DG14™

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PROFESSIONAL

Reference Manual

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General Information

The DG14 GPS receiver processes signals from the Global Positioning System (GPS) satellite constellation, the geostationary satellites from the Satellite-based Augmentation System (SBAS) network including: Wide Area Augmentation System network (WAAS), the European Geostationary Navigation Overlay System network (EGNOS), the Japanese Multi-function Transport System System network (MSAS), and from 300kHz Beacon transmissions to provide real-time position, velocity, and time measurements.

In this manual, the term SBAS (Space Based Augmentation System) includes WAAS, EGNOS, and MSAS.

The DG14 has several options:

- GPS only— 14 GPS channels (you can limit to 12 channels of GPS)
- GPS + SBAS— 12 channels of GPS + 2 channels of SBAS. The [Y] option must be loaded for SBAS channels.
- GPS + Beacon—14 GPS channels + 2 Beacon channels (you can limit to 12 channels of GPS). The [N] option must be loaded for Beacon channels.
- GPS + SBAS + Beacon— 12 channels of GPS + 2 channels of SBAS + 2 channels of Beacon. The [Y] option must be loaded for SBAS channels, and the [N] option loaded for Beacon channels.

The DG14 uses fourteen discrete parallel channels for Coarse/Acquisition (C/A) code-phase (pseudo-range) measurements and carrier phase measurements on the L1 (1575.42 Mhz) band for the GPS, with the [Y] option installed.The DG14 can use two of the parallel channels for WAAS, EGNOS, or MSAS measurements. With the [N] option installed, the DG14 has two additional channels for Beacon signals.

The DG14 receives satellite signals through an L-band antenna and an external low-noise amplifier (LNA).

The DG14 is designed for stand-alone and differential GPS (DGPS) operation; it can operate as a base (reference) station or a remote (rover) station, providing or using real-time differential GPS corrections in RTCM SC-104 format (Version 2.2).

This chapter describes DG14 hardware and functionality, describes the RF interface connector and the power/input/output connector, options, firmware upgrades, and lists power requirements and environmental specifications.

Table 1.1. DG14 Performance Specifications

Position Accuracy (DGPS)	
Horizontal CEP	40 cm
Horizontal (95%)	90 cm
Vertical (95%)	1.6 m
Time to First Fix (TTFF)	
Re-acquisition	3 seconds
Hot Start	11 seconds
Warm Start	35 seconds
Cold Start	90 seconds
Physical Specifications	
Size	Board: 2.300" x 4.250" (± 0.005); 107.95 mm x 57 mm (± 0.13) Sensor: 178 mm x 105 mm x 52 mm
Weight	Board: 2.8 oz Sensor: 1 lb, 4 oz
Humidity	95% Non-condensing
Shock	RTCA DO-160C - op/crash safety: • Operational — ± 40 G's in the X, Y, or Z axis • Non-operational — ± 75 G's in the X, Y, or Z axis
Vibration	• MILSPEC 810E • Category 10: Minimum Integrity Test - General
Acceleration	20 G
Maximum Speed	1,000 knots
Maximum Altitude	60,000 ft

Vibration testing was performed using 4 corner mounting holes. Performance may degrade with the use of the center mounting hole.

Functional Description

Upon application of power, the DG14 runs a built-in self test of its internal memory, and thereafter periodically self-tests various functions during normal operation. Test results are stored for output on command. After self test, the DG14 initializes its battery-backed RAM. If the battery-backed RAM fails self-test (due, for example, to a low battery backup condition), the DG14 clears and

reports the loss of stored data, then initializes its channels and begins searching for all satellites within the field of view of its antenna.

You can view the results of the start-up built-in diagnostics in the response from the **$PASHQ,HST** command. Results from the periodic operational diagnostics can be viewed in the results of the **$PASHQ,BIT** command. See **BIT: Operational Diagnostic Tests** on page 71, and **HST: Start-up Diagnostic Results** on page 94 for more information.

The DG14 can track all GPS satellites as specified in the Navstar GPS Space Segment/Navigation User Interfaces, ICD-GPS-200, Revision B. All 32 satellite PRN (pseudo-random noise) code numbers are programmed into the DG14's firmware. There are at least 24 satellites in the GPS constellation. As it acquires (locks on to) each satellite, the DG14 notes the time and collects almanac and ephemeris data for each orbiting satellite and stores this information in battery-backed memory.

- When tracking one satellite, the DG14 gets a time reference from that satellite's clock.
- When tracking three satellites, the DG14 computes and time-tags the horizontal position (2D) and velocity of its antenna. Input of an initial position estimate is not required. When it receives an appropriate command message from controller equipment through one of its serial communication ports, the DG14 sends the results of its computations to the designated port.
- With four locked satellites, the DG14 determines three-dimensional position and velocity. Stand-alone position accuracy is 2 meters Circular Error Probable (CEP) when Position Dilution of Precision (PDOP) is less than 4; velocity accuracy is 0.1 meter per second. Accuracy levels for position and velocity are subject to the US Government policy of Selective Availability (SA). When the DG14 is operating in differential mode, position accuracy improves to better than 1.0 m CEP.

The DG14 can compute up to 20 independent measurements per cycle (20 Hz), with no interpolation or extrapolation from previous solutions. Position and velocity computations are performed simultaneously using all the satellites in view. The DG14 uses instantaneous doppler values from four satellites to compute dynamic speed, allowing velocity computations to be made independent of the last position fix. All measurements are referenced to the WGS-84 (World Geodetic System-1984) ellipsoid model.

The DG14 features 14-channel/14-Satellite All-In-View operation; each of up to 14 visible satellites can be assigned to a discrete channel for continuous tracking. Each satellite broadcasts almanac and ephemeris information every 30 seconds; this information is recorded in DG14 memory automatically.

With the SBAS option installed, the DG14 can track up to two geostationary satellites at a time and make available the SBAS ranging, ephemeris, and

differential correction data through the serial ports. The DG14 can process SBAS corrections for differential positioning by converting the SBAS corrections to RTCM SC-104 corrections. For more information on how to use SBAS in differential operation, see Chapter 8, **Differential Operation** and "SBAS Commands" on page 313.

SBAS supplements GPS with a ground reference network which provides a real-time assessment of the system integrity. The stations use GPS data along with differential corrections to improve accuracy by broadcasting through geostationary satellites.

While satellite-based augmentation systems are developed to provide differential corrections and integrity data for satellite-based aviation, their signals are available free of charge to all other non-aviation satellite positioning users in the respective coverage areas.

With the Beacon option [N] installed, the DG14 can receive differential corrections from up to two different Beacon stations.For more information on how to use Beacon in differential operation, see "Beacon Commands" on page 324. The DG14 correction output is in RTCM-104 differential format. See "Beacon Operation" on page 286 for additional information.

Hardware Description

The DG14 is available as a board and as a sensor. From a functional point of view, the DG14 receiver consists of two major sections: The radio frequency (RF) section, and the digital section, where the signals from the GPS satellites are converted to digital format and processed.

Both the board and sensor versions of the DG14 have two plus an optional third RS-232 input/output (I/O) ports capable of two-way communication with external equipment, and a coaxial RF port for the antenna.

The RF port can accept GPS and SBAS from the GPS antenna. A Beacon+GPS antenna is used with the Beacon configured model. See "Antenna" on page 23 for more information on the antennae. The RF port also supplies power to the antenna/LNA through the cable, eliminating the necessity of a separate power cable for the antenna. Total power consumption (including the LNA) is approximately 2.0 watts for the board and 2.5 watts for the sensor.

Board Hardware

The DG14 Board is simply the DG14 GPS receiver board assembly without the enclosure, back-up battery, or wide range power supply. It requires a regulated input voltage of 5 VDC (±5%); typical power consumption is approximately 1.2 to

2.0 watts depending on the configuration. User-entered parameters can be maintained in the DG14's internal memory by connecting a 2.5 to 3.5 volt external battery to the appropriate pins on the J801 connector. The physical dimensions of the DG14 GPS board are shown in Figure 1.1.

The 12- pin connector (J101) on the side of the board is intended for factory use only.

The DG14 uses a standard SMA connector for RF input.

Dimensions in inches [mm]
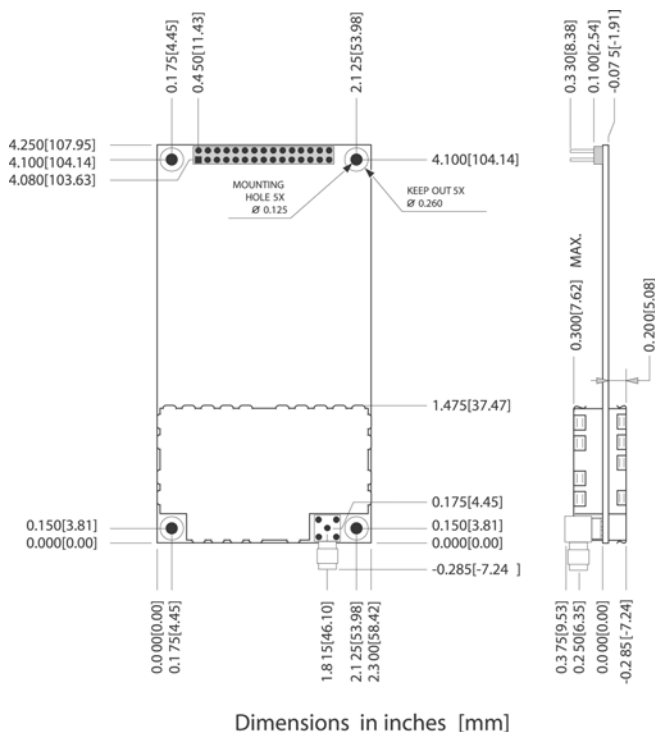
Figure 1.1. DG14 GPS Board Dimensions—inches [mm]

Sensor Hardware

The DG14 Sensor, Figure 1.2, contains the DG14 receiver board, a wide-range power supply, and a back-up battery for internal memory, in a rugged aluminum enclosure. It can accept input voltage levels from 9 to 36 VDC, and typical power consumption is approximately 2.2 watts.

Figure 1.2. DG14 Sensor

Status LEDs

The DG14 Board and Sensor have two status LEDs: a GPS Status LED and a Differential Corrections Status LED.

DG14 Board LEDs

The DG14 Board has a three-color LED on the board which indicates the status of the receiver. Upon power-up the status LED flashes red until a position has been computed. After computing a position, the status LED flashes yellow or green in between the red power status flash to indicate the status for each visible satellite.You can count the number of yellow or green flashes between the red flash to know the number of satellites visible in the sky. Table 1.3 indicates the color and status for the LED.

Table 1.2. DG14 Board LED Description

LED Color	Description
Long Red Flash (0.75 sec)	DG14 is computing a position.
Short Red Flash (0.25 sec)	DG14 lost the position computation.

Table 1.2. DG14 Board LED Description (Continued)

LED Color	Description
Yellow Flash	Satellite is locked, but not used in position computation. No preamble found.
Short Green Flash (0.25 sec)	Satellite is locked and available for position computation, but the ephemeris for the satellite has not been collected.
Long Green Flash (0.75 sec)	Satellite and its ephemeris are available and used in the position computation.

The Differential Status LED is a two-color LED which provides information on the availability of differential corrections to the receiver. The LED shows the number of corrections received for each type: SBAS, Beacon, or Serial. The LED blinks with the following repetitive sequence;

- One red flash followed by the number of SBAS input corrections green flashes.
- Two red flashes followed by the number of Beacon input corrections green flashes.
- Three red flashes followed by the number of Serial input corrections green flashes.

The DG14 supports the use of external LEDs with the same features as the on-board LEDs.

Sensor LED

The DG14 Sensor has a three-color LED on the front of the unit which indicates the status of the receiver. Upon power-up the status LED flashes red until a position has been computed. After computing a position, the status LED flashes yellow or green in between the red power status flash to indicate the status for each visible satellite.You can count the number of yellow or green flashes between the red flash to know the number of satellites visible in the sky. Table 1.3 indicates the color and status for the LED.

Table 1.3. DG14 Sensor LED Description

LED Color	Description
Long Red Flash (0.75 sec)	DG14 is computing a position.
Short Red Flash (0.25 sec)	DG14 lost the position computation.
Yellow Flash	Satellite is locked, but not used in position computation.

Table 1.3. DG14 Sensor LED Description

LED Color	Description
Short Green Flash (0.25 sec)	Satellite is locked and available for position computation, but the ephemeris for the satellite has not been collected.
Long Green Flash (0.75 sec)	Satellite and its ephemeris are available for position computation. The satellite may or may not be used in the position computation.

The Differential Status LED is a two-color LED which provides information on the availability of differential corrections to the receiver. The LED shows the number of corrections received for each type: SBAS, Beacon, or Serial. The LED blinks with the following repetitive sequence;

- One red flash followed by the number of SBAS input corrections green flashes.
- Two red flashes followed by the number of Beacon input corrections green flashes.
- Three red flashes followed by the number of Serial input corrections green flashes.

Power Requirements and Connections

The power requirements and connections differ between the board and the Sensor model.

Table 1.4 outlines the power requirements for the DG14 board and sensor.

Table 1.4. DG14 Board and Sensor Power Requirements

Requirement	Board	Sensor
Power Supply	5 VDC regulated ± 5%	9 to 36 VDC Unregulated
Power Consumption (typical)	1.2 watts GPS only 1.6 watts GPS+Beacon 1.9 watts GPS + Beacon + antenna/LNA	1.3 watts GPS only 1.7 watts GPS + Beacon 2.0 watts GPS + Beacon + antenna/LNA
Backup Battery Consumption[a]	• 5 µ watts typical, 50 µ watts maximum (external battery) • 1µA (without input power applied) • 0.3 µA (with input power applied)	
External wiring	30 gauge (minimum)	

a. Battery consumption may vary based on temperature.

Power Consumption in Sleep Mode

The DG14 has a sleep mode which operates similar to most laptop computers. While in sleep mode, the board consumes significantly less power. Power consumption in sleep mode does not exceed 7%. The sleep mode is particularly beneficial for operations which use batteries or solar panels for power levels. Use the **$PASHS,PWR** command to set the DG14 to sleep mode. The DG14 will reactivate with serial activity or at designated dates and times via session programming. See "SES,SET: Individual Session Programing" on page 126 for more information.

Power Connections

All power and input/output connections are made at the J801 connector for the Board, and through the serial connector for the Sensor.

Attach the serial cable to the DG14 Sensor, and then connect the power source to the serial cable.

CAUTION
To avoid damage to the DG14 Sensor, verify that the power source is off while connecting or disconnecting cables to or from the unit.

J801 is a 30-pin male dual inline (15 x 2) header connector. It provides a host of useful connections in addition to power and I/O, including a connection for an external LED, a connection for battery-backup for RAM maintenance, an input for manual hardware reset, an output for a TTL-level timing pulse, a photogrammetry time-tag input, and a measurement strobe output. Figure 1.3 lists the pin assignments for the J801 connector.The power connect through the serial cable

CAUTION
To avoid damage to the DG14 board, ensure that pin 1 of the connecting cable is attached to pin 1 on J801 as indicated in the drawing. Verify that the power source is off while connecting or disconnecting cables to or from the J801 connector.
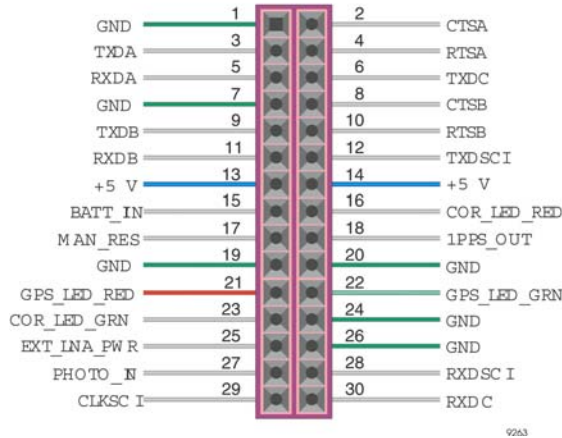
Figure 1.3. Pin Configuration of the J801Connector

📌 **To save user-entered parameters between power cycles, connect the external battery to the corresponding input pins on the J801 connector and set the SAV parameter to Y.**

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

Table 1.5. J801 Pin Assignments

Pin	Code	Description
01	GND	Ground for serial Port A
02	CTSA	RS-232 Port A clear to send
03	TXDA	RS-232 Port A transmit data
04	RTSA	RS-232 Port A request to send
05	RXDA	RS-232 Port A receive data
06	TXDC	RS-232 Port C transmit data
07	GND	Ground for serial Port B

Table 1.5. J801 Pin Assignments (Continued)

Pin	Code	Description
08	CTSB	RS-232 Port B clear to send
09	TXDB	RS-232 Port B transmit data
10	RTSB	RS-232 Port B request to send
11	RXDB	RS-232 Port B receive data
12	TXDSCI	Do not use this pin.
13	+5V	+5 VDC input
14	+5V	+5 VDC input
15	BATT_IN	2.5-3.6 volt battery backup for memory and real-time clock
16	COR_LED_RED	External LED control output, differential corrections status, red (3.3 Volts through 100 Ω)
17	MAN_RES	Connect to ground for manual hardware reset
18	1PPS_OUT	1PPS TTL output synchronized to GPS time
19	GND	Chassis common ground
20	GND	Chassis common ground
21	GPS_LED_RED	External LED control output, GPS status red, (3.3 Volts through 100 Ω)
22	GPS_LED_GRN	External LED control output, GPS status green, (3.3 Volts through 100 Ω)
23	COR_LED_GRN	External LED control output, differential corrections status, green (3.3 Volts through 100 Ω)
24	GND	Chassis common ground
25	EXT_LNA_PWR	+5 VDC Power supply input to external antenna LNA
26	GND	Chassis common ground
27	PHOTO_IN	Photogrammetry pulse input
28	RXDSCI	Do not use this pin.
29	CLKSCI	D not use this pin.
30	RXDC	Do not use this pin.

Backup Power

Power consumption on the back-up battery is 5 μW (typical) and 50 μW (maximum) with the external power supplies. The acceptable battery backup voltage range is 2.5 to 3.5 VDC.

Interfaces to External Equipment

DG14 Board Interfaces

The main interface to the DG14 Board is through the J801 connector. Figure 1.4 shows DG14 interfacing connections for the J801 connector.
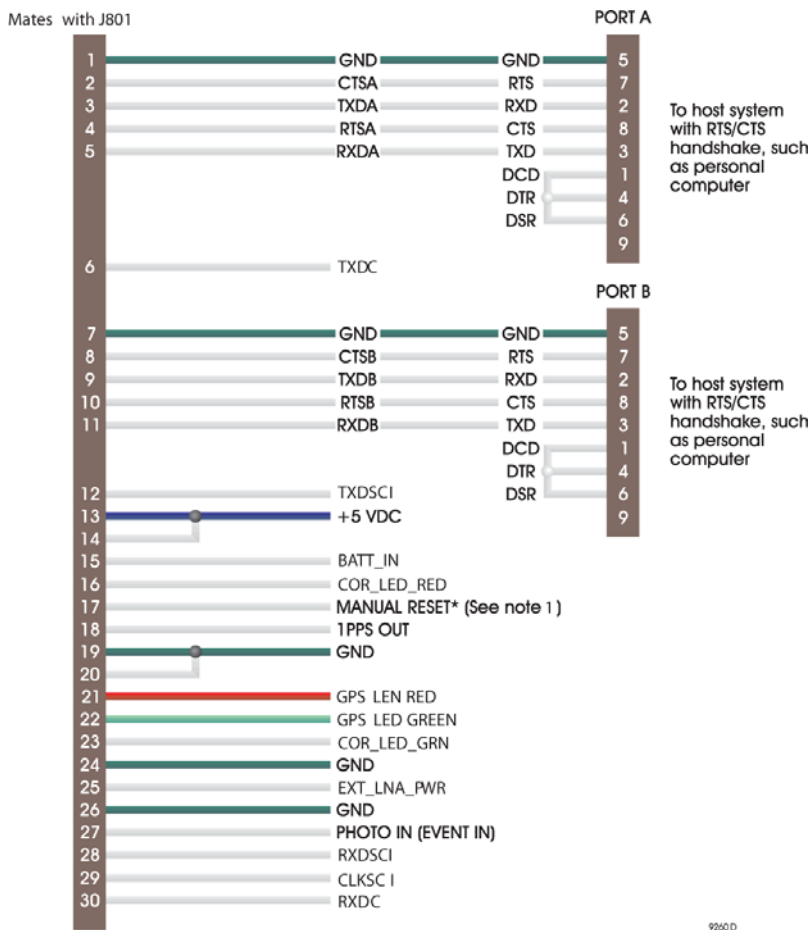
Figure 1.4. External Equipment Interfacing Diagram

Figure 1.4 Note

1. Manual reset (MAN_RES) should be left unconnected if unused. Manual reset should be activated by a switch or open collector gate.

External LEDs support the same features as the on-board LEDs. See "Status LEDs" on page 6 for more information.

DG14 Sensor Interfaces

The main interface to the DG14 Sensor is through the serial connector. Figure 1.5 shows DG14 interfacing connections for the serial connector.
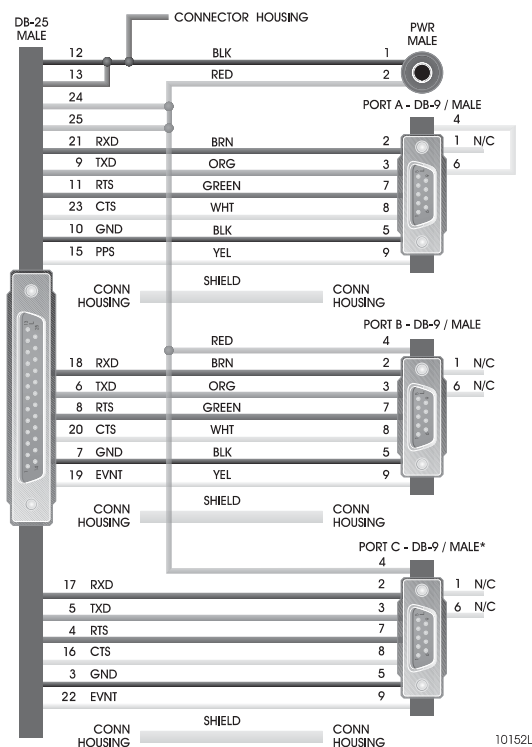
Figure 1.5. DG14 Sensor Power-I/O Connections

> **CAUTION**
>
> **If using ports B or C, limit the input voltage to +25 V. Voltage greater than 25 V may damage the device connected to port B or C.**

Radio Interference

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

Environmental Specifications

The operating temperature range of the DG14 is -30°C to +70°C; storage temperature range is -30°C to +85°C.

RF Connections

A 50-Ohm coaxial cable connects the GPS/Beacon antenna (with integrated LNA) to the DG14 RF connector and the GPS antenna. No separate cable is required to receive WAAS, EGNOS, MSAS, or Beacon signals. The DG14 can supply power to the LNA through the cable. All signals are received through the RF input.

The DG14 board's RF connector is a standard SMA female connector (TNC on the DG14 Sensor, see Figure 1.1). The SMA connector shell is connected to common ground on the DG14 board. The SMA center pin provides +4.8 VDC (to power the LNA) and accepts 1575 MHz RF input from the antenna; the RF and DC signals share the same path. The gain of the antenna LNA minus the loss of the cable is in between 20 and 30 dB. The DG14 includes an antenna protection circuit that limits the current in the antenna in case of short circuit. The current is limited at a level of about 70 mA.

> **CAUTION**
>
> **The DG14 may be damaged if the RF connector center pin is not isolated from the DC ground. Use a DC block between the center pin and ground with the following characteristics:**
> - **VSWR 1.15 maximum at 1575 MHz**
> - **Insertion loss 0.2 dB maximum**
> - **Maximum Voltage 5 VDC**

Hardware Options

Table 1.6 lists the various options of the DG14.

Table 1.6. Hardware Options

Receiver	Beacon	GPS	WAAS	EGNOS	MSAS
DG14 Board	x	x	x	x	x
DG14 Sensor	x	x	x	x	x

The Altitude Limits Removed [A] and the Velocity Limits Removed [V] options require an export license.

For simplicity, this manual uses DG14 in reference to all three configurations. Any deviations from the standard operation will be discussed as necessary.

Receiver Options

The DG14 has a number of available options. The options that are set in the receiver will determine which commands and features you can use. For example, if the photogrammetry option is not installed, you will not be able to use the **$PASHS,TTT** command to output event time tags from the serial port.

The **$PASHQ,RIO** command queries for the receiver's configuration. The response message includes version numbers for the processor and channel firmware, a list of installed options, and the receiver's serial identification number. The response is output in the format:

$PASHR,RIO,f1,f2,f3,f4,f5*cc

where Table 1.7 outlines the parameters.

Table 1.7. $PASHR,RIO Message Format

Field	Description
f1	Receiver name (maximum 10 characters)
f2	Main processor firmware version (maximum 10 characters)
f3	Channel Firmware version (maximum 10 characters). If not applicable, this field is empty
f4	Option setting (maximum 42 characters). ASCII characters represent installed options. For option definitions, see Table 1.8

Table 1.7. $PASHR,RIO Message Format (Continued)

Field	Description
f5	Receiver serial number (maximum 20 characters). Underscores represent blank fields
cc	Checksum. XOR (exclusive or) of all characters between, but not including, the dollar sign ($) and asterisk (*) characters

The DG14 has 18 available options. Each option is represented by a letter or number presented in a certain order. The presence of given option is indicated by the associated letter or number. If the letter or number is displayed, the option is installed. A dash ("-") indicates that the option is available, but not installed. An underscore ("_") indicates a reserved option slot.

Table 1.8 lists the options in the order in which they appear in the RIO response:

Table 1.8. DG14 Option Descriptions

Option	Description
[W = 20 Hz] [T = 10 Hz] [5 = 5 Hz] [2 = 2 Hz] [1 = 1 Hz]	Position/raw update rate
[O]	Raw data output
[P]	Carrier phase tracking
[U]	Differential RTCM - remote station
[B]	Differential RTCM - base station
[K]	RTCM Type 18/19 message generation (available only with RTCM base option)
[L]	Timing pulse output (1PPS)
[E]	Photogrammetry event marker
[C]	Strobe correlator
[N]	Beacon (Not applicable to DG14)
[Y]	SBAS
[X]	User-defined messaging (Not applicable to DG14)
[D]	Integrated differential optimization
[R]	Third serial port (C)
[A]	Altitude limit removed

Table 1.8. DG14 Option Descriptions (Continued)

Option	Description
[V]	Speed limit removed
[M]	Multi-base Differential with WADGPS (available only with RTCM Remote option and max update rate of 10 Hz)
[I]	RAIM

The altitude limits removed [A} option and the velocity limits removed [V] option require an export license.

The following is a typical RIO message:

$PASHR,RIO,DG14,DC11,,WOPUBKLE_C_NYXDR__MI,71168612DG6200146010*05 :

Table 1.9 defines the parameters in this response message.

Table 1.9. Example RIO Response

Field	Description
$PASHR,RIO	Message header
DG14	Receiver type: DG14
DC11	Receiver firmware version
[empty field]	Channel firmware not available

Table 1.9. Example RIO Response (Continued)

Field	Description
WOPUBKLE_C_NYXDR__M I	Options available: [W] 20 Hz position/raw data update rate [O] Raw data output [P] Carrier phase [U] RTCM Differential remote [B] Differential base station [K] RTCM Type 18/19 message generation [L] 1 Pulse per second [E] Photogrammetry [-] Reserved [C] Strobe correlator [-] Reserved [N] Beacon [Y] SBAS [X] User defined messaging [D] Integrated Differential Optimization [R] Third serial port (C) [-] Option not installed [-] Option not installed [M] Multi-base Differential [I] RAIM
71168612DG6200146010	Receiver serial number
*05	Checksum in hexadecimal

See Chapter 4, Command/Response Formats, for more information on the DG14 commands.

CAUTION

Take the following precautions to avoid damaging your DG14 Board:
1. The power supply should be turned off each time the I/O-Power cable is connected to or disconnected from the J801 connector.
2. Ensure that when connecting the I/O-power cable to connector J801, pin 1 is correctly oriented per Figure 1.1.
3. Connect pin 15 (BATT_IN) to ground if it is not being used. Pin 17 (MAN_RES) should be left open if it is not being used.
4. Isolate the center pin on the DG14 antenna connector from DC ground. The DC block used between the center pin and DC ground should have the following characteristics:
  • **1.15 maximum VSWR @ 1575 Mhz**
  • **0.2 db maximum insertion loss**
  • **5 VDC maximum main line voltage**
5. Connect the RAM back-up battery to the appropriate pins on connector J801 and set the SAV parameter to Y.

Firmware Upgrades

DG14 firmware is stored in flash memory. New firmware may be loaded into the receiver through either serial port using a PC. Maintenance releases of firmware are available on a regular basis to fix known bugs and to implement new features.

When embedding the DG14 within another system, Magellan recommends that external access to one of the receiver's serial ports be designed into the system for direct monitoring. For example, many system integrators use an internal data cable to connect one of the DG14 serial ports to an external DB9 connector.

UDM Utility

If you have purchased the User Defined Messaging option [X], then you can use the UDM Utility program to create the script file which defines the custom messages. You can use the custom message feature to set the receiver to output only the information you need in a single message. This can save you from sending several receiver commands. See Appendix B, **UDM Utility** for more information.

2

Getting Started

This chapter is intended to get you started using the DG14 receiver. Please see the chapters on General Information, Basic Operation, Differential Operation, and Command/Response Formats for specific details regarding performance, power requirements, and commands.

This chapter discusses the following topics:

- Connecting the DG14 to power and the antenna
- Default parameters
- Communicating with the DG14 using standard communications software
- Sending common commands to the DG14

Connecting to the DG14

If you use equipment other than Magellan-supplied with the DG14, it must comply with hardware specifications as described in the "Hardware Description" on page 4.

Figure 2.1 shows how to connect the components in the DG14 Board system.
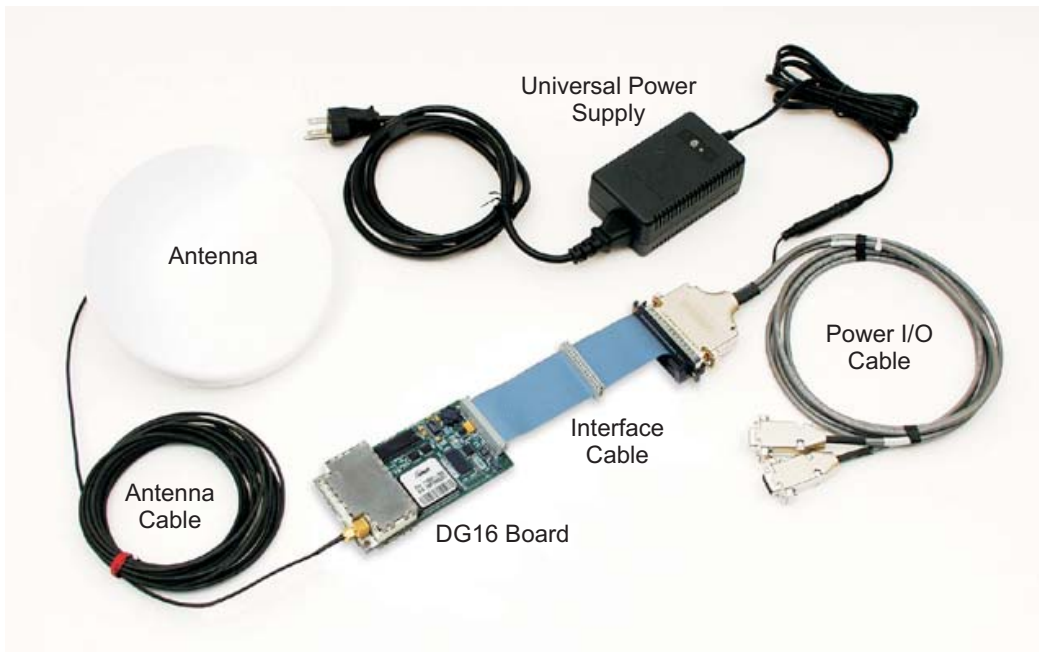
Figure 2.1. DG14 Board Connections

Power

DG14 Board

Before applying power to the DG14 board, connect any controller devices or data logging equipment to the input/output ports of the DG14 by way of connector J301.

CAUTION
To avoid damage to the DG14, always turn off the power supply before connecting or disconnecting power to the connector J301.

1. Connect the female plug on the power cable to the J301 male connector on the DG14.
2. Connect the power cable to the power supply.

   Once power is connected, the LED on the DG14 Board flashes red.

When you apply power to the power input pins on connector J301, the DG14 starts operation.

When you remove power from the power input pins on connector J301, the DG14 stops operation.

Sensor

The power for the DG14 Sensor connects through the serial connector on the unit.

CAUTION

To avoid damage to the DG14, always connect to cable to the DG14 Sensor before connecting the cable to the power source, and turn off the power supply before connecting or disconnecting power to the DG14.

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1. Connect the serial cable to the serial port on the DG14.
2. Connect the power cable to the serial cable.
3. Connect the power cable to the power supply.

   Once power is connected, the LED on the DG14 flashes red.

Antenna

The DG14 is designed to work with an antenna Low Noise Amplifier (LNA) that requires five volts and is isolated from DC ground. The gain of the antenna LNA minus the loss of the cable is between 20 and 30 dB. Table 2.1 outlines the antenna requirements.

Table 2.1. Antenna Requirements

Requirement	Parameter
GPS Operational Band	1575 ±10 MHz
Polarization Type	Right hand circular
Axial Ratio	Less than 3 dB in zenith of up area
Antenna Gain for Elevation Angle of 10°	No less than -2.5 dB

Table 2.1. Antenna Requirements

Requirement	Parameter
Antenna Gain for Elevation Angle Greater than 15°	-1 to -2 dB
Antenna Gain for Elevation Angle of 90°	~ +4 dB

Table 2.2 outlines the antenna LNA requirements

Table 2.2. Antenna LNA Requirements

Requirement	Parameter
Impedance of Antenna Output	50 Ω VSWR <1.8
LNA Gain	Antenna/LNA gain minus the cable loss: between 20 and 30 dB
Noise Figure	< 4.0 dB
LNA Selectivity	-3 dB bandwidth: 35 MHz -20 dB bandwidth: 60-70 MHz

---

CAUTION

The DG14 may be damaged if the center pin of the RF connector (Type SMA) is not isolated from DC ground. Provide a DC block between the center pin and ground; the DC block should have the following characteristics:
- **VSWR 1.15 maximum at 1575 MHz**
- **Insertion loss 0.2 dB maximum**
- **Maximum voltage 5 VDC**

Connect the antenna cable directly to the antenna SMA connector on the DG14.

Once power is on and the antenna is connected, the DG14 acquires satellites (SVs or Space Vehicles) within the field of view of the antenna. As a channel in the DG14 locks on to a satellite, the LED flashes green or yellow between the red power flashes for every channel in use (i.e., locked satellites). See "Status LEDs" on page 6 for a description of the LED flashes.

Important Default Parameters

Communication Port Setup

Table 2.3 lists the default communication parameters of the DG14:

Table 2.3. DG14 Communication Parameters

Baud	Data Bits	Parity	Stop Bits
9600	8	None	One

When first establishing communications with the DG14, the communications interface must use this protocol.

Data Output Options

All the default data output commands are set to OFF. The DG14 does not output any data until you command it to do so.

Communicating with the DG14

After the DG14 is powered and running, you must send commands in order to receive data (such as antenna position). The following procedure describes how to send commands to and receive information from the DG14 using an IBM-compatible PC. You can interface with the DG14 using Evaluate Software™, RCS (Receiver Communication Software™), or standard communication programs such a ProComm or Hyperterminal. To begin, simply connect the standard 9-pin serial cable between port A on the DG14 and COM1 on the computer. When you are using other applications to communicate with the receiver, such as ProComm or HyperTerminal, verify that the <CR>/<LF> outgoing is enabled.

After setting up the interface for establishing communications with the DG14, you can send commands. The letters in the command can be typed in either UPPER or lower case. If you sent the command correctly, the DG14 responds.

The commands used with the DG14 are divided into two groups: set commands and query commands.

Use Set commands to change the DG14's operating parameters or turn on or off output messages. Set commands begin with the command string $PASHS.

Use Query commands to request information from the DG14, such as the current operating parameters, current position, or DGPS status. Query commands begin with the command string $PASHQ.

The DG14 responds to query and set commands by issuing an acknowledgement of a change in operating parameters or with the specific information requested through a query.

To become familiar with the DG14 messages, send a few common commands to the DG14 and observe the responses. In the following steps, command messages appear as COMMAND, and response messages appear as RESPONSE.

Chapters 5, 6, 7, and 8 contains details on these commands and responses, as well as the rest of the commands and responses supported by the DG14.

1. Type **$PASHQ,PRT** and press **<Enter>**. This command queries the communication setup of the port. If you have connected the PC to serial port A, the response message is:

    ```
    $PASHR,PRT,A,5
    ```

    This message indicates Port A of the DG14 is using its default communications setup 5: 9600 baud, eight data bits, no parity, and one stop bit.

    See "PRT: Serial Port Baud Rate" on page 117 for more information on this command.

2. Type **$PASHQ,STA** and press **<Enter>**. This command queries which satellites are locked and their signal strength at the time the command is sent.The response message typically might display:

    ```
    TIME: 18:50:31 UTC
    PRN: 35 .. .. 17 24 04 06 05 30 10 02 .. 09 07
    SNR: 36       51 36 48 44 52 49 48 51    47 35
    ```

    See "STA: Satellite Tracking Status" on page 131 for more information on this command.

3. If interfacing through port A, type **$PASHS,NME,POS,A,ON,1** and press **<Enter>**. This commands the DG14 to return comprehensive position information through port A at a set rate. The default rate for NME commands is once per second. The response message output rate is 1 Hz:

    ```
    $PASHR,POS,1,10,185743.90,3721.07225,N,12156.10795,W,-
    00001.19,SC01,000.00,000.02,-
    000.02,01.4,00.9,01.1,00.7,DC11*3C
    ```

The data string contains the position information, assuming the receiver is tracking a sufficient number of satellites to compute a position.

See "POS: Position Message" on page 245 for more information on this command.

4. If interfacing through port A, type **$PASHS,NME,SAT,A,ON,1** and press **<Enter>**. This command tells the DG14 to return locked satellite information through port A at a set rate. The response message output rate is 1 Hz (default):

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

The data string contains the number of satellites locked plus the elevation, azimuth, and signal strength for each locked satellite, and also indicates whether a given satellite is used (U) or not used (-).

See "SAT: Comprehensive Satellite Tracking Data" on page 253 for more information on this command.

Getting Started

DG14 Receiver Reference Manual

3

Basic Operation

This chapter covers a variety of DG14 operating parameters and options, including system setup, power-up, command format, serial port configuration, receiver settings and status, the satellite search algorithm, position modes, altitude hold definition, the ionospheric model, NMEA outputs, raw data outputs, differential operation, the photogrammetry option, the pulse-per-second option, and other options.

Message Formats

The DG14's three RS-232 ports (ports A, B, and the optional port C) can receive command messages from an external control device, send response messages to an external control device (such as a PC), output data to a separate data logging device, and send or receive differential corrections from a reference or remote station.

DG14 Input Messages

Input messages are comprised of set command messages, query command messages, and general command messages. These messages comply with the format defined in the NMEA 0183 standard to the following extent:

- NMEA 0183 ASCII byte strings following a dollar sign ($) character
- Data fields are separated by commas
- Checksum character delimiter and NMEA checksum bytes are recognized by the DG14 but are optional. The hexadecimal checksum is computed by

exclusive OR-ing all of the bytes in the message between, but not including, the dollar sign ($) and the asterisk (*).

- Messages end with the standard NMEA message terminator characters, [CRLF] (carriage return/line feed).

Input messages deviate from the NMEA standard as follows:

- Headers are Ashtech format
- Message IDs are Ashtech format
- Message length may exceed 80 characters
- Messages defined by the user with the UDM Utility and the [X] option installed

All command messages—set or query—can be composed in uppercase or lowercase characters. All command messages are sent by pressing **<Enter>**. A valid set command causes the DG14 to return the **$PASHR,ACK*3D** (acknowledge) response message. A set command containing a valid $PASHS header followed by character combinations unrecognized by the DG14 causes the receiver to respond with **$PASHR,NAK*30**, a "not acknowledge" response message indicating that the command is invalid. Valid query and messages are acknowledged by return of the requested information. All invalid query and general commands cause the DG14 to return the **$PASHR,NAK*30** "not acknowledged" response message.

DG14 Message Output

The DG14 can be programmed to send data to another device. Output messages include general receiver status messages, ACK/NAK messages, and GPS data messages. The general receiver status messages have free-form Ashtech formats. The acknowledged/not acknowledged messages and GPS data messages comply with NMEA 0183 standards as follows:

- NMEA ASCII byte strings following a dollar sign ($) character
- Headers are standard NMEA or Ashtech-format NMEA
- Message IDs are standard NMEA or Ashtech-format NMEA
- Standard NMEA format messages contain hexadecimal checksum bytes
- Data items are separated by commas; successive commas indicate invalid or missing data (null fields)
- Messages end with [CRLF] (carriage return/line feed), the standard NMEA message terminator characters

User-Defined Messaging

If you have the User-Defined Messaging option [X] installed on your DG14, you can use the UDM Utility to define custom receiver commands to output receiver information to fit your specific application. This feature can minimize the number

of commands you need to send to the DG14 to acquire the output you require for you application.

Messages created by the user, using the UDM Utility, will respond with the ACK/ NAK message.

See Appendix B, **UDM Utility** for more information on user-defined messaging.

Serial Port Configuration

The DG14 receiver has two primary RS-232 serial ports and one optional serial port (available as a firmware option [R]) that support two-way, full-duplex communication. The default protocol for transmitting or receiving data is 9600 baud, eight data bits, no parity, and one stop bit (8N1). The baud rate of the DG14 ports is adjustable using the **$PASHS,SPD** speed set command; the data bit, stop bit and parity protocol is always 8N1.

DEFAULT SETTINGS
The default parameters for the DG14 serial Ports A and B: •**Baud Rate— 9600**   •**Data Bits— 8**   •**Stop Bits— 1**   •**Parity— None**

On initial power-up, or after issuing the **$PASHS,INI** (receiver initialization) command or the **$PASHS,RST** (restore defaults) command, the default data rate is 9600 baud for both standardized DG14 serial ports. Both are capable to 115,200 baud for data transfer.

The baud rates must be the same between the DG14 serial port and the serial port on the device with which it is interfaced.

To maintain communication with the DG14 while changing the baud rate, issue the **$PASHS,SPD** (set port speed) to change the baud rate of the DG14 port, then change the baud rate of the command device to match the new baud rate setting on the DG14 port.

Session Programming

With the Session Programming feature, you can pre-set up to 10 observation sessions in the receiver. You can program the receiver to wake-up at a specified time and preform specified tasks such as output position and velocity data. In

addition, you can set a session time offset that shifts the session start and end times by a predetermined amount every day.

Session programming can also be used to put the receiver into sleep mode. When the receiver is in sleep mode, most of the receiver functions are suspended which conserves power. Using preset session start times, the DG14 automatically wakes up in time to perform specified tasks for the next session and returns to sleep when the session is complete.

Session programming is enabled by the **$PASHS,SES** command. You must enable the individual sessions and set session parameters such as the start/stop times, recording interval, elevation mask, minimum number of satellites, and the data type for each session.

In addition, you need to set the mode (session in use switch), the session reference day, and the desired session offset. The mode is either Yes, No, or Sleep. If the mode is set to No, then session programming is disabled, even id an individual session is set. If the mode is set to Yes, then session programming is enabled, and any enabled individual sessions are activated. if the mode is set to Sleep, then the receiver goes into sleep mode, once an activated session has completed. and the DG14 wakes just prior to the next session.

The session reference day is a mandatory parameter that determines both the start day of session programming data collection and is used in conjunction with the Offset to determine the session start and end times. The reference day must be set equal to or earlier than the current day, or else the sessions will not run. If the reference day is later than the current day, then the session start and end times decrement by the offset multiplied by the numbers of days between the current day and the reference day. For example, suppose you wish to collect data everyday for seven days observing the identical satellite window on each day. Since the GPS window moves backwards four minutes per day, set the offset to 0400 and set the reference day equal to the current day. For each subsequent day of data collection, all sessions will start and end four minutes earlier than the previous day. By the seventh day the sessions will start and end 28 minutes earlier than on day 1.

Daisy-Chain Mode

The Daisy-Chain mode establishes a communication link through the GPS receiver, between a PC or handheld and a peripheral device. When the GPS receiver is in Daisy-Chain mode, all commands entering one serial port are passed out through another serial port. The commands are not interpreted by the DG14. Use the **$PASHS,DSY** command to enable the Daisy-Chain mode and assign which serial ports to use.

A typical example of the use of Daisy-Chain mode is communicating with a radio through a handheld. The radio and handheld are not directly connected, but both are connected to the DG14 via separate serial ports. By enabling the Daisy-Chain mode between the two serial ports used by the handheld and radio, the handheld can communicate with the radio through the DG14.

For more information on the Daisy-Chain command, see "DSY: Daisy Chain Communications Mode" on page 77.

Satellite Tracking

When the DG14 is powered on for the first time, or when the power and back-up battery have been disconnected, there is no almanac or ephemeris data in memory. In these cases, the DG14 assigns the first 12 elements of a 32-element table of SV PRN numbers to its 12 channels as it begins searching for satellites. If no ephemeris data are in memory, or if the data are older than ten hours, 30 to 60 seconds are needed to collect data. The DG14 synchronizes its clock to GPS time within six seconds of locking a satellite. After three or four satellites are locked and the almanac and ephemeris data are collected, the DG14 computes its first position. The DG14 continuously updates almanac, ephemeris, and position data in its battery-backed memory to help optimize satellite requisition and time to first fix when the unit is next powered on.

With the SBAS option installed, the DG14 tracks two geostationary SBAS satellites at a time and makes the ranging ephemeris and SBAS differential correction data messages available over ports A and B. The two SBAS satellites tracked are based on the mode of operation selected by the user. If the Automatic mode is selected, the DG14 automatically searches for and tracks the SBAS satellites in a predefined order. If Manual mode is selected, the DG14 searches for and tracks the SBAS satellites you selected. The search time for each satellite should not exceed one minute for a hot start and three minutes for a cold start.

At the next power-up, if the almanac and ephemeris data are available in battery-backed memory, and if the ephemeris data are less than ten hours old, the DG14 restricts its satellite search to those satellites that should be visible based on this information. Under these conditions, the DG14 on average recomputes position in 10 to 15 seconds (hot start). If the almanac and ephemeris data are available in battery-backed memory, but the ephemeris data are more than ten hours old, the DG14 needs 30 to 40 seconds on average to compute a position (warm start). If almanac and ephemeris data and a valid position are not available at power-up, the DG14 computes position in 60 to 90 seconds on average (cold start).

