of the WGS 84 Reference Frame. It was implemented on Jan20, 2002. The previous realizations were designated WGS 84 (G730) and WGS 84 (G873).

The "G" indicates that GPS measurements were used to obtain the coordinates. The number after the "G" indicates the GPS week number of the week during which the coordinates were implemented in the NGA GPS precise ephemeris estimation process.

The GPS OCS implemented WGS 84 (G730) and WGS (G873) on Jun 23, 1994 and Jan 29, 1997 respectively.

Useful Definitions

Satellite Status

A GNSS satellite is considered to be **visible** if the corresponding healthy almanac is available, a receiver position is available, topo data for the satellite can be computed (at least from the almanac) and the satellite is above the horizon.

In some situations, the receiver can track a satellite below local horizon. These satellites are also considered as visible. All visible satellites are reported in NMEA GSV messages and ATM,PVT,SVS blocks. Each visible satellite must report valid elevation and azimuth.

So if GLONASS is disabled for tracking (e.g. by setting $PASHS,GLO,OFF), this does not mean that GLONASS satellites are no longer visible. On the contrary, these satellites may stay visible (although not tracked) because command $PASHS,GLO,OFF does not clean up the GLONASS almanac.

A visible GNSS satellite is reported to be **tracked** if the corresponding DLL (Delay Locked Loop) is locked for at least one satellite signal. Generally, the fact that a satellite is tracked does not necessarily mean that it can provide the corresponding raw data (pseudo-range, Doppler and carrier phase observables).

A tracked satellite is always associated with a corresponding SNR reported in NMEA GSV messages and ATM,PVT,SVS blocks.

A visible satellite that is not tracked is accompanied by a "zero" SNR value. NMEA messages always report an SNR value for the L1 signal of a given satellite (CA for GPS, SBAS and GLONASS). The ATM,PVT,SVS block reports SNR values for all the tracked signals from a given satellite.

The raw/differential data from a tracked satellite can be available internally but not output from the receiver if these data do not meet some quality requirements. See SOM setting commands for details.

Raw data can be available via different groups of messages, e.g. legacy MPC data, standardized RTCM-3 data and Ashtech proprietary ATM,RNX data.

A tracked GNSS satellite is reported to be **used** in the internal PVT process if at least one observable (pseudo-range, Doppler or Carrier phase) from at least one signal from a given satellite took part in the position epoch update. A satellite may be tracked and its raw data output while not being used in the internal PVT process. Conversely, the raw data from a satellite can be disabled for output, while being used in the internal PVT process. The information about satellite usage status is available via the SAT, ATM,PVT or ATM,RNX messages.

When used in differential mode, the receiver can mix corrected and uncorrected data in the internal PVT process. For example a satellite may be marked as used while there are no corrections received for this satellite. Conversely, a satellite for which corrections are available may not be used in the internal PVT process.

Position Status

In most cases, the messages generated by a GNSS board appear at the output in the same order as they are listed in the response to $PASHQ,PAR,OUT, that is from left to right and top to bottom. That means LTN goes first inside the NME group, while RNX (in the ATM group) goes earlier than MCA (in the RAW group).

The time preference list within each group tries to follow this concept: Position first, then observables, attributes last. There are however a few exceptions:

- Some messages are generated according to the “change” (e.g. SNV) or “event” (e.g. TTT) principle. These may not be tagged exactly to an epoch. That is why in some cases they can appear at unexpected locations in the output stream.
- LTN/ZDA goes earlier than GLL/GGA in the NME group. This is due to the highest importance given to latency and time-tag information in some applications.
- PBN is not the first in the RAW group. This is for legacy reasons.
- TT1/TT2 goes after RNX. This is due to the fact that TT1/TT2 messages contain time-tagged RTK results not synchronized with the receiver's current time tag. Also, when the receiver is configured in time-tagged RTK mode, some messages can also show unusual output behavior depending on local delays caused by the data link.

All the positions the receiver generates in primary position messages refer to the “default” datum. This requires some clarifications.

The Cartesian position the receiver generates (e.g. in PBN message) is defined by:

- The primary GNSS selected
- The current datum realization used for broadcast ephemeris (now IGS05 on current epoch if GPS is primary)
- The datum of the reference position (applicable to DGNSS and RTK modes only).

Generally the receiver does not know a priori what the datum of the reference position is (this depends on the data provider in the local area). As a result, the standalone position a receiver generates is tagged to IGS05 (if GPS is primary). At the same time, the differential position is computed as the reference position (in whichever datum) plus the baseline estimate (IGS05 datum).

To date, the GNSS firmware can support GPS or GLONASS as the primary GNSS system (see $PASHS,PGS description). Once specified, the primary GNSS system defines a “default” receiver datum associated with the given GNSS system:

- WGS-84 (IGS05) if GPS is primary,
- PZ90.02 if GLONASS is primary

The two datums are quite close to each other, and yet with the following differences:

- Ellipsoid centers are about 0.5 meters apart
- Ellipsoid parameters are different

Different ellipsoid parameters means that a given cartesian position will be transformed into different geodetic coordinates, depending on which GNSS is used as primary.

It is therefore the end user's responsibility to be sure that the expected ellipsoid center and parameters are used so that the receiver can provide correct position estimates. For the same purpose, the end user should also make sure the same GNSS primary system is used at the base and rover.

The receiver can accept some user positions and use them in internal algorithms. These are set using the POS and KPI commands. When entering these positions, the user must realize that these will be processed differently depending on which GNSS is used as primary. These positions are always entered as geodetic coordinates (lat, lon, alt) and it is the users' responsibility to make sure the entered coordinates are expressed in the selected primary GNSS.

In most cases, the entered positions are transformed into cartesian coordinates (so they can for example be inserted into the generated reference station message). Transformation parameters are different for GPS and GLO, so cartesian positions will be “primary GNSS” dependent.

Working in RTK rover mode, it is the end user's responsibility to inquire exactly what datum is used to express the received reference position and set the primary GNSS system accordingly (using PGS).

Working in RTK base mode, it is also the end user's responsibility to inquire what datum is used to express the generated (entered) reference position and set the primary GNSS system accordingly.

Working in some NTRIP Networks (e.g. SAPOS) transmitting the so-called coordinate transformation messages, the receiver can additionally compute the position in the local system/datum. This position is available via special blocks from the ATM,PVT message. So the user can get both “default” and ”local” positions simultaneously via the ATM,PVT message.

The GNSS firmware applies the following default geoid model: *NATO STANAG 4294 Navstar Global Positioning System (GPS) System Characteristics-ED 2*.

This model is used to generate the geoid-ellipsoid separation value in GGA (and similar) messages, regardless of the primary GNSS system selected (PGS command).

The GNSS firmware applies the Magnetic table corresponding to model *WMM-2005* (published 12/2004). This model is used for some position/velocity transformations applied in some NMEA messages.

The GNSS firmware applies the default ionosphere model (when no other models, e.g. SBAS, are available), extracted from the GPS navigation stream (called *Klobuchar* model).

The GNSS firmware applies proprietary troposphere models.

By default, user positions reported in all messages are tagged to the antenna L1 phase center. Command ANR (ANtenna Reduction) allows the receiver to tag all user positions to either the Antenna Reference Point or the Ground Mark. This command does not affect reference positions generated in various correcting data streams. These positions may be tagged to either the L1 phase center or the ARP, as required by the standard used.

By default, the reported user positions are always the “best” positions, depending on the availability of correcting data at that time. The formal preference is the following (from best to worst):

- RTK
- DGNSS
- SBAS
- Standalone (autonomous)

Using the TOP command, users can choose which level of position accuracy they wish to output.

There is one exception for the legacy PBN message, which can never contain an RTK position, but only a standalone, SBAS or DGNSS position.

The reported RTK positions being of centimeter level accuracy, they are very sensitive to the availability of supplementary data. They may leap by several centimeters following the change of the reference or local (own) antenna name (resulting in new PCO parameters).

Applying the receiver clock steering procedure (UTS,ON) will affect not only the appearance of some receiver raw data (RAW and MSM data) but also, with high receiver dynamics, the reported position when extrapolating it for up to 1 ms forward or backward.

Differential Positions

Differential positioning is the process of correcting local receiver data (or internal PVT engine states) using some data available from external sources.

Correcting data are divided into two groups:

- *Measurement Space (MS) corrections*
- *State Space (SS) corrections*

MS corrections are numbers that are simply added to the respective local measurement to cancel (or at least reduce) some systematic errors. A typical example of MS corrections is either DGNSS corrections (e.g. RTCM MT 1,31) or RTK corrections (e.g. RTCM-3 MT 1004,1012).

The primary attribute of MS corrections is the position (reference) they are tagged to. MS corrections usually serve a local area around the reference position. MS corrections can correspond to either a physical or virtual reference station. RTK network corrections (MAC, FKP) can be considered as augmentations of MS corrections to extend the area of applicability.

SS corrections are the estimates of particular errors affecting GNSS observations. SS corrections include satellite orbit and clock corrections, ionosphere corrections, satellite signal bias estimates and some others.

SS corrections are usually not tagged to any reference position, serve wider areas compared to MS corrections, but are not always global.

For example the ionosphere correction grid can be available only for some continents, like WAAS ionosphere correction, which is available over the USA only.

The typical example of SS corrections is SBAS and L-band. Unlike precise MS corrections, the current status of SS corrections does not allow receivers to determine centimeter level positions.

But the latest progress with the so-called PPP (Precise Point Positioning) solutions using precise, almost real-time IGS products will lead to centimeter level accuracies in the future.

Depending on the organization of the PVT engine, SS corrections can be applied differently. Ashtech receivers transform SS corrections into MS corrections (and associated accuracy figures) referring to the receiver's current position. The receiver then applies these MS corrections to receiver observations.