Parameter Settings and Status

On initial power-up or after issuing the **$PASHS,RST** (restore defaults) command, the DG14 reverts to its default parameter settings. Enter the following three commands to query the DG14 for the current parameter status:

1. **$PASHQ,PAR** (general parameters)

   The response message for the query command **$PASHQ,PAR** (general parameters) is shown below:

```
SPDA:5 SPDB:5 SPDC:5
GPS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
SBAS:YYYYYYYYYYYYYYYYYYY
SYS:GPS DTM:W84 TDP:04
PMD:1 FIX:0 ALT:+00000.00 PDP:40 HDP:04 VDP:04 ERM:600,1200,300,600
PEM:05 SEM:OFF UNH:N ION:Y TRO:Y SAV:N RAIM:OFF ANTENNA:DETECTED
RTC:OFF PRT:A
SBA:SAM
NMEA: LTN POS GLL GXP GGA VTG GSN MSG GSA GSV SAT GRS RRE TTT ZDA TCM
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
NMEA: RMC GST GNS CRT GDC UTM PTT UKO SUD DTM XMG AIM HPL ALM
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PER:001.00
```

2. **$PASHQ,RAW** (raw data parameters)

   The command **$PASHQ,RAW** is functional only if the Binary Data Outputs option (Option O) is installed in the receiver. An example of the response message for the default values of **$PASHQ,RAW** (raw data parameters) is shown below:

```
RCI:001.00 MSV:3 ELM:05
ANH:0.0000 SIT:???? EPG:000
RAW:  VTB MCA MBN PBN MIS XYZ DIF MSB GGB MCM CMB CT1 CT2 CT3 SNV SAL SNW SAW
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
```

3. **$PASHQ,RTC** (differential parameters)

The **$PASHQ,RTC** query is available only if one of the differential options (B or U) is installed in the receiver. The response message for the **$PASHQ,RTC** (differential parameters and status) query command is shown below:

```
STATUS:
SYNC:   TYPE:00 STID:0000 STHE:0
AGE:+999 QA:000.00% OFFSET:00
SETUP:
MODE:OFF PORT: A SOURCE:SLC,EXT AUT:N FMT:RTCM
SPD:0300 STI:0000 STH:0 IOD:20
MAX:0060 QAF:100 SEQ:N RTCM:V22
TYP:1  2  3   6   7  9 16 18 19
FRQ:99 00 00 OFF 00 00 00 00 00
BASE:   LAT:0000.00000,N LON:00000.00000,E ALT:+00000.00 W84
MSG:
```

Saving Parameter Settings

New parameter settings can be saved by issuing the set command, **$PASHS,SAV,Y**. You can verify that new settings are in effect by issuing query commands to prompt the DG14 for its current status. After the next power-up, the query response messages display the new settings instead of the default parameters. Issue the command **$PASHS,RST** to restore the default settings. If the SAV command is not entered, the new settings will be lost, and the default settings restored at the next power cycle.

Watchdog Timer

The DG14 has a watchdog timer. If the processor hangs up for any reason, the watchdog timer resets the receiver. On reset, the receiver uses the parameters most recently saved during the startup. If parameter settings were not saved, the receiver uses the default settings at startup.

CAUTION
User-entered parameters will be lost and default settings will be restored if the command $PASHS,SAV,Y is not entered before the next power cycle.

Position and Navigation Modes

The DG14 can perform position computations and navigation solutions in several position modes and eight dynamic modes.

Position Modes (Least Squares Algorithm)

Use the **$PASHS,PMD** command allows you to set the position mode. See "PMD: Position Mode" section on page 110 for more information.

- Position Mode 0

    At least four satellites at elevations equal to or above the position elevation mask are needed to compute a position. The receiver stops computing positions if the number of satellites tracked falls below three. All three polar coordinates (latitude, longitude, altitude) are computed in this mode.

- Position Mode 1 (Default)

    At least three satellites with elevation equal to or above the position elevation mask are needed to compute a position. Only the latitude and the longitude are computed if three satellites are locked and the altitude is held fixed. For more information on fixed altitude modes, see "Fixed Altitude Modes" on page 40. The receiver stops computing positions if the number of satellites tracked falls below three. All three polar coordinates are computed if more than three satellites are locked.

- Position Mode 2

    At least three satellites with elevation equal to or above the position elevation mask are needed to compute a position. Only the latitude and the longitude are computed and altitude is always held fixed even if the receiver is tracking more than three satellites. The receiver stops computing positions if the number of satellites tracked falls below three.

- Position Mode 3

    At least three satellites with elevation equal to or above the position elevation mask are needed to compute a position. Only the latitude and longitude are computed, and the altitude is held if only three satellites are locked. If more than three satellites are used and the HDOP is less than the specified HDOP mask, all three polar components are computed. If HDOP is higher than the specified HDOP mask, the DG14 automatically

goes into the altitude hold mode. The receiver stops computing positions if the number of satellites tracked falls below three.

DEFAULT SETTINGS
$PASHS,PMD— Position Mode 1

Position Modes (Kalman Filter Algorithm)

The DG14 can operate in one of two position modes using the Kalman Filter Algorithm: 3D and 2D.

- Mode 0: 3D

3D mode is the standard and default mode of operation for the DG14. In 3D mode, four locked satellites are required to compute the initial position. After the initial fix, the DG14 can maintain operation regardless of the number of satellites tracked. When the number of tracked satellites drops to zero, the DG14 can maintain navigation operation depending on the Kalman filter prediction algorithm; this is the prediction mode. You can choose whether or not the DG14 operates in prediction mode. Position fixes obtained during the prediction mode are flagged "predicted" in GGA and other NMEA messages containing position information, regardless if the receiver is in stand-alone mode or differential mode.

In the **$PASHS,KFP,PRI** command, you can set the maximum allowable length of time for the DG14 to operate in Prediction Mode (Prediction Interval). The default interval for prediction mode is 10 seconds. After the prediction mode has timed-out, the DG14 needs at least four satellites in 3-D mode, and 3 satellites in 2-D mode, to reset its Kalman filter and resume positioning using the reference altitude set in the **$PASHS,FIX** command.

In addition, you can set the receiver to not computea position if the number of satellites used in the solution is less than a set number using **$PASHS,PMD** command.

If you have set the DG14 to Static KF mode and only 1 satellite is available, the position is still not considered predicted because Kalman filter, in this case, is nothing but sequential least squares. Altitude remains constant for the entire prediction interval.

If you set PMD to 1 or 3 (adaptive 2-D mode), the Kalman filter changes from 3-D to 2-D mode if the number of satellites drops below 4., and then the Kalman filter behaves as if PMD was set to 2. The Kalman filter does not reset when it changes from 2-D to 3-D mode.

The Kalman filter automatically resets when either the error mask is exceeded or if the prediction interval is longer than the set maximum interval value.

After the first set of four or more measurements is received after a total-satellite-outage period, the DG14:

- continues operation and uses the received measurements to update the running Kalman filter, if the Prediction Mode was ON
- resets the Kalman filter with the received measurements and resumes operation similar to a hot start.

- Mode 2: 2D

In 2D mode, the DG14 can only calculate latitude, longitude, and time; the altitude is held constant. Use the **$PASHS,ALT** and **$PASHS,FIX** commands to set the altitude.

When FIX is set to 1, the 2D altitude is the altitude entered using the **$PASHS,ALT** command. When FIX is set to 0, the altitude is the most recently determined altitude, which can be either that entered using the **$PASHS,ALT** command, or the altitude from the last computed height value computed when VDOP was less than VDOP mask.

The DG14 requires at least three satellites to be locked for the initial 2D position fix. After the initial fix, there is no required number of locked satellites. The DG14 continues to operate making use of the locked satellites, propagating its internal solution and reporting the predicted position until ERM or any other user set mask exceeds the set value.

You can use the **$PASHS,KFP,ON** command to enable the Kalman filter for prediction. Position fixes obtained during the prediction mode are flagged "predicted" in GGA messages.

If you set PMD to 2 (continuous 2-D mode), the Kalman filter is only initialized with the reference altitude, for all the next epochs the Kalman filter updates the position in correspondence with the current dynamic model and the parameters for this model (maximum velocity and acceleration) for the vertical direction should be ten times less than nominally.

If you have set the DG14 to Static KF mode and only 1 satellite is available, the position is still not considered predicted because Kalman filter, in this case, is nothing but sequential least squares.

In the **$PASHS,KFP,PRI** command, you can set the maximum allowable length of time for the DG14 to operate in Prediction Mode (Prediction Interval). The default for prediction mode is OFF and the default prediction interval is 10 seconds. After the prediction mode has timed-out, the DG14 needs at least four satellites to reset its Kalman filter and resume positioning.

In Prediction Mode, the calculation and output of all standard position and velocity components are maintained. The DG14 continues to operate in prediction mode until one of the user set masks exceeds its set limit; namely ERM and Prediction Interval.

Navigation Solutions

The DG-16 can compute a navigation solution using either a least-squares or Kalman filter method. Use the **$PASHS,KFP,ON/OFF** command to select the navigation solution. Unless you set the DG14, the performance requirements shall apply equally, irrespective of the selected navigation solution.

The DG14 uses statistical testing algorithms to allow for fault detection and isolation in both least squares and Kalman filter modes. In Kalman filter, fault detection may be provided using standard f-test and w-test. You can select either a 2s (95%) or 3s (99%) threshold so that measurements with estimated errors outside this threshold are rejected. Upon exceeding such thresholds, the measurements are excluded from the navigation solution.

Anytime a mask parameter such as ERM or PDOP setting is exceeded, the receiver outputs an empty position message even though a position is computed by the receiver.

Dynamic Modes

You can specify the dynamic mode under for the receiver using the **$PASHS,DYN,d1** command. The navigation solution uses expected dynamics for a given solution. Table 3.1 outlines the DG14 dynamics modes.

Table 3.1. Dynamic Modes

Dynamic Mode	Description	Maximum Horizontal Velocity (m/s)	Maximum Vertical Velocity (m/s)	Maximum Horizontal Acceleration (m/s^2)	Maximum Vertical Acceleration (m/s^2)
1	Static	0	0	0	0
2	Quasi-Static *	0.1	0.02	0.1	0.02
3	Walking	2	0.5	1	0.5
4	Ship	20	1	1	0.5
5	Automobile	50	3	10	1.0
6	Aircraft	400	60	20	10
7	Unlimited	1000	1000	100	100
8	Adaptive Dynamic **	N/A	N/A	N/A	N/A

* Quasi-Static represents a static condition with some tolerance for slight movements within a decimeter or two. An example would be an antenna on a handheld pole or on the back of a person; obviously a person can try to be static but will inevitably move within a decimeter or two. This is unlike "Static" mode where the antenna is placed on a tripod or any other stationery structure with zero tolerance for actual movement.

*"Adaptive Dynamic adapts the filter dynamics settings to any of the modes 2 through 7 in real time allowing the switch from one mode to the other based on the witnessed behavior. Use one of the standard Adaptive filtering algorithms that monitor covariance behavior to determine dynamics model to use.

If you set the Dynamic mode to Static and enable the Kalman filter mode for the navigation solution (**$PASHS,KFP,ON)**, then the velocity values output by the receiver are always zero for both ground speed and vertical velocity.

If you want to determine the appropriate model for your application, choose the Adaptive Dynamic mode. If you select Mode 1 through 7, the DG14 will not accommodate the other dynamic modes. Adaptive Dynamic mode can never be static; under good, open sky, static conditions, the Kalman filter automatically changes to Quasi-Static mode.

DEFAULT SETTINGS
$PASHS,DYN— Adaptive Dynamic (8)

Fixed Altitude Modes

Two modes define the altitude setting when the DG14 is in altitude hold mode. The **$PASHS,FIX** set command can be used to select between these modes. See "FIX: Fixed Altitude Mode" section on page 86 for more information.

- Fixed Altitude Mode 0

    The most recent altitude is used. This is either the altitude entered by using the **$PASHS,ALT** set command or the one computed when four or more satellites are used in the position solution and the VDOP value is below the VDOP mask, whichever is most recent.

- Fixed Altitude Mode 1

    Only the last altitude entered through the command $PASHS,ALT is used in the position fix solution.

On initial power-up, or after issuing the **$PASHS,INI** command (initialize memory) or **$PASHS,RST** command (restore defaults), the antenna altitude is set to zero.

DEFAULT SETTINGS
$PASHS,FIX— Fixed Altitude Mode (0)

Point Positioning

The Point Positioning option improves the accuracy of a stand-alone absolute position of a stationary receiver from about 5 meters to less than one meter over a period of four hours, and can typically get down to the couple of meters level after ten hours. Point positioning uses an averaging technique to reduce the effects of Selective Availability (SA) and other fluctuating errors. You can set the Point Positioning mode with the $PASHS,PPO command See the "PPO: Point Positioning" section on page 115 for more details on this command.

Geoid Model

The DG14 uses the Ohio State University 91A geoid model (OSU91A). For more information on OSU91A, refer to the Ohio State University:

Rapp, R.H., Y.M. Wang and N.K. Pavlis, 1991: The Ohio State 1991 Geopotential and Sea Surface Topography Harmonic Coefficient Models, Report No. 410. Columbus: Department of Geodetic Science and Surveying, The Ohio State University.

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Ionospheric Model

The DG14 can use ionospheric and tropospheric models in its position computations to compensate for errors caused by ionospheric and tropospheric delay when needed. This mode of operation is typically used to improve autonomous accuracy by minimizing the influence of the ionosphere and troposphere on the code phase of the GPS signal. When the DG14 is in differential mode (base or rover), ionospheric and tropospheric modeling is disabled because differential GPS already compensates for delays associated with the ionosphere and troposphere. When the receiver is in autonomous mode, ionospheric and tropospheric modeling is enabled.

The ionospheric model used by the DG14 is based on the model defined in ICD-GPS-200, Revision B. The tropospheric model is based on the Bean and Dutton model. For more information on ICD-GPS-200, refer to ARINC Research Corporation:

ARINC Research Corporation
2250 E. Imperial Highway, Suite 450
El Segundo, CA 90245-3509   USA

Tel: 310-524-1557

Web: http://www.arinc.com/products_services/gpshome.html

Magnetic Variation Model

The DG14 uses the Joint US/UK 1995 Epoch World Magnetic Model (WMM-95). For more information on WMM-95, refer to the USGS National Geomagnetic Information Center:

USGS National Geomagnetic Information Center
Box 25046, Mailstop 968
Denver Federal Center
Denver, CO 80225-0046   USA

Tel: 303-273-8475

Fax: 303-273-8450

Web: http://geomag.usgs.gov

Setting Antenna Position

When in Differential Base Mode, the DG14 uses an accurate antenna position (reference position) entered by the user to calculate range corrections by subtracting the measured range from the true range. Two commands can be used to enter the reference position:

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

$PASHS,ALT (antenna height setting).

NMEA Outputs

The DG14 can output a variety of NMEA messages and Ashtech-format NMEA-style messages. Standard NMEA messages are output as a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards

(version 3.0). Ashtech-format NMEA-style messages are also output in a comma-delimited string of ASCII characters, but may deviate slightly from NMEA standards. For example, the maximum length of a standard NMEA message is eighty characters, but the length of some Ashtech-format messages goes beyond eighty characters.

Both NMEA messages and Ashtech-format NMEA-style messages begin with a dollar sign ($) and end with a Carriage Return/Line Feed <CR><LF> delimiter.

Any combination of these messages can be output through either serial port at the same time, and you can even choose to send the same message to output through both ports. The output rate is determined by the **$PASHS,NME,PER** command, and can be set to any value between 0.05 and 999 seconds depending upon the update rate option installed (20, 10, 5, 2 or 1 Hz). For more information see the Chapter 7, NMEA Commands.

The default setting for the output interval is one second. See Chapter 4, Command/Response Formats, for more information on NMEA messages and Ashtech-format NMEA-style messages.

DEFAULT SETTINGS
When enabled, output interval setting for NMEA messages and Ashtech-format NMEA-style messages is one second.

Basic Operation

Raw Data Output (Optional)

The DG14 has an optional feature that allows you to output raw data (also called real-time data) through serial ports A, B, and C. Five different messages can be output:

- MBN: Contains measurement data for each locked satellite using the Ashtech Type 2 data structure.
- PBN: Contains position and velocity data.
- SNV: Contains satellite ephemeris data.
- SAL: Contains satellite almanac data in a proprietary format.
- MCA: Contains measurement data (same as MBN) for each locked satellite using the Ashtech Type 3 data structure

All raw data messages are in binary format. The transmission protocol remains the same: 8 data bits, 1 stop bit, and no parity bit. Any combination of messages can be output through any of the serial ports, and the same messages can be output through different ports at the same time. The output interval is determined by the **$PASHS,RCI** command, and can be set to any rate between 0.05 and 999 seconds depending upon which option has been selected for the raw measurement update rate (20, 10, 5, 2, or 1 Hz). For more information on the

structure and content for all the above messages, see Chapter 6, Raw Data Commands.

DEFAULT SETTINGS
Output interval setting for raw data messages is 1 seconds.

Photogrammetry / Event Marking (Optional)

With the photogrammetry [E] option installed, the DG14 can measure and record events with high accuracy. The input signal is transmitted at TTL levels with 10 KΩ impedance. In order to measure an event time, a trigger signal must be sent to pin 27 on connector J301. This input can be driven with either a TTL signal or a switch that grounds the pin. The photogrammetry feature allows the event time to be output by using the **$PASHS,NME,TTT** command.

Enabling the TTT message causes the TTT NMEA message to output in synchronization with either the rising or falling edge (selectable) of the triggering signal. The trigger signal can be set to the rising or falling edge using the **$PASHS,PHE** command.

DEFAULT SETTINGS
TTT synchronization message output— synchronize with the rising edge of the trigger signal

The precision of the measured time is 50 nanoseconds (ns) in differential mode and 200 ns in stand-alone mode with SA off. This is based on GPS time, which is output as day number, hours, minutes, seconds, and fractional seconds to 6 digits past the decimal mark.

The photogrammetry time measures the event time relative to the receiver's GPS time. It measures only the first event during the period between 2 GPS epochs (Figure 3.1).
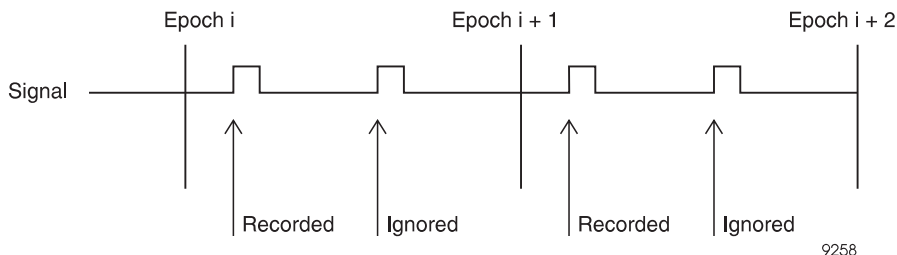
Figure 3.1. GPS Epochs

CAUTION
The DG14 measures only one event time per data collection period. If more than one event time is measured within a data collection period, the receiver measures only the first one. The event time record rate is dependent upon the setting of the RCI parameter.

Because the 1 PPS signal is used to measure the photogrammetry events, the period of the 1 PPS signal must be set to a value equal to or less than the period of the event pulse.

The trigger pulse may be TTL-compatible or open collector. Minimum pulse duration is 100 nanoseconds when the signal is not terminated at the receiver input. The impedance is approximately 5 KΩ.

Use a coaxial cable with BNC connectors to connect the camera trigger output to the photogrammetry input connector of the DG14.

Time Tagging the Shutter Signal

In this technique, the signal generated by the camera shutter is fed to a GPS receiver for accurate time-tagging which can then be post-processed with the GPS observations. Since the time of the picture is not synchronized with the time that the GPS measurement is taken, the two position computations before and after the shutter time are interpolated to compute the position of the camera at the time the picture was taken.

If GPS measurements are recorded at the rate of one per second, the average distance an aircraft travels in ½ second is about 100 meters. Therefore, the distance between the position of the camera at the time the picture was taken and

the GPS position fixes can be as much as 50 meters. The motion of the aircraft during this time may be in the meter range.

To minimize the errors discussed above, the closed loop technique is recommended.

Closed-Loop Technique (Advanced Trigger)

The closed-loop technique combines PPS synchronization and shutter timing (Figure 3.2).
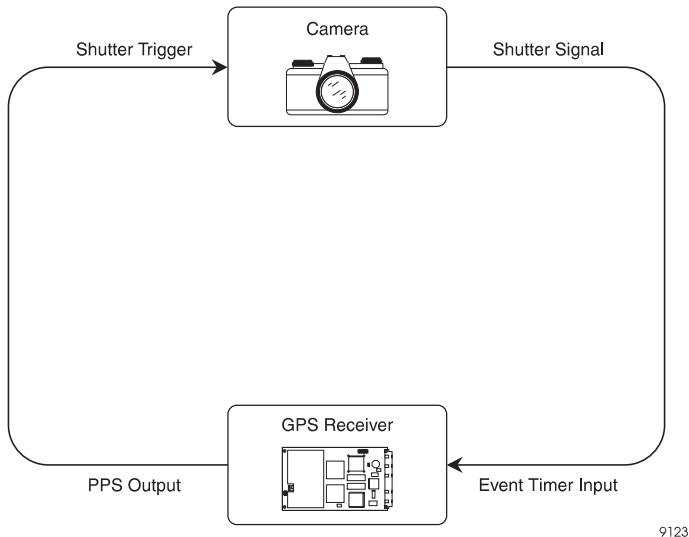
Figure 3.2. PPS Synchronization

In this technique, the 1PPS output of the DG14 triggers a camera shutter. The camera shutter generates a signal that is fed to the DG14 for accurate time tagging, better than one microsecond.

The delay between the camera receiving the pulse and triggering the photogrammetry port should be calculated. This may then be applied so as to advance the 1PPS from the DG14 so that the shutter time exactly matches the GPS time for the epoch. No interpolation between the shutter time and the GPS position time will be needed.

Timing Pulse - Measurement Strobe (Optional)

When the timing pulse option [L] is installed, the DG14 can output a timing pulse synchronized with GPS time to an accuracy of ±200 nanoseconds. The timing pulse is a TTL-compatible square wave signal output on pin 18 of the J301 connector and is fed into a 75-ohm impedance. The pulse is generated by default once every second (1PPS, or 1 pulse-per-second) with no offset from GPS time and with the rising edge of the pulse synchronized to GPS time. Using the **$PASHS,PPS** command, the period of the pulse can be changed from 0.05 of a second up to 99.95 seconds, depending upon the receiver update rate, which, in turn, is dependent upon the installed position update rate and raw data update rate options.The timing pulse may be offset from GPS time within a range of -999.9999 to +999.9999 milliseconds. GPS time can be synchronized to the rising or falling edge of the square wave pulse.

DEFAULT SETTING		
PPS	Period	1 second
	Offset	0.0000 milliseconds
	Synchroniza-tion	GPS time synchronized to the rising edge of the pulse

Figure 3.3 shows timing pulse characteristics under default conditions. The pulse occurs when the TTL-compatible signal goes high. The TTL level compatibility is ensured with 500 ohms or greater impedance. The 1PPS output level when high is from +3.15 V to +3.45 V and in series with a 100-ohm resistor connected to the microcircuit output. The accuracy of 1PPS pulse is ±200 nanoseconds (±50 nanoseconds when in DGPS remote mode) to the GPS second and remains high for 0.67 to 1.34 milliseconds. The DG14 must be computing position and tracking a minimum of four satellites in order for the accuracy of ±200 nanoseconds to be valid.

(Output pulse is TTL compatible)

0.67 to 1.34 msec

+3.3V

0V

GPS Time
0 second
(± 200 nanosec)

GPS Time
0 + 1 second
(± 200 nanosec)

GPS Time
0 + 2 seconds
(± 200 nanosec)

10158
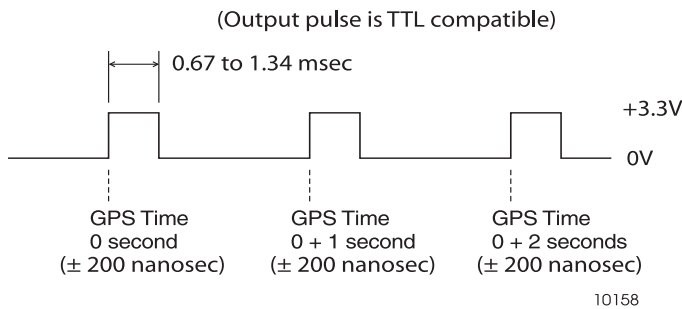
Figure 3.3. Timing Pulse Characteristics

In order to provide notification to peripheral equipment and software with respect to time tagging the occurrence of the timing pulse, it is necessary to set the output of PBN raw data message to match the period of the timing pulse. The GPS time value contained in the PBN message plus one second is the time that the next pulse will occur when the default settings are in effect (Figure 3.4). PBN time is already internally rounded to GPS time, so it is the actual time to which the navigation 1PPS pulse generation which preceded it (unless that pulse has been intentionally advanced or retarded). The latency of PBN message output is normally about 7 to 20 milliseconds after the timing pulse event.
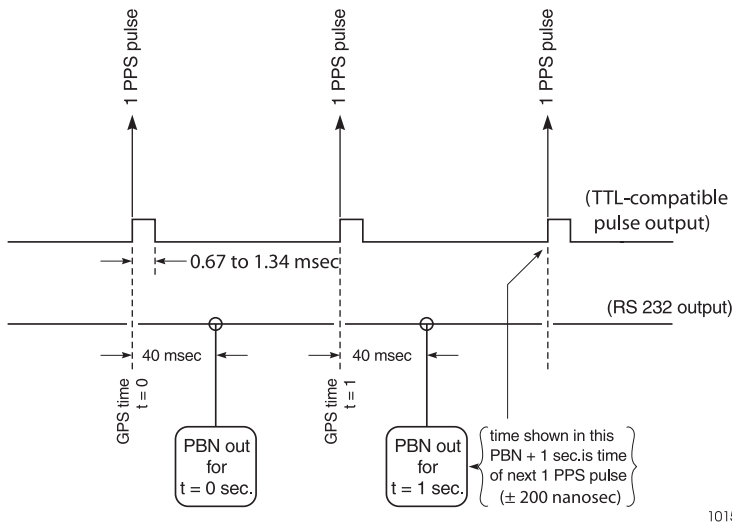
Figure 3.4. Relationship of GPS Time in PRN Record to Output of 1PPS Pulse

10 Hz and 20 Hz Outputs

The DG14 provides the optional capabilities of 10 Hz or 20 Hz internal update rates for position and raw data computations. When these options are installed, the DG14 can output NMEA messages and raw data messages at intervals of 0.1 or 0.05 seconds (see Table 1.8 for a list of the available options). During periods in which a 20 Hz update rate is not required, you can revert to a 10 Hz update rate by issuing the command **$PASHS,RCI** for raw data and **$PASHS,NME,PER** for NMEA messages.

CAUTION

When collecting data at 10 or 20 Hz, a 486-33 MHz or Pentium computer with a fast serial and parallel port card (i.e., 16550 serial and parallel card)   is required because of large amounts of data being output through the serial ports. The serial port baud rate should be set to 115200.

Due to the Windows overhead, at 20Hz, data can be lost if too many messages are enabled or if outputting MCA message and tracking more than 9 satellites.

---

20 Hz option [W] is not available with Muti-base WADGPS otion [M].

Jam Immunity

The DG14 provides jam immunity against in-band and out-of-band interferes.

For in-band interference, the DG14 can suppress in-band jamming signals while maintaining signal tracking, horizontal accuracy and acquisition time requirements. You can set the in-band jam immunity with the **$PASHS,AJM,ON/ OFF** command (default is OFF).

With AJM=ON you will lose approximately 2-3 dB of SNR on all satellites. This will only have a noticeable effect on weak satellite signals.

Datums

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

To set the receiver to output positions in a different datum, use the **$PASHS,DTM** command. Once set to a different datum, then all position outputs in NMEA messages such as GGA and GLL and the position are referenced to the chosen

datum. For a list of Datums, see Table 5.15, "Predefined Datums and Associated Reference Ellipsoids," on page 79.

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

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

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

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

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

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

Example: Define local datum as the WGS-72 datum

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

$PASHS,DTM,USR

This implements the transformations listed in Table 3.2 and below in the following equation:

Table 3.2. Ellipsoid Parameters for WGS-72 and WGS-84

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

$$\Delta x = \Delta y = 0 \qquad \Delta z = 4.5 \text{ meters} \qquad m = 0.23 \times 10^{-6}$$
$$\varepsilon_x = \varepsilon_y = 0 \qquad \varepsilon_z = -2.686 \times 10^{-6} \text{ radians} = -0\overset{''}{.}554$$

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} 0 \\ 0 \\ 4,5 \end{bmatrix} + (1 + 0,23 \times 10^{-6}) \begin{bmatrix} 1 & -2,686 \times 10^{-6} & 0 \\ 2,686 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{1\,WGS72}$$

Internally, the receiver implements the transformation *from* WGS-84 *to* WGS-72. Figure 3.5 demonstrates the change in the coordinate systems.
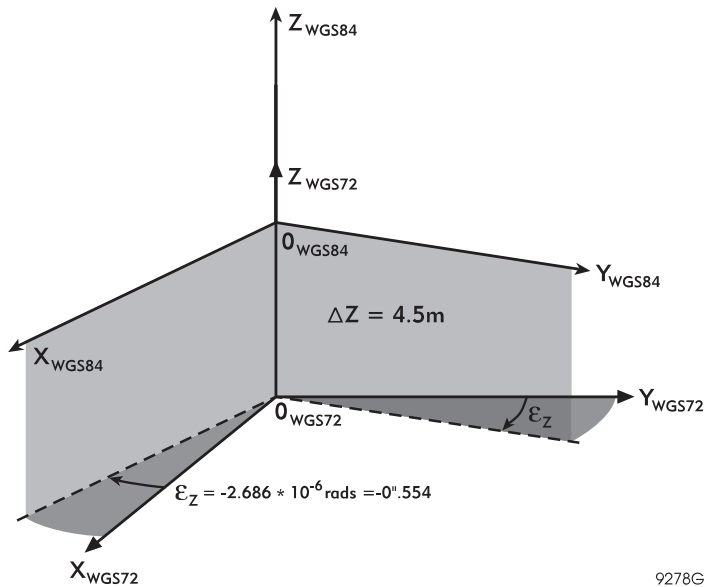
Figure 3.5. Rotation and Translation Between Coordinate Systems

4

Coordinate Transformation

This chapter discusses the coordinate transformation features of your receiver.

Background

GPS determines the three-dimensional positions of surveyed points based on the WGS-84 datum. These coordinates are either presented as geocentric Cartesian coordinates (X,Y,Z) values or geodetic coordinates (latitude, longitude, ellipsoidal height).

There are circumstances where it would be desirable to have positions represented in a different reference frame or format, i.e. based on a different datum or projected onto a plane (grid coordinates).

The DG14 provides the following on-board tools to transform WGS-84 coordinates into various formats and reference frames:

1. Datum-to-Datum transformation

   Using this feature, WGS-84 coordinates can be transformed into coordinates based on another datum.

2. Datum-to-Grid conversion

   With this tool, a grid system can be defined to convert geodetic coordinates into grid coordinates.

3. Elevation Modeling

   Using an on-board geoid model, ellipsoidal heights can be transformed into orthometric heights using this capability.

Table 4.1 provides an overview of user coordinate transformation functions for your receiver.

Table 4.1. User Coordinate Transformation Functionalities

Transformation	Description
Datum to Datum	3D (7-parameter) datum transformation between two Cartesian XYZ systems associated with the WGS-84 datum and local datum defined by the user.
Datum to Grid	Data projected from a geodetic system, associated with WGS-84 or a user-defined datum and a specified grid system. Map Projections Supported • Mercator (EMER) • Transverse Mercator (TM83) • Oblique Mercator (OM83) • Stereographic (Polar and Oblique) (STER) • Lambert Conformal Conic (2 standard parallels) (LC83) Special Map Projections Specific to NAD27 • Transverse Mercator 27 (TM27 and TMA7) • Oblique Mercator 27 (OM83) • Lambert Conformal Conic 27 (LC27)
Elevation Modeling	Interpolation of geoidal undulations

The remainder of this chapter describes in more detail the coordinate transformation features of your receiver.

Datum to Datum

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

To set the receiver to output positions in a different datum, use the **$PASHS,DTM** command. Once set to a different datum, then all position outputs in NMEA messages such as GGA and GLL are referenced to the chosen datum. For a list of Datums, see Table 5.15, "Predefined Datums and Associated Reference Ellipsoids," on page 79.

If the list of datums does not include a datum of interest to you, you can define a datum and load it on the receiver, using the **$PASHS,UDD** command along with the **$PASHS,DTM** command. Prior to using these commands, define the required parameters including the length of the semi-major axis and amount of flattening in the reference ellipsoid, and the translation, rotation, and scale between the user-defined system and WGS-84.

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

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

where $e_{rx} = e_x$ expressed in radians, similarly for e_{ry} and e_{rz}.

Example: Define local datum as the WGS-72 datum

Send the following commands to the receiver:

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

\$PASHS,DTM,UDD

This implements the transformations listed in Table 4.2 and below.

Table 4.2. Ellipsoid Parameters for WGS-72 and WGS-84

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

$\Delta x = \Delta y = 0$

$\Delta z = 4.5$ meters

$m = 0.23 \times 10^{-6}$

$\varepsilon_x = \varepsilon_y = 0$

$\varepsilon_z = -2.686 \times 10^{-6}$ radians $= -0.''554$

in the following equation:

$$
\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} 0 \\ 0 \\ 4,5 \end{bmatrix} + (1 + 0,23 \times 10^{-6}) \begin{bmatrix} 1 & -2,686 \times 10^{-6} & 0 \\ 2,686 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{1 WGS72}
$$

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

Figure 4.1 illustrates the change in the coordinate systems.
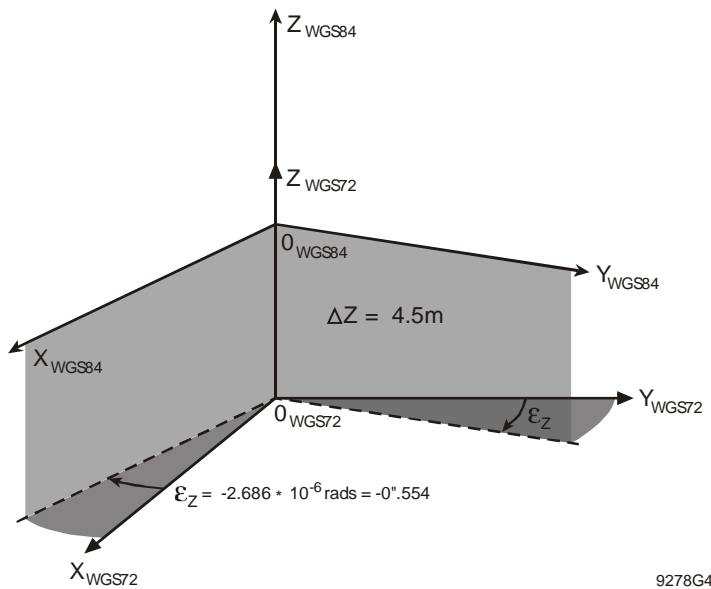
Figure 4.1. Rotation and Translation Between Coordinate Systems

After transforming the datum, the receiver computes geodetic coordinates in the defined system. All coordinates output by the receiver are in this new system.

Do not forget to issue the $PASHS,DTM,UDD command after defining the transformation parameters with the $PASHS,UDD command. Otherwise, the newly entered parameters are not used.

Datum to Grid

Use this transformation to generate coordinates in an <x,y> rectangular system, based on the user's location and mapping requirements or local standard. The user may select any projection along with any base datum for output.

Convert geodetic coordinates into grid coordinates by defining a grid system utilizing one of the supported projection types (Figures 5.2 - 5.6).

CAUTION

Although almost any projection or combination of datums and projections is mathematically possible, some are inappropriate with respect to the project scope or geographic area.

To set the receiver to supply grid coordinates:

1. Select the projection type that best fits your needs.
2. Define the grid system, using this projection type, with the **$PASHS,UDG** command. This command defines the grid system to be used.
3. Enable the grid system with the **$PASHS,GRD,UDG** command. The receiver computes grid coordinates in the system defined.
4. To access the grid coordinates, use either the **$PASHQ,GDC** command to query for one output of the current coordinates, or use the **$PASHS,NME,GDC** command to set the receiver to continuously output the current coordinates.

There is one exception when configuring the receiver to compute and output grid coordinates. If you are interested in computing and outputting WGS-84 based UTM coordinates, there is no need to define the grid system in the receiver. The parameters for WGS-84 UTM are pre-set in the receiver. To use them, set the receiver to output grid coordinates using either the **$PASHQ,UTM** command to query for one output of the current coordinates, or the **$PASHS,NME,UTM** command to set the receiver to continuously output the current coordinates.

Check the GDC message for the currently assigned datum.

Projection Types

The following graphics represent the different types of projections available for the receiver.

Equator
tangent
to cylinder
surface

10087

10092

Figure 4.2. Mercator

Line of Longitude
tangent to
cylinder surface

10088

10094
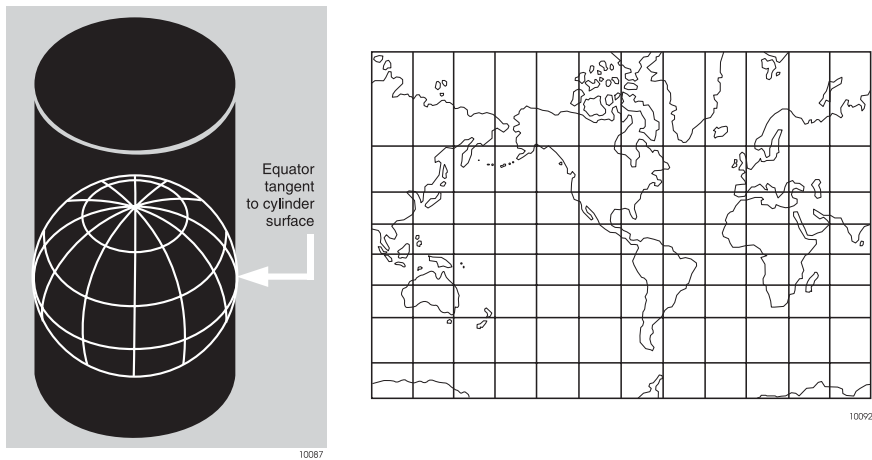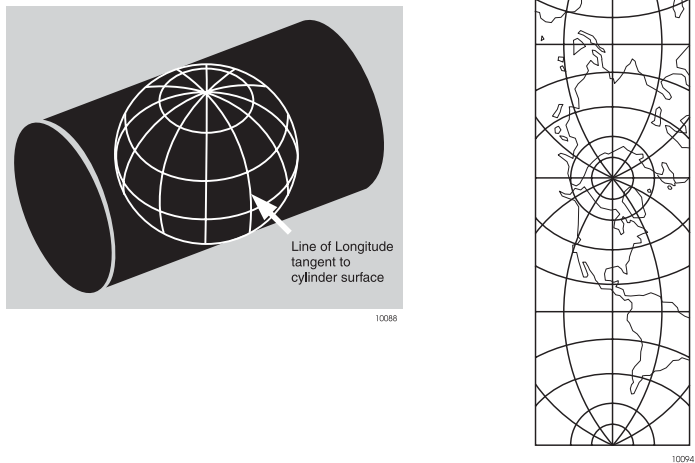
Figure 4.3. Transverse Mercator
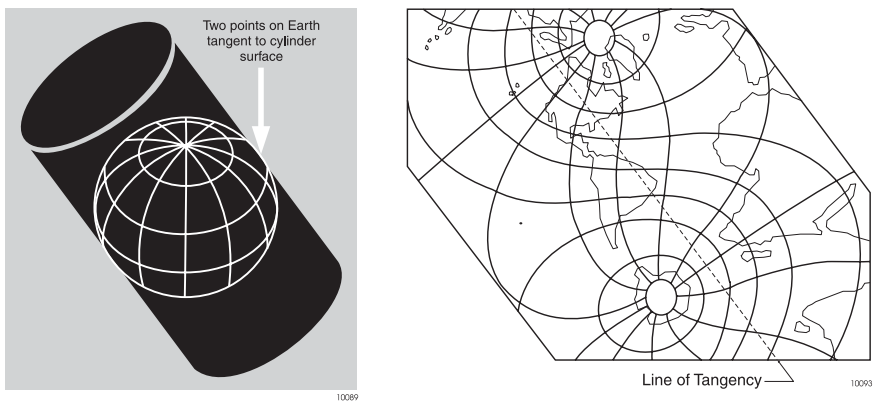
Figure 4.4. Oblique Mercator
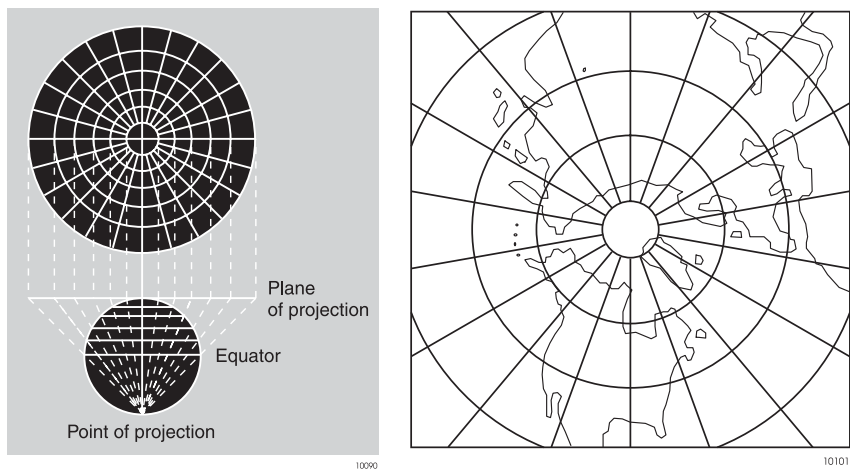
Figure 4.5. Stereographic
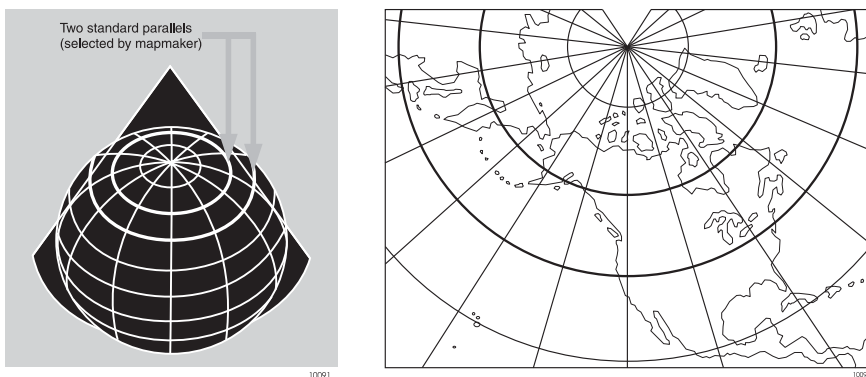
Figure 4.6. Lambert Conformal Conic

Elevation Modeling

In addition to computing and outputting geodetic and cartesian coordinates in different systems, the receiver can compute and output elevations in different systems.

By default, the receiver computes and outputs ellipsoidal heights. In some messages, the geoid separation is included, computed from the internal global model, relative to WGS-84.

To set the receiver to compute and output orthometric heights, use the **$PASHS,HGT,GEO** command. After setting this command, the receiver outputs orthometric heights using the internal global geoid model. Be aware that the internal geoid model used in this calculation is very coarse. Orthometric heights derived from this model could be in error by a meter or more.

If separation is included in the message, it is calculated by adding the difference between WGS-84 and a user- or pre-defined datum to the WGS-84-based geoid separation. An exception to this is the GGA message which ONLY outputs WGS-84 based geoid heights and separation, as per NMEA specifications.

5

Receiver Commands

Chapters 6 through 9 cover the formats and content of the serial port commands through which the DG14 receiver is controlled and monitored. These serial port commands set receiver parameters and request receiver status information and other data. Use Evaluate™ software or any standard serial communication software to communicate with the receiver. Note that the baud rate and protocol of the computer COM port must match the baud rate and protocol of the receiver port for commands and responses to be successfully transmitted and received. The communication protocol is 8 data bits, 1 stop bit, and no parity.

All messages sent by the user to the receiver are either "Set" command messages or "Query" command messages. Set commands generally change receiver parameters and initiate data output. Query commands generally request receiver status information. All set commands begin with the string **$PASHS**; all query commands begin with **$PASHQ**. **$PASHS** and **$PASHQ** are the message headers. They are required for all set or query commands. All commands must end with an **<Enter>** or **<CR><LF>** (Carriage Return/Line Feed) keystroke in order to send the command to the receiver. If desired, an optional checksum may precede the **<Enter>** characters. All response messages also end with **<Enter>** or **<CR><LF>** characters. Please note that some messages are functional only if the appropriate option is installed.

When a command is sent to one of its serial ports, the DG14 responds by outputting a message indicating the acceptance or rejection of the command. In the case of query commands, the DG14 either outputs a response message containing data relevant to the query or sends a "NAK" response, indicating that the query command was invalid. All DG14 response messages begin with the string **$PASHR**, including status messages that are set for output at regular intervals from either of the DG14's serial ports.

DG14 serial port commands fall into seven groups:

- Receiver commands— discussed in Chapter 6
- Raw data commands— discussed in Chapter 7
- NMEA message commands— discussed in Chapter 8
- Differential commands— discussed in Chapter 9
- RTCM commands— discussed in Chapter 9
- SBAS commands— discussed in Chapter 9
- Beacon commands— discussed in Chapter 9

The following chapters discuss each type of command. Within each section, the commands are listed alphabetically and described in detail. A description of the command, the command structure, the range and default states of command parameters, and an example of how a given command is used are presented for each command. These parameters may be either characters or numbers depending upon the command. Table 5.1 lists the symbols and the types of data represented by them used to illustrate message structures in the ASCII format:

Table 5.1. Command Parameter Symbols

Symbol	Parameter Type	Example
c	1 character ASCII	N
d	Numeric integer	3
f	Numeric real	2.45
h	Hexadecimal digit	FD2C
m	Mixed parameter (integer and real) for lat/lon or time	3729.12345
s	Character string	
*hh	Hexadecimal checksum; always preceded by an asterisk (*)	*A5

If you have the User-defined messaging option installed [X], you can use the $PASHS,UDM command to view receiver information you specify the DG14 to output. See Appendix B, **UDM Utility** for more information on setting up a user-defined message.

Receiver Commands

Receiver commands allow you to change or query the status of various operating parameters such as elevation mask, antenna altitude, position mode, etc. In this context, set commands are used to change the DG14's operating parameters. Query commands prompt the DG14 to output status messages for parameter settings and receiver operation.