One of the primary attributes of any differential position is differential age. Ashtech GNSS firmware reports age (e.g. in GGA messages) as follows:

- For time-tagged RTK positions, it is always reported as zero.
- For Fast RTK and any MS DGNSS positions, age is the difference between position time tag and the time tag of the differential corrections last used. It must be emphasized that the last decoded differential corrections are not necessarily applied to the current position.
- For SS differential positions (e.g. SBAS), age is computed by proprietary exclusive formulae because a number of particular correcting data that take part in the position determination are tagged to different times.

Datum for SBAS Differential Positions

For ITRF, strictly speaking, there is no predefined ellipsoid at all. However, it is common practice to use the GRS 1980 ellipsoid for this purpose (there is even official approval for ETRF to do so). This ellipsoid is defined as follows:

- A=6378137 m
- 1/f=298.257222101

This ellipsoid has to be utilized for SBAS differential position (claimed as ITRF2000).

Also, this ellipsoid has to be utilized if we claim that we provide our position not in WGS84, but in the ITRS05 (or ITRS2000) reference frame.

Asynchronous Serial Communication

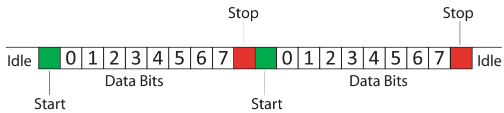
RS 232 ports and LV-UARTs are asynchronous serial communication interfaces used to transfer data bytes in series.

A start signal is sent prior to transferring each byte and a stop signal is sent after the byte has been transferred.

The start signal is used to prepare the receiving mechanism for byte reception and saving.

The stop signal puts the receiving mechanism back to idle state, making it ready for the reception of a new byte.

The diagram below shows a typical bit sequence used in an asynchronous serial communication to transfer two bytes.



Each byte consists of a start bit (green), followed by eight data bits (0-7, LSB first), and one stop bit (red). (There is no parity bit.). The overall transmission for one byte therefore represents a 10-bit character frame (8N1 configuration).

The stop bit is in fact a “wait” period of time, which cannot be shorter than a specified amount of time, usually the duration of one or two data bits.

The “wait” time for the transmitter may be arbitrarily long. The receiver requires a shorter wait time than the transmitter.

After transferring a complete byte, the receiver stops briefly, waiting for the next start bit. It is through the insertion of the stop bit in the sequence that the transmitter and the receiver keep synchronized.

The nominal values of commonly used bit rates are 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800 and 921600 bits per second (bps or baud).

The exact bit rate on each port depends on the internal processor clock and the transmission/reception of the bit sequence. It is recommended not to work with an error greater than 5%.

The table below gives real bit rates and calculated errors.

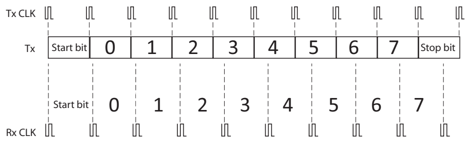
Port	Real Bit Rate, in bps	Nominal Bit Rate, in bps	Error, in%
B	231547.62	230400	0.50
B	442045.45	460800	-4.07
A	231547.62	230400	0.50
A	463095.24	460800	0.50
A	884090.91	921600	-4.07

The table below shows that in some cases, the MB 100 operates with bit rates that differ from the nominal value by more than 4%. For these cases, the bit rate used at the other end of the communication link should be chosen as indicated below:

- **464000 bps max.**, with MB 100 Port B operating at 442045.45 bps
- **928000 bps max.**, with MB 100 port A operating at 884090.91 bps

Not following these recommendations would result in bit rates differing by more than 5% and a high risk of data corruption during the transfer.

The diagram below shows the impact of clock frequencies on transmitter side and receiver side that differ from each other by more than 5%.



The Receive clock frequency being 6.5% less than the Transmit clock frequency, the time required for receiving each bit is 6.25% longer than the time used to transmit it. As a result, bit 7 is likely to be corrupted on receiver side.

Preset Antenna List

As listed when running the $PASHQ,ANP command.

UNKNOWN
L1 N: +000.00 E: +000.00 U: +000.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
MAG111406
L1 N: -000.90 E: +001.40 U: +078.30
L1 PAE:+000.0 +000.1 +000.8 +001.9 +003.1 +004.4 +005.6 +006.5 +007.1 +007.2
+006.8 +005.8 +004.3 +002.2 -000.5 -003.7 -007.4 +000.0 +000.0
L2 N: -001.30 E: +001.00 U: +068.50
L2 PAE:+000.0 -000.1 +000.2 +000.8 +001.5 +002.2 +002.8 +003.3 +003.5 +003.5
+003.3 +002.7 +001.9 +000.9 -000.3 -001.5 -002.7 +000.0 +000.0
MAG111406+CR
L1 N: -000.80 E: +000.00 U: +088.40
L1 PAE:+000.0 -000.1 -000.5 -000.5 -000.4 +000.0 +000.1 +000.2 +000.3 +000.4
+000.3 +000.2 +000.2 +000.0 -000.3 -000.1 +000.1 +000.1 +000.0
L2 N: +002.30 E: +000.10 U: +092.10
L2 PAE:+000.0 -000.4 -000.5 -000.6 -000.6 -000.2 -000.3 -000.2 +000.0 +000.1

+000.2 +000.5 +000.4 +000.7 +000.4 +000.4 +000.0 -000.1 -000.1
MAG990596
L1 N: -000.80 E: -001.40 U: +101.80
L1 PAE:+000.0 +000.9 +001.9 +002.8 +003.7 +004.7 +005.4 +006.0 +006.4 +006.5
+006.3 +005.8 +004.8 +003.2 +001.1 -001.6 -005.1 +000.0 +000.0
L2 N: +000.80 E: -001.10 U: +086.20
L2 PAE:+000.0 -000.9 -001.1 -000.6 +000.2 +001.1 +002.0 +002.7 +003.0 +003.0
+002.6 +001.7 +000.5 -001.1 -003.0 -004.9 -006.8 +000.0 +000.0
ProMark500
L1 N: -000.80 E: -001.40 U: +101.80
L1 PAE:+000.0 +000.9 +001.9 +002.8 +003.7 +004.7 +005.4 +006.0 +006.4 +006.5
+006.3 +005.8 +004.8 +003.2 +001.1 -001.6 -005.1 +000.0 +000.0
L2 N: +000.80 E: -001.10 U: +086.20
L2 PAE:+000.0 -000.9 -001.1 -000.6 +000.2 +001.1 +002.0 +002.7 +003.0 +003.0
+002.6 +001.7 +000.5 -001.1 -003.0 -004.9 -006.8 +000.0 +000.0
DORNE MARGOLIN T
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
AOAD/M_T
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
AOAD/M_TA_NGS
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
DORNE MARGOLIN B
L1 N: +000.00 E: +000.00 U: +078.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

L2 N: +000.00 E: +000.00 U: +096.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
AOAD/M_B
L1 N: +000.00 E: +000.00 U: +078.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +096.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
DORNE MARGOLIN R
L1 N: +000.00 E: +000.00 U: +078.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +096.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
JPLD/M_R
L1 N: +000.00 E: +000.00 U: +078.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +096.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
JPLD/M_RA_SOP
L1 N: +000.00 E: +000.00 U: +078.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +096.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
TRM23903.00
L1 N: +001.20 E: +000.40 U: +077.00
L1 PAE:+000.0 +004.8 +009.3 +013.1 +016.4 +018.8 +020.5 +021.5 +021.7 +021.3
+020.3 +018.9 +017.2 +015.6 +014.2 +013.4 +013.4 +000.0 +000.0
L2 N: +000.50 E: +004.00 U: +075.60
L2 PAE:+000.0 +000.1 +000.5 +001.1 +001.7 +002.2 +002.7 +003.0 +003.1 +003.0
+002.8 +002.4 +001.9 +001.3 +000.8 +000.5 +000.4 +000.0 +000.0
TRM29659.00
L1 N: +000.00 E: +000.00 U: +110.00

L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

TRM33429.00+GP

L1 N: -000.20 E: +001.20 U: +074.00
L1 PAE:+000.0 +003.9 +007.6 +011.1 +014.1 +016.5 +018.3 +019.2 +019.5 +019.1
+018.1 +016.6 +014.9 +013.0 +011.5 +010.4 +010.2 +000.0 +000.0
L2 N: +000.60 E: +000.90 U: +070.30
L2 PAE:+000.0 +000.6 +001.4 +002.4 +003.4 +004.4 +005.1 +005.6 +005.8 +005.7
+005.3 +004.7 +003.9 +003.0 +002.1 +001.4 +000.9 +000.0 +000.0

TRM33429.20+GP

L1 N: -000.40 E: -001.00 U: +072.90
L1 PAE:+000.0 +004.8 +009.3 +013.3 +016.6 +019.3 +021.2 +022.3 +022.7 +022.5
+021.8 +020.6 +019.3 +018.0 +016.9 +016.4 +016.7 +000.0 +000.0
L2 N: -000.40 E: -001.30 U: +075.00
L2 PAE:+000.0 +000.3 +000.9 +001.6 +002.2 +002.9 +003.4 +003.8 +004.0 +004.1
+003.9 +003.6 +003.2 +002.7 +002.2 +001.8 +001.5 +000.0 +000.0

DORNE MARGOLIN TRIM

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

4000ST L1/L2 GEOD

L1 N: +000.00 E: -003.00 U: +078.00
L1 PAE:+000.0 +001.1 +003.1 +006.3 +010.2 +013.7 +015.7 +016.4 +016.3 +015.8
+014.6 +013.0 +011.4 +010.2 +008.5 +007.3 +007.0 +000.0 +000.0
L2 N: -003.10 E: -001.30 U: +074.40
L2 PAE:+000.0 +000.1 +000.5 +000.7 +001.2 +002.2 +003.4 +004.2 +004.2 +003.9
+003.6 +003.3 +002.7 +002.0 +001.5 +001.0 +000.2 +000.0 +000.0

TRM14177.00

L1 N: +000.00 E: -003.00 U: +078.00
L1 PAE:+000.0 +001.1 +003.1 +006.3 +010.2 +013.7 +015.7 +016.4 +016.3 +015.8
+014.6 +013.0 +011.4 +010.2 +008.5 +007.3 +007.0 +000.0 +000.0
L2 N: -003.10 E: -001.30 U: +074.40
L2 PAE:+000.0 +000.1 +000.5 +000.7 +001.2 +002.2 +003.4 +004.2 +004.2 +003.9

+003.6 +003.3 +002.7 +002.0 +001.5 +001.0 +000.2 +000.0 +000.0
TRM14532.00
L1 N: +000.00 E: -003.00 U: +078.00
L1 PAE:+000.0 +001.1 +003.1 +006.3 +010.2 +013.7 +015.7 +016.4 +016.3 +015.8
+014.6 +013.0 +011.4 +010.2 +008.5 +007.3 +007.0 +000.0 +000.0
L2 N: -003.10 E: -001.30 U: +074.40
L2 PAE:+000.0 +000.1 +000.5 +000.7 +001.2 +002.2 +003.4 +004.2 +004.2 +003.9
+003.6 +003.3 +002.7 +002.0 +001.5 +001.0 +000.2 +000.0 +000.0
TRM14532.10
L1 N: -001.60 E: +000.90 U: +096.00
L1 PAE:+000.0 +000.0 +000.7 +001.7 +003.0 +004.3 +005.6 +006.6 +007.3 +007.5
+007.3 +006.6 +005.3 +003.6 +001.3 -001.4 -004.5 +000.0 +000.0
L2 N: +001.60 E: +004.10 U: +094.40
L2 PAE:+000.0 -001.0 -001.3 -001.1 -000.6 +000.2 +000.9 +001.6 +002.1 +002.3
+002.1 +001.6 +000.6 -000.8 -002.6 -004.8 -007.3 +000.0 +000.0
TR GEOD L1/L2 GP
L1 N: +001.50 E: -001.20 U: +075.10
L1 PAE:+000.0 +001.8 +004.6 +008.1 +011.7 +014.5 +016.1 +016.9 +016.9 +016.2
+014.9 +013.4 +011.9 +010.4 +009.0 +007.9 +008.2 +000.0 +000.0
L2 N: -001.10 E: +001.70 U: +069.20
L2 PAE:+000.0 +000.3 +000.9 +001.8 +003.0 +004.1 +004.9 +005.4 +005.6 +005.6
+005.3 +004.5 +003.6 +002.8 +002.1 +001.2 +000.1 +000.0 +000.0
TRM22020.00+GP
L1 N: +001.50 E: -001.20 U: +075.10
L1 PAE:+000.0 +001.8 +004.6 +008.1 +011.7 +014.5 +016.1 +016.9 +016.9 +016.2
+014.9 +013.4 +011.9 +010.4 +009.0 +007.9 +008.2 +000.0 +000.0
L2 N: -001.10 E: +001.70 U: +069.20
L2 PAE:+000.0 +000.3 +000.9 +001.8 +003.0 +004.1 +004.9 +005.4 +005.6 +005.6
+005.3 +004.5 +003.6 +002.8 +002.1 +001.2 +000.1 +000.0 +000.0
TR GEOD L1/L2 W/O GP
L1 N: +003.10 E: +000.90 U: +086.60
L1 PAE:+000.0 +000.2 +000.4 +001.2 +002.5 +003.6 +004.5 +005.1 +005.6 +005.8
+005.5 +005.0 +004.2 +002.7 +000.6 -001.5 -002.6 +000.0 +000.0
L2 N: +001.20 E: -000.10 U: +081.70
L2 PAE:+000.0 +000.0 +000.5 +001.2 +002.0 +002.9 +003.5 +003.9 +004.3 +004.7
+004.9 +004.5 +003.5 +002.2 +001.0 -001.1 -004.8 +000.0 +000.0
TRM22020.00-GP
L1 N: +003.10 E: +000.90 U: +086.60
L1 PAE:+000.0 +000.2 +000.4 +001.2 +002.5 +003.6 +004.5 +005.1 +005.6 +005.8
+005.5 +005.0 +004.2 +002.7 +000.6 -001.5 -002.6 +000.0 +000.0

L2 N: +001.20 E: -000.10 U: +081.70
L2 PAE:+000.0 +000.0 +000.5 +001.2 +002.0 +002.9 +003.5 +003.9 +004.3 +004.7
+004.9 +004.5 +003.5 +002.2 +001.0 -001.1 -004.8 +000.0 +000.0
TRM41249.00
L1 N: +000.30 E: +000.50 U: +071.40
L1 PAE:+000.0 +000.6 +001.4 +002.3 +003.2 +004.1 +004.9 +005.6 +006.1 +006.4
+006.4 +006.1 +005.5 +004.5 +003.1 +001.3 -000.9 +000.0 +000.0
L2 N: -000.40 E: +000.10 U: +068.20
L2 PAE:+000.0 -000.5 -000.6 -000.5 -000.2 +000.1 +000.5 +000.8 +001.0 +001.1
+001.0 +000.9 +000.6 +000.2 -000.2 -000.6 -000.8 +000.0 +000.0
TRM55971.00
L1 N: +001.60 E: +000.70 U: +085.00
L1 PAE:+000.0 +000.7 +001.6 +002.8 +003.9 +004.9 +005.9 +006.6 +007.0 +007.2
+006.8 +006.2 +005.2 +003.7 +001.8 -000.5 -003.2 +000.0 +000.0
L2 N: +000.80 E: +001.20 U: +070.10
L2 PAE:+000.0 -000.1 -000.1 +000.1 +000.4 +000.7 +001.0 +001.2 +001.4 +001.5
+001.4 +001.1 +000.8 +000.2 -000.4 -001.3 -002.2 +000.0 +000.0
TRM55971.00 TZGD
L1 N: +001.10 E: +000.90 U: +085.60
L1 PAE:+000.0 +000.9 +001.9 +003.0 +004.0 +005.0 +005.8 +006.4 +006.8 +006.9
+006.7 +006.0 +005.0 +003.5 +001.6 -000.9 -003.8 +000.0 +000.0
L2 N: +000.70 E: +000.90 U: +070.00
L2 PAE:+000.0 -000.4 -000.5 -000.3 +000.0 +000.4 +000.7 +001.0 +001.2 +001.3
+001.2 +000.9 +000.4 -000.2 -001.1 -002.0 -003.1 +000.0 +000.0
700228
L1 N: +000.50 E: +000.30 U: +079.90
L1 PAE:+000.0 +000.1 +000.5 +001.2 +001.8 +002.1 +002.1 +002.4 +003.0 +003.3
+003.0 +002.8 +002.6 +002.3 +001.5 +000.7 +000.9 +000.0 +000.0
L2 N: -001.20 E: +000.80 U: +079.20
L2 PAE:+000.0 +000.4 +001.1 +001.5 +001.6 +001.8 +002.2 +002.3 +002.1 +002.0
+001.9 +001.7 +001.5 +001.8 +002.4 +001.6 -001.8 +000.0 +000.0
ASH700228A
L1 N: +000.50 E: +000.30 U: +079.90
L1 PAE:+000.0 +000.1 +000.5 +001.2 +001.8 +002.1 +002.1 +002.4 +003.0 +003.3
+003.0 +002.8 +002.6 +002.3 +001.5 +000.7 +000.9 +000.0 +000.0
L2 N: -001.20 E: +000.80 U: +079.20
L2 PAE:+000.0 +000.4 +001.1 +001.5 +001.6 +001.8 +002.2 +002.3 +002.1 +002.0
+001.9 +001.7 +001.5 +001.8 +002.4 +001.6 -001.8 +000.0 +000.0
ASH700228B
L1 N: +000.50 E: +000.30 U: +079.90