If an invalid set or query command is issued, a "not acknowledged" (NAK) response is output:

$PASHR,NAK*30

Set command messages can be sent through serial port. When the DG14 receives a valid set command message, it returns an "acknowledged" (ACK) message:

$PASHR,ACK*3D

The DG14 returns a NAK message if the command is invalid. For example, the set command **$PASHS,SAV,Y<Enter>** instructs the DG14 to save user-entered operation parameters; the DG14 returns **$PASHR,ACK*3D** to acknowledge that the command was valid and the instruction was carried out. The set command **$PASHS,SAV<Enter>** is incomplete, and would cause the DG14 to flag it as an invalid command by responding with a "not acknowledged" response:

$PASHR,NAK*30.

The set command message structure is as follows:

"Header,Command ID,<Command Parameters>*Checksum<Enter>"

The header field always contains **$PASHS**. The command identifier field contains a three character string and is followed by the command parameters. The checksum is strictly optional. All set commands are terminated with an **<Enter>** or **<CR><LF>** keystroke. All command string elements between the dollar sign ($) and the asterisk (*), including the command parameters, are comma delimited; that is, the header, the ID string, and the individual command parameters are separated by commas. Enter the following set command to set the HDOP mask value:

$PASHS,HDP,6<Enter>

Query commands are used to request current GPS information and receiver status information such as baud rate settings, position information, and tracking information. Query command messages can be sent to either of the DG14's serial ports. Most query commands allow you to designate the port from which the response message is sent. The DG14 acknowledges a valid query command message by sending the requested response message through the specified port. If the port is not specified in the query command, the response is sent from the same port which received the query. The requested information is sent once each time the command is issued and is not repeated.

The query command message format is as follows:

$PASHQ,xxx,<optional query parameter>*hh<Enter>

Table 5.2 contains descriptions of the query command elements.

Table 5.2. Query Command Structure

Field	Description
$	NMEA message start character
PASHQ	Ashtech header for query messages.
xxx	Message identifier.
<optional query parameter>	Designates data port from which query response message to be sent.
*	Checksum delimiter.
hh	Hexadecimal checksum value (checksum is optional).

The query command **$PASHQ,CRR** instructs the DG14 to output a response message indicating the currently selected code correlation mode:

$PASHR,CRR,E*5E

The query command **$PASHQ,CR<Enter>** is incomplete, and causes the DG14 to flag it as an invalid message by outputting the NAK response.

Table 5.3 contains a list of the set and query commands falling into the category of receiver commands. The commands are listed alphabetically by function, and then alphabetically within each function. The commands are described in detail in the pages following Table 5.3.

Table 5.3. Receiver Commands

Command	Description	Default	Page
ANTENNA POSITION			
$PASHS,ALT	Set ellipsoidal height of antenna	0.00 m	69
$PASHS,ANH	Set antenna slant height	—	69
$PASHQ,ANH	Query antenna slant height	—	71
$PASHS,ANT	Set antenna offset parameter	—	70
$PASHQ,ANT	Query antenna offset parameters	—	71
$PASHS,POS	Set base station reference position	—	112
$PASHQ,POS	Query current position	—	112
DILUTION OF PRECISION (DOP)			
$PASHS,HDP	Set HDOP mask for position computation	4	90

Table 5.3. Receiver Commands (Continued)

Command	Description	Default	Page
$PASHS,PDP	Set PDOP mask for position computation	40	109
$PASHS,VDP	Set VDOP mask for position computation	4	151
IONOSPHERIC AND TROPOSPHERIC MODELLING			
$PASHQ,ION	Query ionospheric measurements	Y	98
MEMORY, POWER, AND DIAGNOSTICS			
$PASHQ,BIT	Query Operational Diagnostics	—	71
$PASHQ,HST	Query Start-up Diagnostics Results	—	94
$PASHS,INI	Clear internal and BBU memory	—	96
$PASHS,POW	Set the battery power capacity	—	114
$PASHQ,POW	Query the battery power capacity	—	114
$PASHS,PWR,OFF	Turn the receiver power off	—	118
$PASHS,RST	Restore default parameter settings	—	123
$PASHS,SAV	Save parameters to memory	N	123
PHOTOGRAMMETRY/1PPS/STROBE			
$PASHS,PHE	Set photogrammetry edge	Rising	109
$PASHQ,PHE	Query photogrammetry parameters	—	110
$PASHS,PPS	Set period and offset of 1PPS signal	1, 0.0000, R	116
$PASHQ,PPS	Query timing pulse parameters	—	116
VELOCITY COMPUTATION			
$PASHS,DAP	Set the Doppler averaging interval	—	76
$PASHQ,DAP	Query the Doppler averaging interval	—	76
$PASHS,DYN	Set the dynamic mode	8	83
$PASHS,SMV	Set the speed filtering	—	129
$PASHQ,SMV	Query the speed filtering	—	129
SESSION PROGRAMMING			
$PASHS,EPG	Set the kinematic epoch counter	—	84
$PASHS,SES,PAR	Set the session programming parameters	—	126
$PASHS,SES,SET	Set individual session parameters	—	126
RTCM REMOTE STATION STATUS			

Table 5.3. Receiver Commands (Continued)

Command	Description	Default	Page
$PASHQ,DFO	Query the current status of RTCM remote station	—	76
SATELLITE TRACKING PARAMETERS			
$PASHS,UTS	Synchronize measurements & coordinates with GPS system time	Off	150
$PASHS,SUI	Enable satellite usage indicator	Off	131
$PASHS,SVP	Set satellites for position computation	Y	132
$PASHQ,SVP	Query satellites in position computation	—	133
$PASHS,SVS	Set satellites for acquisition and tracking	Y	134
$PASHQ,SVS	Query satellites for acquisition and tracking	—	134
$PASHS,USE	Designate individual satellites for tracking	All	149
$PASHS,USE,ALL	Include/exclude all satellites for tracking	All	149
$PASHS,USP	Set individual satellites to be used in position computation	All	150
$PASHQ,STA	Query for currently locked satellites	—	131
$PASHQ,UTS	Query time synchronization	—	150
$PASHQ,VIS	Query for visible satellites	—	151
POSITION COMPUTATION			
$PASHS,CRR	Set type of code correlator	Edge	72
$PASHQ,CRR	Query code correlator setting	—	73
$PASHS,ERM	Set error masks for position computations	AUT: 600, 1200 DIF: 30, 60	84
$PASHS,FIX	Set fixed altitude mode	0	86
$PASHS,PEM	Set elevation mask for position computation	5°	109
$PASHS,PMD	Set position computation mode	1	110
$PASHS,PPO	Enable/disable point positioning	—	115
$PASHQ,PPR	Query position parameters	—	115
$PASHS,SCM	Set smoothing counter mask	Off	124
$PASHS,SEM	Set secondary elevation mask	Off	124
KALMAN FILTER			
$PASHS,KFP	Set the Kalman filter	Off	99
$PASHQ,KFP	Query the Kalman filter parameters	—	99

Table 5.3. Receiver Commands (Continued)

Command	Description	Default	Page
$PASHS,KFP,FDE	Set Kalman filter fault detection and elimination	99	100
$PASHS,KFP,PRI	Set Kalman filter prediction interval	10 sec	100
$PASHS,KPI	Set coordinates for Kalman filter initialization	—	101
TRANSFORMATIONS			
$PASHS,DTM	Select reference datum	WGS-84	78
$PASHS,FUM	Select UTM zone to be held fixed	N	87
$PASHS,FZN	Enable/disable fixed UTM zone mode	—	87
$PASHQ,GDC	Query position as rendered in user-defined grid coordinates	—	88
$PASHS,GRD	Set datum to grid transformation	—	90
$PASHS,HGT	Set height selection model	—	91
$PASHQ,HGT	Query height selection model	—	91
$PASHS,LGS	Set grid to grid transformation	NON	102
$PASHS,UCT,UDD,APT	Add a point for datum transformation	—	135
$PASHS,UCT,UDD,CAL	Calculate datum transformation parameters	—	136
$PASHQ,UCT,UDD,CAL	Query the datum transformation parameters	—	136
$PASHS,UCT,UDD,EST	Estimate a datum transformation	—	137
$PASHS,UCT,UDH,APT	Add a point for a local geoidal surface transformation	—	138
$PASHS,UCT,UDH,CAL	Calculate local geoidal surface transformation parameters	—	136
$PASHQ,UCT,UDH,CAL	Query local geoidal surface transformation parameters	—	136
$PASHS,UCT,UDH,EST	Estimate a local geoidal surface transformation	—	139
$PASHS,UCT,UG4,APT	Add a point for a grid transformation	—	139
$PASHS,UCT, UG4,CAL	Calculate grid transformation parameters	—	140
$PASHQ,UCT,UG4,CAL	Query the grid transformation parameters	—	140
$PASHS,UCT,UG4,EST	Estimate the grid transformation	—	140
$PASHS,UD4	Set user-defined datum to datum parameters	WGS-84	141
$PASHS,UDD	Set the user-defined datum	—	141
$PASHQ,UDD	Query the user-defined datum	—	141
$PASHS,UDG	Set user-defined datum to grid transformation	—	144
$PASHS,AJM	Enable/disable jam immunity	Off	68
$PASHQ,AJM	Query the jam immunity status	—	68

Table 5.3. Receiver Commands (Continued)

Command	Description	Default	Page
$PASHQ,CLK	Query clock status	—	72
$PASHS,CTS	Enable/disable RTS/CTS handshaking protocol	Off	74
$PASHQ,CTS	Query the current RTS/CTS setting	—	75
$PASHS,DSY	Set serial ports for daisy chain communication	Off	77
$PASHQ,DUG	Query UTC-GPS time difference	—	82
$PASHQ,HLP	Query the available receiver commands	—	92
$PASHS,LPS	Set loop tracking parameters	10, 3, 1	102
$PASHQ,LPS	Query loop tracking parameter setting	—	103
$PASHS,LTZ	Set local zone time	00hr 00 min	104
$PASHS,OOP	Set the order of the output messages	—	105
$PASHQ,OOP	Query the order of the output messages	—	105
$PASHQ,PAR	Query current receiver parameter settings	—	105
$PASHQ,PRT	Query port baud rate	9600	117
$PASHQ,RID	Query receiver identification (Format 1)	—	118
$PASHQ,RIO	Query receiver identification (Format 2)	—	121
$PASHS,SMI	Set the code measurement smoothing	100 sec 1° order	128
$PASHQ,SMI	Query the code measurement smoothing	—	129
$PASHS,SNM	Set the signal to noise mask	0	
$PASHS,SPD	Set baud rate of serial port	—	130

Since they are required for all commands and responses, the <Enter> and <CR><LF> keystrokes are omitted from the examples that follow.

AJM: In-Band Jam Immunity

$PASHS,AJM,x
This command enables or disables in-band jam immunity where x is ON or OFF.

$PASHQ,AJM
This command queries the in-band jam immunity setting.

$PASHR,AJM

The response is in the format:

$PASHR,AJM,x

where x is ON or OFF.

DEFAULT SETTING
AJM—OFF

ALT: Ellipsoidal Height

$PASHS,ALT,f1

This command sets the ellipsoidal height of the antenna, where f1 can be any value from -99999.99 to **+**99999.99. The DG14 uses the altitude value set through this command when it is computing 2D positions.

Example

Enter the following command to set the ellipsoidal height of the antenna to -30.1 meters:

$PASHS,ALT,-30.1

DEFAULT SETTING
ALT—00000.00 meters

ANH: Antenna Height

$PASHS,ANH,f

This command sets the antenna height where f is from 0.0 to 6.4 meters.

Example:

Enter the following command to set the antenna height to 3.534 meters.

$PASHS,ANH,3.534

$PASHQ,ANH,[c]

This command queries the antenna height entered into the receiver, where c is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

Example

Query antenna offsets to port A.

> $PASHQ,ANH,A

$PASHR,ANH

The response is in the format:

> $PASHR,ANH,f

where f is the antenna height in meters.

ANT: Set Antenna Offsets

$PASHS,ANT,f1,f2,f3,m1,x1

This command sets the antenna offsets from reference point to antenna phase center. Table 5.4 outlines the parameters.

Table 5.4. Antenna Offsets Settings

Parameter	Description	Range	Unit
f1	Antenna height: height measured from the reference point to the antenna edge	0 to 6.4	meters
f2	Antenna radius: the distance from the antenna phase center to the antenna edge	0.0 to 9.9999	meters
f3	Antenna offset: the offset set from the antenna phase center to the antenna ground plane.	0.0 to 99.9999	meters
m1	Horizontal azimuth measured from the reference point to the antenna phase center with respect to north (WGS-84).	0 to 180.00	ddmm.mm
x1	Horizontal distance measured from the reference point to the antenna phase center.	0 to 99.9999	meters

This command affects message type 1, 9, and 3 significantly.

Example

Set antenna height to 1.678 meters, radius to 0.1737 meters, offset to 0.5 meters.

> $PASHS,ANT,1.678,0.1737,0.5,0000.00,0.0<Enter>

$PASHQ,ANT,c

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

Example

Query antenna offsets to port A.

> **$PASHQ,ANT,A**

$PASHR,ANT

The response is in the format:

> **$PASHR,ANT,f1,f2,f3,m1,x1*cc**

where Table 5.5 defines the response format.

Table 5.5. ANT Message Structure

Parameter	Description	Range	Unit
f1	antenna height: height measured from the reference point to the antenna edge	0—64.000	meter
f2	antenna radius: the distance from the antenna phase center to the antenna edge	0.0—9.9999	meter
f3	antenna offset: the offset set from the antenna phase center to the antenna ground plane.	0.0—99.9999	meter
m1	Horizontal azimuth measured from the reference point to the antenna phase center with respect to north (WGS-84).	0 to 180.00	ddmm.mm
x1	Horizontal distance measured from the reference point to the antenna phase center.	0 to 99.9999	meters
*cc	Checksum	00-FF	n/a

BIT: Operational Diagnostic Tests

$PASHQ,BIT,[c1]

This commands queries for the results of the periodic operational diagnostic tests, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

The response message is output in the format:

> **$PASHR,BIT,c1,c2,c3,*cc**

Table 5.6 outlines the response message parameters.

Table 5.6. $PASHR,BIT Response Parameters

Parameter	Description	Range
c1	Low battery test, Indicates whether the battery in the real-time clock device has failed.	P = Pass F = Fail
c2	Receiver parameters checksum/CRC test, Indicates whether the Receiver Parameters stored in non-volatile memory have been corrupted.	P = Pass F = Fail
c3	Fatal failure detection tests Fatal failures include volatile and non-volatile memory failures, firmware checksum/CRC failure, and RS-232 serial port A or B failure.	P = Pass F = Fail
*cc	Checksum	00-FF

CLK: Clock Status

$PASHQ,CLK,[c1]

This command queries the real-time UTC clock status, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

The time in the CLK command is UTC.

The response message is output in the format:

$PASHR,CLK,d1,d2,d3,d4,d5,d6,d7,d8

Table 5.7 defines the format for d1 through d88:

Table 5.7. $PASHQ,CLK Format

Parameter	Description	Range
d1	Year	0 to 99
d2	Month	1 to 12
d3	Date	1 to 31
d4	Day of the week	1 to 7
d5	Hour	0 to 23
d6	Minute	0 to 59
d7	Second	0 to 59

Table 5.7. $PASHQ,CLK Format (Continued)

Parameter	Description	Range
d8	Time Difference— the time lapse after the last write to RTC	0 to 2^{32}
*hh	The hexadecimal checksum is computed by exclusive O-Ring all of the bytes in the message between, but not including, the $ and the *. The result is *hh where h is a hex character.	0-9 and A-F

Typical CLK response:

$PASHR,CLK,96,12,04,4,13,25,20,14*05

which translates to 4 December 1996, Wednesday 13.25, 20 sec; last write time to clock operation was at 14sec before this command.

CRR: Code Correlator Mode

$PASHS,CRR,c1

This command selects the type of code correlator used for multipath mitigation; c1 specifies the code correlator type:

E = Edge correlator

S = Strobe correlator.

The selected correlator is applied to all GPS channels and both SBAS channels.

The Edge Correlator is standard features for the DG14. The Strobe Correlator is available for the DG14 as an option.

$PASHQ,CRR,[c1]

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

$PASHR,CRR

The response message is output in the format:

$PASHR,CRR,c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12*hh

Table 5.8 outlines the parameters

Table 5.8. $PASHR,CRR Format

Parameter	Description	Range
c1 to c12	Correlator setting for channels 1-12	E = Edge correlator S = Strobe correlator
hh	Checksum	2-character hex

Typical CRR response:

$PASHR,CRR,E,E,E,E,E,E,E,E,E,E,E,E*37

Table 5.9 describes the typical CRR response message.

Table 5.9. Typical CRR Message

Item	Description
$PASHR	Header
CRR	Message identifier
E	Indicates that channels 1-12 are set in edge correlator mode
*37	Checksum

DEFAULT SETTING
CRR—E

CTS: Handshaking Protocol

$PASHS,CTS,c1,s1

This command enables or disables the CTS/RTS (Clear To Send/Request To Send) handshaking protocol on one or all of the DG14's serial ports. The c1 parameter is the optional port designator (A, B, or C); s1 is ON or OFF.

If a port is not designated, the command applies the change to the port from which the command was sent. Handshaking is enabled on both ports by default. Handshaking requires five connections for each serial port (CTS, TXD, GND, RTS, RXD). When handshaking is disabled, only three connections are required (TXD, GND, RXD). See Figure 1.3 on page 10 for a diagram of the J301 pin configuration.

Example

Enter the following command to disable handshaking on port A:

$PASHS,CTS,A,OFF

$PASHQ,CTS,[c1]

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

$PASHR,CTS

The response message is output in the format:

$PASHR,CTS,c1,s1*hh

Table 5.10 outlines the parameters.

Table 5.10. $PASHR,CTS Format

Parameter	Description	Range
c1	Port identifier	A, B, C
s1	Current CTS setting	ON, OFF
hh	Checksum	2-character hex

Typical CTS response:

$PASHR,CTS,A,ON*70

Table 5.11 describes the typical CTS response message.

Table 5.11. Typical CTS Message

Item	Description
$PASHR	Header
CTS	Message identifier
A	Port identifier
ON	Current CTS setting for the related serial port
*70	Checksum

DEFAULT SETTING
CTS—OFF

DAP: Doppler Averaging Interval

$PASHS,DAP,f1

This command sets the time interval for the average doppler computation where f1 is the value for the output interval between 0.0 and 5.0. To use the raw Doppler value, set f1 to 0.

The Doppler averaging period affects the noise in the computed velocity, and at approximately 0.5, the velocity reaches it's nominal value. The maximum value is 5.0*(maximum position period).

Example

Set the time interval for Doppler averaging to 5 seconds:

$PASHS,DAP,5

$PASHQ,DAP,[c1]

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

$PASHR,DAP

The response message is output in the format:

$PASHR,DAP,f1*hh

Table 5.10 defines the response parameters.

Table 5.12. $PASHR,DAP Format

Parameter	Description	Range
f1	Doppler averaging interval	0.0 to 5.0
hh	Checksum	2-character hex

DFO: Remote Station Status

$PASHQ,DFO,[c1]

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

$PASHR,DFO

The response is in the format:

$PASHR,DFO,d1,d2,d3,d4,d5,d6,d7,{di,+/-fi1,+/-fi2}1-n

Table 5.13 defines the DFO response format:

Table 5.13. $PASHR,DFO Structure

Parameter	Description	Range
d1	RTCM differential mode status	• 0—Not in remote mode, do not sent remaining messages • 2—Receiver in Remote Mode
d2	Message Status	• 0—No message has been received, do not send remaining messages • 1—Message is not synchronized (message is older than maximum age) • 2—Message is synchronized with the last received message
d3	Reference Station ID	0 to 1023
d4	Reference Station Health	0 to 7
d5	Age of received message in seconds	0 to maximum age
d6	Quality factor	0 to 999
d7	Number of satellites for which the PRC and RRC are transmitted	
di	PRN number (loops d7 times)	
fi1	Pseudo-range correction in meters (loops d7 times)	3 bytes, including +/-
fi2	Range rate correction in centimeters per second (loops d7 times)	3 bytes, including +/-
hh	Checksum	2 character, hexidecimal

DSY: Daisy Chain Communications Mode

$PASHS,DSY,c1,c2;

This command redirects all characters from one serial port to the other without interpreting them, where c_1 is the source port and c_2 is the destination port. Any combination may be chosen. When daisy chain mode is in effect, the source port can only interpret the OFF command; all other characters are redirected.

$PASHS,DSY,OFF

The OFF command disables daisy chain mode. A bi-directional daisy chain mode (i.e. A to B and B to A at the same time) can also be enabled.

Table 5.14 lists several daisy chain commands and their effects.

Table 5.14. Daisy Chain Commands

Command	Effect
$PASHS,DSY,A,B	Redirects data going into port A over to port B. Can be issued to either port
$PASHS,DSY,B,A	Redirects data going into port B over to port A. Can be issued to either port
$PASHS,DSY,A,OFF	Turns off redirection from A. Can be issued to either port
$PASHS,DSY,B,OFF	Turns off redirection from B. Can be issued to either port
$PASHS,DSY,A,B $PASHS,DSY,B,A	Both commands must be entered to enable bi-directional daisy chain mode. If you are connecting to the DG14 through port A, enter $PASHS,DSY,B,A first. If you are interfacing to the DG14 through port B, enter $PASHS,DSY,A,B first
$PASHS,DSY,OFF	Disables daisy chain on all ports. Can be issued from any port

DEFAULT SETTING
DSY—OFF

DTM: Set Reference Datum

$PASHS,DTM,UDD

This command allows you to select a user-defined datum type to use as a reference for position computations and measurements. Parameters for the user-defined datum are entered with the **$PASHS,UDD** command described on page 141.

$PASHS,DTM,s1

This command selects one of two datum types to be used as a reference for position computations and measurements; s1 specifies the datum type:

A 3-character string that defines a particular datum

USR (User-Defined Datum— Parameters for user-defined datum are entered with the **$PASHS,UDD** command described on page 141.

Table 5.15 lists the available predefined datums and associated reference ellipsoids.

Table 5.15. Predefined Datums and Associated Reference Ellipsoids

Datum ID	Reference Ellipsoid	Offset in meters (dX,dY,dZ)	Datum Description
ARF	Clarke 1880	-143, -90, -294	ARC 1950 (Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe
ARS	Clarke 1880	-160, -8, -300	ARC 1960 (Kenya, Tanzania)
AUA	Australian National	-133, -48, 148	ANS66 Australian Geodetic Datum 1966 (Australia, Tasmania Island)
AUG	Australian National	-134, -48, 149	ANS84 Australian Geodetic Datum 1984 (Australia, Tasmania Island)
BOO	International 1924	307, 304, -318	Bogota, Bogota Observatory (Columbia)
CAI	International 1924	-148, 136, 90	Campo, S. American Campo Inchauspe (Argentina)
CAP	Clarke 1880	-136, -108, -292	Cape (South Africa)
CGE	Clarke 1880	-263, 6, 431	Carthage (Tunisia)
CHI	International 1924	175, -38, 113	Chatham 1971 (Chatham, New Zealand)
CHU	International 1924	-134, 229, -29	S. American Chua Astro (Paraguay)
COA	International 1924	-206, 172, -6	S. American Corrego Alegre (Brazil)
EUA	International 1924	-87, -96, -120	European 1950 (Western Europe: Netherlands, Austria, France, F.R. of Germany, Switzerland, Denmark)
EUE	International 1924	-104, -101, -140	European 1950 (Cyprus)
EUF	International 1924	-130, -117, -151	European 1950 (Egypt)
EUH	International 1924	-117, -132, -164	European 1950 (Iran)
EUJ	International 1924	-97, -88, -135	European 1950 (Sicily)
EUS	International 1924	-86, -98, -119	European 1979 (Austria, Netherlands, Finland, Norway, Spain, Sweden, Switzerland)
FAH	Clarke 1880	-346, -1, 224	Oman
GAA	International 1924	-133, -321, 50	Gandajika Base (Rep. of Maldives)
GEO	International 1924	84, -22, 209	Geodetic Datum 1949 (New Zealand)
HJO	International 1924	-73, 46, -86	Hjorsey 195 (Iceland)
INA	Everest	214, 836, 303	Indian 1 (Thailand, Vietnam)
INM	Everest	289, 734, 257	Indian 2 (India, Nepal, Bangladesh)

Table 5.15. Predefined Datums and Associated Reference Ellipsoids (Continued)

Datum ID	Reference Ellipsoid	Offset in meters (dX,dY,dZ)	Datum Description
IRL	Modified Airy	506, -122, 611	Ireland 1965
KEA	Modified Everest	-11, 851, 5	Kertau 1948 (West Malaysia, Singapore)
LIB	Clarke 1880	-90, 40, 88	Liberia 1964
LUZ	Clarke 1866	-133, -77, -51	Luzon (Philippines excluding MindanoaIs.)
MAS	Bessel 1841	639, 405, 60	Massawa (Eritrea, Ethiopia)
MER	Clarke 1880	31, 146, 47	Merchich (Morocco)
MIN	Clarke 1880	-92, -93, 122	Minna (Nigeria)
NAC	Clarke 1866	-8, 160, 176	NAD27 N. American CONUS 1927 (North America)
NAD	Clarke 1866	-5, 135, 172	AK27 N. American Alaska 1927 (Alaska)
NAE	Clarke 1866	-10, 158, 187	CAN27 N. American Canada 1927 (Canada including Newfoundland Island)
NAH	Clarke 1880	-231, -196, 482	Nahrwan (Saudi Arabia)
NAN	Clarke 1866	-6, 127, 192	Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Mexico)
NAR	GRS1980	0, 0, 0	GRS80 North American 1983
OEG	Helmert 1906	-130, 110, -13	Old Egyptian
OGB	Airy 1830	375, -111, 431	OSG Ordnance Survey of Great Britain 1936 (England, Isle of Main Scotland, Shetland Islands, Wales)
OHA	Clarke 1866	61, -285, -181	OLDHW Old Hawaiian
PIT	International 1924	185, 165, 42	Pitcairn Astro 1967 (Pitcairn Island)
QAT	International 1924	-128, -283, 22	Qatar National (Qatar)
QUO	International 1924	164, 138, -189	Qornoq (South Greenland)
SAN	S. American 1969	-57, 1, -41	SAMER69 S. American 1969 (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyan, Peru, Paraguay, Venezuela, Trinidad, Tobago)
SCK	Bessel 1841 Namibia	616, 97, -251	Schwarzeck (Namibia)
TIL	Everest	-689, 691, -46	Timbalai 1948 (Brunei, East Malaysia, Sarawak, Sabah)
TOY	Bessel 1841	-128, 481, 664	Tokyo (Japan, Korea, Okinawa)
USR	User Defined	user defined	User defined

Table 5.15. Predefined Datums and Associated Reference Ellipsoids (Continued)

Datum ID	Reference Ellipsoid	Offset in meters (dX,dY,dZ)	Datum Description
W72	WGS-72	0, 0, +4.5	WGS-72 World Geodetic System - 72
W84	WGS-84	0, 0, 0	WGS-84 World Geodetic System - 84
ZAN	International 1924	-265, 120, -358	Zanderij (Surinam)

Table 5.16 lists the predefined ellipsoids.

Table 5.16. Predefined Ellipsoids

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

Example

Enter the following command to select New Zealand Geodetic Datum 1949 for position computation:

$PASHS,DTM,GEO

You can view the current reference datum selection with the **$PASHQ,PAR** command and checking the DTM field.

DEFAULT SETTING
DTM—WGS-84

DUG: GPS/UTC Time Difference

$PASHQ,DUG,[c1]

This command queries the time difference between UTC time and GPS time; c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,DUG

The response message is output in the format:

$PASHR,DUG,<Binary Data String + Checksum>

Table 5.17 outlines the binary data string parameters.

Table 5.17. $PASHR,DUG Format

Binary Type	Size	Content
unsigned short	2	Reference week
unsigned short	2	Reference time
unsigned short	2	GPS-UTC time (seconds)
unsigned short	2	GPS week number when the last leap second was added to GPS time
unsigned short	2	Julian day number when the last leap second was added to GPS time (1 to 365)
unsigned short	2	GPS-UTC time difference after correction (seconds)
unsigned short	2	Checksum (word)
Total bytes 14		

A time step, or leap second, was added to UTC on 12-31-98. GPS time was not physically adjusted, and is now thirteen seconds ahead of UTC. The time change is reflected in the navigation messages generated by the individual satellites as of January 1, 1999.

DYN: Dynamic Mode

$PASHS,DYN,d1

This command sets the dynamic mode under for the receiver where Table 5.18 outlines d1. The navigation solution uses expected dynamics for a given solution.

Table 5.18. Dynamic Modes

d1 (Dynamic Mode)	Description	Maximum Horizontal Velocity (m/s)	Maximum Vertical Velocity (m/s)	Maximum Horizontal Acceleration (m/s^2)	Maximum Vertical Acceleration (m/s^2)
1	Static	0	0	0	0
2	Quasi-Static *	0.1	0.02	0.1	0.02
3	Walking	2	0.5	1	0.5
4	Ship	20	1	1	0.5
5	Automobile	50	3	10	1.0
6	Aircraft	1000	1000	100	100
7	Unlimited	1000	1000	100	100
8	Adaptive Dynamic **	N/A		N/A	N/A

* Quasi-Static represents a static condition with some tolerance for slight movements within a decimeter or two. An example would be an antenna on a handheld pole or on the back of a person; obviously a person can try to be static but will inevitably move within a decimeter or two. This is unlike "Static" mode where the antenna is placed on a tripod or any other stationery structure with zero tolerance for actual movement.

*"Adaptive Dynamic adapts the filter dynamics settings to any of the modes 2 through 7 in real time allowing the switch from one mode to the other based on the witnessed behavior. Use one of the standard Adaptive filtering algorithms that monitor covariance behavior to determine dynamics model to use.

If you are unsure which is the appropriate model for your application, choose the Adaptive Dynamic mode. If you select Mode 1 through 7, the DG14 will not accommodate the other dynamic modes.

DEFAULT SETTINGS
$PASHS,DYN— **Adaptive Dynamic (8)**

EPG: Kinematic Epoch Counter

$PASHS,EPG,d1

This command sets the number of epochs for recording at a site where d is the number of epochs and ranges from 0 to 999. The command is used during kinematic surveys, when you want to occupy a site for a set amount of time. When the number of epoch goes to zero, the site name will automatically set to ???? indicating that the receiver is in motion.

Example

Enter the following command to set the number of epochs in the kinematic epoch counter to 20.

$PASHS,EPG,20

The site name must be set with the $PASHS,SIT command BEFORE the epoch counter works.

ERM: Set Position Error Mask Values

$PASHS,ERM,s1,d1,d2

This command sets mask values for horizontal and vertical error in relation to one of three different positioning modes:

- Autonomous (AUT)— Sets the error masks to autonomous mode
- Code-phase differential (DIF)— Sets the error mask to code-differential mode
- Both Autonomous and Differential (ALL)— Sets equal error masks for AUT and DIF

The s1 parameter represents the positioning mode, d1 is the horizontal error mask value, and d2 is the vertical error mask value. The range for d1 and d2 is 1 to 6000 meters. If the calculated 99% (3 sigma) error estimate of the computed position exceeds the set ERM value, no position will be output. The 99% position error estimate is three times the standard deviation values reported in the GST message. Current ERM settings appear in the **$PASHQ,PAR** message.

The various ERM mask parameters are utilized based on the positioning mode the receiver is operating in. For example, in auto-differential mode (AUT,ON), based on the epoch-to-epoch conditions, the receiver will use the respective mask parameters based on the corresponding positioning mode of each epoch. If the receiver is generating autonomous positions (e.g. due to the lack of current RTCM correction) the AUT mask parameters will be used until differential position fixes are computed, which will be masked by the DIF parameters.

The horizontal position standard deviation is derived from the individual latitude and longitude
standard deviations (GST) every epoch.

Example

Enter the following command to set the error masks for autonomous mode to five
meters for horizontal measurements and ten meters for vertical measurements:

$PASHS,ERM,AUT,5,10

$PASHS,ERM,ALL,d1,d2

This command sets error mask values that are applied to all positioning modes
(AUT, DIF). Error mask values set through this command are in effect regardless
of the receiver's current positioning mode. The various ERM mask parameters are
utilized based on the positioning mode the receiver is operating in. For example, in
auto-differential mode (AUT,ON), based on the epoch-to-epoch conditions, the
receiver will use the respective mask parameters based on the corresponding
positioning mode of each epoch. If the receiver is generating autonomous positions
(e.g. due to the lack of current RTCM correction) the AUT mask parameters will be
used until differential position fixes are computed, which will be masked by the DIF
parameters.

Example

Enter the following command to set the horizontal error mask to 2 meters and the
vertical error mask to 4 meters for all positioning modes:

$PASHS,ERM,ALL,2,4

DEFAULT SETTING			
ERM	**Positioning Mode**	**Horizontal Mask**	**Vertical Mask**
	Autonomous	**600 m**	**1200 m**
	Code Differential	**300 m**	**600 m**

Users who currently use the RMS and standard deviation information reported in the GST message,
and who also use the PDOP mask to screen out position fixes in less than favorable conditions, may
choose to disable the additional ERM masking feature. To disable the ERM, use the default ERM
settings or issue the command: $PASHS,ERM,ALL,6000,6000.

$PASHQ,ERM,c1

This command queries the error mask values for AUT, DIF, and CPD modes. c1 is
the optional port designator for the output of the response. If a port is not specified,
the receiver sends the response to the current port.

$PASHR,ERM

The response is in the format:

   $PASHR,ERM,d1,d2,d3,d4

where Table 5.19 outlines the response format.

Table 5.19. ERM Message Structure

Parameter	Definition
d1	Error mask horizontal setting for AUT.
d2	Error mask vertical setting for AUT.
d3	Error mask horizontal setting for DIF.
d4	Error mask vertical setting for DIF.

FIX: Fixed Altitude Mode

$PASHS,FIX,d1

This command sets the fixed altitude mode. It is typically used when the receiver is in 2-D position mode or when there are not enough visible satellites to compute a 3-D position; d1 can be 0 or 1. You can view the current setting for fixed altitude mode with the **$PASHQ,PAR** command and checking the FIX field.

- Fixed Altitude Mode 0

  The most recently recorded antenna altitude is used. The altitude value is taken either from the altitude entered through the **$PASHS,ALT** command or from the last altitude computed in which the VDOP value is lower than the value entered for the VDOP mask

- Fixed Altitude Mode 1

  Only the most recent altitude value entered through the **$PASHS,ALT** command is used.

Example

Enter the following command to set the DG14 in fixed altitude mode 1:

   $PASHS,FIX,1

DEFAULT SETTING
FIX—Mode 0

FUM: Fix UTM Zone

$PASHS,FUM,c1

This command enables/disables the fixing of the UTM zone, where c_1 is Y (enable) or N (disable). The default is N. This command is typically enabled when the user is near a UTM boundary and wants to avoid the coordinate shift that occurs when crossing from one UTM zone into another. This command is used in conjunction with the **$PASHS,FZN** command which is used to select the zone to be fixed by the FUM command.

Example

Enter the following command to enable the fixed zone setting:

$PASHS,FUM,Y

DEFAULT SETTING
FUM—N

FZN: Select Fixed UTM Zone

$PASHS,FZN,d1

This command selects the UTM zone that will be held fixed, where d_1 is the UTM zone number ranging from 1 to 60. This command is typically used when the user is near a UTM boundary and wants to avoid the coordinate shift that occurs when crossing from one UTM zone into another. This command is used in conjunction with the command **$PASHS,FUM**, which holds fixed the zone selected by the FZN command.

Example

Enter the following command to select UTM zone 10 as the zone to be held fixed:

$PASHS,FZN,10

GDC: 3-D Position in User-defined Grid Coordinates

$PASHQ,GDC,[c1]

This command queries the current position according to the user-defined grid coordinate system selected through the UDG command, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. The response message does not output unless the following three conditions are met:

1. The receiver is computing positions.
2. A grid coordinate system has been selected through the UDG command.
3. The conversion from geodetic coordinates to the selected grid coordinate system has been enabled through the GRD command.

$PASHR,GDC

The response message is output in the format:

$PASHR,GDC,m1,s2,f3,f4,d5,d6,f7,f8,f9,d10,s11,s12*hh

Table 5.20 outlines the parameters.

Table 5.20. GDC Message Structure

Parameter	Description	Range
m1	UTC of position in hours, minutes, and decimal seconds (hhmmss.ss)	000000.00 to 235959.90
s2	Map projection type	EMER, TM83, OM83, LC83, STER, LC27, Tm27, TA22
f3	Easting (x) of the user grid coordinate (meters)	-9999999.999 to +9999999.999
f4	Northing (y) of the user grid coordinate (meters)	-9999999.999 to +9999999.999
d5	Positioning mode Indicator • 1: Autonomous position • 2: RTCM differential, or CPD float position • 3: Carrier Phase differential (CPD) fixed	1, 2, 3
d6	Number of GPS satellites being used	3 to 12
f7	Horizontal Dilution of Position (HDOP)	00.0 to 99.9
f8	Altitude (meters)	-9999999.999 to +9999999.999
M	Altitude units	M(eters)

Table 5.20. GDC Message Structure (Continued)

Parameter	Description	Range
f9	Geoidal separation in meters w.r.t. selected datum and Geoid Model	-999.999 to +999.999
d10	Age of differential corrections	0 to 999
s11	Differential reference station ID	0000 to 1023
s12	Datum type	W84, USR
*hh	Checksum	2-character hex

Typical GDC response message:

$PASHR,GDC,015151.00,EMER,588757.623,+4136720.056,2,04,03.8,00012.123,M, -031.711,M,14,1010,W84*2A

Table 5.21 outlines the response message.

Table 5.21. Typical GDC Response Message

Item	Significance
015151.00	UTM time
EMER	Equatorial Mercator map projection
588757.623	User Grid easting coordinate (x)
4136720.056	User Grid northing coordinate (y)
2	RTCM differential position
04	Number of satellites used to compute position
03.8	HDOP
00012.123	Altitude of position
M	Altitude units (M=meters)
-031.711	Geoidal separation w.r.t. selected datum
M	geoidal separation units (M = meters)
014	age of corrections
1010	Differential Station ID
W84	Datum is WGS-84
2A	Checksum

GRD: Datum to Grid Transformation (Map Projection)

$PASHS,GRD,s1

This command enables or disables the usage of the user-defined datum to grid transformation to position outputs, where s1 is either NON (transformation disabled) or UDG (enable user-defined datum to grid transformation). The GRD command is used in conjunction with the **$PASHS,UDG** command, which is used to select the desired datum to grid transformation parameters.

Example

Enter the following command to enable the user-defined datum to grid transformation:

$PASHS,GRD,UDG

HDP: HDOP Mask Value

$PASHS,HDP,d1

This command sets the value of the HDOP mask, where d1 is a number between 0 and 99.9. If the HDOP value computed by the DG14 is higher than the HDOP mask value, the receiver will automatically go into fixed altitude mode. You can view the current HDOP mask value by entering the query command $PASHQ,PAR and checking the HDP field.

Example

Enter the following command to set an HDOP mask value of 6:

$PASHS,HDP,6

DEFAULT SETTING
HDP—4

HGT: Height Model Selection

$PASHS,HGT,s

This command sets the height model used in the position output, where is a 3 character string defined in Table 5.22:

Table 5.22. $PASHS,HGT Parameter

Height Selection (s)	Altitude Output in GDC	Geoidal Separation in GDC	GGA Altitude
ELG	Ellipsoidal	Geoidal table	Geoidal
ELU	Ellipsoidal	User-defined local geoid	Geoidal
GEO	Geoidal	Geoidal table	Geoidal
UDH	Geoidal	User-defined local geoid	Geoidal

- ELG: (default) ellipsoidal height output, with worldwide geoidal model used for geoidal separation field. (mean-sea-level)
- GEO: geoidal orthometric height output using worldwide geoidal model, also used for geoidal separation field.

This does not affect the position output in the B-file or in the PBN message which are ECEF and always with respect to WGS-84.

To remain NMEA standard, the GGA message always outputs the elevation for the geoidal elevation for both ELG and GEO, and the local orthometric elevation for both ELU and UDH and not the ellipsoidal elevation.

Example

Enter the following command to set geoidal height in the position output.

$PASHS,HGT,GEO

$PASHQ,HGT,c

This command queries the height model selection where c is the optional output port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

Example

Enter the following command to query the height model to port C.

$PASHQ,HGT,C

$PASHR,HGT

The response message is in the form:

> **$PASHR,HGT,s*cc<CR><LF>**

where s is the 3 character string that denotes the current height setting (ELG, ELU, UDH, or GEO).

HLP: Help

$PASHQ,HLP,[str1],[str2],[str3]

This command returns a list of available commands and messages with a brief description in ASCII format. User-defined messages are not included in this list. The commands and messages returned vary on the parameter entered with the command. Table 5.23 outlines the parameters for the command.

Table 5.23. $PASHQ,HLP Command Parameters

Parameter	Results
No parameter	The $PASHQ,HLP commands returns a list of all commands and messages for the receiver.
Single group parameter • PASHS • PASHQ • NME • RAW • SBA • BCN	The $PASHQ,HLP commands returns a list of all commands or messages for the group specified.
Single command string	The $PASHQ,HLP commands returns the commands matching the 3-letter identifier and a description of each command or message.
Multiple Parameters	The $PASHQ,HLP commands returns a list of all commands matching the group and 3-letter identifier, and a description of each command or message.

Examples

Enter the following command to list all NMEA response messages for the receiver.

> **$PASHQ,HLP,NME**

```
NME Periodic responses:
LTN POS GLL GXP GGA VTG GSN MSG GSA GSV SAT GRS RRE TTT ZDA TCM RMC GST
GNS CRT GDC UTM PTT UKO SUD DTM ALM
Format: '$GP...,message'; '$PASHR,...,message';
To turn ON/OFF - '$PASHS,NME,...,port,ON/OFF,[period]';
For more detail help - '$PASHQ,HLP,NME,...';
```

Enter the following command to list the POS commands and messages for the receiver.

$PASHQ,HLP,POS

```
$PASHS,POS,... set command:
Sets the altitude of the antenna.


$PASHR,POS,... message:
Most recently computed position
To turn ON/OFF - '$PASHS,NME,POS,port,ON/OFF,[period]';
```

Enter the following command to list the POS commands in the PASHQ group for the receiver.

$PASHQ,HLP,PASHQ,POS

```
Request for $PASHR,POS,... message:
Most recently computed position
```

Enter the following command to list all commands and messages for the receiver.

$PASHQ,HLP

SET Commands:
987 AJM ALT ANH ANT BCN BRO CHN CLK CMT CPS CRR CSI CSS CTS DAP DLY DSI
DSY DTG DTM DYN ELM ENC EPG ERM FIX FPS FUM FZN GGA GPS GRD GTF GTM GTP
HDP HGT IDT INI ION KCH KFP KPI LAT LGS LON LPS LTZ MSV NME OOP PDP PEM
PFL PHE PMD POP POS POW PPO PPS PWR RAW RCI RST RTC SAV SBA SCM SEM
SES
SIT SMI SMT SMV SNM SPD SUI SVD SVP SVS SYS TDP TRO TSC TST UCT UD4 UDD
UDG UDH UDM UG4 USD USE USP UTS VDP ZDA
Format: '$PASHS,...,parameters';
For more detail help - '$PASHQ,HLP,PASHS,...';

QUERY Commands:
AJM ANH ANT BCN BIT CHS CLK CRR CTS DAP DLY DUG DYN ELM ERM HGT HLP ION
KCH KFP LPS LOD MSV NMO OOP PAR PHE POW PPO PPR PPS PRT RAW RID RIO RTC
RTL RWO SBA SES SFO SMI SMV SPR STA SVD SVP SVS TDP TPA TPD TPF TPP TRO
TSC UCT UDD UDH UTS VIS WHN
LTN POS GLL GXP GGA VTG GSN MSG GSA GSV SAT GRS RRE TTT ZDA TCM RMC GST
GNS CRT GDC UTM PTT UKO SUD DTM ALM MCA MBN PBN MIS XYZ DIF MSB GGB
MCM
CMB CT1 CT2 CT3 SNV SAL SNW SAW STA INF DAT ALM
Format: '$PASHQ,...';

For more detail help - '$PASHQ,HLP,PASHQ,...';

NME Periodic responses:
LTN POS GLL GXP GGA VTG GSN MSG GSA GSV SAT GRS RRE TTT ZDA TCM RMC GST
GNS CRT GDC UTM PTT UKO SUD DTM ALM
Format: '$GP...,message'; '$PASHR,...,message';
To turn ON/OFF - '$PASHS,NME,...,port,ON/OFF,[period]';
For more detail help - '$PASHQ,HLP,NME,...';

RAW Periodic responses:
MCA MBN PBN MIS XYZ DIF MSB GGB MCM CMB CT1 CT2 CT3 SNV SAL SNW SAW
Format: '$PASHR,...,message';
To turn ON/OFF - '$PASHS,RAW,...,port,ON/OFF,[period]';
For more detail help - '$PASHQ,HLP,RAW,...';

SBA Periodic responses:
INF DAT
Format: '($PASHR,SBA,...,message';
To turn ON/OFF - '$PASHS,SBA,...,port,ON/OFF,[period]';
For more detail help - '$PASHQ,HLP,SBA,...';

BCN Periodic responses:
STA ALM
Format: '$PASHR,BCN,...,message';
To turn ON/OFF - '$PASHS,BCN,...,port,ON/OFF,[period]';
For more detail help - '$PASHQ,HLP,BCN,...';

HST: Start-up Diagnostic Results

$PASHQ,HST,[d1],[c1]

This command queries for the results of start-up diagnostics, where d1 is the test number from 1 to 20 and where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. If you do not specify d1, this command returns information on the most recently run diagnostic test.

$PASHR,HST

The response message is output in the format:

$PASHR,HST,d1,d2,d3,d4,d5,m1,h1*cc

Table 5.24 outlines the response message parameters.

Table 5.24. $PASHQ,HST Response Parameters

Parameter	Description	Range
d1	The total number od failures in the history. If this value is zero, then the rest of the message is omitted.	0 to 20
d2	The sequential index number of this failure in history.	1 to 20
d3	The day of the failure	01 to 31
d4	The month of the failure	01 to 12
d5	The year of the failure	0000 to 9999
m1	UTC time of failure (hhmmss.ss)	000000.00 to 235959.00
h1	The results of the built-in self-test • Bit 0: 1—All tests conducted; 0—One or more test not conducted • Bit 1: 1—All tests passed; 0—One or more tests failed • Bit 2: 1—WDI test conducted; 0—WDI test not conducted • Bit 3: 1—WDI test passed; 0—WDI test failed • Bit 4: 1—RTC test conducted; 0—RTC test not conducted • Bit 5: 1—RTC test passed; 0—RTC test failed • Bit 6: 1—DuratA test conducted; 0—DuratA test not conducted • Bit 7: 1—DuratA test passed; 0—DuratA test failed • Bit 8: 1—DuratB test conducted; 0—DuratB test not conducted • Bit 9: 1—DuratB test passed; 0—DuratB test failed • Bit 10: 1—ASIC test conducted; 0—ASIC test not conducted • Bit 11: 1—ASIC test passed; 0—ASIC test failed • Bit 12: 1—SDRAM test conducted; 0—SDRAM test not conducted • Bit 13: 1—SDRAM test passed; 0—SDRAM test failed • Bit 14: 1—BBU test conducted; 0—BBU test not conducted • Bit 15: 1—BBU test passed; 0—BBU test failed • Bit 16: 1—FLASH test conducted; 0—FLASH test not conducted • Bit 17: 1—FLASH test passed; 0—FLASH test failed • Bit 18: 1—TMS test conducted; 0—TMS test not conducted • Bit 19: 1—TMS test passed; 0—TMS test failed	0 to FFFFF
*cc	Checksum	00-FF

Typical Response Messages

$PASHR,HST,0*35

The above response message indicates that no tests failed.