L1 PAE:+000.0 +000.1 +000.5 +001.2 +001.8 +002.1 +002.1 +002.4 +003.0 +003.3
+003.0 +002.8 +002.6 +002.3 +001.5 +000.7 +000.9 +000.0 +000.0
L2 N: -001.20 E: +000.80 U: +079.20
L2 PAE:+000.0 +000.4 +001.1 +001.5 +001.6 +001.8 +002.2 +002.3 +002.1 +002.0
+001.9 +001.7 +001.5 +001.8 +002.4 +001.6 -001.8 +000.0 +000.0
ASH700228C
L1 N: +000.50 E: +000.30 U: +079.90
L1 PAE:+000.0 +000.1 +000.5 +001.2 +001.8 +002.1 +002.1 +002.4 +003.0 +003.3
+003.0 +002.8 +002.6 +002.3 +001.5 +000.7 +000.9 +000.0 +000.0
L2 N: -001.20 E: +000.80 U: +079.20
L2 PAE:+000.0 +000.4 +001.1 +001.5 +001.6 +001.8 +002.2 +002.3 +002.1 +002.0
+001.9 +001.7 +001.5 +001.8 +002.4 +001.6 -001.8 +000.0 +000.0
ASH700228D
L1 N: +000.50 E: +000.30 U: +079.90
L1 PAE:+000.0 +000.1 +000.5 +001.2 +001.8 +002.1 +002.1 +002.4 +003.0 +003.3
+003.0 +002.8 +002.6 +002.3 +001.5 +000.7 +000.9 +000.0 +000.0
L2 N: -001.20 E: +000.80 U: +079.20
L2 PAE:+000.0 +000.4 +001.1 +001.5 +001.6 +001.8 +002.2 +002.3 +002.1 +002.0
+001.9 +001.7 +001.5 +001.8 +002.4 +001.6 -001.8 +000.0 +000.0
700228 NOTCH
L1 N: -000.20 E: -001.00 U: +080.80
L1 PAE:+000.0 +000.7 +001.3 +001.7 +002.1 +002.4 +002.6 +002.9 +003.0 +003.1
+003.0 +002.8 +002.4 +001.8 +001.0 -000.3 -002.0 +000.0 +000.0
L2 N: -001.90 E: +003.80 U: +077.80
L2 PAE:+000.0 -001.7 -002.5 -002.8 -002.6 -002.3 -002.0 -001.7 -001.5 -001.6
-001.8 -002.1 -002.5 -002.9 -003.1 -003.0 -002.3 +000.0 +000.0
700228 RINGS
L1 N: -002.20 E: +000.00 U: +086.00
L1 PAE:+000.0 +001.7 +003.0 +004.0 +004.8 +005.3 +005.7 +005.9 +005.9 +005.9
+005.7 +005.3 +004.8 +004.0 +003.0 +001.7 -000.1 +000.0 +000.0
L2 N: -003.70 E: +003.20 U: +078.20
L2 PAE:+000.0 -001.7 -002.5 -002.7 -002.5 -002.0 -001.6 -001.2 -001.0 -001.0
-001.2 -001.6 -002.1 -002.7 -003.1 -003.1 -002.6 +000.0 +000.0
700578
L1 N: -001.20 E: -001.00 U: +079.50
L1 PAE:+000.0 -000.2 -000.1 +001.1 +002.7 +003.2 +002.7 +002.5 +003.4 +004.2
+004.0 +003.5 +003.3 +002.7 +001.4 +000.9 +003.0 +000.0 +000.0
L2 N: -004.60 E: +001.60 U: +078.30
L2 PAE:+000.0 +000.5 +001.4 +001.6 +001.4 +001.5 +002.0 +002.1 +001.9 +002.1
+002.5 +002.2 +001.3 +001.2 +002.3 +002.0 -002.4 +000.0 +000.0
700718

L1 N: +003.40 E: +001.00 U: +087.30
L1 PAE:+000.0 +001.3 +002.9 +004.6 +006.2 +007.7 +008.8 +009.4 +009.6 +009.2
+008.4 +007.1 +005.4 +003.5 +001.4 -000.6 -002.4 +000.0 +000.0
L2 N: +003.10 E: -001.30 U: +063.40
L2 PAE:+000.0 -002.4 -004.0 -005.2 -005.9 -006.4 -006.8 -007.0 -007.2 -007.3
-007.4 -007.3 -007.0 -006.3 -005.2 -003.5 -000.8 +000.0 +000.0

ASH700699.L1

L1 N: +000.00 E: +000.00 U: +051.50
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700718A

L1 N: +003.40 E: +001.00 U: +087.30
L1 PAE:+000.0 +001.3 +002.9 +004.6 +006.2 +007.7 +008.8 +009.4 +009.6 +009.2
+008.4 +007.1 +005.4 +003.5 +001.4 -000.6 -002.4 +000.0 +000.0
L2 N: +003.10 E: -001.30 U: +063.40
L2 PAE:+000.0 -002.4 -004.0 -005.2 -005.9 -006.4 -006.8 -007.0 -007.2 -007.3
-007.4 -007.3 -007.0 -006.3 -005.2 -003.5 -000.8 +000.0 +000.0

ASH700718B

L1 N: +003.40 E: +001.00 U: +087.30
L1 PAE:+000.0 +001.3 +002.9 +004.6 +006.2 +007.7 +008.8 +009.4 +009.6 +009.2
+008.4 +007.1 +005.4 +003.5 +001.4 -000.6 -002.4 +000.0 +000.0
L2 N: +003.10 E: -001.30 U: +063.40
L2 PAE:+000.0 -002.4 -004.0 -005.2 -005.9 -006.4 -006.8 -007.0 -007.2 -007.3
-007.4 -007.3 -007.0 -006.3 -005.2 -003.5 -000.8 +000.0 +000.0

700829

L1 N: -000.70 E: +000.40 U: +092.00
L1 PAE:+000.0 +001.5 +003.3 +005.3 +007.1 +008.7 +010.0 +010.8 +011.0 +010.7
+009.9 +008.6 +006.8 +004.8 +002.6 +000.5 -001.5 +000.0 +000.0
L2 N: -000.10 E: -000.80 U: +060.10
L2 PAE:+000.0 -002.5 -004.2 -005.4 -006.1 -006.6 -006.9 -007.1 -007.1 -007.1
-007.0 -006.8 -006.3 -005.5 -004.2 -002.4 +000.3 +000.0 +000.0

DORNE MARGOLIN ASH

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH701933A_M

L1 N: +000.00 E: +000.00 U: +110.00

L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701933B_M
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701933C_M
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701941.1
L1 N: -000.20 E: +000.10 U: +108.00
L1 PAE:+000.0 -000.3 -000.5 -000.5 -000.4 -000.3 -000.2 -000.1 +000.0
+000.1
+000.1 +000.0 +000.0 -000.1 -000.2 -000.2 -000.2 +000.0 +000.0
L2 N: -000.30 E: +000.20 U: +126.70
L2 PAE:+000.0 -002.2 -003.3 -003.5 -003.3 -002.9 -002.5 -002.2 -002.1 -002.2
-002.5 -002.9 -003.2 -003.2 -002.7 -001.3 +001.3 +000.0 +000.0
ASH701941.2
L1 N: -000.20 E: +000.10 U: +108.00
L1 PAE:+000.0 -000.3 -000.5 -000.5 -000.4 -000.3 -000.2 -000.1 +000.0
+000.1
+000.1 +000.0 +000.0 -000.1 -000.2 -000.2 -000.2 +000.0 +000.0
L2 N: -000.30 E: +000.20 U: +126.70
L2 PAE:+000.0 -002.2 -003.3 -003.5 -003.3 -002.9 -002.5 -002.2 -002.1 -002.2
-002.5 -002.9 -003.2 -003.2 -002.7 -001.3 +001.3 +000.0 +000.0
ASH701941.A
L1 N: -000.20 E: +000.10 U: +108.00
L1 PAE:+000.0 -000.3 -000.5 -000.5 -000.4 -000.3 -000.2 -000.1 +000.0
+000.1
+000.1 +000.0 +000.0 -000.1 -000.2 -000.2 -000.2 +000.0 +000.0
L2 N: -000.30 E: +000.20 U: +126.70
L2 PAE:+000.0 -002.2 -003.3 -003.5 -003.3 -002.9 -002.5 -002.2 -002.1 -002.2
-002.5 -002.9 -003.2 -003.2 -002.7 -001.3 +001.3 +000.0 +000.0
ASH701941.B
L1 N: -000.20 E: +000.10 U: +108.00

L1 PAE:+000.0 -000.3 -000.5 -000.5 -000.4 -000.3 -000.2 -000.1 +000.0 +000.1
+000.1 +000.0 +000.0 -000.1 -000.2 -000.2 -000.2 +000.0 +000.0
L2 N: -000.30 E: +000.20 U: +126.70
L2 PAE:+000.0 -002.2 -003.3 -003.5 -003.3 -002.9 -002.5 -002.2 -002.1 -002.2
-002.5 -002.9 -003.2 -003.2 -002.7 -001.3 +001.3 +000.0 +000.0
ASH701945B_M
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701945.02B
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701945C_M
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701945E_M
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701945E_M SCIS
L1 N: -000.10 E: +000.50 U: +107.80
L1 PAE:+000.0 -000.2 -000.5 -000.8 -000.9 -001.3 -001.4 -001.6 -001.6 -001.6
-001.6 -001.4 -001.4 -001.3 -001.1 -001.1 -001.1 +000.0 +000.0
L2 N: -000.50 E: +000.60 U: +126.90
L2 PAE:+000.0 -000.3 -000.5 -000.7 -000.8 -000.8 -000.8 -000.8 -000.9 -001.0
-001.0 -001.0 -001.1 -001.0 -000.9 -000.7 -000.3 +000.0 +000.0
ASH701945G_M
L1 N: +000.00 E: +000.00 U: +110.00

L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH701946.022
L1 N: +000.60 E: +000.80 U: +109.80
L1 PAE:+000.0 -000.1 -000.2 -000.2 -000.1 -000.1 +000.0 +000.1 +000.2 +000.2
+000.2 +000.2 +000.3 +000.2 +000.2 +000.1 +000.1 +000.0 +000.0
L2 N: +000.70 E: +001.40 U: +128.40
L2 PAE:+000.0 -000.2 -000.3 -000.3 -000.3 -000.3 -000.3 -000.3 -000.2 -000.2
-000.2 -000.3 -000.3 -000.3 -000.2 -000.2 +000.0 +000.0 +000.0

ASH701946.012
L1 N: +000.60 E: +000.80 U: +109.80
L1 PAE:+000.0 -000.1 -000.2 -000.2 -000.1 -000.1 +000.0 +000.1 +000.2 +000.2
+000.2 +000.2 +000.3 +000.2 +000.2 +000.1 +000.1 +000.0 +000.0
L2 N: +000.70 E: +001.40 U: +128.40
L2 PAE:+000.0 -000.2 -000.3 -000.3 -000.3 -000.3 -000.3 -000.3 -000.2 -000.2
-000.2 -000.3 -000.3 -000.3 -000.2 -000.2 +000.0 +000.0 +000.0

ASH701946.2
L1 N: +000.60 E: +000.80 U: +109.80
L1 PAE:+000.0 -000.1 -000.2 -000.2 -000.1 -000.1 +000.0 +000.1 +000.2 +000.2
+000.2 +000.2 +000.3 +000.2 +000.2 +000.1 +000.1 +000.0 +000.0
L2 N: +000.70 E: +001.40 U: +128.40
L2 PAE:+000.0 -000.2 -000.3 -000.3 -000.3 -000.3 -000.3 -000.3 -000.2 -000.2
-000.2 -000.3 -000.3 -000.3 -000.2 -000.2 +000.0 +000.0 +000.0

ASH701946.3
L1 N: +000.60 E: +000.80 U: +109.80
L1 PAE:+000.0 -000.1 -000.2 -000.2 -000.1 -000.1 +000.0 +000.1 +000.2 +000.2
+000.2 +000.2 +000.3 +000.2 +000.2 +000.1 +000.1 +000.0 +000.0
L2 N: +000.70 E: +001.40 U: +128.40
L2 PAE:+000.0 -000.2 -000.3 -000.3 -000.3 -000.3 -000.3 -000.3 -000.2 -000.2
-000.2 -000.3 -000.3 -000.3 -000.2 -000.2 +000.0 +000.0 +000.0

ASH700936A_M
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700936B_M
L1 N: +000.00 E: +000.00 U: +110.00

L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700936C_M

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700936D_M

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700936E_C

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700936F_C

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH700936E

L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
700936 RADOM
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701073.1
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701073.3
L1 N: +000.00 E: +000.00 U: +110.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +128.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
ASH701975.01A
L1 N: -002.10 E: -004.10 U: +056.40
L1 PAE:+000.0 +001.0 +002.0 +003.1 +004.2 +005.1 +005.9 +006.5 +006.9 +007.1
+007.0 +006.6 +005.9 +005.0 +003.8 +002.4 +000.7 +000.0 +000.0
L2 N: -001.70 E: -003.20 U: +062.20
L2 PAE:+000.0 -000.3 -000.2 +000.2 +000.8 +001.5 +002.3 +002.9 +003.3 +003.6
+003.7 +003.4 +002.8 +002.0 +000.8 -000.7 -002.5 +000.0 +000.0
ASH701975.01Agp
L1 N: -002.00 E: -003.30 U: +056.00
L1 PAE:+000.0 +003.5 +007.1 +010.5 +013.5 +016.1 +018.1 +019.5 +020.2 +020.3
+019.7 +018.8 +017.4 +015.9 +014.2 +012.9 +011.9 +000.0 +000.0
L2 N: -002.00 E: -002.70 U: +046.10
L2 PAE:+000.0 -001.7 -002.9 -003.8 -004.5 -004.9 -005.4 -005.6 -005.9 -006.0
-006.1 -006.1 -005.9 -005.5 -004.8 -003.6 -001.8 +000.0 +000.0
JPSREGANT_DD_E
L1 N: +001.10 E: +000.20 U: +113.10
L1 PAE:+000.0 +000.5 +001.3 +002.1 +003.0 +003.8 +004.6 +005.2 +005.6 +005.8
+005.8 +005.5 +005.0 +004.3 +003.4 +002.3 +001.1 +000.0 +000.0
L2 N: +001.00 E: +001.30 U: +118.60

L2 PAE:+000.0 -000.2 +000.0 +000.4 +001.0 +001.6 +002.1 +002.5 +002.7 +002.8
+002.7 +002.3 +001.9 +001.3 +000.7 +000.2 -000.2 +000.0 +000.0
JPSREGANT_SD_E
L1 N: +001.00 E: -001.10 U: +106.00
L1 PAE:+000.0 +000.8 +001.6 +002.3 +003.1 +003.7 +004.3 +004.7 +005.0 +005.2
+005.3 +005.1 +004.8 +004.4 +003.8 +002.9 +002.0 +000.0 +000.0
L2 N: +001.40 E: +000.50 U: +119.60
L2 PAE:+000.0 -000.3 -000.3 +000.1 +000.6 +001.1 +001.7 +002.1 +002.3 +002.4
+002.3 +002.1 +001.7 +001.2 +000.7 +000.2 -000.2 +000.0 +000.0
LEIAT504
L1 N: +000.30 E: -000.30 U: +109.30
L1 PAE:+000.0 +000.0 -000.1 -000.1 +000.0 +000.0 +000.0 +000.1 +000.1 +000.1
+000.1 +000.2 +000.2 +000.3 +000.4 +000.5 +000.6 +000.0 +000.0
L2 N: +001.10 E: +001.10 U: +128.20
L2 PAE:+000.0 -000.1 -000.1 -000.1 +000.0 +000.0 +000.0 +000.0 +000.0 -000.1
-000.2 -000.2 -000.3 -000.3 -000.2 -000.1 +000.3 +000.0 +000.0
LEIAT504 LEIS
L1 N: +002.50 E: +001.30 U: +106.50
L1 PAE:+000.0 -000.3 -000.7 -001.0 -001.2 -001.4 -001.6 -001.8 -001.9 -001.9
-001.9 -001.8 -001.6 -001.4 -001.1 -000.8 -000.3 +000.0 +000.0
L2 N: -000.70 E: +001.30 U: +125.40
L2 PAE:+000.0 +000.1 +000.2 +000.2 +000.2 +000.1 +000.1 +000.0 -000.1 -000.1
-000.2 -000.2 -000.1 +000.0 +000.2 +000.5 +000.8 +000.0 +000.0
INTERNAL
L1 N: +003.10 E: -000.20 U: +113.10
L1 PAE:+000.0 +000.5 +001.0 +002.0 +003.3 +004.5 +005.7 +007.1 +008.5 +009.0
+008.3 +007.0 +005.8 +004.7 +003.4 +001.8 +000.8 +000.0 +000.0
L2 N: +001.30 E: -003.50 U: +117.20
L2 PAE:+000.0 +000.2 +000.4 +000.8 +001.5 +002.6 +003.6 +004.2 +004.5 +005.0
+005.3 +005.0 +003.8 +002.5 +001.4 -000.8 -005.1 +000.0 +000.0
LEISR299_INT
L1 N: +003.10 E: -000.20 U: +113.10
L1 PAE:+000.0 +000.5 +001.0 +002.0 +003.3 +004.5 +005.7 +007.1 +008.5 +009.0
+008.3 +007.0 +005.8 +004.7 +003.4 +001.8 +000.8 +000.0 +000.0
L2 N: +001.30 E: -003.50 U: +117.20
L2 PAE:+000.0 +000.2 +000.4 +000.8 +001.5 +002.6 +003.6 +004.2 +004.5 +005.0
+005.3 +005.0 +003.8 +002.5 +001.4 -000.8 -005.1 +000.0 +000.0
LEISR399_INT
L1 N: +003.10 E: -000.20 U: +113.10
L1 PAE:+000.0 +000.5 +001.0 +002.0 +003.3 +004.5 +005.7 +007.1 +008.5 +009.0

+008.3 +007.0 +005.8 +004.7 +003.4 +001.8 +000.8 +000.0 +000.0
L2 N: +001.30 E: -003.50 U: +117.20
L2 PAE:+000.0 +000.2 +000.4 +000.8 +001.5 +002.6 +003.6 +004.2 +004.5 +005.0
+005.3 +005.0 +003.8 +002.5 +001.4 -000.8 -005.1 +000.0 +000.0

EXTERNAL WITHOUT GP

L1 N: +000.50 E: +000.10 U: +068.50
L1 PAE:+000.0 +001.2 +002.6 +004.3 +005.8 +006.5 +007.1 +008.3 +010.3 +011.8
+011.1 +008.6 +006.2 +005.6 +005.6 +002.9 -003.8 +000.0 +000.0
L2 N: +000.30 E: -001.90 U: +052.10
L2 PAE:+000.0 -000.2 -000.7 -000.9 -000.9 -001.1 -001.4 -001.2 -000.4 +000.6
+001.0 +000.9 +000.9 +000.6 -001.2 -005.5 -012.0 +000.0 +000.0

LEIAT202-GP

L1 N: +000.50 E: +000.10 U: +068.50
L1 PAE:+000.0 +001.2 +002.6 +004.3 +005.8 +006.5 +007.1 +008.3 +010.3 +011.8
+011.1 +008.6 +006.2 +005.6 +005.6 +002.9 -003.8 +000.0 +000.0
L2 N: +000.30 E: -001.90 U: +052.10
L2 PAE:+000.0 -000.2 -000.7 -000.9 -000.9 -001.1 -001.4 -001.2 -000.4 +000.6
+001.0 +000.9 +000.9 +000.6 -001.2 -005.5 -012.0 +000.0 +000.0

LEIAT302-GP

L1 N: +000.50 E: +000.10 U: +068.50
L1 PAE:+000.0 +001.2 +002.6 +004.3 +005.8 +006.5 +007.1 +008.3 +010.3 +011.8
+011.1 +008.6 +006.2 +005.6 +005.6 +002.9 -003.8 +000.0 +000.0
L2 N: +000.30 E: -001.90 U: +052.10
L2 PAE:+000.0 -000.2 -000.7 -000.9 -000.9 -001.1 -001.4 -001.2 -000.4 +000.6
+001.0 +000.9 +000.9 +000.6 -001.2 -005.5 -012.0 +000.0 +000.0