$PASHR,HST,2,2,25,05,2000,172345.00,23003*35

The above response message indicates the following:

- Two tests failed in the second index
- The failed tests occurred on the 25th day of the 5th month of year 2000, at UTC time of 17:23:45.00.
- The test results: 23003 indicate that
    - All tests were conducted
    - All tests passed
    - SDRAM test was conducted and passed
    - FLASH test was conducted and passed

INI: Initialize the Receiver

$PASHS,INI,d1,d2,d3,d4

This command clears receiver memory and reset serial port baud rates, where d1, d2, and d3 are baud rate setting codes for ports A, B, and C, and d4 is the memory reset code. Table 5.25 and Table 5.26 list the code numbers and the settings associated with them.

Table 5.25. Serial Port Baud Rate Codes

Code	Baud Rate	Code	Baud Rate
0	300	5	9600
1	600	6	19200
2	1200	7	38400
3	2400	8	56800
4	4800	9	115200

The maximum baud rate for Port C is 19,200. Baud rate codes 7, 8, and 9 are invalid for d3.

Table 5.26. Memory Reset Codes

Reset Memory Code	Action
0	No memory reset
1	Reset internal memory (user settings) (battery-backed RAM including ephemeris, almanac, time, date, last position, etc.)

Table 5.26. Memory Reset Codes (Continued)

Reset Memory Code	Action
2	External memory reset N/A
3	Reset internal and external memory

Example

Enter the following command to set Port A with a baud rate of 4800, Port B with a baud rate of 19200, and to reset internal memory:

$PASHS,INI,4,6,6,1

The INI command is not fully functional with the DG14. Since the DG14 does not contain a memory area for data storage, the reset memory code for external memory (2) has no effect on the receiver. Resetting internal memory (1), or resetting internal and external memory (3) have the same effect. The parameter settings for this command were maintained for the DG14 in order to preserve consistency with other Magellan receivers.

ION: Ionospheric and Tropospheric Modelling

$PASHS,ION,c1

This command enables or disables the use of ionospheric modelling, which is used to compensate for delays that occur as the GPS signals travel through the ionosphere, where c1 is either N (disable) or Y (enable). You can see whether ionospheric modelling is enabled or disabled by entering the **$PASHQ,PPR** command.

Example

Enter the following command to enable ionospheric modelling:

$PASHS,ION,Y

DEFAULT SETTING	
ION	Y

.

$PASHQ,ION,[c1]

This command queries the current ionospheric data generated by the GPS satellites, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

Ionospheric and tropospheric modelling are enabled when the receiver is functioning in stand-alone mode (autonomous mode), but are disabled if the receiver is set as an RTCM base or rover, since differential corrections already compensate for ionospheric and tropospheric delays.

$PASHR,ION

The response message is output in binary format:

$PASHR,ION,<Binary Data String + Checksum>

Table 5.27 describes the elements in the binary data string:

Table 5.27. $PASHR,ION Format

Type	Size	Contents
float	4	α_0 ionospheric parameter (seconds)
float	4	α_1 ionospheric parameter (sec. per semicircle)
float	4	α_2 ionospheric parameter (sec. per semicircle)
float	4	α_3 ionospheric parameter (sec. per semicircle)
float	4	β_0 ionospheric parameter (seconds)
float	4	β_1 ionospheric parameter (sec. per semicircle)
float	4	β_2 ionospheric parameter (sec. per semicircle)
float	4	β_3 ionospheric parameter (sec. per semicircle)
double	8	A_0 Constant term of GPS/UTC polynomial
double	8	A_1 Constant term of GPS/UTC polynomial
unsigned long	4	t_{ot} Reference time
short	2	W_{nt} reference week
short	2	Δt_{LS} Delta UTC-GPS time at reference time
short	2	WN_{LSF} Week of leap second correction
short	2	DN day of leap second correction
short	2	Δt_{LSF} Delta time between GPS and UTC
short	2	WN Current GPS week number

Table 5.27. $PASHR,ION Format (Continued)

Type	Size	Contents
unsigned long	4	tow Current time of week
short	2	bulwn Current GPS week number when message was read
unsigned long	4	bultow Time of week when message was read
short	2	Checksum (word)
Total characters = 76 bytes		

The DG14 does not calculate ionospheric parameters on its own. The ionospheric data, listed in Table 5.27, are obtained from subframe 4 of the GPS navigation message.

KFP: Kalman Filter

$PASHS,KFP,s1

This command enables the Kalman filter where s1 is ON or OFF. If you issue this command again, it will reset the Kalman filter.

The Kalman filter supports a known point initialization.

Example

Enter the following command to enable the Kalman filter.

$PASHS,KFP,ON

DEFAULT SETTING
KFP—OFF

$PASHQ,KFP,[c1]

This command queries the Kalman filter parameter setting (ON or OFF) where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

The response is in the readable format below:

KFP SETUP:
MODE:OFF PRI:010.0 FDE:99.0 PAR:001.00,001.00
VFL:OFF,0.050,0001.0,0003.0

where Table 5.28 outlines the response parameters:

Table 5.28. KFP Message Structure

Parameter	Description	Range
KFP SETUP		
MODE	The currently set Kalman Filter mode.	ON, OFF
PRI	The current setting for the prediction interval.	0 to 100
FDE	The fault detection value for the Kalman filter.	95, 99, or 99.9
PAR	Reserved for internal use.	

Remaining fields undocumented and for internal use.

KFP,FDE: Kalman Filter Fault Detection and Elimination

$PASHS,KFP,FDE,x1

This command sets the fault detection and elimination parameters for the Kalman filter where x is percent reliability of outliers and cycle slip detection in the Kalman filter at 95, 99, or 99.9.

Example

Enter the following command to set the reliability to 99 percent:

$PASHS,FKP,FDE,99

DEFAULT SETTINGS
KFP,FDE—99

KFP,PRI: Kalman Filter Prediction Interval

$PASHS,KFP,PRI,f1

This command sets the Kalman filter maximum prediction interval where f1 is the prediction interval from 0 to 100 seconds. The Kalman filter stops outputting the predicted position if the prediction interval is longer than f1 or if the position error mask (ERM) is exceeded. If f1 is set to zero, the prediction mode is disabled/

The predicted position is flagged in the $PASHR,POS message as 8.

Example

Enter the 4following command to set the Kalman filter maximum prediction interval to 45.

$PASHS,KFP,PRI,45

DEFAULT SETTING
KFP,PRI—10 seconds

KPI: Known Point Initialization

$PASHS,KPI,m1,c1,m2,c2,m3,s1,s2,s3

This command sets the known coordinates for an antenna phase center where Table 5.29 outlines the parameters:

Table 5.29. $PASHS,KPI Parameters

Parameter	Description	Format and Range
m1	WGS84 Latitude in degrees and decimal minutes	ddmm.mmmmmmm 0 to 8959.9999999
c1	Direction of latitude	N=North, S=South
m2	WGS84 Longitude in degrees and decimal minutes	dddmm.mmmmmmm 0 to 17959.9999999
c2	Direction of longitude	E=East, W=West
m3	WGS84 ellipsoidal height in meters	mmmm.mmm -9999.999 to +9999.999
s1, s2, s3	A Priori expected sigmas of entered coordinates (meters)	

The receiver will not acknowledge the command if the entered and computed position differ by more than 500 meters.

Empty m fields are interpreted as having no a priori information for the direction (to cover 3D, 2D and 1D initializations).

Empty s fields are interpreted as taking value 0.01 > m.

If you set an s field to 100 m the receiver interprets this as having no a priori information for this direction.

This command is applied only to Kalman filtered positioning (KFP > ON). If the receiver is set to LMS positioning (KFP OFF), the KPI command has no effect. After you have issued this command, the Kalman filter resets and is initialized with

specified coordinates and sigmas. The Kalman filter uses the KPI settings only once for initialization, so you can safely to move in a few seconds after issuing this command.

LGS: Grid to Grid Transformation

$PASHS,LGS,s1

This command selects the UG4 grid to grid transformation (UG4) or no grid to grid transformation (NON) where s1 is UG4 or NON.

Example

Enter the following command to set the grid to grid transformation to UG4.

$PASHS,LGS,UG4

DEFAULT SETTING
LGS—NON

LPS: Third-Order Loop Tracking Parameters

$PASHS,LPS,d1,d2,d3

This command sets third-order loop tracking parameters to optimize loop tracking performance for a specific application, where d1 is the ratio of the carrier loop, d2 is the carrier loop parameter, and d3 is the code loop parameter. The carrier and code loop parameters are set independently. The DG14 uses default loop tracking values until new parameters are set through this command. Loop tracking parameters set through this command are saved in battery-backed memory and used until new settings are selected, battery-backed memory is cleared, or the RST command is issued to the receiver.

The loop tracking parameters are applied to all GPS channels and both SBAS channels.

Thales recommends that you use the $PASHS,DYN command (see 83) instead of $PASHS,LPS. $PASHS,LPS is described in this manual for backward compatibility only.

Example

Set loop tracking parameters for a low-dynamic application:

$PASHS,LPS,1,2,2

$PASHQ,LPS,[c1]

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

$PASHR,LPS

The response message outputs in the format:

$PASHR,LPS,d1,d2,d3*hh

Table 5.30 defines the LPS parameters.

Table 5.30. $PASHR,LPS Format

Parameter	Description	Range
d1	Third-order ratio setting for the carrier loop: • 0: Indicates a ratio of zero; i.e., the third-order ratio is disabled • 1: Indicates a ratio of 0.1; suitable for low acceleration rates • 10: Indicates a ratio of 1.0; suitable for high acceleration rates	0, 1, 10
d2	Carrier loop parameter: • 1: This setting indicates a noise bandwidth of 0=10; suitable for static, very low phase noise conditions • 2: This setting indicates a noise bandwidth of 0=25; suitable for low dynamic, low phase noise conditions (< 2g when d1=1; < 20g when d1=10) • 3: This setting indicates a noise bandwidth of 0=50; suitable for high dynamic, medium phase noise conditions (< 6g when d1=1; < 100g when d1=10)	1, 2, 3
d3	Code loop parameter: • 1: Indicates noise bandwidth of 0=1.0; suitable for fast range availability (5 sec.), medium range noise conditions • 2: Indicates noise bandwidth of 0=0.5; suitable for medium range availability (10 sec.), low range noise conditions • 3: Indicates noise bandwidth of 0=0.1; suitable for slow range availability (50 sec.), very low range noise conditions	1, 2, 3

Typical LPS response message:

$PASHS,LPS,10,3,1,*14

Table 5.31 outlines the response message.

Table 5.31. Typical LPS Response Message

Item	Description
$PASHR	Header
LPS	Message identifier
10	Third-order ratio setting for carrier loop (high acceleration rate)
3	Carrier loop parameter setting (high dynamics, medium phase noise)
1	Code loop parameter setting (fast range availability, medium range noise)
14	Checksum

DEFAULT SETTING
LPS—10, 3, 1

LTZ: Local Time Zone

$PASHS,LTZ,d1,d2

This command sets an offset value from Greenwich Mean Time (GMT) in order to derive local time, where d1 is the number of hours and d2 is the number of minutes that should be added to or subtracted from GMT to get local time. The range for d1 is -13 to +13; the range for d2 is 0 to 59. Issue the command **$PASHQ,ZDA** to get current local time offset values, which are displayed in the last two fields before the checksum. See the section in this chapter entitled "NMEA Commands/Responses" for more information on the ZDA message.

Examples

Add an offset of +7 hours to GMT:

$PASHS,LTZ,+7,0

Add an offset of -4 hours, 25 minutes:

$PASHS,LTZ,-4,25

OOP: Output Messages Order

$PASHS,OOP,s1,s2,s3...

This command sets the order of the output messages where s1, s2, and s3 are the messages. You can set the order for any number of messages.

Example

Set message order to GGA, PBN, SAT.

   $PASHS,OOP,GGA,PBN,SAT

$PASHQ,OOP,c1

This command lists all the ASCII and binary messages in the order the receiver outputs them.

$PASHR,OOP

The response is in the format:

   $PASHR,OOP,s1,s2,s3...

where s1, s2, s3, ... are the message formats in the order the receiver outputs them.

PAR: Query General Receiver Parameters

$PASHQ,PAR,[c1]

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

The response message has a free-form Ashtech format. This message does not have a header or message identifier as shown in the following example:

```
SPDA:5 SPDB:5 SPDC:5
GPS:YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
SBAS:YYYYYYYYYYYYYYYYY
SYS:GPS DTM:W84 TDP:04
PMD:1 FIX:0 ALT:+00000.00 PDP:40 HDP:04 VDP:04 ERM:600,1200,300,600
PEM:05 SEM:OFF UNH:N ION:Y TRO:Y SAV:N RAIM:OFF ANTENNA:DETECTED
RTC:OFF PRT:A
SBA:SAM
NMEA: LTN POS GLL GXP GGA VTG GSN MSG GSA GSV SAT GRS RRE TTT ZDA TCM
```

```
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
NMEA: RMC GST GNS CRT GDC UTM PTT UKO SUD DTM XMG AIM HPL ALM
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PER:001.00
```

Table 5.32 describes the items in the PAR response message:

Table 5.32. PAR Response Format

Item	Description	Range
SPDA:5	Serial port A baud rate. Default is 5 (9600).	0 to 9
SPDB:5	Serial port B baud rate. Default is 5 (9600).	0 to 9
SPDC:5	Serial port C baud rate. Default is 5 (9600).	0 to 9
GPS:Y...Y	Indicates which GPS satellites (1-32) will be used (Y) or ignored (N) in position computations. Default is Y for all satellites.	Y, N
SBAS:N...N	Indicates which SBAS satellites (120 to 137) will be used (Y) or ignored (N) in position computations. Default is Y for all satellites.	Y, N
SYS	Indicates the satellite system used by the receiver.	GPS
DTM	Indicates whether the current geodetic reference datum is WGS-84 (W84) or a user-defined datum (USR). Default is W84.	W84, USR
TDP	Current TDOP (Time Dilution Of Precision) mask setting. The receiver stops computing positions when the calculated TDOP value exceeds the TDOP mask value. The default setting is 04.	00.0 to 99.9
PMD:1	Current position mode setting for the minimum number of satellites required to compute a position. With default value 1, a minimum of 3 satellites are needed to compute a position. With 3 satellites, the altitude is fixed (2-D); with 4 or more, the altitude is computed (3-D).	0 to 3
FIX	Current fixed altitude mode setting used when computing a 2-D position or when there are not enough visible satellites to compute a 3-D position. Mode 0 (default) Indicates that the altitude value is either the most recently entered antenna altitude ($PASHS,ALT) or the most recently computed altitude in which the VDOP value is lower than the VDOP mask.	0, 1
ALT	Current altitude of the antenna position (meters). Default is 00000.00 meters.	-99999.99 to +99999.99

Table 5.32. PAR Response Format (Continued)

Item	Description	Range
PDP	Current PDOP (Position Dilution Of Precision) mask setting. The receiver stops computing positions when the calculated PDOP value exceeds the PDOP mask value. The default setting is 40.	00.0 to 99.9
HDP	Current HDOP (Horizontal Dilution Of Precision) mask setting. The receiver stops computing positions when the calculated HDOP value exceeds the HDOP mask value. Default is 04.	00.0 to 99.9
VDP	Current VDOP (Vertical Dilution Of Precision) mask setting. The receiver stops computing positions when the calculated VDOP value exceeds the VDOP mask value. Default is 04.	00.0 to 99.9
ERM	This setting indicates the mask values for horizontal and vertical error in relation to the different positioning modes. The default is OFF for both autonomous and differential modes which is represented by 600,1200,300,600.	1 to 6000
PEM	Current position elevation mask setting (degrees). The receiver excludes any satellite from the position computation when its elevation falls below the elevation mask setting. Default is 05.	0° to 90°
SEM	This field indicates the secondary elevation mask angle value for a sector of the sky defined by two azimuth angles. The default is OFF.	ON, OFF
UNH	This setting indicates whether the receiver uses (Y) or ignores (N) unhealthy satellites. This setting is always N. The DG14 never uses unhealthy satellites in position computation.	N
ION	Indicates whether ionospheric modelling is enabled (Y) or disabled (N) in position computation. Default is always Y when the receiver is in differential mode and always Y in autonomous mode.	Y, N
TRO	Indicates whether tropospheric modelling is enabled (Y) or disabled (N) in position computation. The tropospheric setting is controlled by the ION setting. When ION is Y, then TRO is automatically set to Y	Y, N
SAV	Indicates whether user-entered parameters are saved (Y) or not saved (N) in battery-backed memory. If user-entered parameters are not saved, the default parameter settings are restored at the next power cycle. Default is N.	Y, N
RAIM	Status of RAIM. Default is OFF	ON or OFF
Antenna	Status of antenna. If current drain is below ~5 mA, then the status is OPEN. If current drain is above ~60 mA, then the status is SHORT. If current drain is between ~5mA and ~60 mA. then the status is DETECTED. If using a DC block, there is no current drain in the antenna from the receiver, so the status is OPEN.	Detected, Open or Short

Table 5.32. PAR Response Format (Continued)

Item	Description	Range
RTC	Current RTCM differential mode setting. OFF indicates RTCM is disabled; BAS indicates base station mode; REM indicates remote mode. Default is OFF.	OFF, BAS, REM
PRT	Port assignment for sending or receiving differential corrections.	A, B, C, Z PRT is "Z" when using Beacon or SBAS corrections.
SBAS	Indicates the SBAS modes	• SAM: Single Auto Mode • DAM: Dual Auto Mode • SMM: Single Manual Mode • DMM: Dual Manual Mode
NMEA	Lists the NMEA and Ashtech NMEA-style messages supported by the DG14.	LTN, POS, GLL, GXP, GGA, VTG, GSN, MSG, GSA, GSV, SAT, GRS, RRE, TTT, ZDA, TCM, RMC, GST, GNS, CRT, GDC, UTM, PTT, UKO, SUD, DTM, XMG, AIM, HPL, ALM
PRTA	Indicates whether a given NMEA or Ashtech NMEA-style message is enabled (ON) or disabled (OFF) for output from Port A. Default is OFF.	ON, OFF
PRTB	Indicates whether a given NMEA or Ashtech NMEA-style message is enabled (ON) or disabled (OFF) for output from Port B. Default is OFF.	ON, OFF
PRTC	Indicates whether a given NMEA or Ashtech NMEA-style message is enabled (ON) or disabled (OFF) for output from Port C. Default is OFF. Note: The "R" option is required.	ON, OFF
PER	Output interval setting for NMEA and Ashtech NMEA-style messages, excluding the TTT message. Default is 1 second.	0.05 to 999

PDP: PDOP Mask Value

$PASHS,PDP,d1

This command sets the value of the PDOP (Position Dilution of Precision) mask, where d1 is a number between 0 and 99. The receiver stops computing positions when the calculated PDOP value exceeds the PDOP mask value. You can view the current PDOP mask setting by entering the **$PASHQ,PAR** command and checking the PDP field.

Example

Set PDOP mask to 30:

$PASHS,PDP,30

DEFAULT SETTING
PDP—40

PEM: Position Elevation Mask Value

$PASHS,PEM,d1

This command sets the elevation mask for position computation, where d1 is 0 to 90 degrees. A GPS or SBAS satellite with an elevation less than the elevation mask setting is excluded from position computations. You can view the current elevation mask value by entering the query command $PASHQ,PAR and checking the PEM field.

Example

Set the elevation mask to 15 degrees:

$PASHS,PEM,15

DEFAULT SETTING
PEM—5°

PHE: Photogrammetry Edge Mode

$PASHS,PHE,c1

This command synchronizes the photogrammetry trigger to the rising edge or the falling edge of the timing pulse, where c1 is either R (rising edge) or F (falling edge). Default is R.

$PASHQ,PHE,[c1]

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

$PASHR,PHE

The response message is output in the format:

$PASHR,PHE,c1*hh

Table 5.33 defines the PHE parameters.

Table 5.33. $PASHR,PHE Format

Parameter	Description	Range
c1	Photogrammetry edge setting	R, F
hh	Checksum	2-character hex

Typical PHE response message:

$PASHR,PHE,R*57

Table 5.34 describes the typical PHE response message.

Table 5.34. Typical PHE Response Message

Item	Description
$PASHR	Header
PHE	Message identifier
R	Indicates that photogrammetry events are synchronized to rising edge of timing pulse
*57	Checksum

DEFAULT SETTING
PHE—R

PMD: Position Mode

$PASHS,PMD,d1

This command sets the position mode. The position mode determines the minimum number of satellites required to compute a position, whether the receiver switches automatically from 2-D to 3-D positioning or is manually locked in 2-D or 3-D positioning mode, and, in 2-D mode, whether the altitude used is the most recently

computed "good" altitude or a fixed altitude value set by the ALT command. Enter 0, 1, 2, or 3 for d1. You can view the current position mode by entering the query command **$PASHQ,PAR** and checking the PMD field. See the section in chapter 3 entitled "Position Modes" for more information on the position mode settings.

- **Position Mode 0: Manual 3-D Mode**

  Sets the receiver for 3-D position computation. The receiver must be tracking a minimum of four satellites in order to compute a position.

- **Position Mode 1: Automatic 3-D Mode**

  The receiver must track a minimum of three satellites to compute a position. With three satellites, latitude and longitude are computed and altitude is held to a fixed value (2-D positioning). With four satellites or more, altitude is computed (3-D positioning).

- **Position Mode 2: Manual 2-D Mode**

  The receiver must track a minimum of three satellites to compute a position. This mode locks the receiver to 2-D positioning, meaning latitude and longitude are computed and altitude is always held fixed regardless of the number of satellites tracked.

- **Position Mode 3: Automatic 3-D Mode**

  The receiver must track a minimum of three satellites to compute a position. With 3 satellites, longitude and latitude are computed and altitude is held fixed (2-D positioning). With 4 satellites, altitude is computed (3-D positioning) unless the calculated HDOP value is greater than HDOP mask setting.

Example

Select Position Mode 3:

  $PASHS,PMD,3

DEFAULT SETTING
PMD—1

POS: 3-D Antenna Position

$PASHS,POS,m1,c2,m3,c4,f5

This command sets a 3-D antenna reference position for a differential base station receiver. m1 is the latitude, c2 is the latitude (N or S) sector, m3 is the longitude, c4 is the longitude sector (E or W), and f5 is the altitude. Use the **$PASHQ,RTC** command to verify that the desired coordinates are in effect.

Table 5.35. $PASHS,POS Parameters

Parameter	Description	Range
m1	Latitude measured in degrees, minutes, and decimal minutes (ddmm.mmmmm)	0° to 90°
c2	Latitude sector	N or S
m3	Longitude measured in degrees, minutes, and decimal minutes (dddmm.mmmmm)	0° to 180°
c4	Longitude sector	E or W
f5	Altitude (±aaaaa.aa) ellipsoid height in meters. In 2-D positioning mode, this field contains the fixed altitude value	-3000.00 to +3000.00

$PASHQ,POS,[c1]

This command queries the receiver's current 3-D position, where c1 is the optional port designator for the output of the response message. If a port is not specified, the receiver sends the response to the current port.

$PASHR,POS

The response message is output in the format:

$PASHR,POS,d1,d2,m1,m2,c1,m3,c2,f1,f2,f3,f4,f5,f6,f7,f8,f9, s1*hh

Table 5.36 defines the POS parameters.

Table 5.36. $PASHR,POS Message Format

Parameter	Description	Range
d1	Indicates whether the position solution has been computed autonomously or with the aid of RTCM differential corrections: • 0: Autonomous position • 1: Corrected position	0, 1
d2	Indicates the number of satellites used in computing positions	0 to 12

Table 5.36. $PASHR,POS Message Format (Continued)

Parameter	Description	Range
m1	Current time (UTC)	00 to 235959.50
m2	Current latitude measured in degrees, minutes, and decimal minutes (ddmm.mmmmm)	0° to 90°
c1	Latitude sector	N or S
m3	Current longitude measured in degrees, minutes, and decimal minutes (dddmm.mmmmm)	0° to 180°
c2	Longitude sector	E or W
f1	Current altitude (±aaaaa.aa) ellipsoid height in meters. In 2-D positioning mode, this field contains the fixed altitude value	-3000.00 to +3000.00
f2	Site ID	????
f3	Course over the ground (ttt.tt); referenced to true north	0.00°-359.99°
f4	Speed over the ground (knots)	000.00 to 999.99
f5	Vertical velocity (meters per second)	-999.9 to +999.9
f6	Current computed PDOP value	0.00 to 99.9
f7	Current computed HDOP value	00.0 to 99.9
f8	Current computed VDOP value	0.00 to 99.9
f9	Current computed TDOP value (seconds)	0.00 to 99.9
s1	Firmware version code	4-character ASCII
hh	Checksum	2-character hex

POW: Battery Parameters

$PASHS,POW,d1,d2,f1

This command sets the parameters associated with the external battery. The query and response uses the entered parameters to compute the approximate amount of remaining battery time. Table 5.37 defines the parameters.

Table 5.37. $PASHS,POW Parameters

Parameter	Description	Range
d1	Battery Capacity in mAh	500 to 10000
d2	Battery capacity in percent (percent charged)	0 to 100
f1	Battery voltage	5.0 to 28.0

Example

Set battery capacity to 1000 mAh, capacity to 100%, and voltage to 12.0 VDC.

$PASHS,POW,1000,100,12.0

The data for the external battery is estimated based on user entered parameters and the power consumption of the DG14. Re-enter the battery parameters after clearing the DG14's internal memory, or connecting to a different battery. Using the DG14 to power external devices such as a radio can reduce the effectiveness of this command.

$PASHQ,POW,[c1]

The query command requests current available battery power data, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,POW,d1,d2,f3

The available battery power displayed in the response is computed from the battery parameters entered and the amount of time the receiver has been on:

$PASHR,POW,d1,d2,d3,f1*cc

where Table 5.38 defines the POW response format:

Table 5.38. POW Message Structure

Parameter	Description	Unit
d1	battery capacity (time)	minutes
d2	capacity remaining	minutes

Table 5.38. POW Message Structure (Continued)

Parameter	Description	Unit
d3	battery capacity (power)	mAh
f1	battery voltage	volts
*cc	checksum	n/a

PPO: Point Positioning

$PASHS,PPO,c

This command enables or disables the point positioning mode, where c is either Y (enable) or N (disable). Point positioning is an averaging algorithm that improves the stand alone accuracy of a static point after about 4 hours.

Example

Enable point positioning.

$PASHS,PPO,Y

$PASHQ,PPO

This command queries the point position mode.

$PASHR,PPO

The response is in the format:

$PASHR,PPO,c

where c is Y or N.

PPR: Position Parameters

$PASHQ,PPR

This command queries for the position computation parameters.

$PASHR,PPR

The response is in the format:

$PASHR,PPR,h1,h2,h3,h4,h5,h6,h7,h8,h9,h10

where the parameters are as defined in Table 5.39.

Table 5.39. $PASHR,PPR Response Format

Parameter	Description	Range
h1	Position Mode	0 to 3
h2	Altitude fix mode	0 to 1
h3	PDOP mask	0 to 99
h4	HDOP mask	0 to 99
h5	VDOP mask	0 to 99
h6	Position elevation mask	0 to 90
h7	Point position mode	N or Y
h8	Use unhealthy satellites for position computation	N or Y
h9	Use ionospheric model	N or Y
h10	Satellite System Used	GPS

PPS: Pulse Per Second

$PASHS,PPS,f1,f2,c1

The DG14 can generate a timing pulse with programmable period and offset. The timing pulse is a square-wave signal which is generated by default once every second (1PPS) with its rising edge synchronized to the GPS time and no offset from GPS time. The PPS command changes the period, offset (from GPS time), and synchronization edge of the pulse. The f1 parameter sets the period of the pulse in seconds with a range between 0.05 and 60.00. The minimum setting depends upon the receiver update rate, which is dependent upon the installed position update rate or raw data update options. The f2 parameter is the offset from GPS time in milliseconds, with 100 ns resolution (range between -999.9999 and +999.9999). The c3 parameter determines whether the GPS time is synchronized with the rising edge of the pulse (R) or the falling edge of the pulse (F).

$PASHQ,PPS,[c1]

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

$PASHR,PPS

The response message is output in the format:

$PASHR,PPS,f1,f2,c3*hh

Table 5.40 defines the PPS parameters.

Table 5.40. $PASHR,PPS Message Format

Parameter	Description	Range
f1	Timing pulse output interval (seconds). Timing pulse output is disabled when this parameter is set to zero	0 to 60.00
f2	Timing pulse offset value (milliseconds)	-999.9999 to +999.9999
c3	Synchronization parameter setting for GPS time	R(ising edge) F(alling edge)
*hh	Checksum	

DEFAULT SETTING		
PPS	**Period**	**1 second**
	Offset	**0.0000**
	Synchronization	**GPS time synchronized to the rising edge of the pulse**

See *Timing Pulse on page 47* for more information on the conditions surrounding timing pulse generation, accuracy, and precision.

PRT: Serial Port Baud Rate

$PASHQ,PRT,[c1]

This command queries the baud rate code of the DG14 serial port to which you are currently connected, where c1 is the optional serial port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. Issue the query command **$PASHQ,PAR** to see the baud rate codes for both serial ports.

$PASHR,PRT

The response is output in the format:

$PASHR,PRT,c1,d2*hh

Table 5.41 defines the PRT message parameters.

Table 5.41. $PASHR,PRT Message Format

Parameter	Description	Range
c1	Identifier for the serial port to which you are currently connected	A, B, C (optional)
d2	Baud rate code (see Table 5.42)	0 to 9
hh	Checksum	2-character hex

Table 5.42 lists baud rate codes and the corresponding baud rates:

Table 5.42. DG14 Baud Rate Codes

Code	Baud Rate	Code	Baud Rate
0	300	5	9600
1	600	6	19200
2	1200	7	38400
3	2400	8	56800
4	4800	9	115200

DEFAULT SETTING

PRT—Code 5 (9600 baud)

PWR: Receiver Power

$PASHS,PWR,OFF

This command turns the receiver power off. Any activity from the serial port turns on the receiver power.

RID: Receiver Identification Parameters (Format 1)

$PASHQ,RID,[c1]

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

> **When you contact customer support, the customer support agent will request the response to the $PASHQ,RID command for your receiver.**

$PASHR,RID

The response message contains a receiver type code, a firmware version number, and a list of installed options; it is output in the format:

$PASHR,RID,s1,s2,s3*hh

Table 5.43 defines the RID message parameters.

Table 5.43. $PASHR,RID Fields

Field	Description
s1	Receiver model identifier
s2	Firmware version number
s3	List of installed options
hh	Checksum

Twenty-two options are available for the DG14. Each option is represented by a letter or number in a definite order. The presence of a given option is indicated by the presence of the corresponding letter or number. A dash ("-") indicates that a given option is not installed. An underscore ("_") indicates a reserved option slot.

Table 5.44 lists the letters and numbers in conjunction with the options they represent.

Table 5.44. Available DG14 Options

Option	Description
[W = 20 Hz] [T = 10 Hz] [5 = 5 Hz] [2 = 2 Hz] [1 = 1 Hz]	Position/raw data update rate
[O]	Raw Data Output
[P]	Carrier Phase Tracking
[U]	RTCM Differential Remote Station
[B]	RTCM Differential Base Station
[I]	Integrated Differential Optimization (available only with RTCM Remote option)
[K]	RTCM Type 18/19 message generation (available only with RTCM Base option)
[L]	Timing Pulse Output (1PPS)- includes 1, 2, 5, and 10

Table 5.44. Available DG14 Options (Continued)

Option	Description
[E]	Photogrammetry Event Marker
[C]	Strobe Correlator
[N]	Beacon
[Y]	SBAS
[X]	User-defined messaging
[D]	Integrated Differential Optimization
[R]	Third serial port
[A]	Altitude limit removed (Export license required)
[V]	Speed limit removed (Export license required)
[M]	Multi-base differential
[I]	RAIM

Typical RID response message:

$PASHR,RID,DG,DC11,WOPUBKLE_C_NYXDR__MI*00

Table 5.45 describes the typical RID response message.

Table 5.45. $PASHR,RID Fields

Field	Description
$PASHR	Header
RID	Message identifier
DG	DG14 receiver model identifier
DC11	Firmware version number

Table 5.45. $PASHR,RID Fields (Continued)

Field	Description
WOPUBKLE_C_NYXDR__MI	Options available: [W] 20 Hz position/raw measurement update rate [O] Raw data output [P] Carrier phase [U] Differential remote station [I] Integrated Differential Optimization [B] Differential base station [K] RTCM Type 18/19 message generation [L] 1 Pulse Per Second [E] Photogrammetry [-] Reserved [C] Code Correlator [-] Option not available [N] Beacon [Y] SBAS [X] PASHX customized messages [D] Integrated Differential Optimization [R] Serial Port C [-] Option not installed [-] Option not installed [M] Multi-Base Differential [I] RAIM
*00	Checksum

RIO: Receiver Identification Parameters (Format 2)

$PASHQ,RIO,[c1]

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

When you contact customer support, the customer support agent will request the response to the $PASHQ,RIO command for your receiver.

$PASHR,RIO

The response message contains the receiver model name, a firmware version number, a list of installed options, and a receiver serial number. The response is output in the format:

$PASHR,RIO,s1,s2,s3,s4,f5*hh

Table 5.46 defines the RIO message parameters.

Table 5.46. RIO Structure

Field	Description
s1	Receiver model name (maximum 10 characters)
s2	Main processor firmware version number (maximum 10 characters)
s3	Channel firmware version number (maximum 10 characters). This field is empty for the DG14
s4	Option list (maximum 42 characters). ASCII characters represent options not available. For option definitions, see Table 5.44
s5	Receiver serial number (maximum 20 characters). Underscores represent blank fields
*hh	Checksum: XOR of all characters between the dollar sign ($) and the asterisk (*), but not including the dollar sign and asterisk

As with the RID query, the presence of a given option is indicated by the presence of the corresponding letter or number. A dash ("-") indicates that a given option is not installed. An underscore ("_") indicates a reserved option slot.

Typical RIO response message:

$PASHR,RIO,DG14,DC11,,WOPUBKLE_C_NYXDR__MI,71168612DG6200146010*05

Table 5.47 describes the typical RIO response message.

Table 5.47. $PASHR,RIO Fields

Field	Description
$PASHR	Header
RIO	Message identifier
DG14	Receiver model identifier
DC11	Firmware version number

Table 5.47. $PASHR,RIO Fields

Field	Description

WOPUBKLE_C_NYXDR__MI	Options available:
	    [W] 20 Hz position/raw measurement update rate
	    [O] Raw data output
	    [P] Carrier phase
	    [U] Differential remote station
	    [I] Integrated Differential Optimization
	    [B] Differential base station
	    [K] RTCM Type 18/19 message generation
	    [L] 1 Pulse Per Second
	    [E] Photogrammetry
	    [_] Reserved
	    [C] Code Correlator
	    [-] Option not available
	    [N] Beacon
	    [Y] SBAS
	    [X] PASHX customized messages
	    [D] Integrated Differential Optimization
	    [R] Serial Port C
	    [-] Option not installed
	    [-] Option not installed
	    [M] Multi-Base Differential
	    [I] RAIM

71168612DG6200146010	Receiver serial number
*5E	Checksum

See Table 5.44 for more information on available options for the DG14.

RST: Restore Default Parameters

$PASHS,RST

This command restores the DG14 parameters to their default values. After issuing the RST command, you can query PAR (general receiver parameters), RAW (raw data output parameters), and RTC (RTCM and differential GPS parameters) to obtain DG14 default settings. This command does not clear the receiver almanac.

SAV: Save Parameter Settings

$PASHS,SAV,c1

This command enables or disables saving of user-entered parameters in battery-backed memory, where c1 is Y (save) or N (don't save). If c1 is set to Y, user-entered parameters are saved until external memory is cleared through the INI

command or default settings are restored through the RST command. If c1 is set to N, default parameter settings will be restored at the next power cycle. You can see whether user-entered parameters have been saved by issuing the **$PASHQ,PAR** command and checking the SAV field.

User-enter parameters cannot be saved unless a back-up battery is wired to appropriate pins on the J301 connector. Without a back-up battery, user-entered parameters will be lost after each power cycle even if the SAV parameter is set to Y.

The DG14 has a "watchdog" timer. If the processor hangs up for any reason, the watchdog timer will reset the receiver. On reset, the receiver parameters most recently saved using the set command $PASHS,SAV will be used at startup following the reset. If parameter settings were not saved, the default settings will be used at startup.

SCM: Smoothing Counter Mask

$PASHS,SCM,d1

This command sets the smoothing counter mask where d1 ranges from 0 to 100 seconds. If the smoothing counter mask is set to 30 seconds, and the DG14 acquires a new satellite, then the data from the new satellite is only used in positioning after 30 seconds.

DEFAULT SETTING
SCM— 0

SEM: Secondary Elevation Mask

$PASHS,SEM,d1,d2,d3

This command sets a secondary elevation mask angle value for a sector of the sky defined by two azimuth angles. The second sector is the region between the first and second azimuths measured clockwise from North. d1 is the secondary elevation mask angle. d2 is the first azimuth defining the second sector. d3 is the second azimuth defining the secondary sector.

When you send the SEM command, it overrides any previously existing values. PEM commands issued after the SEM command change the elevation mask for only the primary PEM zone. The previously issued SEM setting continues in effect. To apply PEM to the whole sky, you must disable the SEM.

DEFAULT SETTING
SEM— OFF

Example

Set mask zone in Figure 5.1.

$PASHS,PEM 10
$PASHS,SEM,20,300,60
—OR—
$PASHS,PEM 20
$PASHS,SEM,10,60,300
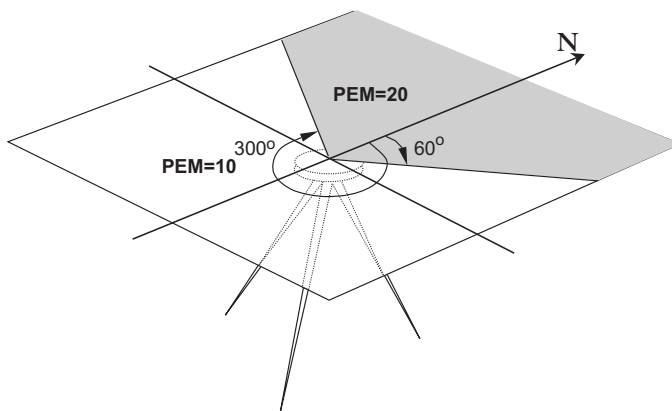
Figure 5.1. SEM Mask Zone

$PASHS,SEM,OFF

This command disables the SEM command.

SEM only applies to PEM or the elevation mask angle used in position computation. ELM functionality remains unchanged without zoning.

SES,PAR: Session Programming Parameters

$PASHS,SES,PAR,c1,d1,d2

This command sets session programming parameters, where c1 sets the session mode and d2 and d3 set the reference day and daily offset. The reference day must be equal to or less than the current day for session programming to operate. Use the **$PASHS,SES,SET** command to program individual sessions.

Table 5.48. SES,PAR Message Structure

Setting Parameter	Description	Range
c1	Session in use Y = Yes N = No S = Sleep Mode	Y or N or S
d2	Session reference day	0 to 366
d3	Session offset (mm:ss)	0 to 59

Example

Enable session programming parameters with 4 minute daily offset to keep track of the daily change of the GPS satellite configuration.

> **$PASHS,SES,PAR,Y,121,0400**

SES,SET: Individual Session Programing

$PASHS,SES,SET,c1,c2,d3,d4,f5,d6,d7,d8

This command sets the individual sessions for session programming. This command sets a single session. Up to 10 sessions may be programmed. You must use this command with the **$PASHS,SES,PAR** command.

Table 5.49. SES,SET Message Structure

Setting Parameter	Description	Range
c1	Session name	A to J
c2	Session flag	Y = Yes N = No
d3	Session start time (hhmmss)	hh = 0-23 mm = ss = 0-59

Table 5.49. SES,SET Message Structure

Setting Parameter	Description	Range
d4	Session end time (hhmmss)	hh = 0-23 mm = ss = 0-59
f5	Session record interval	0.1 to 999
d6	Session Elevation Mask	0 to 90
d7	Session min satellite	1 to 9
d8	Session data type	0, 2, or 4

Example

Set a session starting at 0100 that will run for 2 hours.

$PASHS,SES,SET,A,Y,010000,030000,10.0,10,3,0

If sleep mode is enabled, the receiver automatically powers on 2 minutes prior to session time to ensure all available satellites are tracked by the time recording starts.

$PASHQ,SES,[c1]

This command queries session programming parameters, where c1 is the optional output serial port.

Example

Query session programming parameters.

$PASHQ,SES

The response is in the format:

```
                START     END    INT     MASK    MIN    TYPE
    A N     00:00:00 00:00:00 020.0     10      3       0
    B N     00:00:00 00:00:00 020.0     10      3       0
    C N     00:00:00 00:00:00 020.0     10      3       0
    D N     00:00:00 00:00:00 020.0     10      3       0
    E N     00:00:00 00:00:00 020.0     10      3       0
    F N     00:00:00 00:00:00 020.0     10      3       0
    G N     00:00:00 00:00:00 020.0     10      3       0
    H N     00:00:00 00:00:00 020.0     10      3       0
    I N     00:00:00 00:00:00 020.0     10      3       0
    J N     00:00:00 00:00:00 020.0     10      3       0
    INUSE:N     REF:000 OFFSET:00:00    TODAY:000
```

Table 5.50 lists the parameters in alphabetic order:

Table 5.50. SES Message Structure

Return Parameter	Description	Range
1st Column	Session Name	A to J
2nd Column	Session enabled flag	Y or N
3rd Column	Session start time (hours, minutes, seconds)	hh:mm:ss
4th Column	Session end time (hours, minutes, seconds)	hh:mm:ss
5th Column	Session recording interval (seconds)	0 to 1-999
6th Column	Session elevation mask	0 to 90
7th Column	Session minimum satellites	1 to 9
8th Column	Session data type	0, 2, or 4
INUSE	Session use	Y, N, or S
REF	Session reference day	0 to 366
OFFSET	Session time offset (minutes, seconds)	mm:ss
TODAY	Date of the year	0 to 366

SMI: Code Measurement Smoothing

$PASHS,SMI,d1,d2

Set the interval in seconds of code measurements smoothing, which reduces the effect of noise, where d is the smoothing interval in seconds ranging from 0 to 1200, and d2 is the order of smoothing, 1 or 2.If d2 is omitted, then the DG14 assumes first order of smoothing. This smoothing setting is independent of the internal receiver update interval.

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

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

Example

Set code measurement smoothing to 100 seconds.

$PASHS,SMI,100

DEFAULT SETTING		
SMI	Smoothing Interval	100 second
	Order of Smoothing	1

$PASHQ,SMI,[c1]

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

$PASHR,SMI

The response message is in the form:

$PASHR,SMI,d1,d2*cc

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

SMV: Speed Filtering

$PASHS,SMV,d

This command sets the interval of speed filtering for the receiver velocity, which reduces the noise effects on speed, where d is the interval ranging from 0 to 99 seconds. A filter interval of 0 seconds indicates no filtering.

$PASHQ,SMV,[c1]

This command queries the interval of speed filtering for the receiver velocity; c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SMV

The response is in the format:

$PASHR,SMV,d1

where d1 is the interval which ranges from 0 to 99.

SNM: Signal-to-Noise Mask

$PASHS,SNM,d

This command sets the signal-to-noise mask for all satellites used in positioning where d is the SNM mask value from 0 to 50. If the d is set to 35, then satellites with a signal to noise ratio less than 35 dB are not used in the position solution.

DEFAULT SETTING
SNM— 0

SPD: Serial Port Baud Rate

$PASHS,SPD,c1,d1

This command sets the baud rate for the DG14's serial ports, where c1 is port A, B, or C (optional port) and d1 is a code number between 0 and 9 corresponding to the baud rates listed in Table 5.51. The default baud rate is 9600. You can view the baud rate settings for ports A, B, and C by entering the **$PASHQ,PAR** command and checking the SPDA, SPDB, and SPDC fields.

Table 5.51. DG14 Baud Rate Codes

Code	Baud Rate	Code	Baud Rate
0	300	5	9600
1	600	6	19200
2	1200	7	38400
3	2400	8	56800
4	4800	9	115200

Example

Set baud rate of port A to 19200:

$PASHS,SPD,A,6

Set baud rate of port B to 4800:

$PASHS,SPD,B,4

If you change the baud rate of the DG14's serial port, be sure that the serial port of the device to which the DG14 port is connected is set to the same baud rate.

STA: Satellite Tracking Status

$PASHQ,STA,[c1]

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

The response message has a free-form Ashtech format. Like the MEM and PAR response messages, the STA response message does not have a header or message identifier as shown in the following example:

```
TIME: 00:48:18 UTC
LOCKED: 31 25 29 23 21 15 08 03 01
COUNT: 42 46 47 37 45 48 40 36 49
```

Table 5.52 describes the STA parameters.

Table 5.52. STA Response Format

Item	Description
Time	Current UTC time
Locked	The PRN numbers of the satellites being tracked
Count	The signal count for each tracked satellite

SUI: Satellite Usage Indicator

$PASHS,SUI, x

Enables or disables the satellite usage indicator, where x is ON or OFF.

If **$PASHS,SUI, OFF** is sent the usage indicator in the SAT message will be U for used or - for not used. If **$PASHS,SUI,ON** is sent the usage indicator in the SAT message will be U for used or one of the letters listed in Table 5.53 in the SAT column.