LEIAT303

L1 N: +001.00 E: -000.50 U: +078.20
L1 PAE:+000.0 +001.4 +002.4 +003.2 +003.8 +004.2 +004.4 +004.6 +004.7 +004.8
+004.7 +004.5 +004.2 +003.7 +003.0 +002.0 +000.7 +000.0 +000.0
L2 N: +001.80 E: +000.80 U: +093.90
L2 PAE:+000.0 +000.6 +001.1 +001.5 +001.9 +002.3 +002.5 +002.7 +002.8 +002.9
+002.7 +002.5 +002.2 +001.7 +001.0 +000.1 -000.9 +000.0 +000.0

EXTERNAL WITH GP

L1 N: +004.80 E: +001.90 U: +049.20
L1 PAE:+000.0 +000.0 +000.4 +001.7 +003.4 +004.4 +004.6 +004.9 +005.9 +006.7
+006.6 +005.6 +004.6 +003.7 +002.6 +001.7 +001.9 +000.0 +000.0
L2 N: +003.40 E: -005.20 U: +041.80
L2 PAE:+000.0 -000.2 -000.6 -000.8 -000.6 -000.2 +000.1 +000.1 +000.0 +000.0
+000.2 +000.7 +000.9 +000.5 -000.6 -001.8 -002.5 +000.0 +000.0

LEIAT202+GP

L1 N: +004.80 E: +001.90 U: +049.20
L1 PAE:+000.0 +000.0 +000.4 +001.7 +003.4 +004.4 +004.6 +004.9 +005.9 +006.7

+006.6 +005.6 +004.6 +003.7 +002.6 +001.7 +001.9 +000.0 +000.0
L2 N: +003.40 E: -005.20 U: +041.80
L2 PAE:+000.0 -000.2 -000.6 -000.8 -000.6 -000.2 +000.1 +000.1 +000.0 +000.0
+000.2 +000.7 +000.9 +000.5 -000.6 -001.8 -002.5 +000.0 +000.0

LEIAT302+GP

L1 N: +004.80 E: +001.90 U: +049.20
L1 PAE:+000.0 +000.0 +000.4 +001.7 +003.4 +004.4 +004.6 +004.9 +005.9 +006.7
+006.6 +005.6 +004.6 +003.7 +002.6 +001.7 +001.9 +000.0 +000.0
L2 N: +003.40 E: -005.20 U: +041.80
L2 PAE:+000.0 -000.2 -000.6 -000.8 -000.6 -000.2 +000.1 +000.1 +000.0 +000.0
+000.2 +000.7 +000.9 +000.5 -000.6 -001.8 -002.5 +000.0 +000.0

LEIAX1202

L1 N: +002.80 E: -000.70 U: +083.40
L1 PAE:+000.0 +000.9 +002.0 +003.2 +004.4 +005.6 +006.7 +007.5 +008.1 +008.3
+008.1 +007.4 +006.2 +004.4 +002.1 -000.8 -004.4 +000.0 +000.0
L2 N: -000.90 E: -000.30 U: +076.90
L2 PAE:+000.0 -001.1 -001.3 -001.0 -000.3 +000.6 +001.4 +002.1 +002.6 +002.8
+002.6 +002.0 +001.1 -000.2 -001.8 -003.5 -005.2 +000.0 +000.0

MACROMETER X-DIPOLE

L1 N: +002.20 E: -008.20 U: +163.10
L1 PAE:+000.0 -003.7 -003.3 -000.3 +003.9 +008.5 +012.3 +015.0 +015.9 +014.8
+011.6 +006.6 +000.1 -007.4 -015.1 -022.0 -027.0 +000.0 +000.0
L2 N: +004.30 E: +002.00 U: +091.30
L2 PAE:+000.0 -003.0 -002.9 -000.9 +002.1 +005.4 +008.3 +010.6 +011.9 +012.2
+011.6 +010.3 +008.8 +007.6 +007.6 +009.6 +014.8 +000.0 +000.0

MAC4647942

L1 N: +002.20 E: -008.20 U: +163.10
L1 PAE:+000.0 -003.7 -003.3 -000.3 +003.9 +008.5 +012.3 +015.0 +015.9 +014.8
+011.6 +006.6 +000.1 -007.4 -015.1 -022.0 -027.0 +000.0 +000.0
L2 N: +004.30 E: +002.00 U: +091.30
L2 PAE:+000.0 -003.0 -002.9 -000.9 +002.1 +005.4 +008.3 +010.6 +011.9 +012.2
+011.6 +010.3 +008.8 +007.6 +007.6 +009.6 +014.8 +000.0 +000.0

TOP700779A

L1 N: +003.40 E: +001.00 U: +087.30
L1 PAE:+000.0 +001.3 +002.9 +004.6 +006.2 +007.7 +008.8 +009.4 +009.6 +009.2
+008.4 +007.1 +005.4 +003.5 +001.4 -000.6 -002.4 +000.0 +000.0
L2 N: +003.10 E: -001.30 U: +063.40
L2 PAE:+000.0 -002.4 -004.0 -005.2 -005.9 -006.4 -006.8 -007.0 -007.2 -007.3
-007.4 -007.3 -007.0 -006.3 -005.2 -003.5 -000.8 +000.0 +000.0

72110

L1 N: -003.90 E: +007.30 U: +147.10

L1 PAE:+000.0 -001.1 -001.1 -000.3 +000.9 +002.3 +003.7 +004.8 +005.3 +005.3
+004.5 +002.9 +000.3 -003.2 -007.6 -012.9 -019.0 +000.0 +000.0
L2 N: -004.40 E: +006.50 U: +127.80
L2 PAE:+000.0 -000.5 -000.7 -000.8 -000.7 -000.6 -000.5 -000.5 -000.6 -001.0
-001.6 -002.5 -003.7 -005.3 -007.3 -009.7 -012.5 +000.0 +000.0

TOP72110

L1 N: -003.90 E: +007.30 U: +147.10
L1 PAE:+000.0 -001.1 -001.1 -000.3 +000.9 +002.3 +003.7 +004.8 +005.3 +005.3
+004.5 +002.9 +000.3 -003.2 -007.6 -012.9 -019.0 +000.0 +000.0
L2 N: -004.40 E: +006.50 U: +127.80
L2 PAE:+000.0 -000.5 -000.7 -000.8 -000.7 -000.6 -000.5 -000.5 -000.6 -001.0
-001.6 -002.5 -003.7 -005.3 -007.3 -009.7 -012.5 +000.0 +000.0

TOPCR3_GGD

L1 N: +000.10 E: +000.00 U: +080.50
L1 PAE:+000.0 +000.8 +001.3 +001.6 +001.7 +001.8 +001.8 +001.8 +001.8 +001.8
+001.9 +002.0 +002.0 +001.8 +001.5 +000.9 -000.1 +000.0 +000.0
L2 N: +000.70 E: +000.80 U: +103.50
L2 PAE:+000.0 -000.5 -000.5 -000.2 +000.2 +000.7 +001.1 +001.5 +001.8 +001.8
+001.7 +001.5 +001.1 +000.7 +000.2 -000.1 -000.3 +000.0 +000.0

TPSCR3_GGD

L1 N: +000.10 E: +000.00 U: +080.50
L1 PAE:+000.0 +000.8 +001.3 +001.6 +001.7 +001.8 +001.8 +001.8 +001.8 +001.8
+001.9 +002.0 +002.0 +001.8 +001.5 +000.9 -000.1 +000.0 +000.0
L2 N: +000.70 E: +000.80 U: +103.50
L2 PAE:+000.0 -000.5 -000.5 -000.2 +000.2 +000.7 +001.1 +001.5 +001.8 +001.8
+001.7 +001.5 +001.1 +000.7 +000.2 -000.1 -000.3 +000.0 +000.0

TPSCR3_GGD CONE

L1 N: +000.20 E: +000.10 U: +080.30
L1 PAE:+000.0 +001.2 +001.9 +002.4 +002.6 +002.6 +002.6 +002.5 +002.5 +002.4
+002.4 +002.4 +002.4 +002.4 +002.3 +002.1 +001.6 +000.0 +000.0
L2 N: +000.40 E: +000.60 U: +102.70
L2 PAE:+000.0 -000.8 -001.0 -000.7 -000.1 +000.5 +001.1 +001.7 +002.0 +002.1
+001.9 +001.6 +001.1 +000.5 +000.0 -000.4 -000.5 +000.0 +000.0

M-PULSE L1/L2 SURVEY

L1 N: +000.00 E: +000.00 U: +079.60
L1 PAE:+000.0 +000.4 +000.4 +000.9 +002.1 +003.1 +003.5 +003.6 +003.9 +003.8
+003.0 +002.2 +001.8 +001.7 +000.9 +000.9 +002.6 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +093.20
L2 PAE:+000.0 +000.1 +000.1 +000.0 +000.0 +000.6 +001.3 +001.7 +001.5 +001.2
+000.9 +000.7 +000.6 +000.7 +000.7 -000.6 -004.1 +000.0 +000.0

MPLL1/L2_SURV

L1 N: +000.00 E: +000.00 U: +079.60
L1 PAE:+000.0 +000.4 +000.4 +000.9 +002.1 +003.1 +003.5 +003.6 +003.9 +003.8
+003.0 +002.2 +001.8 +001.7 +000.9 +000.9 +002.6 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +093.20
L2 PAE:+000.0 +000.1 +000.1 +000.0 +000.0 +000.6 +001.3 +001.7 +001.5 +001.2
+000.9 +000.7 +000.6 +000.7 +000.7 -000.6 -004.1 +000.0 +000.0

MPLL1/L2SURV

L1 N: +000.00 E: +000.00 U: +079.60
L1 PAE:+000.0 +000.4 +000.4 +000.9 +002.1 +003.1 +003.5 +003.6 +003.9 +003.8
+003.0 +002.2 +001.8 +001.7 +000.9 +000.9 +002.6 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +093.20
L2 PAE:+000.0 +000.1 +000.1 +000.0 +000.0 +000.6 +001.3 +001.7 +001.5 +001.2
+000.9 +000.7 +000.6 +000.7 +000.7 -000.6 -004.1 +000.0 +000.0

2200

L1 N: +000.80 E: -001.70 U: +095.40
L1 PAE:+000.0 +001.3 +002.7 +004.4 +006.0 +007.2 +008.0 +009.1 +010.2 +010.4
+009.4 +008.3 +007.8 +007.4 +006.3 +004.6 +003.7 +000.0 +000.0
L2 N: +000.40 E: +000.10 U: +073.90
L2 PAE:+000.0 -000.3 -001.7 -003.9 -005.8 -006.3 -006.1 -006.4 -007.3 -007.8
-007.5 -006.9 -006.0 -004.1 -001.7 -001.7 -006.4 +000.0 +000.0

AERAT2775_43

L1 N: +002.30 E: -000.60 U: +088.30
L1 PAE:+000.0 +000.1 +000.6 +001.3 +002.0 +002.7 +003.4 +003.8 +004.1 +004.2
+004.0 +003.7 +003.2 +002.6 +002.1 +001.6 +001.3 +000.0 +000.0
L2 N: -000.20 E: +000.20 U: +094.10
L2 PAE:+000.0 -000.7 -001.0 -001.2 -001.3 -001.3 -001.3 -001.4 -001.4 -001.6
-001.7 -001.7 -001.7 -001.4 -000.8 +000.3 +001.8 +000.0 +000.0

3S-02-TSADM

L1 N: +001.70 E: +003.60 U: +272.50
L1 PAE:+000.0 +000.0 +000.2 +000.5 +001.0 +001.5 +002.0 +002.5 +002.9 +003.3
+003.6 +003.9 +004.2 +004.5 +004.9 +005.4 +006.0 +000.0 +000.0
L2 N: +000.80 E: +004.20 U: +291.60
L2 PAE:+000.0 +000.1 +000.3 +000.4 +000.6 +000.9 +001.1 +001.5 +001.8 +002.2
+002.5 +002.9 +003.3 +003.6 +003.9 +004.2 +004.3 +000.0 +000.0

3S-02-TSATE

L1 N: +000.00 E: +000.00 U: +171.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +171.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

NOV503+CR
L1 N: +002.30 E: -001.40 U: +086.50
L1 PAE:+000.0 +000.3 +000.8 +001.5 +002.3 +003.0 +003.7 +004.2 +004.5 +004.6
+004.6 +004.2 +003.7 +003.0 +002.3 +001.6 +001.0 +000.0 +000.0
L2 N: -000.10 E: +000.30 U: +092.30
L2 PAE:+000.0 -001.5 -002.3 -002.5 -002.6 -002.5 -002.3 -002.2 -002.1 -002.2
-002.3 -002.5 -002.5 -002.4 -001.8 -000.8 +001.0 +000.0 +000.0
NOV503+CR SPKE
L1 N: +002.00 E: -002.60 U: +087.10
L1 PAE:+000.0 -000.1 +000.5 +001.4 +002.4 +003.4 +004.4 +005.1 +005.6 +005.6
+005.5 +005.0 +004.2 +003.3 +002.4 +001.5 +000.9 +000.0 +000.0
L2 N: -000.80 E: -000.20 U: +094.60
L2 PAE:+000.0 -001.1 -001.7 -001.9 -001.8 -001.5 -001.3 -001.0 -000.8 -000.8
-000.9 -000.9 -001.1 -001.1 -000.9 -000.5 +000.5 +000.0 +000.0
NOV600
L1 N: -001.30 E: +000.30 U: +090.50
L1 PAE:+000.0 +000.7 +001.6 +002.7 +004.0 +005.2 +006.2 +007.1 +007.8 +008.1
+008.1 +007.6 +006.7 +005.4 +003.6 +001.4 -001.2 +000.0 +000.0
L2 N: +000.20 E: -000.40 U: +091.80
L2 PAE:+000.0 -000.6 -000.6 -000.2 +000.5 +001.4 +002.2 +002.9 +003.3 +003.6
+003.5 +003.1 +002.4 +001.4 +000.2 -001.2 -002.7 +000.0 +000.0
NULLANTENNA
L1 N: +000.00 E: +000.00 U: +000.00
L1 PAE:+000.0 +000.3 +001.2 +002.6 +004.4 +006.4 +008.6 +010.6 +012.4 +013.8
+014.8 +015.5 +015.6 +015.4 +014.6 +013.0 +010.7 +007.6 +003.9
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.2 +000.6 +001.4 +002.3 +003.4 +004.5 +005.6 +006.7 +007.6
+008.1 +008.2 +007.9 +007.3 +006.4 +005.3 +003.7 +001.4 -001.7
ADVNULLANTENNA
L1 N: +000.00 E: +000.00 U: +000.00
L1 PAE:+000.0 +000.3 +001.2 +002.6 +004.4 +006.4 +008.6 +010.6 +012.4 +013.8
+014.8 +015.5 +015.6 +015.4 +014.6 +013.0 +010.7 +007.6 +003.9
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.2 +000.6 +001.4 +002.3 +003.4 +004.5 +005.6 +006.7 +007.6
+008.1 +008.2 +007.9 +007.3 +006.4 +005.3 +003.7 +001.4 -001.7
GPP_NULLANTENNA
L1 N: +000.00 E: +000.00 U: +000.00
L1 PAE:+000.0 +000.3 +001.2 +002.6 +004.4 +006.4 +008.6 +010.6 +012.4 +013.8
+014.8 +015.5 +015.6 +015.4 +014.6 +013.0 +010.7 +007.6 +003.9
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.2 +000.6 +001.4 +002.3 +003.4 +004.5 +005.6 +006.7 +007.6

+008.1 +008.2 +007.9 +007.3 +006.4 +005.3 +003.7 +001.4 -001.7

GPPNULLANTENNA

L1 N: +000.00 E: +000.00 U: +000.00

L1 PAE:+000.0 +000.3 +001.2 +002.6 +004.4 +006.4 +008.6 +010.6 +012.4 +013.8

+014.8 +015.5 +015.6 +015.4 +014.6 +013.0 +010.7 +007.6 +003.9

L2 N: +000.00 E: +000.00 U: +000.00

L2 PAE:+000.0 +000.2 +000.6 +001.4 +002.3 +003.4 +004.5 +005.6 +006.7 +007.6

+008.1 +008.2 +007.9 +007.3 +006.4 +005.3 +003.7 +001.4 -001.7

THA_ZMAX

L1 N: +003.80 E: -002.30 U: +000.00

L1 PAE:+000.0 -001.7 -002.2 -001.7 -000.7 +000.5 +001.6 +002.6 +003.2 +003.4

+003.0 +002.0 +000.7 -001.1 -003.2 -005.2 -007.1 +000.0 +000.0

L2 N: +003.80 E: -000.80 U: -004.90

L2 PAE:+000.0 +000.6 +000.9 +001.1 +001.3 +001.5 +001.8 +002.1 +002.6 +003.0

+003.3 +003.3 +003.0 +002.0 +000.2 -002.7 -007.0 +000.0 +000.0

110454

L1 N: +000.00 E: +000.00 U: +069.00

L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

L2 N: +000.00 E: +000.00 U: +000.00

L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

NAP100

L1 N: +000.00 E: +000.00 U: +073.00

L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

L2 N: +000.00 E: +000.00 U: +000.00

L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

AT1675-20W

L1 N: +001.50 E: -001.90 U: +098.70

L1 PAE:+000.0 +000.1 +000.7 +001.7 +002.8 +003.9 +004.9 +005.6 +005.9 +005.8

+005.4 +004.6 +003.4 +001.9 +000.3 -001.3 -002.6 +000.0 +000.0

L2 N: +000.10 E: +000.30 U: +104.30

L2 PAE:+000.0 -000.1 -000.1 -000.1 +000.0 +000.0 +000.1 +000.1 +000.2 +000.2

+000.2 +000.1 +000.1 +000.1 -000.1 -000.1 -000.2 +000.0 +000.0

AERAT1675_182

L1 N: +000.00 E: -002.40 U: +050.00

L1 PAE:+000.0 +000.7 +001.6 +002.8 +004.0 +005.3 +006.4 +007.4 +008.1 +008.4

+008.3 +007.5 +006.2 +004.1 +001.1 -002.7 -007.7 +000.0 +000.0

L2 N: -001.90 E: -001.40 U: +033.10
L2 PAE:+000.0 +000.3 +000.9 +001.6 +002.2 +002.9 +003.4 +003.7 +003.9 +003.9
+003.7 +003.3 +002.8 +002.1 +001.4 +000.8 +000.3 +000.0 +000.0

AERAT1675_32
L1 N: -000.40 E: -002.60 U: +050.40
L1 PAE:+000.0 +000.7 +001.6 +002.7 +003.8 +005.0 +006.1 +007.0 +007.7 +007.9
+007.8 +007.1 +005.8 +003.7 +000.7 -003.1 -008.0 +000.0 +000.0
L2 N: -001.80 E: -002.50 U: +032.40
L2 PAE:+000.0 +000.9 +001.7 +002.4 +003.1 +003.7 +004.2 +004.5 +004.7 +004.7
+004.5 +004.2 +003.8 +003.3 +002.6 +001.8 +000.9 +000.0 +000.0

ASH802111
L1 N: +000.00 E: +000.00 U: +000.00
L1 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH111660
L1 N: +000.30 E: -000.70 U: +075.40
L1 PAE:+000.0 +000.7 +001.7 +002.8 +004.1 +005.3 +006.3 +007.2 +007.7 +007.8
+007.6 +006.9 +005.6 +003.7 +001.2 -001.9 -005.7 +000.0 +000.0
L2 N: +000.00 E: +000.00 U: +000.00
L2 PAE:+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
+000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0