Table 5.53. MCA Good/Bad Flags and SAT Messages When SUI is ON

MCA good/ bad Flag	SAT	Description
24	U	Used and position computed
23	U	Used and position not computed
22	-	RESERVED
21	M	Satellite NOT used because of low elevation

Table 5.53. MCA Good/Bad Flags and SAT Messages When SUI is ON

MCA good/ bad Flag	SAT	Description
20	S	Satellite NOT used because the pseudo-range is not settled (transient is not over)
19	H	Satellite NOT used because marked 'unhealthy' in ephemeris
18	B	Satellite NOT used because of bad URA (or some accuracy problem indicated in navigational data)
17	Z	Satellite NOT used because marked 'unhealthy' in almanac
16	D	Satellite NOT used because differential corrections are old or invalid
15	J	Satellite NOT used because big code outlier was detected
14	R	Satellite NOT used because RAIM or some other algorithm detected a pseudo-range bias
13	I	Satellite NOT used because satellite disabled by external command SVP,USP)
12	L	Satellite NOT used because Signal To Noise Ratio is less than Mask
11	G	Satellite NOT used because it's possibly a ghost satellite
10	V	Satellite NOT used because computed satellite coordinates are suspicious
09	N	Satellite NOT used because satellite true number unknown (for modes, where we need the true satellite number
08	K	Satellite NOT used because it was disabled by RTK engine (N/A in DG14)
07	P	Satellite NOT used because no full range is available
02	O	Satellite NOT used because of some other case
01	E	Satellite NOT used because no navigational data (ephemeris) is available

DEFAULT SETTING

SUI— 0

SVP: Include/Exclude Satellites for Position Computations

$PASHS,SVP,c1c2c3…c32

This command includes and excludes specific satellites for use in position computations, where c is Y (include) or N (exclude). Unlike most of the other set commands, the c parameters are not separated by commas. A satellite which has been excluded can still be acquired and tracked, but is not used in computing positions. All satellites are included for position computation by default. The parameters c_1 through c_{32} correspond to GPS satellites PRN numbers 1 through

32. It is not necessary to enter a setting for all 32 satellites when using this command.

Examples

To exclude satellites 10 and 15 from the position computation, you could enter the following command:

$PASHS,SVP,YYYYYYYYYNYYYYN

This command excludes satellites 10 and 15 from the position computation, but does not change the settings for satellites 16 through 32

$PASHQ,SVP,[c1]

Queries current SVP settings, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SVP

The response message contains the current SVP settings for all 32 satellites. The format of the response message is nearly identical to the format used in the SVP set command:

$PASHR,SVP,c1c2c3…c32*hh

Table 5.54 defines the SVP response message parameters.

Table 5.54. $PASHR,SVP Message Format

Field	Description	Range
c1...c32	Indicates whether a satellites is included (Y) or excluded (N) for position computations	Y, N
*hh	Checksum	2-character hex

Typical SVP message:

$PASHR,SVP,YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY*0D

Table 5.55 outlines the response message.

Table 5.55. $PASHR,SVP Message Format

Parameter	Description
$PASHR,SVP	Header
YYY…Y	Indicates that all 32 PRN numbers are included for position computations
*0D	Checksum

SVS: Include/Exclude Satellites for Acquisition and Tracking

$PASHS,SVS,c1,c2,c3...c32

This command includes and excludes specific satellites for acquisition and tracking, where c is Y (include) or N (exclude). Like the SVP set command, the c parameters are not separated by commas. The receiver will not track a satellite which has been excluded through this command. All satellites are included for acquisition and tracking by default. The parameters c1 through c32 correspond to GPS satellites PRN numbers 1 through 32. It is not necessary to enter a setting for all 32 satellites when using this command.

Examples

To exclude satellites 4 and 7 from the position computation, enter the following command:

$PASHS,SVS,YYYNYYN

This command excludes satellites 4 and 7 from being acquired and tracked, but does not change the settings for satellites 8 through 32

$PASHQ,SVS,[c1]

This command queries the current SVS settings, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SVS

The response message contains the current SVP settings for all 32 satellites. The format of the response message is nearly identical to the format used in the SVP set command:

$PASHR,SVS,c1c2c3...c32*hh

Table 5.56 defines the SVS response message parameters.

Table 5.56. $PASHR,SVS Message Format

Field	Description	Range
c1...c32	Indicates whether a satellites is included (Y) or excluded (N) for acquisition and tracking	Y, N
*hh	Checksum	2-character hex

Typical SVS message:

$PASHR,SVS,YYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY*0E

Table 5.57 describes the typical SVS response message.

Table 5.57. $PASHR,SVS Message Format

Parameter	Description
$PASHR,SVP	Header
YYY…Y	Indicates that all 32 PRN numbers are included for acquisition and tracking
*0E	Checksum

DEFAULT SETTING

SVS—Y (all satellites included)

UCT,UDD,APT: Add point for 3-D Datum Transformation

$PASHS,UCT,UDD,APT,m1,c2,m3,c4,f5,m6,c7,m8,c9,f10,f11, f12,f13,f14,f15,f16

This commands adds a point for the estimation of 3D datum transformation parameters where Table 5.58 outlines the parameters. You must enter this command for each of the seven required data points to compute the 3-D datum transformation parameters.

Table 5.58. $PASHS,UCT,UDD,APT Parameters

Parameter	Description	Range
m1	Latitude of the position in WGS-84 (ddmm.mmmmm)	dd—0 to 90 mm.mmmmm—0 to 59.99999
c2	Latitude sector	N or S
m3	Longitude of the position in WGS-84 (dddmm.mmmmm)	dd—0 to 180 mm.mmmmm—0 to 59.99999
c4	Longitude sector	E or W
f5	Ellipsoidal height on WGS-84 (mm)	0 to 18000
m6	Latitude of the position in the local datum (ddmm.mmmmm)	dd—0 to 90 mm.mmmmm—0 to 59.99999

Table 5.58. $PASHS,UCT,UDD,APT Parameters

Parameter	Description	Range
c7	Latitude sector	N or S
m8	Longitude of the position in the local datum (dddmm.mmmmm)	dd—0 to 180 mm.mmmmm—0 to 59.99999
c9	Longitude sector	E or W
f10	Ellipsoidal height on the local datum (mm)	0 to 18000
f11	Sigma latitude of WGS-84 point	0
f12	Sigma longitude of WGS-84 point	0
f13	Sigma altitude of WGS-84 point	0
f14	Sigma latitude of local datum	0
f15	Sigma longitude of local datum	0
f16	Sigma altitude of local datum	0

UCT,UDD,CAL: Calculate Datum Transformation Parameters

$PASHS,UCT,UDD,CAL

This command computes the estimated datum transformation parameters for the user-defined datum. In order to compute the estimated datum transformation parameters, you must have entered in at least seven data points with the **$PASHS,UCT,UDD,APT** command.

$PASHQ,UCT,UDD,CAL

This command queries for the estimated datum transformation parameters of the user-defined datum.

$PASHR,UCT,UDD,CAL,f1,f2,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f13,f14,f15

The response is in the format:

   $PASHR,UCT,UDD,CAL,f1,f2,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f13,f14,f15

Table 5.59 defines the UDD,CAL response parameters.

Table 5.59. $PASHS,UTC,UDD,CAL Parameters

Parameter	Description	Range
f1	Semi-major axis of local datum (meters)	6300000 to 6400000
f2	Inverse flattening of local datum (meters)	290 to 310
f3	X shift origin of coordinates of ellipsoid (meters)	±1000.000
f4	Y shift origin of coordinates of ellipsoid (meters)	±1000.000
f5	Z shift origin of coordinates of ellipsoid (meters)	±1000.000
f6	Rotation in x axis (seconds) + rotation is counter clockwise - rotation is clockwise rotation	±10.000
f7	Rotation in y axis (seconds)	±10.000
f8	Rotation in z axis (seconds)	±10.000
f9	Delta Scale factor (scale factor - 1.0). (ppm)	±25.000
f10	Sigma latitude of WGS-84 point	0
f11	Sigma longitude of WGS-84 point	0
f12	Sigma altitude of WGS-84 point	0
f13	Sigma latitude of local datum	0
f14	Sigma longitude of local datum	0
f15	Sigma altitude of local datum	0

UCT,UDD,EST: Estimating a 3-D Datum Transformation

$PASHS,UCT,UDD,EST,f1,f2

Indicates the start of a sequence of entering points for estimating 3D datum transformation parameters. Table 5.60 defines the UDD,EST parameters.

Table 5.60. $PASHS,UCT,UDD,EST Parameters

Parameter	Description	Range
f1	Semi-major axis of local datum	6300000 to 6400000
f2	Inverse flattening of local datum	290 to 310

UCT,UDH,APT: Add Point for Local Geoidal Surface Transformation

$PASHS,UCT,UDH,APT,f1,f2,f3,f4,f5,f6

Adds a point for the estimation of local geoidal surface transformation parameters where the parameters are as defined in Table 5.61. You must enter this command for each of the three required data points to compute the 3-D datum transformation parameters.

Table 5.61. $PASHS,UCT,UDH,APT Parameters

Parameter	Description	Range
f1	Easting based on user selected grid system (meters)	±9999999.99
f2	Northing based on user selected grid system (meters)	±9999999.99
f3	Ellipsoidal height	0 to 18000
f4	Orthometric height	0 to 18000
f5	Sigma ellipsoidal height	0
f6	Sigma orthometric height	0

UCT,UDH,CAL: Calculate Local Geoidal Surface

$PASHS,UCT,UDH,CAL

This command computes the estimated parameters for local geoidal surface. In order to compute the estimated grid transformation parameters, you must have entered the four data points with the **$PASHS,UCT,UDH,APT** command.

$PASHQ,UCT,UDH,CAL

This command queries for the estimated parameters of the local geoidal surface.

$PASHQ,UCT,UDH,CAL

The response is in the format $PASHR,UCT,UDH,CAL,f1,f2,f3,f4,f5,f6 where the response parameters are as defined in Table 5.62.

Table 5.62. $PASHQ,UCT,UDH,CAL Response Parameters

Parameter	Description	Range
f1	Rotation about x axis (seconds)	
f2	Rotation about y axis (seconds)	

Table 5.62. $PASHQ,UCT,UDH,CAL Response Parameters

Parameter	Description	Range
f3	Vertical shift (meters)	
f4	Sigma rotation about x axis	0
f5	Sigma rotation about y axis	0
f6	Sigma vertical shift	0

UCT,UDH,EST: Estimating Local Geoidal Surface Transformation

$PASHS,UCT,UDH,EST

This commands indicates the start of a sequence of entering points for estimating local geoidal surface transformation parameters.

UCT,UG4,APT: Add Point for Grid Transformation

$PASHS,UCT,UG4,APT,f1,f2,f3,f4,f5,f6,f7,f8

This commands adds a point for the estimation of grid to grid transformation parameters where Table 5.63 outlines the parameters. You must enter this command for each of the four required data points to compute the grid to grid transformation parameters.

Table 5.63. $PASHS,UCT,UG4,APT Parameters

Parameter	Description	Range
f1	Easting in known projection (meters)	±9999999.99
f2	Northing in known projection (meters)	±9999999.99
f3	Easting in local grid system (meters)	±9999999.99
f4	Northing in local grid system (meters)	±9999999.99
f5	Sigma easting in known projection	0
f6	Sigma northing in known projection	0
f7	Sigma easting in local grid system	0
f8	Sigma northing in local grid system	0

UCT,UG4,CAL: Calculate Grid Transformation Parameters

$PASHS,UCT,UG4,CAL

This command computes the estimated grid transformation parameters for the user-defined grid. In order to compute the estimated grid transformation parameters, you must have entered the four data points with the **$PASHS,UCT,UG4,APT** command.

$PASHQ,UCT,UG4,CAL

This command queries for the estimated grid to grid transformation parameters.

$PASHR,UCT,UG4,CAL,f1,f2,f3,f4,f5,f6,f7,f8

The response is in the format `$PASHR,UCT,UG4,CAL,f1,f2,f3,f4,f5,f6,f7,f8` where Table 5.64 outlines the response parameters.

Table 5.64. $PASHR,UCT,UG4,CAL Response Parameters

Parameter	Description	Range
f1	Displacement easting (meters)	±9999999.99
f2	Displacement northing (meters)	±9999999.99
f3	Rotation in z axis (seconds)	
f4	Delta Scale factor (scale factor - 1.0). (ppm)	
f5	Sigma easting in "known" projection	0
f6	Sigma northing in "known" projection	0
f7	Sigma easting in local grid system	0
f8	Sigma northing in local grid system	0

UCT,UG4,EST: Estimating a Grid Transformation

$PASHS,UCT,UG4,EST

This command indicates the start of a sequence of entering points for estimating parameters in a user-defined grid transformation.

UD4: User-Defined Datum to Datum Parameters

$PASHS,UD4,d1,f1,f2,f3,f4

This command sets the parameters for a 2-D datum-to-datum transformation. Table 5.65 defines the translation parameters.

Table 5.65. $PASHS,UD4 Parameters

Parameter	Definition	Range
d1	Base System	0 = WGS-84 1 = PZ-90
f1	Translation 1	-1000 to 1000
f2	Translation 2	-1000 to 1000
f3	Datum rotation in seconds of arc	-10.00 to 10.00
f4	Datum scale value in parts per million	-10.0 to 10.0

Example

Set conversion parameters for a user-defined datum. You can use the **$PASHS,DTM** command to enable the conversion to the user-defined datum.

$PASHS,UD4,0,100.0,295.5,0.00001,9.5

> **DEFAULT SETTING**
>
> **UD4 Base System—WGS-84**

UDD: User-Defined Datum

$PASHS,UDD,d1,f2,f3,$\Delta$x,$\Delta$y,$\Delta$z,$\varepsilon_x$,$\varepsilon_y$,$\varepsilon_z$,f4

This command sets parameters for the user-defined datum and store them in battery-backed memory. Use this command with the **$PASHS,DTM,UDD** command, described on page 78. Table 5.66 lists the parameters of the **$PASHS,DTM,UDD** command.

$PASHQ,UDD,[c1]

This is the associated query command, where c1 is the optional output port. If a port is not specified, the receiver sends the response to the current port.

The response message is in the format:

$PASHR,UDD,d1,f2,f3,$\Delta$x,$\Delta$y,$\Delta$z,$\varepsilon$x,$\varepsilon$y,$\varepsilon$z,f4

Table 5.66 defines the response parameters.

Table 5.66. User-defined Datum Parameters

Field	Description	Range	Units	Default
d1	Identifier for the geodetic reference datum; always zero	0	N/A	0
f2	Semi-major axis	6300000.000 to 6400000.000	meters	6378137.000
f3	Inverse flattening. 1/f3 = f2/(f2-b), where b is semi-minor axis	290.00000000 to 301.00000000	meters	298.257223563
$\Delta x, \Delta y, \Delta z$	Translation from the local datum to WGS-84	-1000.000 to +1000.000	meters	0.00
$\varepsilon_x, \varepsilon_y, \varepsilon_z$	Rotations from the local datum to WGS-84. Viewed from the positive end of the axis about which the rotation takes place, the positive rotation is counterclockwise; the negative rotation is clockwise	-10.0000 to +10.0000	seconds of arc	0.00
f4	Delta scale factor (scale factor = 1 + delta scale factor)	-25.000 to +25.000	ppm	0.00

Example

To activate the user-defined datum for position computations and measurements, enter the following command after defining datum parameters with the UDD command:

$PASHS,DTM,USR

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

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

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

$\varepsilon_{rx} = \varepsilon_x$ expressed in radians (this also applies to ε_{ry} and ε_{rz}).

To clarify the datum transformation process, create a user-defined datum using parameters from the WGS-72 datum. Table 5.67 contains ellipsoid parameters for the WGS-84 datum and the WGS-72 datum:

Table 5.67. Ellipsoid Parameters for WGS-72 and WGS-84

Datum	Reference Ellipsoid	f2[f4]	1/f3
WGS-72	WGS-72	6378135.0	298.26
WGS-84	WGS-84	6378137.0	298.257223563

1. Enter the following UDD command which lists parameters from the WGS-72 datum:

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

2. After entering the datum parameters, enter the following command to activate the new datum:

   $PASHS,DTM,USR

The following ellipsoid values are now in effect:

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

$\varepsilon_x = \varepsilon_y = 0$ $\qquad$ $\varepsilon_z = -2.686 \times 10^{-6} = -0".554$

Taking these values, the following equation is used in calculating the transformation from WGS-84 coordinates to WGS-72 coordinates:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS84} = \begin{bmatrix} 0 \\ 0 \\ 4,5 \end{bmatrix} + (1 + 0,23 \times 10^{-6}) \begin{bmatrix} 1 & (-2,686) \times 10^{-6} & 0 \\ 2,686 \times 10^{-6} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}_{WGS72}$$

The DG14 performs an internal coordinate transformation *from* WGS-84 *to* WGS-72 so that geodetic position messages can be output in the desired coordinates as dictated by the parameters specified in the UDD command. Figure 5.2 illustrates the translation and rotation that occur in the WGS-84 to WGS-72 transformation.

Z_{WGS84}

Z_{WGS72}

0_{WGS84}

Y_{WGS84}

$\triangle Z = 4.5m$

X_{WGS84}

Y_{WGS72}

0_{WGS72}

ε_Z

$\varepsilon_Z = -2.686 * 10^{-6} rads = -0".554$

X_{WGS72}

9278G4
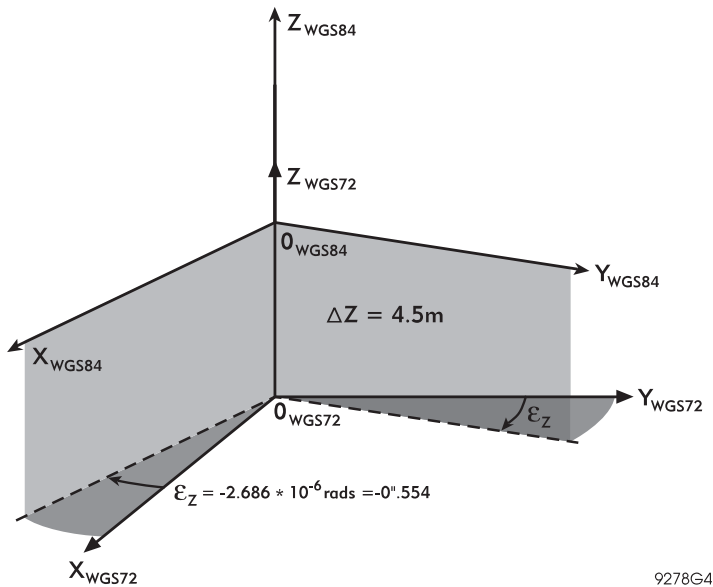
Figure 5.2. Rotation & Translation Between WGS-72 & WGS-84

UDG: User-Defined Datum to Grid Transformation

$PASHS,UDG,s1,d2,f3,f4,f5,f6,f7,f8,f9,f10,f11,f12,f13

This command sets parameters to transform geodetic coordinates specified by the UDD command to grid coordinates. The DG14 performs the transformation internally. The number of UDG parameters required for the transformation depends on the type of map projection selected, and must be indicated by the user in the d2 parameter.

Table 5.68 through Table 5.75 lists the parameters for each map projection:

Table 5.68. UDG Structure for Equatorial Mercator

Field	Description	Range / Name	Units
s1	Map projection type	EMER	n/a
d2	Number of parameters for the selected projection	3	n/a

Table 5.68. UDG Structure for Equatorial Mercator

Field	Description	Range / Name	Units
f3	Longitude for the Central Meridian	±1800000.0000	dddmmss.sss
f4	False Northing	±10,000,000	meters
f5	False Easting	±10,000,000	meters

Table 5.69. UDG Structure for Transverse Mercator

Field	Description	Range / Name	Units
s1	Map projection type	TM83	n/a
d2	Number of parameters for the selected projection	5 or 7 (last 2 optional)	n/a
f3	Longitude for Central meridian	±1800000.0000	dddmmss.ssss
f4	Scale factor at Central Meridian	0.5 to 1.5	n/a
f5	Latitude of the grid origin of the projection	±900000.0000	ddmmss.ssss
f6	False Easting	±10000000	meters
f7	False Northing	±10000000	meters
f8	Zone width (Default is 6°)	3 or 6	degrees
f9	Zone number at 0° longitude (Default is 31°)	1 to 60	N/A

Table 5.70. UDG Structure for Oblique Mercator

Field	Description	Range / Name	Units
s1	Map projection type	OM83	n/a
d2	Number of parameters for the selected projection	6	n/a
f3	Azimuth of the skew axis	±1800000.0000	ddmmss.ssss
f4	Scale factor at center of projection	0.5 to 1.5	n/a
f5	Longitude of the grid origin of the projection	±1800000.0000	ddmmss.sss
f6	Latitude of the grid origin of the projection	±900000.0000	ddmmss.sss
f7	False Easting	±10,000,000	meters
f8	False Northing	±10,000,000	meters

Table 5.71. UDG Structure for Stereographic (Polar and Oblique)

Field	Description	Range / Name	Units
s1	Map projection type	STER	n/a
d2	Number of parameters for the selected projection	5	n/a
f3	Latitude of the grid origin of the projection	±900000.0000	ddmmss.sss
f4	Longitude of the grid origin of the projection	±1800000.0000	ddmmss.sss
f5	Scale factor at center of projection	0.5 to 1.5	n/a
f6	False Easting	±10,000,000	meters
f7	False Northing	±10,000,000	meters

Table 5.72. UDG Structure for Lambert CC SPC83 (2 Standard Parallels)

Field	Description	Range / Name	Units
s1	Map projection type	LC83	n/a
d2	Number of parameters for the selected projection	6	n/a
f3	Latitude of Southern Standard parallel	±900000.0000	ddmmss.ssss
f4	Latitude of Northern Standard parallel	±900000.0000	ddmmss.ssss
f5	Longitude of the grid origin of the projection	±1800000.0000	ddmmss.ssss
f6	Latitude of the grid origin of the projection	±900000.0000	ddmmss.ssss
f7	False Easting	±10,000,000	meters
f8	False Northing	±10,000,000	meters

The SPC27 map projections presented in Table 5.73 must be used in conjunction with the Clark 1866 ellipsoid: (a = 6378206.4 m and 1/f= 294.978698200) and the following datum (Tx = -8.0, Ty = 160.0, Tz = 176.0, rotation and scale = 0) which is included in the preset datum list as NAC.

Values are derived from tables which can be obtained from various sources, including NGS Publication 62-4 (1986 Reprint) which also includes discussion and definitions of applied formulas and parameters.

Table 5.73. UDG Structure for Lambert Conformal Conic for SPC27

Field	Description	Range / Name
s1	Map projection type.	LC27
d2	Number of parameters for the selected projection	11

Table 5.73. UDG Structure for Lambert Conformal Conic for SPC27 (Continued)

Field	Description	Range / Name
f3	False Easting or x coordinate of central meridian	L1
f4	Longitude of Central meridian	L2
f5	Map radius of central parallel (Φ_0)	L3
f6	Map radius of lowest parallel of the projection table plus y value on central meridian at this parallel (y = 0 in most cases)	L4
f7	Scale (m) of the projection along the central parallel (Φ_0)	L5
f8	Sine of latitude of central parallel (Φ_0) computed from basic equations for Lambert projection with 2 standard parallel	L6
f9	Degree, minute portion of the rectifying latitude ω_0 for Φ_0, latitude of origin	L7
f10	Remainder of ω_0	L8
f11	$1/6 * R_o * N_o * 10^6$	L9
f12	$\tan\Phi_o / 24 * (R_o * N_o)^{3/2} * 10^{24}$	L10
f13	$[(5 + 3 * \tan^2 \Phi_o)/120 * R_o * N0^3] * 10^{32}$	L11
	Number of parameters for the selected projection	11

f9: $\omega = \Phi - [1052.893882 - (4.483344 - 0.002352 * \cos^2\Phi) * \cos^2 \Phi] * \sin \Phi * \cos \Phi$

f11/f12/f13: $R_o = a * (1 - e^2) / (1 - e^2 *\sin^2 \Phi_o)^{3/2}$: radius of curvature in meridian plane at Φ_o

$N_o = a / (1-e^2 * \sin^2 \Phi_o)^{1/2}$: radius of curvature in prime vertical at Φ_o

Table 5.74. UDG Structure for Transverse Mercator for SPC27

Field	Description	Range / Name
s1	Map projection type.	TM27
d2	Number of parameters for the selected projection	6
f3	False Easting or x coordinate of central meridian	T1
f4	Longitude of Central meridian	T2
f5	Degree, minute portion of the rectifying latitude ω_0 for Φ_0, latitude of origin	T3
f6	Remainder of ω_0	T4

Table 5.74. UDG Structure for Transverse Mercator for SPC27 (Continued)

Field	Description	Range / Name
f7	Scale along central meridian	T5
f8	$(1/6 * Rm * Nm * T5^2) * 10^{15}$ Rm = radius of curvature in meridian plane Nm = radius of curvature in prime vertical Both are calculated for the mean latitude of the area in the zone.	T6

Table 5.75. UDG Structure for Transverse Mercator SPC27 Alaska Zones 2-9

Parameters	Description	Range / Name
s1	Map projection type	TMA7
d2	Number of parameters for the selected projection	2
f3	False Easting or x coordinate of central meridian	C
f4	Longitude of Central meridian	CM

Examples

Set datum-to-grid transformation parameters for Lambert Conformal CA-zone 4:

$PASHS,UDG,LC83,6,360000.0,371500.0,-1190000.0,352000.0, 2000000,500000

Set datum-to-grid transformation parameters:

$PASHS,UDG,LC83,637 8240,297.323,121.4,18.9,0,0,0,1.5

UDH: Geoidal Surface in a Local Area

$PASHS,UDH,f1,f2,f3

This command sets the parameters to determine a linear approximation of a geoidal surface in a local area where f1, f2, and f3 are the linear parameters that approximate a geoidal surface in a local area.

After you enter this command, and enter a UDH elevation model with the **$PASHS,HGT,UDH** command, the receiver computes the orthometric height based on the following equation:

Orthometric Height = f1 * X + f2 * Y + f3.

X and Y are the current grid coordinates.

$PASHQ,UDH

This command queries the linear parameters entered by the **$PASHS,UDH** command.

$PASHR,UDH

The response is in the format:

$PASHR,UDH,f1,f2,f3

where f1, f2, and f3 are the 3 parameters entered by the **$PASHS,UDH** command.

USE: Satellites for Acquisition

$PASHS,USE,d1,c2

This command excludes specific satellites from being tracked by the DG14, where d1 is the satellite PRN number (01 to 32 for GPS and 120 to 137 for SBAS) or ALL to enable or disable all satellites. c2 is N (exclude) or Y (include). All satellites are included for tracking by default.

Example

Exclude satellite 13 from being tracked by the receiver:

$PASHS,USE,13,N

DEFAULT SETTING
USE—ALL

$PASHS,USE,ALL,c1

This command includes or excludes all GPS satellites simultaneously, where c1 is Y (include) or N (exclude). In a case where several satellites were excluded from being tracked, this shortcut command once again includes all satellites for tracking instead of constructing a lengthy command to re-enable those specific satellites for tracking.

To enable or disable the tracking of all SBAS satellites, use the $PASHS,USE,SBA command. See *USE: SBAS Satellites for Acquisition* section on page 322 for a description of this command.

USP: Satellites Used in Position Computation

$PASHS,USP,d1,c2

This command selects specific satellites to be used in computing positions, where d1 is the satellite PRN number (01 to 32 for GPS and 120 to 137 for SBAS) or ALL (all satellites simultaneously) and c2 is Y (include) or N (exclude).

Example

Exclude PRN 4 from being used in position computation:

$PASHS,USP,4,N

DEFAULT SETTING
USP—All satellites included for position computation

To enable or disable all SBAS satellites in the position solution, use the $PASHS,USP,SBA command. See *USP: SBAS Satellites Used in Position Computation* section on page 322 for a description of this command.

UTS: Synchronize with GPS Time

$PASHS,UTS,s

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

If processing raw data from the receiver with your own processing algorithms, enable UTS.

DEFAULT SETTING
UTS—ON

$PASHQ,UTS,[c1]

The associated query command is **$PASHQ,UTS,[c1]**, where c1 is the optional output port. If a port is not specified, the receiver sends the response to the current port.

$PASHQ,UTS,

The response message is in the format:

$PASHR,UTS,x*cc

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

VDP: VDOP Mask

$PASHS,VDP,d1

This command sets the value of the VDOP mask, where d1 is a number between 0 and 99. If the VDOP value computed by the DG14 is higher than the VDOP mask value, the receiver will automatically go into fixed altitude mode. You can view the current VDOP mask value by entering the query command $PASHQ,PAR and checking the VDP field.

Example

Set VDOP mask value to 6:

$PASHS,VDP,6

DEFAULT SETTING
VDP—4

VIS: Satellite Visibility

$PASHQ,VIS,[c1]

This command queries the satellites currently visible in the sky, where c1 is the optional output port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,VIS

The response is in the format:

```
SATELLITES VISIBILITY:
GPS: FULLTIME:0690921841 TIME:18:44:01 NSV:06
 SV:  01  02 #03  04  05 #06 #07  08 #09 #10 #11 #12  13 #14 #15 #16
 EL: *51 *27 -99 -02 -80 -99 -99 *32 -99 -99 -99 -99 *82 -99 -99 -99
 SV: #17 #18 #19 #20 #21 #22 #23 #24 #25 #26  27  28 #29 #30 #31 #32
 EL: -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 *58 *09 -99 -99 -99 -99
WAS: FULLTIME:0690921841 TIME:18:44:01 NSV:01
 SV: #01 #02 #03 #04 #05 #06 #07 #08 #09 #10 #11 #12 #13 #14  15 #16
```

EL: -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 *15 -99

SV: #17 #18 #19 #20 #21 #22 #23 #24 #25 #26 #27 #28 #29 #30 #31 #32

EL: -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99 -99

where the paremeters are as defined in Table 5.76.

Table 5.76. $PASHR,VIS Response Format

Parameter	Description
GPS	
FULLTIME	Number of seconds elapsed since the beginning of GPS evaluation (January 6, 1980)
TIME	The current UTC time
NSV	The number of visible GPS satellites, based on the almanac. Since this is based on the almanac, NSV represents a theoretical visibility.
SV	GPS satellite PRN number
EL	GPS satellite elevation
WAS	
FULLTIME	The number of seconds elapsed since the beginning of SBAS evaluation (January 6, 1980)
TIME	The current UTC time
NSV	The number of visible SBAS satellites, based on the almanac. Since this is based on the almanac, NSV represents a theoretical visibility.
SV	SBAS satellite PRN number
EL	SBAS satellite elevation

6

Raw Data Commands

Raw data commands allow you to set and query raw data parameters and raw data messages, including enabling or disabling the output of raw data messages, setting thresholds for the output of raw data messages, and setting an output interval for raw data messages. All raw data messages are disabled for output by default. Table 6.1 lists the raw data commands.

Table 6.1. Raw Data Commands

Function	Command	Description	Default	Page
Almanac Data	$PASHS,RAW,SAL	Enable/disable raw almanac data.		185
	$PASHQ,SAL	Query GPS raw almanac data.		185
	$PASHS,RAW,SAW	Enable/disable SBAS almanac data.		187
	$PASHQ,SAW	Query SBAS almanac data.		187
Raw Data Output	$PASHS,RAW,ALL	Enable/disable raw data messages		109
Ephemeris Data	$PASHS,RAW,SNV	Enable/disable raw ephemeris message		189
	$PASHQ,SNV	Query raw ephemeris data		189
	$PASHS,RAW,SNW	Enable/disable SBAS ephemeris data		190
	$PASHQ,SNW	Query SBAS ephemeris data		191

Table 6.1. Raw Data Commands (Continued)

Function	Command	Description	Default	Page
Measurement Data	$PASHS,RAW,MBN	Enable/disable raw measurement data messages with Ashtech type 2 data structure		166
	$PASHQ,MBN	Query raw measurement data messages with Ashtech type 2 data structure		166
	$PASHS,RAW,MCA	Enable/disable raw measurements data (MCA)		168
	$PASHQ,MCA	Query raw measurements data (MCA)		168
Position Data	$PASHS,RAW,GGB	Enable/disable position data (GGB)		165
	$PASHQ,GGB	Query GGB position data		165
	$PASHS,RAW,PBN	Enable/disable raw position data (PBEN)		182
	$PASHQ,PBN	Query raw position data (PBEN)		182
	$PASHQ,XYZ	Query the 3-D satellite positions for tracked satellites		193
Raw Data Parameters	$PASHS,RAW,CMB	Enable the Channel Measure Block		157
	$PASHQ,CMB	Query the Channel Measure Block		157
	$PASHS,ELM	Set raw data output elevation mask	5°	164
	$PASHS,MSV	Set minimum number of satellites	3	181
	$PASHS,RCI	Set recording interval	1	184
	$PASHS,SIT	Set site name	????	188
Speed measurement	$PASHS,RAW,VTB	Enable speed output message		192
	$PASHQ,VTB	Query raw position data		192
	$PASHR,VTB	Raw data message		192

Table 6.1. Raw Data Commands (Continued)

Function	Command	Description	Default	Page
Combined Raw Data	$PASHS,RAW,CT1	Enable/disable combined raw data in the CT1 Format data structure		159
	$PASHQ,CT1	Query combined raw data in the CT1 Format data structure		159
	$PASHS,RAW,CT2	Enable/disable combined raw data in the CT2 Format data structure		161
	$PASHQ,CT2	Query combined raw data in the CT2 Format data structure		161
	$PASHS,RAW,CT3	Enable/disable combined raw data in the CT3 Format data structure		163
	$PASHQ,CT3	Query combined raw data in the CT3 Format data structure		163
Encapsulated and Miscellaneous Data	$PASHS,RAW,MSB	Enable/disable encapsulated data message		178
	$PASHQ,MSB	Query encapsulated data message		178
	$PASHS,RAW,MIS	Enable/disable miscellaneous data structure message		174
	$PASHQ,MCM	Query miscellaneous data structure message		174
Missile Application	$PASHS,RAW,MCM	Enable/disable missile application condensed measurement message		171
	$PASHQ,MCM	Query missile application condensed measurement message		172

The general format for the set commands controlling the output of raw messages is as follows:

$PASHS,RAW,s1,c1,s2,[f1]

In this context, set commands are used to enable the output of raw data messages at regular intervals or to disable output of raw messages, where s1 is a three character message identifier (SNV, MBN, PBN, etc.), c1 is the port designator for message output, s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

If the output is set without a period, f1, and the period set by the $PASHS,RCI command is issued after individual RAW message output periods have been set, all individual message periods will be reset to the RCI output period setting.

Query commands prompt the receiver to output the corresponding response message once only. Message output prompted by a query command occurs independently of any related message output settings.

To enable the output of the MBN message on port A at five second intervals, enter the following command:

    $PASHS,RAW,MBN,A,ON,5

To disable the output of the MBN message on port B, enter the following command:

    $PASHS,RAW,MBN,B,OFF

To query for the MBN message and designate port B for the output of the response message, enter the following command:

    $PASHQ,MBN,B

As with the other query commands, the port designator (B) is optional. If a port is not specified, the receiver sends the response to the current port.

Message Structure

Real-time messages are output in binary format:

```
HEADER,MESSAGE ID,DATA + CHECKSUM<CR><LF>
```

The header field always contains **$PASHR**. The message identifier field contains the three-character message identifier **(MBN, PBN, SAL, etc.)** and is followed by a field containing the binary data string. The header, identifier, and data string fields are comma delimited. Depending on the message selected, the checksum is contained in the last one or two bytes of the binary data string. All real-time messages are terminated with a Carriage Return/Line Feed <CR><LF> delimiter. The MBN message is output:

```
$PASHR,MPC,<Binary Data String + Checksum><CR><LF>
```

The general format for the set command to enable or disable output of raw data messages is **$PASHS,RAW,s1,c1,s2** where s1 is the three-character message identifier, c1 is the port designator, and s2 is ON or OFF. The port designator is a required parameter in enabling or disabling the output of raw data messages.

Checksum

There are three different algorithms used in the checksum calculation, one for text messages and two for binary messages:

- Text Messages:
  - The hexadecimal checksum is computed by exclusive-O-Ring all of the bytes in the message between, but not including, the $ and the * The result is *hh where h is a hex character.
- Binary Messages:
  - The checksum for all binary messages except MCA is computed by breaking the structure into 20 unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
  - The checksum for the MCA message is computed by a bytewise exclusive OR (XOR) of all bytes from sequence tag (just after header) to the byte before the checksum.

All bytes are in MC6800 order: most significant byte first (IBM PC uses Intel order: least significant byte first).

CMB: Channel Measure Block

$PASHS,RAW,CMB,c1,s2,[f1]

This command enables or disables the channel measure block (CMB) message, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,CMB,[c1]

This command queries for the CMB message.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,CMB

The message is output in the format:

```
$PASHR,CMB,<structure>
```

Table 6.3 outlines the data string format.

Table 6.2. $PASHR,CMB Data String

Binary Type	Bytes	Content
unsigned int	2	The number of bytes remaining in the message. This value varies depending on the number of channels reported in the message.
char [2]	2	The version number for this message. For example 2.01. The first byte specifies the major part (2) and the second byte specifies the minor part (.01).
long	4	The time value for the internal receiver counter in milliseconds modulo one week.
int	2	Satellite PRN number associated with the data that follows. Values 1 to 32. 0 indicates that the channel is not used. This repeats for each channel.
int	2	• LBS bit0 = TRUE: the carrier loop locked at the instant the phase value was harvested. • LBS bit1 = TRUE: carrier phase lock indicator continuously locked since the last report. This repeats for each channel.
long	4	The raw doppler from the carrier loop ($HZ*2^{12}/100$). This repeats for each channel.
long	4	The raw accumulated carrier phase (cycles * 2^{16}). This phase reading shows jumps due to rollover of the long variable. This repeats for each channel.
long	4	Measured sub 1 ms code phase (chips*2^{16}). This repeats for each channel.
int	2	Measure of the quality of code phase (absolute value of tracking loop error). This repeats for each channel.
int	2	Signal-to-noise ratio from the carrier loop. This repeats for each channel.
int	2	Peak value of 10 ms sums of Q from the carrier loop since the last report. This repeats for each channel.
int	2	• LBS bit0 = TRUE: Preamble found: data count and sample count are good. • LBS bit1 = TRUE: TOW decoded for this PRN. This repeats for each channel.
int	2	Number of data bits since the beginnign of the preamble. This repeats for each channel.

Table 6.2. $PASHR,CMB Data String (Continued)

Binary Type	Bytes	Content
int	2	Number of epochs since the last bit edge. This repeats for each channel.
long	4	GPS time of week for the satellite PRN. This repeats for each channel.
short [checksum]	2	Checksum.
Total bytes = (32 * number of channel tracking satellites) + 10		

CT1: Combined Measurement/Position Data (Format 1)

$PASHS,RAW,CT1,c1,s2,[f1]

This command enables or disables the combined measurement and position data message format 1, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,CT1,[c1]

This command queries for a combined raw data message in the CT1 data structure, which contains elements derived from the MCA and PBN messages.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,CT1

This message is not output unless the receiver is tracking at least one satellite. The CT1 message contains an adjusted receive time (the time at which the data was received) with satellite PRN numbers and channel assignments in association with smoothed pseudo ranges. This message contains data for a maximum of six satellites. If the receiver is tracking more than six satellites, two CT1 messages are output. The message is output in the format:

```
$PASHR,CT1,<Format 1 Data String + Checksum>
```

Table 6.3 outlines the data string format.

Table 6.3. $PASHR,CT1 Data String

Binary Type	Bytes	Content
Long [adj_rcvtime]	4	The time at which the data was received, based on the following formula using the rcvtime and navt values from the PBN message: adj_rcvtime = rcvtime - navt/speed of light
char [sv_no]	1	The number of satellites in the message (1...6).
char [remainder]	1	The number of satellites remaining for the current epoch; i.e., since the CT1 message can contain data for a maximum of six satellites, if the receiver is tracking eight satellites, two are remaining
char [chn1]	1	Channel (1...14)
char [prn1]	1	Satellite PRN number
double [smooth_rng1]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn2]	1	Channel (1...14)
char [prn2]	1	Satellite PRN number
double [smooth_rng2]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn3]	1	Channel (1...14)
char [prn3]	1	Satellite PRN number
double [smooth_rng3]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn4]	1	Channel (1...14)
char [prn4]	1	Satellite PRN number
double [smooth_rng4]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn5]	1	Channel (1...14)
char [prn5	1	Satellite PRN number
double [smooth_rng5]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn6]	1	Channel (1...14)
char [prn6]	1	Satellite PRN number
double [smooth_rng6]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message

Table 6.3. $PASHR,CT1 Data String (Continued)

Binary Type	Bytes	Content
short [checksum]	2	The checksum is calculated by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result
Total bytes: 10*number of satellites in the message + 8 (68 for 6 satellites)		

CT2: Combined Measurement/Position Data (Format 2)

$PASHS,RAW,CT2,c1,s2,[f1]

This command enables or disables the combined measurement and position data message format 2, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,CT2,[c1]

This command queries for a combined raw data message in the CT2 data structure. This message contains elements derived from the MCA and PBN messages.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,CT2

This message is not output unless the receiver is tracking at least one satellite. The CT2 message contains an adjusted receive time (the time at which the data was received) with satellite PRN numbers and channel assignments in association with full carrier phase measurements and smoothed pseudo ranges. This message contains data for a maximum of four satellites. If the receiver is tracking eight satellites, two CT2 messages are output. If the receiver is tracking more than eight satellites, three CT2 messages are output. The message is output in the format:

```
$PASHR,CT2,<Format 2 Data String + Checksum>
```

Table 6.4 outlines the data string format.

Table 6.4. $PASHR,CT2 Data String

Binary Type	Bytes	Content
Long [adj_rcvtime]	4	The time at which the data was received, based on the following formula using the rcvtime and navt values from the PBN message: adj_rcvtime = rcvtime - navt/speed of light
char [sv_no]	1	The number of satellites in the message (1...4)

Table 6.4. $PASHR,CT2 Data String (Continued)

Binary Type	Bytes	Content
char [remainder]	1	The number of satellites remaining for the current epoch; i.e., since the CT2 message can contain data for a maximum of four satellites, if the receiver is tracking eight satellites, four are remaining
char [chn1]	1	Channel (1...14)
char [prn1]	1	Satellite PRN number
double [full_phase1]	8	Full carrier measurements in cycles as defined in the MCA message
double [smooth_rng1]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn2]	1	Channel (1...14)
char [prn2]	1	Satellite PRN number
double [full_phase2]	8	Full carrier measurements in cycles as defined in the MCA message
double [smooth_rng2]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn3]	1	Channel (1...14)
char [prn3]	1	Satellite PRN number
double [full_phase3]	8	Full carrier measurements in cycles as defined in the MCA message
double [smooth_rng3]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
char [chn4]	1	Channel (1...14)
char [prn4]	1	Satellite PRN number
double [full_phase4]	8	Full carrier measurements in cycles as defined in the MCA message
double [smooth_rng4]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
short [checksum]	2	The checksum is calculated by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result
Total bytes: 18*number of satellites in the message + 8 (80 for 4 satellites)		

CT3: Combined Measurement/Position Data (Format 3)

$PASHS,RAW,CT3,c1,s2,[f1]

This command enables or disables the combined measurement and position data message format 3, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,CT3,[c1]

This command queries for a combined raw data message in the CT3 data structure. This message contains elements derived from the MCA and PBN messages.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,CT3

This message is not output unless the receiver is tracking at least one satellite. The CT3 message contains an adjusted receive time (the time at which the data was received) with satellite PRN numbers and channel assignments in association with full carrier phase measurements, smoothed pseudo ranges, and doppler measurements. This message contains data for a maximum of three satellites. If the receiver is tracking nine satellites, three CT3 messages are output. If the receiver is tracking more than nine satellites, four CT3 messages are output. The message is output in the format:

```
$PASHR,CT3,<Format 3 Data String + Checksum>
```

Table 6.5 outlines the data string format.

Table 6.5. $PASHR,CT3 Data String

Binary Type	Bytes	Content
Long [adj_rcvtime]	4	The time at which the data was received, based on the following formula using the rcvtime and navt values from the PBN message: adj_rcvtime = rcvtime - navt/speed of light
char [sv_no]	1	The number of satellites in the message (1, 2, 3).
char [remainder]	1	The number of satellites remaining for the current epoch; i.e., since the CT3 message can contain data for a maximum of three satellites, if the receiver is tracking six satellites, three are remaining
char [chn1]	1	Channel (1...14)
char [prn1]	1	Satellite PRN number
double [full_phase1]	8	Full carrier measurements in cycles as defined in the MCA message

Table 6.5. $PASHR,CT3 Data String (Continued)

Binary Type	Bytes	Content
double [smooth_rng1]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
long [doppler1]	4	Doppler measurement as defined in the MCA message
char [chn2]	1	Channel (1...14)
char [prn2]	1	Satellite PRN number
double [full_phase2]	8	Full carrier measurements in cycles as defined in the MCA message
double [smooth_rng2]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
long [doppler2]	4	Doppler measurement as defined in the MCA message
char [chn3]	1	Channel (1...14)
char [prn3]	1	Satellite PRN number
double [full_phase3]	8	Full carrier measurements in cycles (as defined in the MCA message)
double [smooth_rng3]	8	Smoothed pseudo-range measurement, derived from raw range data and smoothing as defined in the MCA message
long [doppler3]	4	Satellite doppler measurement (10^{-4} Hz) as defined in the MCA message
short [checksum]	2	The checksum is calculated by breaking the structure into shorts, adding them together, and taking the least significant 16 bits of the result
Total bytes: 22*number of satellites in the message + 8 (74 for 3 satellites)		

ELM: Elevation Mask for Raw Measurements Outputs

$PASHS,ELM,d1

This command sets the minimum elevation for the output of raw measurement data (CT1, MBN, MCA, etc.), where d1 is a number between 0 and 90. The receiver can be set to output raw measurement data for each satellite it is tracking that is above the elevation mask. It stops outputting raw measurement data for any satellite (GPS and/or SBAS) at or below the elevation mask. If the elevation mask is set to 10°, the receiver outputs raw measurement data for all tracked satellites with an elevation of 11° or higher, but not output raw measurement data for any tracked satellites with an elevation of 10° or lower. You can view the current raw data elevation mask setting $PASHQ,RAW and checking the ELM field.

The ELM command sets the elevation mask for both GPS and SBAS satellites.

Examples

Enter the following command to set the elevation mask at ten degrees:

$PASHS,ELM,10

Enter the following command to set the elevation mask at fifteen degrees:

$PASHS,ELM,15

DEFAULT SETTING	
ELM	**5°**

GGB:GGB Position Data

$PASHS,RAW,GGB,c1,s2,f1

This command enables or disables the position data (GGB) messages, where c1 is port A, B or C, s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,GGB,[c1]

This command queries for one GGB position data. c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,RCI** command If the **$PASHS,RCI** command is issued after this message period has been set, the period resets to the RCI setting.

$PASHR,GGB

This message is not output unless the receiver is tracking at least one satellite. The GGB message contains some of the same measurement information as is contained in the GGB message: doppler, raw pseudo-range, full carrier phase, satellite PRN number, elevation, and azimuth. A separate MCA message is output for each satellite being tracked. The structure of the message is in the format:

```
$PASHR,GGB,<Ashtech type 3 data string + checksum>
```

Table 6.6 outlines the data string format.