ASH111661
L1 N: -000.50 E: -001.40 U: +075.40
L1 PAE:+000.0 +000.6 +001.5 +002.6 +003.8 +005.0 +006.0 +006.9 +007.5 +007.7
+007.4 +006.6 +005.3 +003.4 +000.8 -002.5 -006.5 +000.0 +000.0
L2 N: -002.20 E: -001.00 U: +071.90
L2 PAE:+000.0 -000.7 -000.8 -000.3 +000.4 +001.2 +002.0 +002.6 +002.9 +003.0
+002.7 +002.1 +001.1 -000.2 -001.8 -003.5 -005.3 +000.0 +000.0

ASH802129
L1 N: -002.00 E: +000.70 U: +103.00
L1 PAE:+000.0 +001.0 +002.1 +003.5 +004.8 +006.0 +006.9 +007.7 +008.0 +008.1
+007.7 +006.9 +005.8 +004.3 +002.5 +000.5 -001.6 +000.0 +000.0
L2 N: -003.40 E: -002.20 U: +100.80

L2 PAE:+000.0 -000.6 -000.6 +000.0 +000.9 +001.8 +002.7 +003.3 +003.8 +004.0
+003.7 +003.0 +002.0 +000.6 -001.1 -003.1 -005.2 +000.0 +000.0
ASH802147
L1 N: 0.3 E: 2.2 U: 104.0
L1 PAE : 0.0 0.9 1.9 3.1 4.4 5.5 6.4 7.2 7.6 7.7
7.4 6.7 5.5 4.1 2.2 0.0 -2.3 0.0 0.0
L2 N: -2.1 E: -1.0 U: 100.1
L2 PAE : 0.0 -0.3 0.0 0.6 1.5 2.4 3.2 3.9 4.3 4.4
4.2 3.5 2.5 1.1 -0.7 -2.8 -5.1 0.0 0.0
SPP39105.90
L1 N: +000.00 E: +000.20 U: +071.20
L1 PAE:+000.0 +001.0 +002.2 +003.4 +004.6 +005.8 +007.0 +008.0 +008.7 +009.2
+009.2 +008.9 +008.0 +006.5 +004.3 +001.4 -002.5 +000.0 +000.0
L2 N: -000.70 E: +000.90 U: +067.40
L2 PAE:+000.0 -000.3 -000.1 +000.4 +001.1 +001.9 +002.8 +003.5 +004.0 +004.4
+004.4 +004.1 +003.3 +002.1 +000.6 -001.5 -004.0 +000.0 +000.0
SPP67410_42
L1 N: -001.50 E: -000.70 U: +115.90
L1 PAE:+000.0 +000.8 +001.9 +003.1 +004.4 +005.6 +006.6 +007.5 +007.9 +008.1
+007.7 +007.0 +005.6 +003.7 +001.2 -001.9 -005.7 +000.0 +000.0
L2 N: +000.00 E: +000.30 U: +107.60
L2 PAE:+000.0 -001.1 -001.5 -001.3 -000.8 -000.2 +000.6 +001.2 +001.6 +001.8
+001.6 +001.1 +000.2 -001.0 -002.6 -004.4 -006.6 +000.0 +000.0
SPP67410_44
L1 N: -001.50 E: -000.70 U: +115.90
L1 PAE:+000.0 +000.8 +001.9 +003.1 +004.4 +005.6 +006.6 +007.5 +007.9 +008.1
+007.7 +007.0 +005.6 +003.7 +001.2 -001.9 -005.7 +000.0 +000.0
L2 N: +000.00 E: +000.30 U: +107.60
L2 PAE:+000.0 -001.1 -001.5 -001.3 -000.8 -000.2 +000.6 +001.2 +001.6 +001.8
+001.6 +001.1 +000.2 -001.0 -002.6 -004.4 -006.6 +000.0 +000.0
SPP67410_46
L1 N: -001.50 E: -000.70 U: +115.90
L1 PAE:+000.0 +000.8 +001.9 +003.1 +004.4 +005.6 +006.6 +007.5 +007.9 +008.1
+007.7 +007.0 +005.6 +003.7 +001.2 -001.9 -005.7 +000.0 +000.0
L2 N: +000.00 E: +000.30 U: +107.60
L2 PAE:+000.0 -001.1 -001.5 -001.3 -000.8 -000.2 +000.6 +001.2 +001.6 +001.8
+001.6 +001.1 +000.2 -001.0 -002.6 -004.4 -006.6 +000.0 +000.0
SPP68410_10
L1 N: +000.60 E: -000.60 U: +118.90
L1 PAE:+000.0 +000.8 +001.8 +003.1 +004.4 +005.7 +006.8 +007.7 +008.2 +008.3
+008.0 +007.0 +005.6 +003.5 +000.9 -002.5 -006.5 +000.0 +000.0

L2 N: -000.80 E: +000.80 U: +106.80
L2 PAE:+000.0 -000.1 +000.1 +000.5 +001.1 +001.7 +002.3 +002.9 +003.2 +003.4
+003.2 +002.8 +001.9 +000.6 -001.1 -003.3 -006.1 +000.0 +000.0
TRM59800.00
L1 N: +000.70 E: +001.20 U: +107.70
L1 PAE:+000.0 +000.0 +000.0 -000.1 -000.1 -000.2 -000.2 -000.2 -000.2 -000.2
-000.1 -000.1 -000.1 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: -000.60 E: +000.40 U: +127.30
L2 PAE:+000.0 -000.4 -000.5 -000.6 -000.6 -000.6 -000.6 -000.5 -000.5 -000.5
-000.5 -000.6 -000.6 -000.7 -000.7 -000.7 -000.6 +000.0 +000.0
TRM59800.80
L1 N: +000.70 E: +001.20 U: +107.70
L1 PAE:+000.0 +000.0 +000.0 -000.1 -000.1 -000.2 -000.2 -000.2 -000.2 -000.2
-000.1 -000.1 -000.1 +000.0 +000.0 +000.0 +000.0 +000.0 +000.0
L2 N: -000.60 E: +000.40 U: +127.30
L2 PAE:+000.0 -000.4 -000.5 -000.6 -000.6 -000.6 -000.6 -000.5 -000.5 -000.5
-000.5 -000.6 -000.6 -000.7 -000.7 -000.7 -000.6 +000.0 +000.0
EPOCH50
SPP EPOCH 50 NONE
L1 N: +000.60 E: -000.60 U: +118.90
L1 PAE:+000.0 +000.8 +001.8 +003.1 +004.4 +005.7 +006.8 +007.7 +008.2 +008.3
+008.0 +007.0 +005.6 +003.5 +000.9 -002.5 -006.5 +000.0 +000.0
L2 N: -000.80 E: +000.80 U: +106.80
L2 PAE:+000.0 -000.1 +000.1 +000.5 +001.1 +001.7 +002.3 +002.9 +003.2 +003.4
+003.2 +002.8 +001.9 +000.6 -001.1 -003.3 -006.1 +000.0 +000.0
TRM57971.00 NONE
L1 N: +000.60 E: +000.10 U: +085.60
L1 PAE:+000.0 +000.2 +000.8 +001.6 +002.7 +003.8 +004.7 +005.4 +005.8 +005.9
+005.6 +005.0 +004.1 +002.8 +001.1 -001.0 -003.7 +000.0 +000.0
L2 N: -000.20 E: +001.40 U: +065.80
L2 PAE:+000.0 +000.0 +000.1 +000.2 +000.4 +000.7 +000.9 +001.2 +001.4 +001.5
+001.4 +001.2 +001.0 +000.7 +000.3 -000.3 -001.1 +000.0 +000.0
TRM57971.00
L1 N: +000.60 E: +000.10 U: +085.60
L1 PAE:+000.0 +000.2 +000.8 +001.6 +002.7 +003.8 +004.7 +005.4 +005.8 +005.9
+005.6 +005.0 +004.1 +002.8 +001.1 -001.0 -003.7 +000.0 +000.0
L2 N: -000.20 E: +001.40 U: +065.80
L2 PAE:+000.0 +000.0 +000.1 +000.2 +000.4 +000.7 +000.9 +001.2 +001.4 +001.5
+001.4 +001.2 +001.0 +000.7 +000.3 -000.3 -001.1 +000.0 +000.0
AERAT1675_382 NONE
L1 N: -001.10 E: +000.40 U: +067.70

L1 PAE:+000.0 +001.1 +002.3 +003.5 +004.8 +005.9 +006.9 +007.7 +008.1 +008.2
+007.9 +007.2 +006.0 +004.3 +002.1 -000.7 -004.1 +000.0 +000.0
L2 N: -002.70 E: -000.20 U: +064.60
L2 PAE:+000.0 -001.5 -002.0 -001.7 -001.0 -000.1 +000.9 +001.8 +002.4 +002.6
+002.3 +001.6 +000.4 -001.3 -003.3 -005.6 -008.1 +000.0 +000.0
AERAT1675_382
L1 N: -001.10 E: +000.40 U: +067.70
L1 PAE:+000.0 +001.1 +002.3 +003.5 +004.8 +005.9 +006.9 +007.7 +008.1 +008.2
+007.9 +007.2 +006.0 +004.3 +002.1 -000.7 -004.1 +000.0 +000.0
L2 N: -002.70 E: -000.20 U: +064.60
L2 PAE:+000.0 -001.5 -002.0 -001.7 -001.0 -000.1 +000.9 +001.8 +002.4 +002.6
+002.3 +001.6 +000.4 -001.3 -003.3 -005.6 -008.1 +000.0 +000.0

Symbols

A

B

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