Table 6.6. $PASHR,GGB Data String

Binary Type	Name	Description
Char	cHour	UTC Hour
Char	cMin	UTC Minute
Float	fSec	UTC Second
Double	dLatitude	Latitude in radians
Double	dLongitude	Longitude in radians
Char	cQuality	GPS quality indicator: 0=no pos, 1=Raw pos, 2=Differential/Float, 3=Fixed
Char	cSatNum	Number of satellites used
Float	fHDOP	Horizontal dilution of precision (HDOP)
Float	fHeigh	Antenna height in meters above geoid
Float	fGeoInd	Geoidal undulation in meters. the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid), "-" = mean-sea-level below ellipsoid
Float	fDifAge	Age of differential data (seconds)
long	sId	Differential reference station ID 1 to 1023
short	sCS	2 bytes sum from cHour to sCS (exclude sCS itself)

MBN: Raw Measurements (Ashtech Type 2 Data Structure)

$PASHS,RAW,MBN,c1,s2,[f1]

This command enables or disables the measurement data (MBN) messages with Ashtech Type 2 data structure, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

The DG14 outputs this message in binary format on every recording interval (RCI) for locked satellites with an elevation equal to or greater than the elevation mask (ELM), and only if the number of locked satellites is equal to or greater than the minimum satellite mask (MSV).

$PASHQ,MBN,[c1]

This command queries for raw satellite measurement data contained in the Ashtech Type 2 data structure.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,RCI** command If the **$PASHS,RCI** command is issued after this message period has been set, the period resets to the RCI setting.

$PASHR,MBN

This message is not output unless the receiver is tracking at least one satellite. The MBN message contains measurement information for doppler, carrier phase, and satellite transmit time, as well as satellite PRN number, signal strength, elevation, and azimuth. A separate MBN message is output for each satellite being tracked. The structure of the message is n the format:

```
$PASHR,MBN,<Astech type 2 data string + checksum>
```

Table 6.7 outlines the data string format.

Table 6.7. $PASHR,MBN Data String

Field	Bytes	Content
char [datatype]	1	Always = 1
char [count]	1	Number of measurement structures to follow after this one
char [svprn]	1	Satellite PRN number
char chnind	1	Channel (1 to 14) assigned to the satellite
long [lost_lock_ctr]	4	Continuous counts since satellite is locked. This number is incremented about 500 times per second
char [polarity]	1	This number is either 0 or 5. 0 indicates that satellite is just locked, and 5 indicates that the beginning of the first frame has been found
char [goodbad]	1	This number is either 22 or 24. Twenty-two indicates the satellite is not usable; twenty-four indicates the satellite is usable for position computation.
char [warning]	1	Always zero
char [ireg]	1	Satellite signal strength
double [codetxmt]	8	The fractional part of the satellite transmit time in seconds. The integer part of this number is ignored.
long [doppler]	4	Satellite doppler measurement (10^{-4} Hz)
double [intdoppler]	8	Total phase in cycles - available only if carrier phase option installed
short carphase1	2	Reserved
short carphase2	2	Reserved
short elevation	2	Satellite elevation in units of 0.01 degrees

Table 6.7. $PASHR,MBN Data String (Continued)

Field	Bytes	Content
short azimuth	2	Satellite azimuth in degrees
checksum	2	The checksum is computed by breaking the structure into 20 unsigned shorts, adding them together, and taking the least significant 16 bits of the result
Total bytes: 42		

This message is output in binary format on every recording interval (RCI) for those locked satellites with elevation equal to or greater than the elevation mask (ELM), and only if the number of locked satellites is equal to or greater than minimum satellite mask (MSV).

MCA: Raw Measurements (Ashtech Type 3 Data Structure)

$PASHS,RAW,MCA,c1,s2,[f1]

This command enables or disables the measurement data (MCAA) messages with Ashtech Type 3 data structure, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

The DG14 outputs this message in binary format on every recording interval (RCI) for locked satellites with an elevation equal to or greater than the elevation mask (ELM), and only if the number of locked satellites is equal to or greater than the minimum satellite mask (MSV).

$PASHQ,MCA,[c1]

This command queries for raw satellite measurement data contained in the Ashtech Type 3 data structure.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,RCI** command If the **$PASHS,RCI** command is issued after this message period has been set, the period resets to the RCI setting.

$PASHR,MCA

This message is not output unless the receiver is tracking at least one satellite. The MCA message contains some of the same measurement information as is contained in the MBN message: doppler, raw pseudo-range, full carrier phase, satellite PRN number, elevation, and azimuth. A separate MCA message is output for each satellite being tracked. The structure of the message is in the format:

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

Table 6.8 outlines the data string format.

Table 6.8. $PASHR,MCA Data String

Field	Bytes	Content
unsigned short [sequence tag]	2	Sequence ID number in units of 50 ms, modulo 30 minutes
unsigned char [left]	1	Number of remaining MCA messages to be sent for current epoch
unsigned char [svprn]	1	Satellite PRN number (1 to 32 for GPS and 33 to 64 for SBAS)
unsigned char [elev]	1	Satellite elevation angle in degrees
unsigned char [azim]	1	Satellite azimuth angle in increments of 2 degrees
unsigned char [chnind]	1	Channel (1 to 14) assigned to the satellite
unsigned char [warning]	1	Warning flag: • Bit 1 set - See note below • Bit 2 set - See note below • Bit 3 set - Carrier phase questionable • Bit 4 set - Code phase questionable • Bit 5 set - Code phase integration questionable • Bit 6 set - Not used • Bit 7 set - Possible loss of lock • Bit 8 set - Loss of lock; counter reset The interpretation of bits 1 and 2 is as follows: [Bit 1, Bit 2] • [0, 0] Same as 22 in good/bad flag (see next field) • [1, 0] Same as 23 in good/bad flag • [0, 1] Same as 24 in good/bad flag Note that more than one bit may be set at the same time, e.g., if bits 1, 3, and 6 are set at the same time, the warning flag is 37 (1 + 4 + 32)

Table 6.8. $PASHR,MCA Data String (Continued)

Field	Bytes	Content
unsigned char [goodbad]	1	Indicates the quality of the position measurement: • 24—Used and position computed. • 23—Used, position not computed • 22—RESERVED • 21—Satellite NOT used because of low elevation • 20—Satellite NOT used because the pseudo-range is not settled (transient is not over) • 19—Satellite NOT used because marked 'unhealthy' in ephemeris • 18—Satellite NOT used because of bad URA (or some accuracy problem indicated in navigational data) • 17—Satellite NOT used because marked 'unhealthy' in almanac • 16—Satellite NOT used because differential corrections are old or invalid • 15—Satellite NOT used because big code outlier was detected • 14—Satellite NOT used because RAIM or some other algorithm detected a pseudo-range bias. • 13—Satellite NOT used because SV disabled by external command SVP,USP) • 12—Satellite NOT used because Signal To Noise Ratio is less than Mask • 11—Satellite NOT used because it's possibly a ghost satellite • 10—Satellite NOT used because computed satellite coordinates are suspicious • 09—Satellite NOT used because satellite true number unknown (for modes, where we need the true SV number • 08—Satellite NOT used because it was disabled by RTK engine (N/A in DG14) • 02—Satellite NOT used because of some other case • 01—Satellite NOT used because no navigational data (ephemeris) is available
unsigned char [polarity_known]	1	This number is either 0 or 5, 0 meaning satellite is just locked, and 5 meaning the beginning of the first frame has been found
unsigned char [ireg]	1	Signal-to-noise measurement for the satellite observation
unsigned char [qa_phase]	1	Not used; always zero
double [full phase]	8	Full carrier phase measurements in cycles. Not available unless carrier phase option is installed
double [raw_range]	8	Raw range to satellite in seconds, i.e., receive time - raw range = transmit time
long [doppler]	4	Doppler (10^{-4} Hz)

Table 6.8. $PASHR,MCA Data String (Continued)

Field	Bytes	Content
long [smoothing]	4	32 bits where 31-24 are the smooth_count, unsigned, and normalized, representing the amount of smoothing specified in the **$PASHS,SMI** command: • 0 - Unsmoothed • 1 - Least smoothed • 255 - Most smoothed Bits 23-0 are smooth_corr, where bit 23 (MSB) is the sign and the LSBs (22-0) are the magnitude of correction in centimeters
checksum	1	Checksum, a bytewise exclusive OR (XOR) of all bytes from sequence_tag (just after header) to the byte before checksum
Total Bytes: 37		

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

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

MCM: Missile Application Condensed Measurement Record (MACM)

This message optimizes the data output and data transmission in high dynamic applications requiring high speed data output with communications bandwidth limitations.

$PASHS,RAW,MCM,c1,s2,[f3]

This command enables or disables the missile application condensed measurement record, where c1 is the output port (A, B, or C) for the response message. s2 is ON (enable) or OFF (disable), and f3 is the optional message interval in seconds ranging from 0.05 to 999 seconds. If the command is set without an interval, the G12 uses the period set by the **$PASHS,RCI** command If the **$PASHS,RCI** command is issued after this message period has been set, the period resets to the RCI setting.

Examples

Enter the following command to enable the missile application condensed measurement record through port A at the current RCI setting:

$PASHS,RAW,MCM,A,ON

Enter the following command to enable the missile application condensed measurement record through port A every 5 seconds:

$PASHS,RAW,MCM,A,ON,5

$PASHQ,MCM,c1

This command allows you to query for raw satellite and position measurement data in the Missile Application Condensed Measurement (MACM) format.

c1 is the optional port designator (port A, B, or C) for the response. If a port is not specified, the receiver sends the response to the current port.

If the command is set without a period, the G12 uses the period set by the **$PASHS,RCI** command If the **$PASHS,RCI** command is issued after this message period has been set, the period resets to the RCI setting.

MACM Message Structure

This message is not output unless positions are being computed. MCM is a combined message containing elements from the MBN, MCA, and PBN messages. The MCM message was designed for high speed data output under the limited bandwidth conditions common to high dynamic telemetry. Satellite PRN number, receive time (the time at which the data was received), doppler measurements, pseudo-range measurements, and full carrier phase measurements are contained in this message. The MCM message is variable in length, defined by the count field in the header. The message begins with a 4-byte sync word [4D 41 43 4D] (ASCII "MACM") and ends with a checksum byte. The **<CR><LF>** characters that terminate the majority of DG14 response messages are not used in this case. In addition, the usual response header, $PASHR, is not used here. If the receiver is set to output the MCM message at regular intervals, the MACM sync word appears only the first time the message is output and is excluded from the messages that follow; however, the sync word is output each time MCM is queried. The following is the output for one epoch. The syntax for each parameter is listed in brackets ads [parameter name:number of bytes for parameter]. At the right of each line is an identifier and byte count.

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
[MACM:4] [COUNT:2] [RCVTIME:4] [NAVT: 4]                         Header: 14

[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1] PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24
[PRN:1][WRN:1][POL:1][CN0:1][PHASE:8][RANGE:4][DPL:4][LCK_TIME:4] Prn Data: 24

[CHECKSUM:1]                                                     Checksum: 1
```

~~~~~~

The total message length for 8 satellite measurements is 207 bytes.

Table 6.9 outlines the data string format.

Table 6.9. MACM Data String

Byte #	Name	Type	Size	Content	Origin
1	MACM	char	4	Name of Message ("MACM")	sync_word (ASCII "MACM")
5	COUNT	char	2	Number of remaining structures to be sent for the current epoch.	MBN record, count
7	RCVTIME	long	4	Signal received in milliseconds of week GPS system time. This is the time tag for all measurements and position data.	PBN record, rcvtime
11	NAVT	float	4	Receiver clock offset in meters.	PBN record, navt
24*j-9	PRN	unsigned char	1	Satellite PRN number	MCA record, svprn
24*j-8	WRN	unsigned char	1	Warning flag, where: • Bit 1 set = see note below • Bit 2 set = see note below • Bit 3 set = carrier phase questionable • Bit 4 set = code phase questionable • Bit 5 set = code phase integration questionable • Bit 6 set = not used • Bit 7 set = possible loss of lock • Bit 8 set = loss of lock counter reset The interpretation of bits 1 and 2 is as follows: Bit 1 Bit 2 • 0 0 Same as 22 in goodbad flag (see next field) • 1 0 Same as 23 in goodbad flag • 0 1 Same as 24 in goodbad flag More than one bit may be set at the same time, e.g., if bits 1, 3, and 6 are set at the same time, the warning flag is 37 (1 + 4 + 32)	MCA record, warning
24*j-7	POL	unsigned char	1	This number is either 0 or 5, 0 meaning satellite is just locked, and 5 meaning the beginning of the first frame has been found.	MCA record, polarity_known

Table 6.9. MACM Data String (Continued)

Byte #	Name	Type	Size	Content	Origin
24*j-6	CN0	unsigned char	1	Signal-to-noise of satellite observation	MCA record, ireg
24*j-5	PHASE	double	8	Full carrier phase measurements in cycles. Not available unless carrier phase option is installed.	MCA record, full_phase
24*j+3	RANGE	unsigned long	4	Pseudo-range in seconds, sf=3.0e10	G-8 ITA record, raw_range
24*j+7	DPL	long	4	Doppler (10^{-4} Hz)	MCA record, doppler
24*j+11	LCK_TIME	unsigned long	4	Continuous counts since satellite is locked. This number increments about 500 times per second	MBN record, lost_lock_ctr
24*N+15	checksum	unsigned char	1		MCA record

j = 1,2...N; N = the order number of the PRN record in the message.

MIS: Miscellaneous Data Structure

$PASHS,RAW,MIS,c1,s2,[f1]

This command enables or disables the miscellaneous data message (MIS). c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,MIS, [c1]

This command queries for miscellaneous data message. c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,MIS,<struct>

The response is in the format $PASHR,MIS,<struct>*hh. The output varies depending on the RTCM message type. Table 6.11 outlines the $PASHR,MIS response structure for RTCM Type 1 message.

Table 6.10. $PASHR,MIS Response Format for Message Type 1

Field	Length (bytes)	Content
long RcvTime	4	Signal received time in milliseconds of week of GPS system time or in milliseconds of week/day of GLONASS system time. This is the time tag for all measurements and position data and is the same as RcvTime in the PBN binary response message.
unsigned short RcvTimeFrac	2	Fraction of RcvTime field in **$PASHR,PBN** message in microseconds, ranging from 0 to 999us. Receive Time (us) = RcvTime(ms) * 1000 + RcvTimeFrac
unsigned short NumGpsSatsUsed	1	Number of GPS satellites used in position computation.
unsigned short NumGloSatsUsed	1	Number of GLONASS satellites used in position computation. Always 0.
unsigned short NumGpsSatsTrkd	1	Number of GPS satellites tracked.
unsigned short NumGloSatsTrkd	1	Number of GLONASS satellites tracked. Always 0.
unsigned short PositionMode	2	Mode status for position fix computation: Bit 15 Bit 14 (MSBit is 15, LSBit is 0) • 0 0 — Altitude not held fixed. • 0 1 —Last computed altitude held fixed. • 1 0 —Externally supplied altitude held fixed. Bit 13 Bit 12 • 0 0 —GLONASS time shift not held fixed. • 0 1 —Last computed GLONASS time shift held fixed. • 1 0 —Externally supplied GLONASS time shift held fixed. Bit 11 Bit 10 • 0 0 —Position not computed. • 0 1 —Raw; position not differentially corrected, ephemeris data used to compute position fix. • 1 0 —Differential Corrections applied. • 1 1 —Almanac (not ephemeris) used to compute position fix. Bits 9-0 reserved.
signed short GeoidalSeparation	2	Geoidal separation in meters multiplied by 100.
unsigned short HDOP	2	HDOP multiplied by 100.

Table 6.10. $PASHR,MIS Response Format for Message Type 1

Field	Length (bytes)	Content
unsigned short VDOP	2	VDOP multiplied by 100.
unsigned short ModZCnt	2	Modified Z-count (with a resolution of 0.2 seconds and an acceptable range of 20 minutes) from the RTCA Type 1 message containing the differential corrections used in the position computation.
float GloTimeShift	4	Current GLONASS time shift relative to GPS time in microseconds, ranging from 0.0000 to +/-5000000.0000us.
unsigned long GpsNavFlags	4	Each bit is a "GPS Nav Flag" for a GPS satellite. The most significant bit corresponds to PRN 32. When navigation data is collected from a GPS satellite, a GPS Nav Flag bit is set for any of the following reasons: • User Range Accuracy (URA) Flag ("accuracy alert", bit 18 of the Hand-Over-Word (HOW)) is set (ref. paragraph 2.4.2.2 of GPS SPS Signal Specification); • Failure of parity on 3 successive words of the navigation data; • All data bits in subframe 1, 2 or 3 are 0's; • Default navigation data (alternate 1's and 0's) is transmitted in words 3 through 10 of subframe 1, 2 or 3 for that satellite (ref. paragraph 2.4.1.3 of GPS SPS Signal Specification).
signed short GeoidalSeparation	2	Geoidal separation in meters multiplied by 100.
unsigned short HDOP	2	HDOP multiplied by 100.
unsigned short VDOP	2	VDOP multiplied by 100.
unsigned short ModZCnt	2	Modified Z-count (with a resolution of 0.2 seconds and an acceptable range of 20 minutes) from the RTCA Type 1 message containing the differential corrections used in the position computation.
float GloTimeShift	4	Current GLONASS time shift relative to GPS time in microseconds, ranging from 0.0000 to +/-5000000.0000us.

Table 6.10. $PASHR,MIS Response Format for Message Type 1

Field	Length (bytes)	Content
unsigned long GpsNavFlags	4	Each bit is a "GPS Nav Flag" for a GPS satellite. The most significant bit corresponds to PRN 32. When navigation data is collected from a GPS satellite, a GPS Nav Flag bit is set for any of the following reasons: • User Range Accuracy (URA) Flag ("accuracy alert", bit 18 of the Hand-Over-Word (HOW)) is set (ref. paragraph 2.4.2.2 of GPS SPS Signal Specification); • Failure of parity on 3 successive words of the navigation data; • All data bits in subframe 1, 2 or 3 are 0's; • Default navigation data (alternate 1's and 0's) is being transmitted in words 3 through 10 of subframe 1, 2 or 3 for that satellite (ref. paragraph 2.4.1.3 of GPS SPS Signal Specification).
unsigned long GloNavFlags	4	Each bit is a "GLONASS Nav Flag" for a GLONASS satellite. The most significant bit corresponds to PRN 32, thus bit 23 corresponds to PRN 24. When navigation data is collected from a GLONASS satellite, a GLONASS Nav Flag bit is set for any of the following reasons: • A parity error on three successive lines of the navigation data; • Ephemeris time offset (time scale shift) equals zero; • All three components of the satellite ephemeris coordinates or velocity vector equal zero; • All data bits in a string of any frame 1, 2, 3, 4 or 5 are 0's;
unsigned long GpsExcSats	4	Each bit is a "GPS Exclude Flag" for a GPS satellite. The most significant bit corresponds to PRN 32. When a GPS satellite has been excluded from being used to compute position, its corresponding GPS Exclude Flag bit is set.
unsigned long GloExcSats	4	Each bit is a "GLONASS Exclude Flag" for a GLONASS satellite. The most significant bit corresponds to PRN 32, thus bit 23 corresponds to PRN 24. When a GLONASS satellite has been excluded from being used to compute position, its corresponding GLONASS Exclude Flag bit is set.
Checksum	2	integer
Total Characters	42	

MSB: Encapsulated Data Message

$PASHS,RAW,MSB,c1,s2,[f1]

This command enables or disables the encapsulated data message when differential mode is enabled in the base and remote stations and Message Type 1 enabled in the base station. c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,MSB,[c1]

This command queries for the encapsulated data message. The receiver must be set in base mode to output this message. Differential mode must be enabled in both the base and remote stations and Message Type 1 enabled in the base station. c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,MSB,<struct>

The response is in the format $PASHR,MSB,<struct>*hh. The output varies depending on the RTCM message type. Table 6.11 outlines the $PASHR,MSB response structure for RTCM Type 1 message.

Table 6.11. $PASHR,MSB Response Format for Message Type 1

Field	Type	Length (bytes)
Bytes Count	integer	2
RTCM Message Type	character	1
Repeat Counter (# of satellites)	character	1
Base Station ID	integer	2
Z Count	integer	2
Station Health	character: 3	1
Sequence Number	character: 5	
UTC Hour	character	1
UTC Minute	character	1
UTC Second	character	1
UDRE	character: 2	1
Satellite PRN number	character: 6	
IODE	character	1
PRC	float	4

Table 6.11. $PASHR,MSB Response Format for Message Type 1

Field	Type	Length (bytes)
RRC	float	4
Checksum	integer	2

Table 6.12 outlines the $PASHR,MSB response structure for RTCM Type 3 message.

Table 6.12. $PASHR,MSB Response Format for Message Type 3

Field	Type	Length (bytes)
Bytes Count	integer	2
RTCM Message Type	character	1
Repeat Counter (# of satellites)	character	1
Base Station ID	integer	2
Z Count	integer	2
Station Health	character: 3	1
Sequence Number	character: 5	
UTC Hour	character	1
UTC Minute	character	1
UTC Second	character	1
X Component (cm)	long	4
Y Component (cm)	long	4
Z Component (cm)	long	4
Checksum	integer	2

Table 6.13 outlines the $PASHR,MSB response structure for RTCM Type 18 message.

Table 6.13. $PASHR,MSB Response Format for Message Type 18

Field	Type	Length (bytes)
Bytes Count	integer	2
RTCM Message Type	character	1
Repeat Counter (# of satellites)	character	1
Base Station ID	integer	2

Table 6.13. $PASHR,MSB Response Format for Message Type 18

Field	Type	Length (bytes)
Z Count	integer	2
Station Health	character: 3	1
Sequence Number	character: 5	
UTC Hour	character	1
UTC Minute	character	1
UTC Second	character	1
AddTime	long	4
Carrier Phase (1/256 cycle)	long	4
Frequency Indicator	character: 2	1
Reserved	character: 6	2
LastInd	character: 1	
PInd	character: 1	1
Reserved	character: 3	
Quality	character: 3	
Satellite ID	character	1
Cumulative Loss of Continuity	character	1
Checksum	integer	2

Table 6.14 outlines the $PASHR,MSB response structure for RTCM Type 19 message.

Table 6.14. $PASHR,MSB Response Format for Message Type 19

Field	Type	Length (bytes)
Bytes Count	integer	2
RTCM Message Type	character	1
Repeat Counter (# of satellites)	character	1
Base Station ID	integer	2
Z Count	integer	2
Station Health	character: 3	1
Sequence Number	character: 5	
UTC Hour	character	1

Table 6.14. $PASHR,MSB Response Format for Message Type 19

Field	Type	Length (bytes)
UTC Minute	character	1
UTC Second	character	1
AddTime	long	4
Range (0.02 m)	long	4
Frequency Indicator	character: 2	1
Reserved	character: 4	
Smoothing Interval	character: 2	
LastInd	character: 1	1
PInd	character: 1	
Reserved	character: 2	
Quality	character: 4	
Satellite ID	character	1
Reserved	character: 3	1
Multipath	character: 5	
Checksum	integer	2

MSV: Minimum Satellites for Raw Measurement Output

$PASHS,MSV,d1

This command sets the minimum number of satellites the receiver is required to track in order for it to output raw measurement data (MBN, MCA, etc.), where d1 is a number between 1 and 9. The receiver stops outputting measurement data if the number of satellites it is tracking falls below this minimum. You can view the current setting for minimum satellites by entering the **$PASHQ,RAW** command and checking the MSV field.

Examples

Enter the following command to set the minimum number of satellites to 4:

   $PASHS,MSV,4

Enter the following command to set the minimum number of satellites to 1:

$PASHS,MSV,1

DEFAULT SETTING	
MSV	**3**

PBN: Raw Position Data

$PASHS,RAW,PBN,c1,s2,[f1]

This command enables or disables the position data (PBN) messages, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,PBN,[c1]

This command allows to query for raw position data.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,PBN

The PBN message contains raw position data, including the time at which the data was received, antenna position, antenna velocity, receiver clock offset, and PDOP. The message is output in the format:

```
$PASHR,PBN,<Raw Position Data + Checksum>
```

Table 6.15 outlines the message format.

Table 6.15. PBN Data String

Field	Bytes	Content
long rcvtime	4	Signal received time in milliseconds of week of GPS time. This is the time tag for all measurements and position data
char sitename	4	4 character string (user entered)
double navx	8	X coordinate of the antenna position (ECEF) in meters
double navy	8	Antenna position ECEF y coordinate in meters
double navz	8	Antenna position ECEF z coordinate in meters
float navt	4	Receiver clock offset in meters
float navxdot	4	The antenna x velocity in meters per second

Table 6.15. PBN Data String (Continued)

Field	Bytes	Content
float navydot	4	The antenna y velocity in meters per second
float navzdot	4	The antenna z velocity in meters per second
float navtdot	4	Receiver clock drift in meters per second
unsigned short PDOP	2	PDOP multiplied by 100
checksum	2	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 bytes: 56		

RAW: RAW Data Query Command

$PASHQ,RAW,x

Show current settings of raw data parameters, where x is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

The response is in the format:

```
RCI:001.00 MSV:3 ELM:05
ANH:0.0000 SIT:???? EPG:000
RAW:  VTB MCA MBN PBN MIS XYZ DIF MSB GGB MCM CMB CT1 CT2 CT3 SNV SAL SNW SAW
PRTA: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF OFF
```

Table 6.16 outlines the response parameters:

Table 6.16. $PASHQ,RAW Response Parameters

Field	Description
RCI:001.00	This is the output interval of the data in seconds. This example has an output of 1 second. The default is once every 1 seconds.
MSV:3	Minimum number of satellites for the data to be output. Default is 3.
ELM:05	Data elevation mask. Elevation below which data from that satellite will not output.
SIT:????	Four-character site name.
EPG	Number of Kinematic epoch for a site.

Table 6.16. $PASHQ,RAW Response Parameters

Field	Description
RAW:	Raw data types: MCA, MBN, PBN, MIS, XYZ, DIF, MSB, CT1, CT2, CT3, SNV, SAL, SNG, SAG, SNW, SAW. Note: DIF message is undocumented and for internal use only.
PRTA PRTB PRTC	Communication Ports A, B, and C
OFF/XX	OFF indicates that the RAW data message is not sent to the port. If the message is sent to the communication port, this field delivers the output rate (XX).

RCI: Set Output Interval for Raw Messages

$PASHS,RCI,f1

This command sets a global output interval for all raw messages, where f1 is the value for the output interval. Use Table 6.17 to determine the value for f1. This command overrides individual settings for output interval. That is, if the CT1 message is enabled for output at intervals of two seconds and the MBN message is enabled for output at intervals of ten seconds, you can ese the RCI command to set an output interval of five seconds and reset the output interval of both messages to five seconds. You can view the current raw data output interval setting by entering the **$PASHQ,RAW** command and checking the RCI field.

Example

Enter the following command to set the global raw data output interval to 5 seconds:

$PASHS,RCI,5

Table 6.17. Raw Data Update Rate Options and Settings

Installed Option	Option Symbol	RCI Range (seconds)	Increment
1 Hz	1	1-999	1 second
2 Hz	2	0.5-999	0.5 second from 0.5 to 1 1 second from 1 to 999
5 Hz	5	0.2-999	0.2 second from 0.2 to 1 1 second from 1 to 999

Table 6.17. Raw Data Update Rate Options and Settings

Installed Option	Option Symbol	RCI Range (seconds)	Increment
10 Hz	T	0.1-999	0.1 from 0.1 to 1 1 from 1 to 999
20 Hz	W	0.05-999	0.05 from 0.05 to 0.1 0.1 from 0.1 to 1 1 from 1 to 999

DEFAULT SETTING	
RCI	1

The DG14 is designed to synchronize raw message output with the hour rollover, so that message output from multiple receivers can be synchronized regardless of when they were turned on.

Almanac data for all satellites is output once every hour, with one almanac message output for each satellite in the constellation. The almanac messages are output at interval prescribed by the $PASHS,RCI command.

At the 10 Hz output rate (0.1 seconds), a baud rate of 115,000 bps is required to output all the raw data (MBN, PBN, SNV, and SAL). For greater output rates, the raw data must be split between the two serial ports, or some of the messages should be turned off. To receive data at high baud rates (e.g., 115,000), you must ensure that your computer has a suitable serial I/O capability. Most newer computers with Pentium or 486 processors have good enough serial communication to support high data rates.

SAL: Satellite Almanac Data

$PASHS,RAW,SAL,c1,s2,[f1]

This command enables or disables the almanac data (SAL) messages, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

The DG14 output almanac data for all satellites once every hour, and outputs one satellite at each recording interval (RCI).

$PASHQ,SAL,[c1]

This command queries for satellite almanac data. c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SAL

This message is not output until the DG14 has completed downloading the current GPS almanac file. The receiver begins downloading the almanac file automatically almanac file can be obtained directly from the satellites, which happens automatically and takes about twelve minutes, or, with the aid of software, a current almanac file from another receiver can be manually downloaded into the DG14. A separate almanac message is output for each satellite being tracked. The SAL message contains information on satellite health, the almanac week number, and a variety of orbital measurements. The response is output in the format:

```
$PASHR,SAL,<Satellite almanac data string + checksum>
```

Table 6.18 outlines the data string format.

Table 6.18. $PASHR,SAL Data String

Field	Bytes	Content
short prn	2	Satellite PRN number -1
short health	2	Satellite health
float e	4	Eccentricity
long toa	4	Reference time for orbit (sec)
float i0	4	Inclination angle (semicircles)
float omegadot	4	Rate of right ascension (semicircles/sec)
double roota	8	Square root of semi-major axis (meters 1/2)
double omega0	8	Longitude of ascending node (semicircles)
double omega	8	Argument of perigee (semicircles)
double m0	8	Mean anomaly at reference time (semicircles)
float af0	4	Clock correction (sec)
float af1	4	Clock correction (sec/sec)
short wna	2	Almanac week number
short wn	2	Week number
long tow	4	Seconds of GPS week
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 Bytes: 70		

SAW: SBAS Almanac

$PASHS,RAW,SAW,c1,s2

This command enables or disables the SBAS almanac data, where c1 is port A, B or C (optional port), s2 is ON or OFF.

The DG14 outputs the SBAS almanac data each time the reference time changes (at a maximum of 5 minutes) with data for one satellite at each recording interval.

$PASHQ,SAW,[c1]

This command queries for SBAS almanac data. c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SAW

The response is one binary message per satellite in the format:

```
$PASHR,SAW,(almanac data)
```

Table 6.19 outlines the data string format.

Table 6.19. $PASHR,SAW Data String

Field	Bytes	Content
char	1	Data ID—Two LSB of byte. In the current specification, the format is 00.
char	1	Health— • Bit0—Ranging On (0) or Off (1) • Bit1—Corrections On (0) or Off (1) • Bit2—Broadcast integrity On (0) or Off (1) • Bit3—Reserved • Bit4-7—Filled by zero
long	4	t0—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' (m/s).
long	4	tow—Time within week in GPS time scale when SBAS almanac was received.
char	1	wn—Week number in GPS time scale when SBAS almanac was received.
char	1	Satellite number (33 to 64)

Table 6.19. $PASHR,SAW Data String (Continued)

Field	Bytes	Content
unsigned short	2	Checksum computed by breaking the structure into 40 unsigned shorts, adding them together and taking the least significant 16 bits of the result.
Total Bytes: 38 (51 including header and <LF><CR>)		

SIT: Site Name for Observation Session

$PASHS,SIT,s1

This command sets a site name for your observation session, where s1 is a user-defined string of 4 characters. The site name is captured in the PBN message; if a site name is not defined by the user, this part of the PBN message is occupied by four question marks. You can view the current site name by entering the query command **$PASHQ,RAW** and checking the SIT field.

Examples

Enter the following command to set site name to 0001:

$PASHS,SIT,0001

Enter the following command to set the site name to SQR1:

$PASHS,SIT,SQR1

DEFAULT SETTING	
SIT	**????**

SNV: Satellite Ephemeris Data

$PASHS,RAW,SNV,c1,s2,[f1]

This command enables or disables the ephemeris data (SNV) messages, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

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

$PASHQ,SNV,[c1]

This command queries for ephemeris data from each satellite currently being tracked by the receiver, where c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SNV

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

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

Table 6.20 outlines the data string format.

Table 6.20. $PASHQ,SNV Response Structure

Field	Bytes	Content
short wn	2	GPS week number
long tow	4	Seconds of GPS week
float tgd	4	Group delay (seconds)
long aodc	4	Clock data issue
long toc	4	Clock data reference time in seconds
float af2	4	Clock correction (sec/sec2)
float af1	4	Clock correction (sec/sec)
float af0	4	Clock correction (sec)
long aode	4	Orbit data issue
float deltan	4	Mean anomaly correction (semicircles/sec)
double m0	8	Mean anomaly at reference time (semicircles)
double e	8	Eccentricity
double roota	8	Square root of semi-major axis (meters 1/2)
long toe	4	Reference time for orbit (sec)
float cic	4	Harmonic correction term (radians)
float crc	4	Harmonic correction term (meters)
float cis	4	Harmonic correction term (radians)
float crs	4	Harmonic correction term (meters)
float cuc	4	Harmonic correction term (radians)

Table 6.20. $PASHQ,SNV Response Structure (Continued)

Field	Bytes	Content
float cus	4	Harmonic correction term (radians)
double omega0	8	Longitude of ascending node (semicircles)
double omega	8	Argument of perigee (semicircles)
double i0	8	Inclination angle (semicircles)
float omegadot	4	Rate of right ascension (semicircles/sec)
float idot	4	Rate of inclination (semicircles/sec)
short accuracy	2	User range accuracy
short health	2	Satellite health
short fit	2	Curve fit interval
char prnnum	1	Satellite PRN number minus 1 (0 to 31)
char res	1	Reserved character
checksum	2	The checksum is computed by breaking the structure into 65 unsigned shorts, adding them together, and taking the least significant 16 bits of the result
Total Bytes: 132		

SNW: SBAS Ephemeris Data

$PASHS,RAW,SNW,c1,s2

This command enables or disables the SBAS ephemeris data on port s1, where c1 is port A, B or C (optional port), s2 is ON or OFF.

The DG14 outputs the ephemeris data each time the IOD changes (at a maximum of 2 minutes) with data for one satellite at each recording interval.

Example

Enter the following command to send the ephemeris data to port B.

$PASHS,RAW,SNW,B,ON

$PASHQ,SNW,[c1]

This command queries the current SBAS ephemeris data, where c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,SNW

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

```
$PASHR,SNW,<SBAS Ephemeris data string + checksum>
```

Table 6.21 outlines the data string format.

Table 6.21. $PASHQ,SNW Response Structure

Field	Bytes	Content
char	1	IOD—Issue of data.
char	1	Accuracy.
long	4	t0—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' (m/s).
float	3*4	Satellite ECEF acceleration X", Y", Z" (m/s^2).
float	4	aGf0—Time offset between satellite time scale and SBAS system time scale (seconds).
float	4	aGf1—Time drift between satellite time scale and SBAS system time scale (seconds).
long	4	tow—Time within week in GPS time scale when SBAS ephemeris was received.
char	1	wn—Week number in GPS time scale when SBAS ephemeris was received.
char	1	Satellite number (33 to 64)
unsigned short	2	Checksum computed by breaking the structure into 40 unsigned shorts, adding them together and taking the least significant 16 bits of the result.
Total Bytes: 70 (83 when include header and <CR><LF>		

VTB: Speed Output

$PASHS,RAW,VTB,A,ON

This command enables or disables the short binary speed output (VTB) message, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,VTB,[c1]

This command allows you to query for raw position data.

c1 is the optional port designator for the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,VTB

The PBN message contains raw position data, including the time at which the data was received, antenna position, antenna velocity, receiver clock offset, and PDOP. The message is output in the format:

```
$PASHR,VTB,<binary structure>Checksum>
```

Table 6.22 outlines the message format.

Table 6.22. VTB Data String

Field	Bytes	Content
unsigned short	2	Speed over ground in knots as unsigned short integer (16 Bit) with resolution of 0.01 knots. Range 0.00 to 655.35 knots.
unsigned short	2	Course over ground reference to true north as unsigned short integer (16 bytes) with resolution of 0.01 degree (range 0.00 to 359.99 degrees.
Unsigned char	1	Mode indicator as in $GPVTG.
Unsigned char	1	Checksum – a bytewise exclusive OR (XOR) on all bytes in binary structure starting from SOG and to the byte before the checksum.

XYZ: 3D Satellite Positions

$PASHS,RAW,XYZ,c1,s2,[f1]

This command enables or disables the 3-dimensional satellites position messages, where c1 is port A, B or C (optional port), s2 is ON or OFF, and f1 is the optional numeric output interval setting supporting a range of 0.05 to 999 seconds, depending on the measurement update rate option installed.

$PASHQ,XYZ,c1

This command allows you to query the three-dimensional position for each tracked satellite, where c1 is the optional output serial port. If a port is not specified, the receiver sends the response to the current port.

$PASHR,XYZ

In addition to satellite positions, the XYZ message also contains the time at which the satellite signals were received and a pseudo-range value which has been corrected to eliminate atmospheric delays and uncertainties resulting from the differences in velocity between the DG14 and the satellites (relativistic errors).

The XYZ message is output in the format below:

```
$PASHR,XYZ<Satellite position data string + checksum>
```

Table 6.23 outlines the response message.

Table 6.23. XYZ Data String

Field	Bytes	Content
long [RcvTime]	4	Time at which the signal was received in milliseconds of the week referenced to GPS system time, or milliseconds of the day referenced to GLONASS system time. This time tag is used as a reference for all time and position measurements.
short [Total Satellites]	2	The total number of satellites appearing in the message.
short [sv_1]	2	The PRN number of the satellite (1 - 56) being tracked on channel 1 of the DG14.
double [satx_1]	8	The x coordinate of the satellite being tracking on channel 1 of the DG14; referenced to WGS-84.
double [saty_1]	8	The y coordinate of the satellite being tracking on channel 1 of the DG14; referenced to WGS-84.
double [satz_1]	8	The z coordinate of the satellite being tracking on channel 1 of the DG14; referenced to WGS-84.
double [range_1]	8	The corrected pseudo-range of the satellite referenced in [sv_1].
(These rows are repeated for each channel that is tracking a satellite. That is, if the DG14 is tracking seven satellites, these rows are repeated seven times; if the DG14 is tracking twelve satellites, these rows are repeated twelve times.)		
short [sv_n]	2	The PRN number of the satellite (1 - 56) being tracked on channel *n* of the DG14.
double [satx_n]	8	The x coordinate of the satellite being tracking on channel *n* of the DG14; referenced to WGS-84.
double [saty_n]	8	The y coordinate of the satellite being tracking on channel *n* of the DG14; referenced to WGS-84.
double [satz_n]	8	The z coordinate of the satellite being tracking on channel *n* of the DG14; referenced to WGS-84.
double [range_n]	8	The corrected pseudo-range of the satellite referenced in [sv_n].
checksum	2	The checksum is computed by breaking the structure into unsigned shorts, adding them together, and taking the least significant 16 bits of the result.
Total bytes: minimum = 42; maximum = 416		

7

NMEA Commands

NMEA commands allow you to set parameters for outputting NMEA messages and Ashtech format NMEA-style messages. These commands can be sent to the DG14 through either serial port. Table 7.1 lists the set and query commands used in controlling NMEA message output. All NMEA messages and Ashtech format NMEA-style messages are disabled for output by default.

Table 7.1. NMEA Data Message Commands

	Command	Description	Default	Page
General Command for Controlling NMEA output	$PASHS,NME,ALL	Enable or disable all messages		200
	$PASHS,NME	Enable or disable one or more NMEA message		132
Latency Information	$PASHS,NME,LTN	Enable or disable the latency message		231
	$PASHQ,LTN	Query position output latency		232
Differential Information	$PASHS,NME,MSG	Enable or disable base station message		233
	$PASHQ,MSG	Query base station status messages		233
	$PASHS,NME,TCM	Enable or disable RTCM rover status		256
	$PASHQ,TCM	Query RTCM rover station status		256
Output Rate Parameter	$PASHS,NME,PER	Set send interval of NMEA response message		245
Photogrammetry	$PASHR,TTT	Photogrammetry message		258
Almanac Information	$PASHS,NME,ALM	Enable or disable almanac message		204
	$PASHQ,ALM	Query almanac message		204

Table 7.1. NMEA Data Message Commands (Continued)

	Command	Description	Default	Page
Position Information	$PASHS,NME,DTM	Enable or disable Datum Reference offsets		207
	$PASHQ,DTM	Query Datum Reference offsets		208
	$PASHS,NME,GGA	Enable or disable 3-D position response message	FUL	211
	$PASHQ,GGA	Query 3-D position message		211
	$PASHS,NME,GLL	Enable or disable latitude/longitude message		213
	$PASHQ,GLL	Query latitude/longitude message		213
	$PASHS,NME,GXP	Enable or disable horizontal position message		227
	$PASHQ,GXP	Query horizontal position message		227
	$PASHQ,GNS	Query GNSS fix data		215
	$PASHS,NME,GNS	Enable or disable GNSS fix data		215
	$PASHS,NME,POS	Enable or disable NMEA position response message		245
	$PASHS,NME,RMC	Enable or disable minimum position, course/speed message		249
	$PASHQ,RMC	Query for minimum position, course/speed message		249
	$PASHS,AIM	Enable/disable the RAIM feature		200
	$PASHs,NME,HPL	Enable or disable the HPL message		229
	$PASHS,NME,CRT	Enable or disable Cartesian coordinates message		206
	$PASHQ,CRT	Query Cartesian coordinates message		206
	$PASHS,NME,GDC	Enable or disable Grid coordinates message		208
	$PASHQ,GDC	Query Grid coordinates message		209
	$PASHS,NME,UTM	Enable or disable Universal Transverse Mercator (UTM) coordinates message		260
	$PASHQ,UTM	Query Universal Transverse Mercator (UTM) coordinates message		260

Table 7.1. NMEA Data Message Commands (Continued)

	Command	Description	Default	Page
Time and Date	$PASHS,NME,PTT	Enable or disable pulse time tag message		251
	$PASHQ,PTT	Query pulse time tag information		251
	$PASHS,NME,ZDA	Enable or disable time and date message		265
	$PASHQ,ZDA	Query time and date information		266
Course and Speed	$PASHS,NME,VTG	Enable or disable velocity/course message		262
	$PASHQ,VTG	Query velocity and course information		263
Residual Information	$PASHS,NME,RRE	Enable or disable satellite residual and position error		251
	$PASHQ,RRE	Query satellite residual and position error information		251
	$PASHS,NME,GRS	Enable or disable satellite range residual information message		216
	$PASHQ,GRS	Query satellite range residual information message		217
	$PASHS,NME,GST	Enable or disable pseudo-range error message		222
	$PASHQ,GST	Query pseudo-range error message		223
Satellite Information	$PASHS,NME,GSA	Enable or disable satellites used message		218
	$PASHQ,GSA	Query satellites used message		218
	$PASHS,NME,GSN	Enable or disable signal strength and satellite number message		220
	$PASHQ,GSN	Query signal strength and satellite number message		221
	$PASHS,NME,GSV	Enable or disable satellites in view message		224
	$PASHQ,GSV	Query satellites in view message		225
	$PASHS,NME,SAT	Enable or disable satellite status message		253
	$PASHQ,SAT	Query satellite status message		253
UKOOA Message	$PASHS,NME,UKO	Enable or disable UKOOA message		259
	$PASHQ,UKO	Query OKOOA information		259

Table 7.1. NMEA Data Message Commands (Continued)

	Command	Description	Default	Page
RAIM - HLP	$PASHS,AIM	Enables/disables RAIM feature		200
	$PASHS,NME,AIM	Enables/disables RAIM message		201
	$PASHQ,AIM	Queries RAIM message		202
	$PASHR,AIM	Response to query in ASCII format		203
	$PASHS,NME,HPL	Enables/disables HPL feature		229
	$PASHQ,HPL	Queries HPL message		230
	$PASHR,HPL	Response to query in ASCII format		231
Exception Message	$PASHS,NME,XMG	Enable or disable exception message		264
	$PASHQ,UKO	Query exception message information		264

Note: The SUD message is undocumented and for internal use only.

The general format for the set commands used to control the NMEA message output is as follows:

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

In this context, set commands are used to enable the output of NMEA messages at regular intervals or to disable message output, where s1 is a three character message identifier (GGA, VTG, SAT, etc.). c1 is the port designator (A or B) for message output. s3 is ON or OFF. f4 is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Query commands prompt the receiver to output the corresponding response message once only. Message output prompted by a query command occurs independently of any related message output settings.

To enable the output of the POS message on port A at five second intervals, enter the following command:

$PASHS,NME,POS,A,ON,5

To disable the output of the GGA message on port B, enter the following command:

$PASHS,NME,GGA,B,OFF

To query for the POS message and designate port B for the output of the response message, enter the following command:

$PASHQ,POS,B

As with the other query commands, the port designator (B) is optional. If a port is not specified, the receiver sends the response to the current port.

Message Structure

Standard NMEA messages are output as a string of ASCII characters delimited by commas, in compliance with NMEA 0183 Standards (version 3.0). Ashtech format NMEA-style messages are also output in a comma-delimited string of ASCII characters, but may deviate slightly from NMEA standards. For example, the maximum length of a standard NMEA message is eighty characters, but the length of some Ashtech format messages are variable (i.e., SAT) and may go beyond eighty characters. Both NMEA messages and Ashtech format NMEA-style messages begin with a dollar sign ($) and end with a Carriage Return/Line Feed **<CR><LF>** delimiter. Any combination of these messages can be output through different ports at the same time. The output rate can be set to any value between 0.05 and 999 seconds. The default output interval is one second.

Standard NMEA messages have the following structure:

```
HEADER,DATA*CHECKSUM<CR><LF>
```

The comma after the header is followed by the ASCII data string and the message checksum. The checksum is separated from the data string by an asterisk. Both standard and non-standard NMEA messages use a dollar sign ($) to indicate the beginning of a message, and both types are terminated with a <CR><LF> delimiter. GGA, which is a standard NMEA message:

```
$GPGGA,DATA*CHECKSUM<CR><LF>
```

The structure of non-standard NMEA messages:

```
HEADER,MESSAGE ID,DATA*CHECKSUM<CR><LF>
```

Standard NMEA messages include the message identifier in the header. Non-standard messages, which have an Ashtech format, have the message identifier in a separate field. SAT, a non-standard message:

```
$PASHR,SAT,DATA*CHECKSUM<CR><LF>
```

The data types that appear in NMEA messages can be integers, real numbers (decimal), hexadecimal numbers, alphabetic characters, and alphanumeric character strings.

Data items are separated by commas; successive commas indicate data not available. Two successive commas indicate one missing data item; three successive commas indicate two missing items.

See the *NMEA 0183 Standard for Interfacing Marine Electronic Navigational Devices* for more details on protocols and message formats.

NME: Enable/Disable All NMEA Messages

$PASHS,NME,ALL,x,OFF

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

Example

Enter the following command to disable all NMEA messages for Port A.

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

Enter the following command to disable all NMEA messages for Port B.

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

You must enter both of the above commands to disable the output of all messages from both ports.

At 10 Hz output rate, a baud rate of 115,000 bps is required to output all the NMEA messages. At greater output rates, the raw data must be split between the two serial ports, or some of the messages should be turned off. To receive data at high baud rates (e.g., 115,000), ensure that the computer has a suitable serial I/O capability. Most newer computers with Pentium or 486 processors have good enough serial communication to support high data rates.

AIM Command

The $PASHS,AIM command is used to enable/disable the RAIM feature and also to select a pre-defined or user-set alarm limit.

The [I] option is needed to use this command. If the RAIM option is not installed, then the AIM command will have no effect.

Format: $PASHS,AIM,s<CR><LF>

Where s is:

OFF - Disables RAIM. In this case, the FDE algorithm is turned OFF but HPL is still computed.
NPA - Non-precision approach, alarm limit is 0.030 NM
TER - Terminal, alarm limit is 1.00 NM
ERT - En route, alarm limit is 2.00 NM
x.x - User-defined alarm limit, x.x can be any value between 0.015 and 1000.00 NM.

The RAIM setting currently used by the receiver should be indicated in the response to $PASHQ,PAR. The default RAIM setting is OFF. The RAIM setting should be kept in BBU memory along with other settings.

AIM Message

$PASHS,NME,AIM

This command allows you to enable or disable the RAIM message.

Format

$PASHS,NME,AIM,x,s<CR><LF>

Where:

Parameter	Description
x	Identifier of the serial port through which the RAIM message will be output: A - Port A B - Port B C - Port C
s	Ouput control: 0N - Enables RAIM message to be output OFF - Disables RAIM message

Return Message

After you send the $PASHS,NME,AIM command, one of the following two messages will be returned, depending on whether the command could be processed or not:

$PASHR,ACK*3D: The command was successfully processed

$PASHR,NAK*30: The command failed.

Note

If the output is set without a period, the period set by the $PASHS,NME,PER command is used. If a $PASHS,NME,PER command is sent after individual NMEA message output periods were set, the previous individual message period is superseded by the latest NME,PER value.

Example

The following command will enable the RAIM message on port B:

$PASHS,NME,AIM,B,ON

$PASHQ,AIM

This command allows you to output the RAIM message.

Format

$PASHQ,AIM,[c]<CR><LF>

Where:

Parameters	Description
c	Identifier of the serial port through which the RAIM message will be output: A - Port A B - Port B C - Port C

In response to this command, the RAIM message is delivered on the specified port. The RAIM message in in the form $PASHR,RAIM,... <CR><LF>. This message is detailed below.

$PASHR,AIM

This is the RAIM message, in ASCII format, that is output in response to the set or query command described above.

Format

$PASHR,AIM,s1,d1,n(d2-d3)*cc

Where:

Parameters	Description
s1	Current RAIM mode (3 characters or digits): OFF - Turns RAIM off NPA - Non-precision approach, alarm limit is 0.030 NM TER - Terminal, alarm limit is 1.00 NM ERT - En route, alarm limit is 2.00 NM n.nn - User-selectable alarm limit between 0.015 and 1.00 NM
d1	RAIM value, i.e. one of the possible 4 figures: 0 - No errors detected 1 - Error detected and corrected 2 - Error detected, correction not possible 3 - Detection not available (lack of satellite or poor geometry) 4 - Error detected, rest of satellite set not available.
n(d2-d3)	Each d2-d3 represents a pair of excluded channel and its corresponding satellite, where d2 is the number of the excluded channel and d3 is the number of corresponding satellite. Depending on the number of excluded channels, there may be a certain number (*n*) of "d2-d3" pairs in the RAIM message
*cc	Checksum

Example

$PASHR,AIM,NPA,1,10-12,05-20*FF

Where:

NPA - Non-precision approach mode
1 - Error detected and corrected
10-12 - Channel 10, satellite 12 excluded
05-20 - Channel 5, satellite 20 excluded

More about the RAIM value

If d1=0 in the RAIM message, this means none of the detected errors exceeds the alarm limit. All computed satellite ranges are used in the position velocity calculation.

If d1=1, RAIM has detected errors, has excluded satellites with large range errors and corrected the position and velocity. If the number of channel-satellite pairs is not greater than 1, the corrected position and velocities are acceptable for applications requiring 0.999 probability. If the number of channel-satellite pairs is greater than 1, there is no assurance that the positions and velocities have been properly corrected. However, in many cases, RAIM corrects the results satisfactorily, even in adverse conditions.

If d1=2, RAIM has detected a problem but cannot eliminate the questionable satellites because of too few satellites (e.g. 5 satellites in view). In this case, the computed data (position and velocity) does not meet the 0.999 probability.

If d1=3, the satellite geometry is poor and detection is unavailable. This value is returned whenever the number of satellites is less than 5.

Finally, if d1=4, RAIM indicates that errors do exist (the message contains channel-satellite pairs), but it fails to correct positions and velocities. In such cases, you can exclude questionable satellites by using the $PASHS,USE or $PASHS,SVS commands.

When RAIM rejects a satellite from the position solution, the satellite should be marked with the letter "R" in SAT messages when SUI=ON.

ALM: Almanac Message

$PASHS,NME,ALM,c,s

This command enables or disables the almanac message where c is the receiver serial port (A, B, or C) and s is ON or OFF.

Example

Enter the following command to enable ALM message on port C

$PASHS,NME,ALM,C,ON

$PASHQ,ALM,c

Query the almanac message, where c is the optional output port.

$GPALM

There is one response message for each satellite in the GPS constellation. The length of the message is calculated by the characters, in halves of bytes, not full bytes. The response to the set or query command is in the form:

```
$GPALM,d1,d2,d3,d4,h5,h6,h7,h8,h9,h10,h11,h12,h13,h14,
h15*cc <Enter>
```

Table 7.2. ALM Response Message

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. Eccentricity (In ASCII Hex)	4 bytes
h7	toe. Almanac reference time (seconds. In ASCII Hex)	2 bytes
h8	Io. Inclination angle (semicircles. In ASCII Hex)	4 bytes
h9	OMEGADOT. Rate of ascension (semicircles/sec. In ASCII Hex)	4 bytes
h10	A½. Square Root of semi-major axis (Meters & ½ In ASCII Hex)	6 bytes
h11	ω. Argument of perigee (semicircle. In ASCII Hex)	6 bytes
h12	OMEGA0. Longitude of ascension mode (semicircle. In ASCII Hex)	6 bytes
h13	Mo. Mean anomaly (semicircle. In ASCII Hex)	6 bytes
h14	afo. Clock parameter (seconds. In ASCII Hex)	3 bytes
h15	af1. Clock parameter (sec/sec. In ASCII Hex)	3 bytes
*cc	Checksum	

Typical Response message:

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

Table 7.3. Typical ALM Response Message

Item	Significance
$GPALM	Header
26	Total number of messages
01	Number of this message
01	Satellite PRN Number
0899	GPS week number
00	Satellite Health

Table 7.3. Typical ALM Response Message (Continued)

Item	Significance
1E8C	Eccentricity
24	Almanac Reference Time
080B	Inclination angle
FD49	Rate of ascension
A10D58	Root of semi-major axis
EB4562	Argument of perigree
BFEF85	Longitude of ascension mode
227A5B	Mean anomaly
011	Clock parameter
000	Clock parameter
*0B	checksum

CRT: Cartesian Coordinates Message

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

This command outputs the computed Cartesian coordinates and velocities. Enable or disable the NMEA position response message on output port x, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

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

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,CRT,x

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

$PASHR,CRT

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

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

Table 7.4 outlines the message format.

Table 7.4. $PASHR,CRT Message Format

Parameter	Description	Range
d1	position solution type: 0 = autonomous 1 = position differentially corrected with RTCM code 2 = position differentially corrected with CPD float solution 3 = position is CPD fixed solution	0 to 3
d2	Number of satellites used in position computation	3 to 12
m1	Current UTS time, (hhmmss), of position computation in hours, minutes, and seconds	00 to 235959.50
m2	Antenna position ECEF x coordinate in meters	
m3	Antenna position ECEF y coordinate in meters	
m4	Antenna position ECEF z coordinate in meters	
f2	Receiver clock offset in meters	
f3	X-component of velocity vector in m/s	
f4	Y-component of velocity vector in m/s	
f5	Z-component of velocity vector in m/s	
f6	Receiver clock drift in m/s	
f7	PDOP—position dilution of precision	0 to 99.9
f8	HDOP—horizontal dilution of precision	0 to 99.9
f9	VDOP—vertical dilution of precision	0 to 99.9
f10	TDOP—time dilution of precision	0 to 99.9
s*cc	Firmware version ID	4 character string

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

DTM: Datum Reference

$PASHS,NME,DTM,x,c,(f)

This command outputs the local geodetic datum and datum offsets from a reference datum. This sentence is used to define the datum to which a position location, and geographic locations in subsequent sentences, is referenced. Latitude, longitude and altitude offset from the reference datum, and the selection of the reference datum, are also provided.

$PASHQ,DTM,(c1)

This command queries the local geodetic datum and datum offsets from a reference datum. The response in this format is:

```
$GPDTM,W84,,0.0000,N,0.0000,E,0.0000,W84*5F
```

Table 7.5 is in the format:

```
$GPDTM,m1,,m2,c1,m3,c2,m3,m4*hh
```

Table 7.5. $GPDTM Message Format

Parameter	Description	Range
m1	Local Datum code	WGS84=W84 WGS72=W72 SGS85=S85 PZ90=P90 User defined=999 IHO datum code Null if unknown
,,	Local Datum subdivision code	Always null
m2	Latitude offset, minutes	
c1	Latitude offset sector	N/S
m3	Longitude offset, minutes	
c2	Longitude offset sector	E/W
m3	Altitude offset, meters	
m4	Reference datum code	WGS84=W84 WGS72=W72 SGS85=S85 PZ90=P90
hh	Checksum	2-character hex

GDC: Grid Coordinates

$PASHS,NME,GDC,c1,s,[f]

This command enables or disables the $PASHR,GDC message. c1 is the port designator (A or B) for message output. s3 is ON or OFF. f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,GDC,[c1]

This command queries the current position according to the user-defined grid coordinate system selected through the UDG command, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. The response message does not output unless the following three conditions are met:

1. The receiver is computing positions.
2. A grid coordinate system has been selected through the UDG command.
3. The conversion from geodetic coordinates to the selected grid coordinate system has been enabled through the GRD command.

$PASHR.GDC

The response is in the format:

```
$PASHR,GDC,m1,s2,f3,f4,d5,d6,f7,f8,M,f9,M,d10,s11,s12*cc
```

Table 7.6 outline the message format:.

Table 7.6. GDC Message Structure

Parameter	Description	Range
m1	UTC of position in hours, minutes, and decimal seconds (hhmmss.ss)	000000.00 to 235959.90
s2	Map projection type	EMER, TM83, OM83, LC83, STER, LC27, Tm27, TA22
f3	Easting (x) of the user grid coordinate (meters)	-9999999.999 to +9999999.999
f4	Northing (y) of the user grid coordinate (meters)	-9999999.999 to +9999999.999
d5	Positioning mode Indicator • 1: Autonomous position • 2: RTCM differential, or CPD float position • 3: Carrier Phase differential (CPD) fixed	1, 2, 3
d6	Number of GPS satellites being used	3 to 12
f7	Horizontal Dilution of Position (HDOP)	00.0 to 99.9
f8	Altitude (meters)	-9999999.999 to +9999999.999

Table 7.6. GDC Message Structure (Continued)

Parameter	Description	Range
M	Altitude units	M(eters)
f9	Geoidal separation in meters w.r.t. selected datum and Geoid Model	-999.999 to +999.999
d10	Age of differential corrections	0 to 999
s11	Differential reference station ID	0000 to 1023
s12	Datum type	W84, USR
*hh	Checksum	2-character hex

Typical GDC Message:

```
$PASHR,GDC,015454.00,EMER,588757.623,4136720.056,2,04,03.8,0001
2.123,M,-031.711,M,14,1010,W84*2A
```

Table 7.6 outline the message format:

Table 7.7. Typical GDC Message

Item	Description
015454.00	UTC time
EMER	Equatorial Mercator map projection
588757.623	User Grid easting (X) coordinate
4136720.056	User Grid northing (Y) coordinate
2	RTCM differential position
04	Number of satellites used to compute position
03.8	HDOP
00012.123	Altitude
M	Altitude units (M = meters)
-031.711	geoidal separation w.r.t. selected datum
M	geoidal separation units (M = meters)
014	age of corrections
1010	Differential Station ID
W84	Reference datum is WGS 84
2A	checksum

GGA: 3-D GPS Position

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

Enable or disable NMEA GPS position response message on port x, where x is the output port A, B, or C. s is ON or OFF. f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,GGA,c1

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

$GPGGA

This message is not output unless positions are being computed. In addition to a 3-D position (latitude/longitude/altitude), the GGA message contains information on the type of position fix (i.e., autonomous or differentially corrected), HDOP, and current time. The DG14 can be set to output the GGA message at regular intervals by using the command $PASHS,NME. The message is output in the format:

```
$GPGGA,m1,m2,c3,m4,c5,d6,d7,d8,f9,c10,d11,c12,d13,d14*hh
```

Table 7.8 outlines the message format.

Table 7.8. $GPGGA Message Format

Parameter	Description	Range (STD)
m1	UTC time (hhmmss.s) of the position fix	0 to 235959.99
m2	Latitude of the position fix (ddmm.mmmmm)	0 to 9000.00000
c3	Latitude sector	N or S
m4	Longitude of the position fix (dddmm.mmmmm)	0 to 18000.00000
c5	Longitude sector	E or W

Table 7.8. $GPGGA Message Format (Continued)

Parameter	Description	Range (STD)
d6	GPS quality indicator • 0—Invalid position or position not available • 1—GPS Standard Positioning Service (SPS) mode (C/A code), fix valid • 2—Differential GPS, SPS mode, fix valid • 3—GPS Precise Positioning Service (PPS) mode (P-code). N/A for DG14 • 4—Real Time Kinematic. System used in RTK mode with fixed integers. N/A for DG14 • 5—Float RTK. Satellite system used in RTK mode, floating integers. N/A for DG14 • 6—Estimated (dead reckoning) mode • 7—Manual input mode • 8—Simulator mode	0, 1, 2, 6, 7, or 8
d7	Number of satellites used in position computation	3 to 14
d8	HDOP (horizontal dilution of precision)	00.0 to 99.9
f9	Altitude above Mean Sea Level (geoidal height)	-1000.00 to 18000.00
c10	Altitude unit of measure (always M)	M
d11	Geoidal separation value	-999.99 to 999.99
c12	Geoidal separation unit of measure (always M)	M
d13	Age of differential corrections (seconds)	0 to 99
d14	Differential base station ID number	0 to 1023
hh	Checksum	

Typical GGA message:

```
$GPGGA,183805.50,3722.36223,N,12159.82741,W,2,7,2.8, 16.12,M,-
31.24,M,005,0001 *6F
```

Table 7.9 outlines the response message.

Table 7.9. Typical GGA Message

Item	Description
$GPGGA	Header
183805.50	Time of position fix
3722.36223	Latitude
N	North

Table 7.9. Typical GGA Message (Continued)

Item	Description
12159.82741	Longitude
W	West
2	Differential corrections applied to position fix
7	Number of satellites used in position computation
2.8	HDOP
+00016.12	Altitude
M	Altitude unit of measure (meters)
-31.24	Geoidal separation value
M	Geoidal separation unit of measure (meters)
005	Age of differential corrections
0001	Base station ID number
6F	Checksum

GLL: 2-D Position

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

Enable or disable NMEA latitude/longitude response message on port x, where x is the output port, s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable GLL message on port A.

   $PASHS,NME,GLL,A,ON

$PASHQ,GLL,[c1]

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

$GPGLL

This message is not output unless position is computed. The GLL message contains a 2-D position (latitude/longitude only) and time of position fix. The DG14 can be set to output the GLL message at regular intervals by using the command $PASHS,NME. The message is output in the format:

```
$GPGLL,m1,c2,m3,c4,m5,c6,d7*hh
```

Table 7.10 outlines the message format.

Table 7.10. $GPGLL Message Format

Parameter	Description	Range
m1	Latitude of the position fix (ddmm.mmmmm)	0° to 90°
c2	Latitude sector	N—North S—South
m3	Longitude of the position fix (dddmm.mmmmm)	0° to 180°
c4	Longitude sector	E—East W—West
m5	UTC time (hhmmss.ss) of the position fix	000000.00 to 235959.90
c6	Status of the position fix (always A): • A—Valid • V—Invalid	A, V
d7	Positioning system mode indicator • A—Autonomous mode • D—Differential mode • E—Estimated (dead reckoning) mode • M—Manual input mode • S—Simulator mode • N—Data not valid	A, D, E, M, S, or N
hh	Checksum	2-character hex

Typical GLL message:

```
$GPGLL,3722.36223,N,12159.82741,W,170003.00,A,A*7F
```

Table 7.11 outlines the response message.

Table 7.11. Typical GLL Message

Item	Description
$GPGLL	Header
3722.36223	Latitude

Table 7.11. Typical GLL Message (Continued)

Item	Description
N	North
12159.82741	Longitude
W	West
170003.00	UTC of position fix
A	Valid position fix
A	Autonomous mode
7F	Checksum.

GNS: GNSS Fix Data

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

Enable or disable fix data for single or combined satellite navigation systems (GNSS) response message to port x, where x is the output port, and s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable GNS message on port B.

  $PASHS,NME,GNS,B,ON

$PASHQ,GNS,[c1]

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

$GPGNS

The response is in the format

```
GPGNS,m1,m2,c3,m4,c5,d6,d7,d8,f9,f10,f11,d12*cc
```

Table 7.12 outlines the message format.

Table 7.12. $GPGNS Message Format

Parameter	Description	Range
m1	UTC (hhmmss.ss)	0 to 235959.99
m2	Latitude (ddmm.mmmmmm	0 to 9000.000000
c3	Latitude sector	N—North S—South
m4	Longitude (dddmm.mmmmmm)	0 to 18000.000000
c5	Longitude sector	E—East W—West
d6	Positioning system mode indicator (one character for GPS, one character for GLONASS) • A—Autonomous mode • D—Differential mode • P—Precise. No SA and P-code • R—Fixed RTK (N/A) • F—Float RTK (N/A) • N—No fix	NN, AA, DD, RR, FF, PP
d7	Total number of satellites used in the computation	0 to 99
d8	HDOP	0.0 to 9.9
f9	Geoidal height (altitude above MSL) in meters	-1000.0 to 18000.0
f10	Geoidal separation in meters	-99.9 to 99.9
f11	Age of differential corrections	0 to 999
d12	Base station ID	0 to 1023
*cc	Checksum	2-character hex

GRS: Satellite Range Residuals

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

Enable or disable NMEA satellite range residual response message to port x, where x is the output port, and s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The receiver does not output this message if a position is not computed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable GRS message on port B.

  $PASHS,NME,GRS,B,ON

$PASHQ,GRS,[c1]

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

$GPGRS

The GRS message contains current time, an indicator for the mode used to calculate the residual error in the satellite pseudo-range, and the residual error values for each locked satellite. The order in which the residual error values are listed corresponds to the order in which the satellites are listed in the GSA message. A minus sign (-) in front of the residual error value indicates a Residual pseudo-range error is not calculated until at least five satellites are being used to compute positions. The response is output in the format:

  `$GPGRS,m1,d2,(f3*n)*hh`

Table 7.13 outlines the message format.

Table 7.13. $GPGRS Message Format

Parameter	Description	Range
m1	Current UTC time (hhmmss.ss) as taken from the GGA message	000000.00 to 235959.90
d2	Mode used to calculate residual errors in the pseudo-range measurement (always 1): • 0—Residual error values are calculated at the same time the GGA position is computed • 1—Residual error values are recalculated after the GGA position is computed	0, 1
f3*n	Pseudo-range residual error value. This field is repeated for each satellite used in position computation, where f3 is the calculated error value and n is the number of satellites ($\leq$ 5) used in computing positions. The order in which the error values are listed matches the order in which the satellites are listed in the GSA message	-999.9 to 999.9
*hh	Checksum	2-character hex

Typical GRS message:

```
$GPGRS,180257.50,1,019.3,004.6,-009.3,-005.6,-004.5,005.4*49
```

Table 7.14 outlines the response message.

Table 7.14. Typical GRS Message

Field	Description
$GPGRS	Header
180257.50	UTC time of position fix
1	Pseudo-range residual error calculation mode
019.3	Range residual for first satellite in GSA message
004.6	Range residual for second satellite in GSA message
-009.3	Range residual for third satellite in GSA message
-005.6	Range residual for fourth satellite in GSA message
-004.5	Range residual for fifth satellite in GSA message
005.4	Range residual for sixth satellite in GSA message
*49	Checksum

GSA: DOP and Active Satellites

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

Enable or disable DOP and active satellite message to be sent out to the serial port, where x is the output port, and s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The receiver does not output this message if a position is not computed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable GSA message on port B.

$PASHS,NME,GSA,B,ON

$PASHQ,GSA,[c1]

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

$GPGSA

The GSA message contains indicators for current position mode (see the **$PASHS,PMD** command on page 110), a list of the satellites being used to compute position, and the values for PDOP, HDOP, and VDOP. This message is not output until positions are being computed. The response is output in the format:

```
$GPGSA,c1,d2,d3,d4,d5,d6,d7,d8,d9,d10,d11,d12,d13,d14,d15,d16,d
17*hh
```

Table 7.15 outlines the message format.

Table 7.15. $GPGSA Message Format

Parameter	Significance	
c1	Position mode indicator: • A—Automatic mode • M—Manual mode	A, M
d1	Position mode indicator: • 1— Position fix not available • 2—2D mode • 3—3D mode	1, 2, 3
d3-d16	These 14 fields represent the receiver's 14 channels listed in ascending order. The number 17 appearing in field d5 indicates that DG14 channel 3 is locked on satellite 17. If a given channel is not locked on a satellite, the corresponding field will be empty. SBAS satellites are indicated with numbers from 33 to 64.	1 to 64
d15	Current PDOP value	0 to 99.9
d16	Current HDOP value	0 to 99.9
d17	Current VDOP value	0 to 99.9
hh	Checksum	2-character hex

Typical GSA message:

```
$GPGSA,A,3,31,29,23,26,,21,17,09,08,,03,,01.7,01.0,01.4*0B
```

Table 7.16 outlines the response message.

Table 7.16. Typical $GPGSA Message

Field	Description
$GPGSA	Header
A	Indicates automatic 2-D/3-D switching mode
3	Indicates 3D position mode

Table 7.16. Typical $GPGSA Message (Continued)

Field	Description
31	DG14 channel 1 locked on satellite 31; satellite 31 used in position computations
29	DG14 channel 2 locked on satellite 29; satellite 29 used in position computations
23	DG14 channel 3 locked on satellite 23; satellite 23 used in position computations
26	DG14 channel 4 locked on satellite 26; satellite 26 used in position computations
empty field	Indicates that this channel (5) is not locked on a satellite or that the locked satellite is not being used in position computations
21	DG14 channel 6 locked on satellite 21; satellite 21 used in position computations
17	DG14 channel 7 locked on satellite 17; satellite 17 used in position computations
09	DG14 channel 8 locked on satellite 09; satellite 09 used in position computations
08	DG14 channel 9 locked on satellite 08; satellite 08 used in position computations
empty field	Indicates that this channel (10) is not locked on a satellite or that the locked satellite is not being used in position computations
03	DG14 channel 11 locked on satellite 03; satellite 03 used in position computations
empty field	Indicates that this channel (12) is not locked on a satellite or that the locked satellite is not being used in position computation
01.8	Current PDOP value
01.0	Current HDOP value
01.5	Current VDOP value
*0B	Checksum

GSN: Satellite PRN Number and Signal Strength

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

Enable or disable the signal strength/satellite number response message on port x, where x is the output port, and s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The receiver does not output this message if a position is not computed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable GSN message on port B.

$PASHS,NME,GSN,B,ON

$PASHQ,GSN,[c1]

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

$GPGSN

This message is not output until the receiver has locked on at least one satellite. The first data field in the GSN message contains the number of satellites currently being used to compute positions, followed by two fields containing a satellite PRN number and the measured (dbHz) signal to noise ratio for that satellite. The last field before the checksum contains the age of correction for differential GPS. Generally speaking, the receiver will be able to lock more quickly, and will be better able to maintain lock, on satellites whose signals register higher signal to noise values. The response is output in the format:

```
$GPGSN,d1,((d2,d3)*d1),d4*hh
```

The fields containing the PRN number (d2) and the signal to noise ratio (d3) are repeated for each locked satellite, with the d1 value used as a multiplier.

Table 7.17. $GPGSN Message Format

Parameter	Description	Range
d1	Number of satellites currently locked	0 to 14
d2	Satellite PRN number	01 to 32 for GPS 33 to 64 for SBAS
d3	Signal to noise ratio for the corresponding satellite	000 to 999
d4	Age of differential correction. The number 999 is registered in this field when the DG14 is set in differential rover mode but is not receiving corrections or when differential GPS is disabled.	1 to 999
*hh	Checksum	2-character hex

Typical GSN message:

```
$GPGSN,07,01,048,29,046,25,048,08,040,31,037,15,048,21,046,
999*4F
```

Table 7.18 outlines the response message.

Table 7.18. Typical GSN Message

Field	Description
$GPGSN	Header
07	Number of satellites currently locked
01	PRN number of the first satellite
048	Signal strength of the first satellite
29	PRN number of the second satellite
046	Signal strength of the second satellite
25	PRN number of the third satellite
048	Signal strength of the third satellite
08	PRN number of the fourth satellite
040	Signal strength of the fourth satellite
31	PRN number of the fifth satellite
037	Signal strength of the fifth satellite
15	PRN number of the sixth satellite
048	Signal strength of the sixth satellite
21	PRN number of the seventh satellite
046	Signal strength of the seventh satellite
999	Indicates that the DG14 is unable to receive differential corrections or differential GPS is disabled
*4F	Checksum

GST: Pseudo-Range Error Statistics

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

Enables/disables the GST message where x is the serial port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The GST message provides a real time estimate (1 sigma) of the position error. The receiver does not output this message if a position is not computed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable GST message on port B.

$PASHS,NME,GST,B,ON

$PASHQ,GST,[c1]

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

$GPGST

The GST message contains UTC time, the RMS value of the standard deviation for satellite range measurements, and the corresponding standard deviation values for latitude, longitude, and altitude. The response is output in the format:

```
$GPGST,m1,f2,f3,f4,f5,f7,f8,f9*hh
```

Table 7.19 outlines the message format.

Table 7.19. $GPGST Message Format

Parameter	Description	Range
m1	UTC time (hhmmss.ss) of the position fix	000000.00 to 235959.95
f2	RMS value of the standard deviation of the satellite range inputs to the navigation processor. This field is related to remaining fields as follows: • (RMS value of standard deviation range inputs)^2* (HDOP)^2 = (Standard deviation of latitude error)^2 + (Standard deviation of longitude error)^2 • (RMS value of standard deviation of range inputs)^2* (VDOP)^2 = (Standard deviation of altitude error)^2	0.00 to 99.99
f3	Standard deviation of semi-major axis of error ellipse (meters).	0.00 to 99.99 (might be an empty field)
f4	Standard deviation of semi-minor axis of error ellipse (meters).	0.00 to 99.99 (might be an empty field)
f5	Orientation of semi-major axis of error ellipse (degrees from true north).	0.00 to 99.99 (might be an empty field)

Table 7.19. $GPGST Message Format

Parameter	Description	Range
f6	Standard deviation of latitude error (meters)	0.00 to 99.99
f7	Standard deviation of longitude error (meters)	0.00 to 99.99
f8	Standard deviation of altitude error (meters)	0.00 to 99.99
*hh	Checksum	2-character hex

Typical GST message:

```
$GPGST,182233.85,0.533,0.337,0.286,164.219,0.334,0.290,0.669*52
```

Table 7.20 outlines the response message.

Table 7.20. Typical GST Message

Field	Description
$GPGST	Header
182233.85	UTC time of the position fix
0.533	RMS value of the standard deviation of satellite range inputs (1sigma position error)
0.337	Standard deviation of semi-major axis of error ellipse (meters)
0.286	Standard deviation of semi-minor axis of error ellipse (meters)
164.219	Orientation of semi-major axis of error ellipse (degrees from true north)
0.334	Standard deviation of the latitude error (meters)
0.290	Standard deviation of the longitude error (meters)
0.669	Standard deviation of the altitude error (meters)
*52	Checksum

GSV: Satellites in View

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

This command allows you to enable or disable the GSV response message on the output port x, where c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,GSV,[c1]

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

$GPGSV

The GSV message contains the PRN number, elevation, azimuth, and signal to noise ration for each visible satellite. This message contains data for a maximum of four satellites. If seven satellites are visible, two GSV messages are output.

The total number of messages transmitted and the number of messages transmitted are indicated in the first two fields of the first message. The first three messages contain GPS satellite information and the second three messages contain GLONASS satellite information.

The message is output in the format:

```
$GPGSV,d1,d2,d3,d4,d5,d6,f7,d8,d9,d10,f11,d12,d13,d14,f15,d16,
d17,d18,f19*hh
```

Table 7.21 outlines the response message.

Table 7.21. $GPGSV Message Format

Parameter	Description	Range
d1	Total number of GSV messages to be output	1 to 9
d2	Message number	1 to 9
d3	Total number of satellites in view	1 to 14
d4	Satellite PRN number	1 to 32 for GPS 33 to 64 for SBAS
d5	Elevation (degrees)	0° to 90°
d6	Azimuth (degrees)	0° to 359°
f7	Signal to noise ration (dbHz)	30 to 60
d8	Satellite PRN number	1 to 32 for GPS 33 to 64 for SBAS
d9	Elevation (degrees)	0° to 90°
d10	Azimuth (degrees)	0° to 359°
f11	Signal to noise ration (dbHz)	30 to 60

Table 7.21. $GPGSV Message Format (Continued)

Parameter	Description	Range
d12	Satellite PRN number	1 to 32 for GPS 33 to 64 for SBAS
d13	Elevation (degrees)	0° to 90°
d14	Azimuth (degrees)	0° to 359°
f15	Signal to noise ration (dbHz)	30 to 60
d16	Satellite PRN number	1 to 32 for GPS 33 to 64 for SBAS
d17	Elevation (degrees)	0° to 90°
d18	Azimuth (degrees)	0° to 359°
f19	Signal to noise ration (dbHz)	30 to 60
*hh	Checksum	2-character hex

SBAS satellites numbers are actually 120 to 138, but are represented in the NMEA messages with numbers 33 to 64. The offset from NMEA SBAS satellite ID to SBAS satellite ID is 87. Add 87 to the satellite ID fields in the NMEA messages to derive the actual SBAS PRN number.

Typical GSV message:

```
$GPGSV,2,2,8,08,43,294,47,07,19,062,42,05,49,314,49,02,03,120,2
9 *45
```

Table 7.22 outlines the response message.

Table 7.22. Typical GSV Message

Field	Description
$GPGSV	Header
2	Indicates that two GSV messages will output
2	Indicates that this is the second message
8	Indicates that eight satellites are visible
08	Indicates PRN 8 is visible
43	Elevation of PRN 8
294	Azimuth of PRN 8
47	Signal to noise ration of PRN 8
07	Indicates PRN 7 is visible
19	Elevation of PRN 7

Table 7.22. Typical GSV Message (Continued)

Field	Description
062	Azimuth of PRN 7
42	Signal to noise ratio of PRN 7
05	Indicates PRN 5 is visible
49	Elevation of PRN 5
314	Azimuth of PRN 5
49	Signal to noise ration of PRN 5
02	Indicates PRN 2 is visible
03	Elevation of PRN 2
120	Azimuth of PRN 2
29	Signal to noise ration of PRN 2
*45	Checksum

GXP: Horizontal Position Message

$PASHS,NME,GXP,c,s

This command enables/disables the horizontal position message where c is either A, B, or C, and s is ON or OFF. If no position is computed, this message is output but the position related fields will be empty.

Example

Enter the following command to enable the horizontal position message on port C.

$PASHS,NME,GXP,C,ON

$PASHQ,GXP,c

This command queries horizontal position where c is the optional output serial port.

$GPGXP

The response message is in the form:

```
$GPGXP,m1,m2,c3,m4,c5*cc
```

where Table 7.23 outlines the response format.

Table 7.23. GXP Message Structure

Parameter	Description	Range
m1	UTC of fix in hours, minutes and seconds (hhmmss.ss)	00-235959.90
m2	Latitude in degrees and decimal minutes (ddmm.mmmmmm)	0 - 90.00
c3	Direction of latitude	N = North S = South
m4	Longitude in degrees and decimal minutes (dddmm.mmmmmm)	0 - 180.00
c5	Direction of longitude	E = East, W = West
cc	checksum	

Typical response message:

```
$GPGXP,212958.00,3722.396956,N,12159.849225,W*7A
```

Table 7.24 describes each item in a typical GXP message.

Table 7.24. Typical GXP Message

Item	Significance
$GPGXP	Header
212958.00	UTC time of position
3722.396956	Latitude
N	North Latitude
12159.849225	Longitude
W	West Longitude
*7A	checksum

HPL Command and Message

$PASHS,NME,HPL

This command allows you to enable or disable the HPL message.

The [I] option is needed to use this command. If the RAIM option is not installed, then the HLP command will have no effect.

Horizontal Protection Level (HPL) is defined as the radius of a circle in the horizontal plane, centered at the true aircraft position, that is assured to contain the indicated horizontal position, with a given probability of missed detection and false alert.

Format

$PASHS,NME,HPL,x,s<CR><LF>

Where:

Parameter	Description
x	Identifier of the serial port through which the HPL message will be output: A - Port A B - Port B C - Port C
s	Ouput control: 0N - Enables HPL message to be output OFF - Disables HPL message

Return Message

After you send the $PASHS,NME,HPL command, one of the following two messages will be returned, depending on whether the command could be processed or not:

$PASHR,ACK*3D: The command was successfully processed
$PASHR,NAK*30: The command failed.

Note

If the output is set without a period, the period set by the $PASHS,NME,PER command is used. If a $PASHS,NME,PER command is sent after individual NMEA message output periods were set, the previous individual message period is superseded by the latest NME,PER value.

Example

The following command will enable the HPL message on port B:

$PASHS,NME,HPL,B,ON

$PASHQ,HPL

This command allows you to output the HPL message.

Format

$PASHQ,AIM,[c]<CR><LF>

Where:

Parameters	Description
c	Identifier of the serial port through which the HPL message will be output: A - Port A B - Port B C - Port C

In response to this command, the HPL message is delivered on the specified port. The HPL message in in the form $PASHR,HPL,... <CR><LF>. This message is detailed below.

$PASHR,HPL

This is the HPL message, in ASCII format, that is output in response to the set or query command described above.

Format

$PASHR,HPL,t1,f2,d3*hh

Where:

Parameters	Description
t1	Current UTC time: Hours (0-23), Minutes (0-59), Seconds (0-59.99)
f2	HPL value in Nautical Miles (NM). Range: 0-... Blank (empty) field if HPL not computed.
d3	Number of satellites used in HPL computation (4-14) Blank (empty) field if HPL not computed.
*hh	The hexadecimal ckecksum 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 hex character (0-9 or A-F).

Note that any satellite found unhealthy and rejected from the position solution will ALSO be rejected from the HPL computation.

Examples

$PASHR,HPL,221546.00,0.056,8*FF

Where:

221546.00 - current time
0.056- HPL value in NM
8 - Number of satellites used to compute HPL

$PASHR,HPL,221546.00,,*FF

LTN: Position Output Latency

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

Enable or disable message containing latency information on port x, where x is the output port (A or B), s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

The receiver outputs this message even when a position is not computed.

Example

Enter the following command to enable the LTN output message on port B.

$PASHS,NME,LTN,B,ON

$PASHQ,LTN,[c1]

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

$PASHR,LTN

This single-field message is output even if a position is not computed. Latency is defined as the number of milliseconds it takes the receiver to compute a position (from the position fix tag time) and prepare data to be output through the serial port. The latency range is typically between 20 and 40 milliseconds, depending on the number of satellites tracked and the number of satellites used in the position solution. The response is output in the format:

```
$PASHR,LTN,d1*hh
```

Table 7.25 outlines the message format.

Table 7.25. $PASHR,LTN Message Format

Parameter	Description	Range
d1	Latency value (milliseconds)	0 to 99
*hh	Checksum	2-character hex

The more satellites used in the solution, and the more features employed will result in higher latency. Latency of 0 would be typical when no satellites are being tracked.

Typical LTN message:

```
$PASHR,LTN,29*05
```

Table 7.26 outlines the response message.

Table 7.26. $PASHQ,LTN Query Response

Field	Significance
$PASHR,LTN	Header
29	Latency value (milliseconds)
05	Checksum

MSG: Differential Base Station Data

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

Enable or disable message containing RTCM reference (base) station message types 01, 03, 09, 16, 18, and 19 on port x, where x is the output port, and s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

The DG14 ignores this command unless the it is sending or receiving differential corrections.

Example

Enter the following command to enable the MSG message on port A

$PASHS,NME,MSG,A,ON

$PASHQ,MSG,[c1]

This command queries the MSG message, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port. This command is ignored if the DG14 is not sending or receiving differential corrections.

$GPMSG

The MSG messages contain base station status data for incoming or outgoing RTCM messages. Fields containing base station ID number, current Z count, current GPS time, and base station health status are common to all MSG messages.

In addition to the foregoing data items, the MSG message generated for RTCM message type 1 also contains pseudo-range correction values (PRC), range rate correction values (RRC), ephemeris data (IODE), and user differential range error values (UDRE) referenced to the PRN number for each locked satellite. This message can be set for output in one second increments.

The MSG message generated for RTCM message type 2 includes UDRE and IODE data, but also contains delta pseudo-range corrections (delta PRC) and delta range rate corrections (delta RRC) for each locked satellite. This message can be set for output in one minute increments.

The MSG message generated for RTCM message type 3 contains the common data fields (station ID number, Z count, etc.), but also contains the X, Y, and Z components (earth-centered/earth-fixed; ECEF) of the base station's GPS coordinates. This message can set for output in one minute increments.

The MSG message generated for RTCM message type 6 contains the common data fields only. This message is typically used as "transmission fill" to assist in establishing and maintaining message frame synchronization. This message can be set for output in one second increments.

The MSG message generated for RTCM message type 9 is an abbreviated version of the MSG message for RTCM message type 1. It contains the common data fields, but contains PRC, RRC, UDRE, and IODE data for a maximum of three satellites per message. This message can be set for output in one second increments.

The MSG message generated for the RTCM type 16 message contains the common data fields and a text message of up to 90 characters, spaces included. The text in the type 16 message is entered through the command $PASHS,RTC,MSG. See the next section, RTCM Commands, for more information on set commands for differential operation.

MSG Formats

The MSG format for RTCM message type 1 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,n*(d8,d9,f10,f11,d12)*hh
```

The MSG format for RTCM message type 2 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,n*(d8,d9,f10,f11,d12)*hh
```

The MSG format for RTCM message type 3 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,f8,f9,f10*hh
```

The MSG format for RTCM message type 6 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7*hh
```

The MSG format for RTCM message type 9 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,(3*(d8,d9,f10,f11,d12))*hh
```

The MSG format for RTCM message type 16 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,s8*hh
```

The MSG format for RTCM message type 18 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,d13,d14,f15,n(d16,d17,d18,d19,f20)*
hh
```

The MSG format for RTCM message type 19 is in the format:

```
$GPMSG,d1,d2,f3,d4,d5,d6,m7,d13,d14,d21,f15,n(d16,d22,d18,d23,f
24)*hh
```

In MSG messages generated for RTCM message types 1 and 2, fields d8 through d12 are repeated "n" times; n = the number of locked satellites. For RTCM message type 9, fields d8 through d12 are repeated 3 times per message.

The data fields common to each MSG message are listed in Table 7.27:

Table 7.27. Common MSG Data Fields

Fields	Description	Range
d1	RTCM message type	1, 2, 3, 6, 9, 16
d2	Station Identifier	0 to 1023
f3	Z count	0 to 9999.9
d4	Sequence number	0 to 9
d5	Station health	0 to 7
d6	Total number of characters following the time tag (including commas and <CR><LF> characters)	0 to 999
m7	Current GPS time of position fix (hhmmss.ss)	00 to235959.90

Table 7.28 lists the remainder of the MSG message for RTCM type 1. The remainder for RTCM type 9 is identical.

Table 7.28. Remainder of Type 1

Fields	Description	Range
d8	User differential range error (UDRE)	0 to 9
d9	Satellite PRN number	1 to32
f10	Pseudo range correction (PRC) in meters	±9999.99
f11	Range rate correction (RRC) in meters/ sec	±9.999

Table 7.28. Remainder of Type 1

Fields	Description	Range
d12	Issue of data ephemeris (IODE)	0 to 999
*hh	Checksum	2-character hex

Table 7.29 lists the remainder of the MSG message for RTCM type 2:

Table 7.29. Remainder of Type 2 Message

Fields	Description	Range
d8	User differential range error (UDRE)	0 to 9
d9	Satellite PRN Number	1 to 32
f10	Delta Pseudo range correction (Delta PRC) in meters	±99.99
f11	Delta Range rate correction (Delta RRC) in meters/sec	±9.999
d12	Issue of data ephemeris (IODE)	0 to999
*hh	Checksum	2-character hex

Table 7.30 lists the remainder of the MSG message for RTCM type 3:

Table 7.30. Remainder of Type 3 Message

Fields	Description	Range
f8	Base station X component	±9999999.99
f9	Base station Y component	±9999999.99
f10	Base station Z component	±9999999.99
*hh	Checksum	2-character hex

Table 7.31 lists the remainder of message for Type 16. The structure of the remainder for Type 6 is the same, but contains no text.

Table 7.31. Remainder of Type 16 Message

Fields	Description	Range
s8	text message send from base receiver	Up to 80 alpha-numeric characters
*cc	Checksum	

Table 7.32 lists the remainder of message for Type 18.

Table 7.32. Remainder of Type 18 Message

Parameter	Description	Range
d13	GPS/GLONASS constellation indicator	GPS or GLO
d14	Frequency indicator	00—L1 message 01—L2 message
f15	GNSS time of measurement (in GPS or GLONASS time)	
d16	Multiple message indicator	1—more messages will follow with same time tag 0—last message
d18	Data quality indicator	
f19	Cumulative loss of continuity indicator (unfixed cycle slips of loss of lock)	
f20	Uncorrected Carrier phase (cycles) sppppppp.pppp	
*hh	Checksum	2-character hex

Table 7.33 lists the remainder of message for Type 19

Table 7.33. Remainder of Type 19 Message

Parameter	Description	Range
d13	GPS/GLONASS constellation indicator	GPS or GLO
d14	Frequency indicator	00—L1 message 01—L2 message
d21	Smoothing interval	0—1 minute 1—1 to 5 minutes 2—5 to 15 minutes 3—undefined

Table 7.33. Remainder of Type 19 Message

Parameter	Description	Range
f15	GNSS time of measurement (in GPS or GLONASS time)	
d16	Multiple message indicator	1—more messages will follow with same time tag 0—last message
d22	GPS PRN number	0 to 31
d18	Data quality indicator	
d23	Pseudo-range multipath error indicator quantization	
f24	Uncorrected pseudo-range (meters)	
*hh	Checksum	2-character hex

Typical MSG message for RTCM type 1:

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

Table 7.34 outlines the response message.

Table 7.34. Typical MSG message for RTCM Type 01

Field	Description
$GPMSG	Header
01	RTCM message type
0000	Station ID
2220.0	Z count in seconds and tenths
1	Sequence number
0	Station health
127	Total number of characters of the time item
003702.00	Current time in hours, minutes, and seconds
2	UDRE for SV 12
12	Satellite PRN number
-0081.30	PRC for SV 12
+0.026	RRC for SV 12
235	IODE for SV 12
2	UDRE for SV 13

Table 7.34. Typical MSG message for RTCM Type 01 (Continued)

Field	Description
13	Satellite PRN number
0022.86	PRC for SV 13
0.006	RRC for SV 13
106	IODE for SV 13
2	UDRE for SV 26
26	Satellite PRN number
-0053.42	PRC for SV 26
-0.070	RRC for SV 26
155	IODE for SV 26
2	UDRE for SV 02
02	Satellite PRN number
0003.56	PRC for SV 02
0.040	RRC for SV 02
120	IODE for SV 02
2	UDRE for SV 27
27	Satellite PRN number
0047.42	PRC for SV 27
-0.005	RRC for SV 27
145	IODE for SV 27
7A	Checksum

Typical MSG message for RTCM type 2:

```
$GPMSG,02,0000,0790.8,5,0,205,151258.00,0,30,0000.98,0.000,200,
0,04,000.14,0.000,078,0,10,0002.22,0.000,235,0,24,0001.42,0.000
,142,0,06,0000.02,0.000,171,0,09,0000.04,0.000,110,0,08,0000.00
,0.000,192,0,05,0000.00,0.000,080*66
```

Table 7.35 outlines the response message.

Table 7.35. Typical MSG message for RTCM Type 2

Field	Description
$GPMSG	Header
02	RTCM message type

Table 7.35. Typical MSG message for RTCM Type 2 (Continued)

Field	Description
0000	Station ID
0790.8	Z count in seconds and tenths
5	Sequence number
0	Station health
205	Total number of characters following the time tag
003702.00	Current time in hours, minutes, and seconds
0	Current UDRE
30	Satellite PRN number
0000.98	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
200	Current IODE
0	Current UDRE
04	Satellite PRN number
0000.14	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
078	Current IODE
0	Current UDRE
10	Satellite PRN number
-0002.22	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
235	Current IODE
0	Current UDRE
24	Satellite PRN number
0001.42	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
142	Current IODE
0	Current UDRE
06	Satellite PRN number
0000.02	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)

Table 7.35. Typical MSG message for RTCM Type 2 (Continued)

Field	Description
171	Current IODE
0	Current UDRE
09	Satellite PRN number
0000.04	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
110	Current IODE
0	Current UDRE
08	Satellite PRN number
0000.00	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
192	Current IODE
0	Current UDRE
05	Satellite PRN number
0000.00	Current delta pseudo-range correction (meters)
0.000	Current delta range rate correction (meters)
080	Current IODE
*66	Checksum

Typical MSG message for RTCM type 3:

```
$GPMSG,03,0000,1200.0,7,0,038,231958.00,-2691561.37,
-4301271.02,3851650.89*6C
```

Table 7.36 outlines the response message.

Table 7.36. Typical MSG Message for RTCM Type 3

Field	Description
03	RTCM type
0000	Station ID
1200.0	Z count in seconds and tenths
7	Sequence number
0	Station health
038	Total number of characters after the time item

Table 7.36. Typical MSG Message for RTCM Type 3 (Continued)

Field	Description
231958.00	Current time in hours, minutes and seconds
-2691561.37	Station X component
-4301271.02	Station Y component
3851650.89	Station Z component
*6C	Checksum

RTCM TYPE 3 messages transmit the saved-base position following a power cycle.

Typical MSG message for RTCM type 16:

```
$GPMSG,16,0000,0888.0,5,0,033,191436.00,BASE STATION TEXT
MESSAGE*71
```

Table 7.37 outlines the response message.

Table 7.37. Typical MSG Message For RTCM Type 16

Field	Description
$GPMSG	Header
16	RTCM message type
0000	Station ID
1209.6	Z count in seconds and tenths
5	Sequence number
0	Station health
038	Total number of characters following the time tag
232008.00	Current time in hours, minutes and seconds
TEXT	Message content
*71	Checksum

Typical MSG message for RTCM type 18:

```
$GPMSG,18,0000,1747.8,4,0,170,202908.5,GPS,0,200000,0,0,20,4,01
,-8259701.2187,0,0,04,4,01,+5708064.4*53
```

Table 7.38 outlines the response message.

Table 7.38. Typical MSG Message For RTCM Type 18

Field	Description
$GPMSG	Header
16	RTCM message type
0000	Station ID
1747.8	Z count in seconds and tenths
4	Sequence number
0	Station health
170	Total number of characters following the time tag
202908.5	Current time in hours, minutes and seconds
GPS	GPS Constellation
0	L1 frequency used
200000	GPS system time of measurement basis
0	Last message for this satellite
0	Code indicator 0 = C/A code
20	GPS slot number (ID)
4	Data quality indicator (phase error $\leq$ 0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
-8259701.2187	Carrier phase (cycles)
0	Last message for this satellite and time tag
0	Code indicator 0 = C/A code
04	GPS slot number (ID)
4	Data quality indicator (phase error $\leq$ 0.03933 cycle)
01	Cumulative loss of continuity error (cycle slips)
+5708064.4	Carrier phase (cycles)
*53	Checksum

Typical MSG message for RTCM type 19:

```
$GPMSG,19,0000,1747.8,6,0,148,202908.5,GPS,0,3,200000,0,0,20,14
,15,21322294.20,0,0,04,14,15,23304544.46,*53
```

Table 7.39 outlines the response message.

Table 7.39. Typical MSG Message For RTCM Type 19

Field	Description
$GPMSG	Header
16	RTCM message type
0000	Station ID
1747.8	Z count in seconds and tenths
4	Sequence number
0	Station health
148	Total number of characters following the time tag
202908.5	Current time in hours, minutes and seconds
GPS	GPS Constellation
0	L1 frequency used
3	Smoothing Interval (3—undefined)
200000	GPS system time of measurement basis
0	Last message for this satellite and time tag
20	GPS slot number (ID)
14	Data quality indicator ($\leq$ 5.409 meters)
15	Pseudo-range multipath error indicator quantization not determined
21322294.20	Uncorrected pseudo-range (meters)
0	Last message for this satellite and time tag
04	GPS slot number (ID)
14	Data quality indicator ($\leq$ 5.409 meters)
15	Pseudo-range multipath error indicator quantization not determined
23304544046	Uncorrected pseudo-range (meters)
*53	Checksum

PER: Global Output Interval

$PASHS,NME,PER,f1

This command allows you to set the global output interval for all NMEA messages and Ashtech format NMEA-style messages, where f1 is the value for the output interval. This command overrides individual settings for output interval. That is, if the GGA message is enabled for output at intervals of two seconds and the SAT message is enabled for output at intervals of ten seconds, using the PER command to set an output interval of five seconds will cause reset the output interval of both messages to five seconds.

Example

Enter the following command to set the global NMEA output interval to 5 seconds:

$PASHS,NME,PER,5

POS: Position Message

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

Enable or disable NMEA position response message on output port x, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The receiver displays an empty message if no position is computed.

Example

Enter the following command to enable position message on port B.

$PASHS,NME,POS,B,ON

$PASHQ,POS,x

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

$PASHR,POS

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

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

Table 7.40 defines the POS response structure.

Table 7.40. POS Response Structure

Field	Description	Range
d1	position type: 0 = autonomous 1 = position differentially corrected	0 to 1
d2	Number of satellites used in position computation (no leading zero)	3 to 14
m1	Current UTC time, (hhmmss), of position computation in hours, minutes and seconds	00 to 235959.50
m2	Latitude component of position in degrees, minutes, and fraction of minutes (ddmm.mmmm)	0 to 90.00000°
c1	Latitude sector: N = North, S = South	N or S
m3	Longitude component of position in degrees, minutes, and fraction of minutes	0 to 180.00000°
c2	Longitude sector: E = East, W = West	W or E
f1	Altitude in meters above WGS-84 reference ellipsoid. For 2-D position computation this item contains the altitude held fixed. If f1 positive, "+" sign not mentioned	± 30000.00
f2	Site ID	4-character alphanumerical field set by $PASHS,SIT,xxxx command. "????" when not set
f3	True track/true course over ground in degrees (000.00 to 359.99 degrees)	0 to 359.9
f4	Speed over ground in knots	0 to 999.9
f5	Vertical velocity in meters per second	± 999.9
f6	PDOP—position dilution of precision	0 to 99.9
f7	HDOP—horizontal dilution of precision	0 to 99.9
f8	VDOP—vertical dilution of precision	0 to 99.9
f9	TDOP—time dilution of precision	0 to 99.9
s1	Firmware version ID	4 character string
*hh	checksum	2-character hex

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

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

Typical Response:

```
$PASHR,POS,0,6,183805:00,3722.36221,N, 12159.82742, W,
00016.06,????,179.22,021.21,+003.96+34,06.1,04.2,03.2,01.4,GA00
*cc
```

Table 7.41 outlines a typical POS response message.

Table 7.41. Typical POS Response Message

Item	Description
$PASHR,POS	Header
0	Position is autonomous
06	Number of satellites used in position computation
183805.00	Time of position computation
3722.36221	Latitude
N	North
12159.82742	Longitude
W	West
+00016.06	Altitude in meters
????	Site Name
179.22	Course over ground in degrees (True)
021.21	Speed over ground in knots
+003.96	Vertical velocity in meters per second
06.1	PDOP
04.2	HDOP
03.3	VDOP
01.4	TDOP
GA00	Version number
cc	Message checksum in hexadecimal

PTT: Pulse Time Tag

$PASHS,NME,PTT,c,s,[f]

Enables/disables the output of the PTT pulse time tag message where c is the serial port, s is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

If a 1 PPS pulse is not enabled, then the PTT message does not output. The time stamp in the PTT message represents the time at which the most recent PPS pulse was sent out, including any offset. The latency of the PTT message after the PPS pulse is on the order of 10 to 30 milliseconds.

Example

Enter the following command to enable the pulse time tag message on port B.

$PASHS,NME,PTT,B,ON

$PASHQ,PTT,[c1]

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

$PASHR,PTT

The response is output in the format:

```
$PASHR,PTT,s1,c2*hh
```

Table 7.42 outlines the message format.

Table 7.42. $PTT Message Format

Parameter	Description	Range
s1	Day of GPS week	1 to 7 (1 = Sunday)
c2	Time of the most recent PPS pulse (hh:mm:ss.sssssss)	000000.00 to 235959.95

RMC: Recommended Minimum Course

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

Enables/disables the output of the NMEA recommended minimum course message which contains time, position, course, and speed data where x is the serial port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable the RMC message on port C.

$PASHS,NME,RMC,C,ON

$PASHQ,RMC,[c1]

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

$GPRMC

This message contains UTC time, date, position status, latitude, longitude, course and speed over the ground, and magnetic variation. The RMC message is not output unless positions are being computed. The message is output in the format:

```
$GPRMC,m1,c2,m3,c4,m5,c6,f7,f8,d9,f10,c11,d12*hh
```

Table 7.43 outlines the message format.

Table 7.43. $GPRMC Message Format

Parameter	Description	Range
m1	UTC time of the position fix (hhmmss.ss)	000000.00 to 235959.95
c2	Status of the position fix (always A) • A—Autonomous, position data is valid • D—Differential, position data valid • V—Invalid for all values of the Indicator mode	A, D, V
m3	Latitude (ddmm.mmmmmm)	0000.000000° to 8959.999999°
c4	Latitude sector	N—North S—South
m5	Longitude (dddmm.mmmmmm)	00000.000000° to 17959.999999°

Table 7.43. $GPRMC Message Format (Continued)

Parameter	Description	Range
c6	Longitude sector	E—East W—West
f7	Speed over the ground (knots)	000.0 to 999.9
f8	Course over the ground (degrees); referenced to true north	000.0° to 359.9°
d9	Date (ddmmyy)	010100 to 123199
f10	Magnetic variation (degrees)	0.0° to 99.9°
c11	Direction of magnetic variation: • Easterly variation - subtract this value from true north course • Westerly variation - add this value to true north course	E—East W—West
d12	Positioning system mode indicator • A—Autonomous mode • D—Differential mode • E—Estimated (dead reckoning) mode • M—Manual input mode • S—Simulator mode • N—Data not valid The positioning system mode indicator field supplements the positioning system for the Status field.	A, D, E, M, S, or N
*hh	The hexadecimal 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 hex character.	0 to 9 and A through F

Typical RMC message:

```
$GPRMC,213357.20,A,3722.410857,N,12159.773686,W,000.3,102.4,290
498,15.4,W*43
```

Table 7.44 outlines the response message.

Table 7.44. Typical RMC Message

Parameter	Description
213357.20	UTC time of the position fix (hhmmss.ss)
A	Valid position
3722.410857	Latitude
N	North Latitude ddmm.mmmmmm
12159.773686	Longitude ddmm.mmmmmm
W	West Longitude

Table 7.44. Typical RMC Message

Parameter	Description
000.3	Speed over ground, knots
102.4	Course Over Ground, degrees True
290498	29 April 1998
15.4	Magnetic Variation, degrees
W	Westerly variation (add to the True course)
*43	Checksum

RRE: Satellite Range Residuals and Position Error

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

Enable or disable satellite residual and position error message to port x, where x is the output port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The DG14 does not output this message unless it computes a position.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable RRE message on port A.

   $PASHS,NME,RRE,A,ON

$PASHQ,RRE,[c1]

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

$GPRRE

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

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

Table 7.45 outlines the message format.

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

Table 7.45. $GPRRE Message Format

Parameter	Description	Range
d1	The number of satellites used to compute position	0 to 14
d2	PRN number for each of the satellites used in the position computation	1 to 32 for GPS 33 to 64 for SBAS
f1	Magnitude of the residual range error (meters) for each satellite used in the position computation	-999.9 to +999.9
f2	RMS value for the horizontal position error (meters)	0000.0 to +9999.9
f3	RMS value for the vertical position error (meters)	0000.0 to +9999.9

Typical RRE message:

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

Table 7.46 outlines the response message.

Table 7.46. Typical RRE Message

Field	Description
$GPRRE	Header
05	Number of satellites used to compute position
18	PRN of first satellite
000.2	Range residual for first satellite (meters)
29	PRN of second satellite
000.2	Range residual for second satellite (meters)
22	PRN of third satellite
-000.1	Range residual for third satellite (meters)
19	PRN of fourth satellite
-000.1	Range residual for fourth satellite (meters)
28	PRN of fifth satellite
000.5	Range residual for fifth satellite (meters)
0002.0	Horizontal position error (meters)

Table 7.46. Typical RRE Message (Continued)

Field	Description
0001.3	Vertical position error (meters)
*76	Checksum

SAT: Comprehensive Satellite Tracking Data

$PASHS,NME,SAT,x,y,[f]

Enable or disable satellite status message on port x, where x is the output port, and y is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enable SAT message on port B.

$PASHS,NME,SAT,B,ON

$PASHQ,SAT,[c1]

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

$PASHR,SAT

The SAT message contains information on the number of visible satellites, whether the satellite is being used in position computations, plus elevation, azimuth, and signal to noise measurements for each satellite. The message is output in the format:

```
$PASHR,SAT,d1,((d2,d3,d4,d5,c6)*d1)*hh
```

Table 7.47 outlines the response message.The data fields for PRN number (d2), azimuth (d3), elevation (d4), signal to noise ratio (d5), and the used/not used flag (c6) are repeated for each satellite, using the value in the d1 field as a multiplier.

Table 7.47. $PASHR,SAT Message Format

Field	Description	Range
d1	The number of satellites locked by the receiver	1 to 14
d2	Satellite PRN number	1 to 32 for GPS 33 to 64 for SBAS
d3	Satellite azimuth angle	0° to 359°
d4	Satellite elevation angle	0° to 90°
d5	Satellite signal-to-noise ratio (dbHz)	0 to 99
c6	Indicates whether the locked satellite is used in position computations: • U—Used • A dash (-) indicates that the satellite is not being used in position computations • M—Satellite NOT used because of low elevation • S—Satellite NOT used because the pseudo-range is not settled (transient is not over) • H—Satellite NOT used because marked 'unhealthy' in ephemeris • B—Satellite NOT used because of bad URA (or some accuracy problem indicated in navigational data) • Z—Satellite NOT used because marked 'unhealthy' in almanac • D—Satellite NOT used because differential corrections are old or invalid • J—Satellite NOT used because big code outlier was detected • R—Satellite NOT used because RAIM or some other algorithm detected a pseudo-range bias. • I—Satellite NOT used because SV disabled by external command SVP,USP) • L—Satellite NOT used because Signal To Noise Ratio is less than Mask • G—Satellite NOT used because it's possibly a ghost satellite • V—Satellite NOT used because computed satellite coordinates are suspicious • N—Satellite NOT used because satellite true number unknown (for modes, where we need the true SV number • K—Satellite NOT used because it was disabled by RTK engine (N/A in DG14) • O—Satellite NOT used because of some other case • E—Satellite NOT used because no navigational data (ephemeris) is available • p—Satellite NOT used because no full range is available	
*hh	Checksum	2-character hex

The SAT message displays more information on unused satellites. Used satellites are indicated with a U and unused satellites, by default, are indicated with a -. If you enable the satellite usage indicator, SUI, switch, a variety of flags display instead of a - to indicate the reason why the respective satellite is not used in the solution.

Typical SAT message:

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

Table 7.48 outlines the response message.

Table 7.48. Typical SAT Message

Field	Description
$PASHR,SAT	Header
03	Number of satellites locked
03	PRN number of the first satellite
103	Azimuth of the first satellite in degrees
56	Elevation of the first satellite in degrees
60	Signal strength of the first satellite
U	Satellite used in position computation
23	PRN number of the second satellite
225	Azimuth of the second satellite in degrees
61	Elevation of the second satellite in degrees
39	Signal strength of the second satellite
U	Satellite used in position computation
16	PRN number of the third satellite
045	Azimuth of the third satellite in degrees
02	Elevation of the third satellite in degrees
21	Signal strength of the third satellite
U	Satellite used in position computation
6E	Checksum

TCM: Differential Remote Station Status

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

This command enables or disables the RTCM rover data message, where x is the port, A or B, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,TCM,[c1]

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

$PASHR,TCM

The TCM message contains status information for the remote differential station as well as information on the transmitting base station, such as the base station ID number, base station health, remote station synchronization status, the RTCM message type being received, a quality indicator for message reception, and age of correction. the response is output in the format:

```
$PASHS,NME,TCM,d1,d2,d3,d4,f5,d6,d7*hh
```

Table 7.49 outlines the response message.

Table 7.49. $PASHS,NME,TCM Response Structure

Parameter	Description	Range
d1	Message synchronization indicator: • 0—synchronization between base and remote not established or lost. • 1—synchronization established between base and remote	0, 1
d2	RTCM message type received by the remote	1, 2, 3, 6, 9, 16
d3	Base station ID number	0 to 1023

Table 7.49. $PASHS,NME,TCM Response Structure (Continued)

Parameter	Description	Range
d4	Base station health indicator • 0—UDRE scale factor 1 • 1—UDRE scale factor 0.75 • 2—UDRE scale factor 0.5 • 3—UDRE scale factor 0.3 • 4—UDRE scale factor 0.2 • 5—UDRE scale factor 0.1 • 6—Reference Station transmission not monitored • 7—Reference Station not working	0 to 7
f5	Modified Z count (seconds; variable length number) in seconds	0 to 3599.4
d6	Message reception quality indicator. Message reception quality is defined as follows: (Number of good measurements / total number of measurements)*100	000 to 100
d7	Age of the received correction messages	0 to 99
*hh	Checksum	2-character hex

Typical TCM message:

```
$PASHR,TCM,1,31,0000,0,2644.0,100,01*28
```

Table 7.50 outlines the response message.

Table 7.50. Typical TCM Message

Field	Description
$PASHR,TCM	Header
1	Indicates that the base and remote station are synchronized
31	Indicates that the remote station is receiving RTCM message types 1 and 3
0000	Base station ID number
0	Base station health code
2644.0	Z count
100	Indicates that message reception quality is 100%
01	Indicates that the age of the correction messages is one second
*28	Checksum

TTT: Photogrammetry Event Marker

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

Enable or disable event marker message on port x, where x is the output port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed. This message is not output unless a photogrammetry pulse is being input, and the photogrammetry option (E) is available in the receiver.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable TTT message on port A

$PASHS,NME,TTT,A,ON

There is no query command for TTT.

$PASHR,TTT

The response message is in the form:

```
$PASHR,TTT,d1,m2*cc
```

Table 7.51 outlines the TTT response message structure.

Table 7.51. $PASHR,TTT Message Format

Field	Description	Range
d1	Day of GPS week (Sunday = 1; Monday = 2; Tuesday = 3; etc.)	1 to 7
m2	Time at which the pulse was input (hh:mm:ss.sssssss)	00:00:00.0000000 to 23:59:59.9999999
*hh	Checksum	2-character hex

Example

Enter the following command to enable TTT event marker on port A

Set: **$PASHS,NME,TTT,A,ON**

Typical Response: `$PASHR,TTT,6,20:41:02.0000000*OD`

Table 7.52 outlines the example TTT response message.

Table 7.52. Example TTT Response Message

Item	Description
$PASHR,TTT	Header
6	Day of week (Friday)
20:41:02.000000 0	Time
OD	Message checksum in hexadecimal

UKO: UKOOA Message

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

This command enables or disables UKOOA message on port x, where x is the output port, and y is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

$PASHQ,UKO,[c1]

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

$GPUKO

The response is in the format:

```
$GPUKO,d1,d2,d3,f1,n(d4,d5,d6,d7,d8,d9)
```

where Table 7.53 outlines the response message.

Table 7.53. $GPUKO Response message format

Parameter	Description	Range
d1	GPS week number	0 to 1023
d2	TOW (seconds)	0 to 604800
d3	Number of satellites used in the solution	0 to 14
f1	Scale factor	0 to 1
n	**Fields d4 through d9 are repeated "n" times; n = the number of satellites used in the solution**	0 to 14
d4	PRN number	0 to 64

Table 7.53. $GPUKO Response message format

Parameter	Description	Range
d5	Post-fit residuals, m	-999.9 to +999.9
d6	Line of sight, latitude sensitivity, sf = 7/100 (m/rad)	-99999999 to +99999999
d7	Line of sight, longitude sensitivity, sf = 7/100 (m/rad)	-99999999 to +99999999
d8	Line of sight, altitude sensitivity, sf = $1.0 * e^{-8}$	-99999999 to +99999999
d9	Weight of satellite	0 to 9999

UTM: Universal Transverse Mercator (UTM) Coordinates

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

This command enables or disables the UTM message on port x, where x is the output port, and y is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The DG14 does not output this message unless it computes a position.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

$PASHQ,UTM,[c1]

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

$PASHR,UTM

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

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

Table 7.54 outlines the message format.

Table 7.54. $PASHR,UTM Message Format

Parameters	Description	Range
m1	UTC of position in hours, minutes, and decimal seconds (hhmmss.ss)	0 to 235959.90
m2	Zone number for the coordinates	1 to 60, 99 N—North S—South
f3	East UTM coordinate (meters)	-9999999.999 to +9999999.999
f4	North UTM coordinate (meters)	-9999999.999 to +9999999.999
d5	Position fix mode indicator. • 1—Raw position • 2—RTCM differential or CPD float • 3—Carrier phase differential (CDP) fixed	1, 2, 3
d6	Number of GPS satellites being used to compute positions	3 to 14
f7	Horizontal dilution of precision (HDOP)	0.00 to 999.9
f8	Antenna height (meters)	-99999.999 to +99999.999
m	Antenna height units	M = meters
f9	Geoidal separation in meters	±999.999
m	Geoidal separation units (meters)	M
d10	Age of differential corrections	0 to 999
s11	Differential reference station ID	4 character string
*hh	Checksum	

The antenna altitude is either ellipsoidal (default) or geoidal (mean-sea-level) depending on the selection made with $PASHS,HGT (see UCT section). The geoidal altitude can be also derived by subtracting the geoidal separation from the ellipsoidal altitude.

Typical UTM message:

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

Table 7.55 outlines the response message.

Table 7.55. Typical UTM Message

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

VTG: Course and Speed Over the Ground

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

This command enables or disables the velocity/course message on port x, where x is the output port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The DG14 does not output this message unless it computes a position.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to enable VTG message on port B.

$PASHS,NME,VTG,B,ON

$PASHQ,VTG,[c1]

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

$GPVTG

This message is not output unless positions are being computed. The VTG contains course over the ground referenced to both true and magnetic north and speed over the ground in kilometers per hour and nautical miles per hour (knots). The message is output in the format:

```
$GPVTG,f1,c2,f3,c4,f5,c6,f7,c8,d9*hh
```

Table 7.56 outlines the message format.

Table 7.56. $GPVTG Response Structure

Field	Description	Range
f1	Course over ground; referenced to true north	000.00° to 359.99°
c2	North reference indicator (always T; true north)	T
f3	Course over the ground; referenced to magnetic north	000.00° to 359.99°
c4	North reference indicator (always M; magnetic north)	M
f5	Speed over ground (knots)	000.00 to 999.99
c6	Speed unit of measure (always N; nautical miles per hour)	N
f7	Speed over ground (kilometers per hour)	000.00 to 999.99
c8	Speed unit of measure (always K; KPH)	K
d9	Positioning system mode indicator • A—Autonomous mode • D—Differential mode • E—Estimated (dead reckoning) mode • M—Manual input mode • S—Simulator mode • N—Data not valid	A, D, E, M, S, or N
*hh	Checksum	2-character hex

Typical VTG message:

```
$GPVTG,179.00,T,193.00,M,000.11,N,000.20,K*3E
```

Table 7.57 outlines the response message.

Table 7.57. Typical VTG Message

Field	Description
$GPVTG	Header
179.00	Course over ground (degrees)
T	True course over ground marker
193.00	Magnetic course over ground
M	Magnetic course over ground marker
000.11	Speed over ground (knots)
N	Nautical miles per hour
000.20	Speed over ground in kilometers/hour
K	Kilometers per hour
*3E	Checksum

XMG: Exception Messages

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

This command enables or disables the exception messages or port x, where x is the output port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The DG14 does not output this message unless it computes a position.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

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

$PASHS,NME,XMG,B,ON

$PASHQ,XMG,[c1]

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

$PASHR,XMG, d1,d2

The response is in the format `$PASHR,XMG, d1,d2` where d1 is the exception number and d2 is a description of the exception message. Table 7.58 describes the exception numbers.

Table 7.58. $PASHR,XMG Exception Number Descriptions

Exception Number (d1)	Description	Meaning
01	SRAM corrupted	The DG14 enters Set Defaults state due to lost data.
02	Real Time Clock Corrupted	The DG14 initiates a cold start due to loss of time information.
03	No Position or Almanac	The DG14 initiates a cold start due to lack of position or almanac data.
04	BIT completed	End of built-in-test routines.
05	Cannot converge with 4 or more satellites	No navigation solution in auto mode with 4 satellites.
06	Cannot converge with 3 satellites	No navigation solution in auto mode with 3 satellites.
07	Too few satellites for 3D solution	No navigation solution in 3D mode with 3 or fewer satellites.
08	No 3D solution - PDOP mask exceeded	No navigation solution possible in 3D mode because of bad PDOP.
09	Too few satellites for 2D solution	No navigation solution in 2D mode with 2 or fewer satellites.
10	No 2D solution - PDOP mask exceeded	No navigation solution possible in 2D mode because of bad PDOP.
11	Time only - No Solution	No satellites above mask angle.
12	Solution valid.	A valid solution is now being generated.

ZDA: Time and Date

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

This command enables or disables the time and date message or port x, where x is the output port, c is ON or OFF, and f is the optional message output rate ranging from 0.05 to 999 seconds depending on the measurement update rate option installed.

The DG14 does not output this message unless it computes a position.

If the command is set without a period, the DG14 uses the period set by the **$PASHS,NME,PER** command If the **$PASHS,NME,PER** command is issued after this message period has been set, the period resets to the PER setting.

Example

Enter the following command to disable ZDA message on port A.

$PASHS,NME,ZDA,A,OFF

$PASHQ,ZDA,[c1]

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

$GPZDA

This message is not output until the receiver has locked on at least one satellite. The ZDA message contains UTC time, the current date, and offset values for converting UTC time to local time. The message is output in the format:

    $GPZDA,m1,d2,d3,d4,d5,d6*hh

Table 7.59 outlines the message format.

Table 7.59. $GPZDA Message Format

Field	Description	Range
m1	UTC time	000000.00 to 235959.90
d2	Current day	01 to 31
d3	Current month	01 to 12
d4	Current year	0000 to 9999
d5	Local time zone offset from UTC time (hours)	-13 to +13
d6	Local time zone offset from UTC time (minutes). This value has the same sign [+\-] as d5, but the sign is not displayed for this field	00 to 59
*hh	Checksum	2-character hex

Typical ZDA message:

    $GPZDA,222835.10,21,07,1999,-07,00*4D

Table 7.60 outlines the response message.

Table 7.60. Typical ZDA Message

Field	Description
$GPZDA	Message header
222835.10	Current UTC time
21	Current day
07	Current month
1999	Current year
-07	Local time zone offset from UTC (hours)
00	Local time zone offset from UTC (minutes)
4D	Checksum

NMEA Commands

8

Differential Operation

The DG14 can operate as either a Remote Station or Base Station for differential GPS, and it can be set to operate as a combined base and remote station. The DG14 also makes use of multiple correction data streams and offers a multi-base differential solution.

This chapter contains a general discussion of real-time differential operation, including available options, basic concepts, sources of error, DG14 commands related to differential GPS.Differential remote [U] and base [B] operation are available as receiver options. Both options must be installed in order for the DG14 to be able to support both differential modes (base and rover).

General

Real-time differential positioning involves a reference (base) station calculating range corrections for each satellite it is tracking and transmitting them to the remote (rover) stations through a real-time data communications link. Remote receivers apply the corrections to their own range measurements and use the corrected ranges to compute positions.

The base receiver determines range correction by subtracting the measured range from the true range. A precise reference position must be entered in the base receiver before true range can be calculated.

RTCM type 1 corrections with a UDRE (User Differential Range Error) field set to 3 (one-sigma differential error > 8 meters) are not used.

As a stand-alone receiver, the DG14 can compute a position with ± 3 meter CEP (Circular Error Probable) of accuracy (on average) with Selective Availability (SA) off. Autonomous accuracy worsens to an average of ±100

meters with SA on. In differential mode, a DG14 in rover mode can achieve sub-meter accuracy.

Real-time differential operation requires a communication link between the base and rover receivers. A wireless link, such as a radio-modem link or cellular/modem link is typically used, although any other medium that can transfer digital data can be used.

Sources of Error

The major sources of error affecting the accuracy of GPS range measurements are satellite orbit estimation, satellite clock estimation, ionosphere, troposphere, multipath, and receiver noise in measuring range. The first four sources of error are almost totally removed by differential corrections. The residual error is in the order of one millimeter for every kilometer of separation between base and remote receivers.

Receiver noise is not correlated between the base and the remote receiver and is not canceled by differential GPS. However, in the DG14, integrated doppler measurements are used to smooth the range measurements and reduce the errors resulting from receiver noise.

At the instant an satellite is locked, there is also RMS noise affecting the range measurement. RMS noise is reduced over time by the square root of the number of measurements computed by the receiver. For example, after 100 seconds of locking to a satellite, the rms noise in range measurement is reduced by a factor of 10 (one meter of noise is reduced to 0.1 meter). The noise is further reduced with each additional measurement.

If the lock to a satellite is lost, the noise goes back to one meter and smoothing starts from the one-meter level. The loss of lock to a satellite is rare, and typically happens only when the DG14 antenna's line of sight to the satellite is blocked by an object, or when the satellite goes below the horizon.

Total position error (or error-in-position) is a function of the range errors (or errors-in-range) multiplied by the PDOP (three-coordinate position dilution of precision). PDOP is a function of satellite geometry; that is, the positions of the satellites in relation to one another.

RTCM Messages

The DG14 accepts differential correction messages in the RTCM format (refer to *RTCM Recommended Standards for Differential GNSS*, version 3.0). The DG14 can be set to output or receive RTCM messages using either of its two ports by issuing the set command **$PASHS,RTC,s1,c2** where s1 is either BAS (base station mode) or REM (remote mode) and c2 is the port designator for the input or output of differential corrections. The DG14

supports six out of the 64 different types of RTCM messages. Message type 3 contains base station status information. Message type 16 contains a special ASCII message of up to 90 characters. Type 16 messages are used to communicate special information. For example, a base station operator may wish to construct a message informing users that the base station will go offline temporarily in order to perform routine maintenance or repairs. Message types 1, 2, and 9 contain data used for position correction. The type 6 message is a null frame message which is used to establish and maintain RTCM message frame synchronization for remote differential stations. RTCM messages are processed automatically by the DG14. Although RTCM messages are output in binary format, it is possible to convert them to ASCII format through the **$PASHS,NME,MSG** set command and the **$PASHQ,MSG** query command.

All RTCM messages except type 1 are generated by the base station only if they are enabled using the **$PASHS,RTC,TYP** set command. In addition, if type 1 or type 9 messages are enabled and a change of ephemeris occurs in one or more satellites, the base station automatically generates a type 2 message with the delta IODE (Issue of Data, Ephemeris) information. The type 2 message is generated regardless of whether the type 2 message has been enabled for output. When a DG14 set in differential remote mode receives a type 2 message, and the IODE information in type 1 or 9 messages does not match, the remote receiver uses the delta ephemeris information in the received type 2 message until the IODE information in the incoming type 1 or 9 messages matches the IODE information in the received type 2 message.

On initial power-up, or after issuing the **$PASHS,RST** command (restore defaults), the DG14's setting for differential mode is OFF, and the setting for the maximum age of an RTCM differential correction is 60 seconds, meaning that an incoming correction whose age is greater than 60 seconds is not used. If automatic differential GPS mode is not enabled **($PASHS,DIF,AUT)**, and if the differential correction data is unavailable or is older than the maximum age specified by the **$PASHS,RTC,MAX** set command, a DG14 set as a remote differential station will not output position data. If automatic differential mode is enabled, a DG14 set as a remote differential station will output uncorrected positions if differential correction data is unavailable or if the age of correction exceeds the maximum age setting.

RTCM 104 Format, Version 3.0

When the RTCM base option is enabled and the DG14 is configured as a reference station, it computes differential corrections for up to 12 satellites, converts those corrections to RTCM format and outputs the converted messages through its serial ports. The DG14 generates message types 1, 2,

3, 6, 9, and 16, listed in Table 8.1:

Table 8.1. RTCM Format

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

The DG14 uses the six-of-eight format (data bits a1 through a6 of an eight-bit byte) for differential corrections.

When the RTCM remote option [U] is installed and the DG14 is set in differential remote mode, it can decode RTCM message types 1, 2, 3, 6, 9, and 16, but uses only types 1, 2, and 9 to correct its position calculations. When using radio-modems for the communication link, the DG14 in remote mode is able to recover bit slippage.

Base Station

You can configure the DG14 as an RTCM Base (Reference) Station, and can enable or disable differential-correction message output from the receiver. When enabled, the DG14 sends message types 1, 2, and 9 continuously and can send either type 3 or type 16 individually. If type 1 or type 9 messages have been enabled and the ephemeris changes in one or more satellites, the base station automatically generates a type 2 message with the delta IODE information. This automatic type 2 message generates independently of the setting for type 2 messages.

For all messages, you can set the period and internal bit rate of correction transmission using the **$PASHS,RTC,TYP** and **$PASHS,RTC,SPD** commands. You can control the delay for switching to the new IODE using the **$PASHS,RTC,IOD** command.

The DG14 computes differential corrections for up to 12 GPS satellites, can compute differential corrections for up to two SBAS satellites, and can make use of SBAS integrity information. The DG14 can also output RTCM corrections based on SBAS satellite correction data.

The DG14 can output differential corrections in either RTCM SC-104 or RTCA DO-217 format via a serial port. The DG14 uses the six-of-eight format (data bits a1 through a6 of an eight-bit byte) for communication between the reference station and user equipment.

RTCM recommends that you use of a highly stable clock with the Type 9 implementation to prevent degradation of navigation accuracy due to clock drift that can occur between Type 9 messages. Since the DG14 does not support an external frequency input, be aware of possible degradation in positioning using Type 9 instead of Type 1 corrections.

Setting Up a Differential Base Station

You must have the Base option [**B**] installed on the receiver.

Figure 8.1 displays a typical DGPS base station configuration.

<table>
<tr><td>CAUTION</td></tr>
<tr><td>Errors in the base station reference position will be duplicated in positions computed by the remote system.</td></tr>
</table>

Differential Operation

Figure 8.1. RTCM Base Station System

Send the commands listed in Table 8.2 to the receiver to generate RTCM differential corrections using message type 1.

Table 8.2. Differential Base Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,PEM,4	Set the Base differential mask to four degrees
$PASHS,POS,ddmm.mmm,d,dddmm.mmm,d,saaaaa.aa	Enter the phase center of the antenna
$PASHS,RTC,BAS,x	Turn on RTCM corrections on port x When this command is sent, a base station automatically sends RTCM message type 1 once per second.

Table 8.2. Differential Base Station Commands (Continued)

Command	Description
$PASHS,RTC,SPD,9	Set internal bit-rate for corrections to burst mode. Only use the Burst mode with Types 18 and 19.
$PASHS,LPS,1,1,1	Set loop setting for stationary receiver.
$PASHS,SAV,Y	Save settings

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

Moving Base Operation

The DG14 will function as a moving base station. In Differential Base mode, the DG14 can continuously input real-time reference position updates (at a rate of 1Hz or less) to the operating remote station using **$PASHS,POS** command. The DG14 remote station accepts and utilizes the entered reference position in less than 100ms. The remote receiver must receive continuously transmitted corrections to update the reference position.

Advanced Settings for Differential Base Stations

There are many parameters that control the operation of the receiver. Most should be left at default values, except for the settings identified in Table 8.2.

Antenna

Locate the antenna with a clear view of the sky.

The antenna position, entered with the **$PASHS,POS** command, is the WGS-84 phase center of the antenna. The relative accuracy of the remote receiver positions is the same, with respect to the base station, as if you had entered the true position of the antenna. The absolute accuracy translates by the difference between the nominal base station position and the true WGS-84 position. That is, if the nominal base station position is one meter north of the true position, then all remote positions are translated north by one meter. You may check which position was set by using the **$PASHQ,RTC** command.

Message Rate

To improve Differential performance, minimize base station data latency by using the highest possible data rates that your data link supports. There are three different settings that affect data rates:

- RTCM message bit rate. **$PASHS,RTC,SPD**. This is the internal bit rate used to generate the RTCM messages. This should be as high as possible without exceeding the baud rate of the serial port.
- Serial port baud rate. This should be as high as possible.
- RTCM message rate. This is the rate at which messages are generated.
- Differential messages (Type 1) are next most important, ideally once per second. If the data rate does not support this, these messages may be generated slower, with a corresponding decrease in differential accuracy.

Base Station Position

The RTCM message 3 broadcast the base station position.

Base Station Antenna Offset

If you set up the base station antenna over a known, surveyed point, you may enter the position of the surveyed point and the offset from this point to the antenna phase center. Or you may enter the phase center directly.

If you are using Type 3:

- At the base station, enter the phase center of the antenna directly using **$PASHS,POS** or
- At the base station, enter the surveyed reference point using **$PASHS,POS** and enter the antenna offset using **$PASHS,ANT**.

Using Reference Station ID

You may monitor which reference or base station the remote receiver uses by setting a reference station ID at the base station. Set the reference station ID using the command **$PASHS,RTC,STI**.

You may also control which reference station the remote receiver uses by setting the desired station ID at the remote receiver, or all the remote receiver to use corrections from any base station.

Reference Station Health

You may set the reference station to unhealthy, which causes all remote receivers to ignore the messages they receive from that base station.

Other RTCM Messages

Partial Differential corrections: Message 9

These are alternatives to messages 1. They should only be used if you have a low bandwidth data link (~100bps). Use of high-bandwidth data links, and messages 1 are recommended.

Message type 1 cannot generate at the same time as type 9.

Message 2

These are automatically generated when the base station is transmitting differential corrections and a new ephemeris is downloaded from the satellites.

Filler: Message 6 Null Frame

This message is provided for data links that require continuous transmission of data, even if there are no corrections to send.

Special Message: Message 16

This message allows you to transmit an ASCII message from the base station.

Using a PC Interface

If you are using the Thales Evaluate™ software to interface to your receiver you may use initialization files (`*.gps`) to send the base station setting commands for you.

To monitor the corrections from a PC, turn on the MSG message

$PASHS,NME,MSG,y,ON

This generates an ASCII representation of the RTCM messages transmitted by the base station and decoded by the rover. Use different receiver serial ports for MSG and the actual transmitted RTCM messages.

Remote Station

The DG14 can accept differential corrections from a SBAS satellite, through the beacon receiver, and/or through a serial port input. You can select the set of corrections you want to use in the navigation solution (Integrated Differential Optimization or a single type of correction data).

The DG14 validate all received differential corrections including the checksum and parity validation checks included in the RTCM and SBAS specifications, and uses only the valid correction data in the navigation solution.

When in DGPS operation and using RTCM corrections, the DG14 supports

the Type 2 message for IODE changes.

A differential navigation solution is only computed when there is a sufficient number of matched sets of satellite parameters and corrections. The DG14 will never calculate a partial differential solution. If there are enough corrected satellites to compute a position even though not all tracked satellites have corrections, the navigation solution disregards uncorrected measurement data and/or unused corrections and includes only corrected measurement data in the computation. When a navigation solution is computed using the least-squares algorithm, the measurement data and corrections data for a given satellite must both be available for the particular epoch. Satellites with propagated measurement data and valid corrections data are included in a differential navigation solution generated with the Kalman filter. Regardless of the navigation algorithm, the number of satellites required to produce a valid solution depends on the position mode: at least four satellites for a 3D solution, and at least three satellites for a 2D solution.

The DG14 conducts validity tests on incoming RTCM messages before incorporating them into the navigation solution.

Setting Up a Differential Remote with External Corrections

You must have the Differential remote option **[U]** installed on your receiver.

Figure 8.1 displays a typical DGPS remote station configuration

REMOTE

Figure 8.2. RTCM Remote System

You must have a source of differential corrections. In the DG14, the user has a choice of corrections from the on-board beacon receiver, SBAS corrections, or corrections from an external source. In this example, we connect a radio to one of the DG14 serial ports.

Send the following commands to the receiver. The receiver will accept RTCM differential corrections in message types 1 or 9. You do not have to tell the receiver which message types to expect, it will automatically use whatever it receives on serial port x.

Table 8.3. Differential Remote Station Commands

Command	Description
$PASHS,RST	Reset the receiver to factory defaults
$PASHS,RTC,REM,x	Set the receiver as a remote station, receiving corrections on serial port x

Table 8.3. Differential Remote Station Commands (Continued)

Command	Description
$PASHS,SPD,x,n	Set the baud rate of serial port x to the same as the radio providing the corrections.
$PASHS,SAV,Y	Save settings

You have now set up the remote station. Turn on the GGA, GLL, or POS message to obtain position.

Recommended Settings for Differential Remote Stations

There are many parameters that control the operation of the receiver. Most should be left at default values. The following settings are recommended for differential remote stations.

$PASHS,CRR,S

$PASHS,LPS,10,3,1 (for high dynamic or high vibration applications)

Other parameter settings at factory default.

Base Data Latency

Differential operation works better the lower the latency of the base-remote data link. To minimize latency set the baud rate of the radios as high as possible, and use radios that are optimized for low latency GPS operation, such as the Thales SSRadio.

The actual base-remote data latency is given in the GGA message.

Maximum acceptable base-remote data latency is controlled by the **$PASHS,RTC,MAX** command.

Automatic Differential Mode

When you are using a rover receiver in differential mode (either code phase or carrier phase), a failure at the base station or in the data link causes the rover receiver to cease outputting differentially corrected positions. You can use the auto differential mode to output an autonomous position at the rover receiver if differential data from

the base station is unavailable. Enabled the auto differential mode with the **$PASHS,RTC,AUT,Y** command. Table 8.4 describes how auto differential mode affects position output at the rover receiver.

Table 8.4. Auto Differential Modes and Position Output

Mode	Position Output
Code Differential Auto Differential Off (Default code mode)	Differential position output if the age of corrections is less than maximum age (maximum age as defined in the rover by $PASHS,RTC,MAX,xx). No position otherwise.
Code Differential Auto Differential On	Differential position is output if the age of corrections is less than maximum age, otherwise an autonomous position is output.

SBAS Operation

The DG14 can track two geostationary SBAS satellites at a time and make ranging, ephemeris, and SBAS differential correction data messages available through the serial ports. In addition, the DG14 can process SBAS corrections for DGPS positioning and also provide the corrections for output through the serial ports in RTCM SC-104 format.

The DG14 has several modes of SBAS operation:

- Automatic Mode—the receiver determines which SBAS satellite(s) to use
  - Single Automatic Mode
  - Dual Automatic Mode
- Manual Mode—you manually set which SBAS satellite(s) to use
  - Single Manual Mode
  - Dual Manual Mode

The default SBAS mode is Single.

Automatic Modes of Operation

In Automatic mode, the DG14 automatically searches for and tracks the SBAS satellite listed in the available almanac. If no SBAS almanac is available, the DG14 searches for and tracks the SBAS satellites in a predefined re-programmable order: satellites 35, 33, 47, 51, 34, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 48, 49, 50. Use the **$PASHS,SBA,SSO** command to set a different search order.

NOTE: The SBAS PRN numbers range from 120 to 138. The offset from SBAS SVID to SBAS PRN numbers is 87. Add 87 to the SVID to derive the SBAS PRN number.

Single Automatic Mode

In Single Automatic SBAS mode, the DG14 automatically detects all available SBAS signals and selects the best ONE satellite, switching automatically as you move from one coverage area to another. The automatic selection uses both SBAS channels. Channel 1 tracks the best available SBAS signal and Channel 2 scans for another available SBAS satellite signals, maintaining a SBAS satellite directory in a battery-backed memory. The quality of the SBAS satellite tracked on Channel 1 (signal strength, elevation, etc.) is continuously compared to the quality threshold. When the quality of the signal on Channel 1 is less than the quality threshold, the DG14 checks the quality of the signal of the Channel 2 satellite. If Channel 2 satellite has a better signal, the DG14 switches to it. If, on the other hand, the signal on Channel 1 drops below the threshold and the signal on Channel 2 is no better or any SBAS satellite, the DG14 continues to use and track the satellite on Channel 1.

Use the **$PASHS,SBA,SAM** command to set the receiver in Single Automatic mode to track SBAS satellites and use the data in the navigation solution.

The best SBAS satellite is determined based collectively on the satellite SNR, elevation angle, continuity of signal reception, etc.

Dual Automatic Mode

In Dual Automatic SBAS mode the DG14 automatically detects all available SBAS signals and selects the best two satellites. Channel 1 tracks the best satellite available, and Channel 2 tracks the second-best available satellite. In this mode, the DG14 has no capability to continue to scan for other, better SBAS signals. Therefore, once selected, the DG14 continues to track these two selected SBAS satellites so long it is able. If the signal on one of the channels is lost, the DG14 scans the available frequencies to find another SBAS satellite.

Use the **$PASHS,SBA,DAM** command to set the receiver in Dual Automatic mode to track two SBAS satellites and use the data in the navigation solution.

The best SBAS satellite is determined based collectively on the satellite SNR, elevation angle, continuity of signal reception, etc.

Manual Modes of Operation

In Manual SBAS mode, the DG14 searches for and tracks the SBAS satellite(s) you specify. You can specify either one or two SBAS satellites for either Single Manual Mode or Dual Manual Mode.

Single Manual Mode

In Single Manual SBAS mode, the DG14 searches for and tracks the specified SBAS satellite (PRN = xx) on Channel 1. Channel 2 automatically searches for and tracks the best available SBAS signal. Use the **$PASHS,SBA,MAN,xx** to enable the Single Manual SBAS mode and use the SBAS data in the navigation solution.

Dual Manual Mode

In Dual Manual SBAS Mode, the DG14 searches for and tracks the two specified SBAS satellites (PRN = xx and PRN=yy) on Channel 1 and Channel 2, respectively. Use the **$PASHS,SBA, MAN,xx,yy** to enable the Dual Manual SBAS mode and use the SBAS data in the navigation solution.

DGPS Positioning Using SBAS Corrections

The DG14 can decode, process, and apply SBAS differential corrections received from the SBAS channels.

Use SBAS message types 6, 8 and 10 to determine and report the quality of the corrections/solution (e.g. in the GST message). If message type 10 is not available, then the corresponding error component is set to a NOMINAL VALUE.

Use the **$PASHS,RTC,SLC,SBA** command to enable the SBAS corrected position with all available SBAS correction components. If you do not want a differential position output with partial corrections of the SBAS messages, use the **$PASHS,SBA,PAR,OFF** command.

On cold start, the first solution is corrected with all components but the ionosphere and then the subsequent position fixes are corrected with all components.

Utilizing SBAS Channel Data

In any of the above SBAS modes of operation, you can select one of three data utilization options:

1. Use Channel 1 data only: **$PASHS,SBA,CDU,CH1**
2. Use Channel 1 data when available, and Channel 2 data only as backup: **$PASHS,SBA,CDU,BCP**
3. Use data from both Channels simultaneously: **$PASHS,SBA,CDU,BTH**

Modes 2 and 3 only work in either manual or automatic dual mode of operation.

The default is **$PASHS,SBA,CDU,BTH**— use data from both Channels simultaneously.

Using SBAS Data

You can choose from up to five options to specify how to use the SBAS channel data:

1. Decode and output
2. SBAS-to-RTCM conversion and output
3. Utilization of SBAS corrections in DGPS solution and SBAS-to-RTCM conversion and output
4. Integrity information utilization
5. Ranging signal utilization in navigation solution

Decoding and Outputting SBAS Data

If the SBAS option is enabled and if the SBAS mode is activated, you can set the DG14 to decode and output SBAS data using the **$PASHS,SBA,DAT** command. The number of SBAS channels used for the decoding and outputting SBAS data depends on the **$PASHS,SBA,CDU** settings.

Converting SBAS Correction to RTCM SC-104

The SBAS corrections are converted to RTCM SC-104 format for output. The RTCM corrections are optimized for the current DG14 location. The generated RTCM corrections include RTCM message types 1, 2, 3, 6, and 9. Message Type 3 contains the current Reference Position of the receiver, if in BASE mode, or the current GPS/DGPS position of the receiver, if in stand-alone or REMOTE mode.

Use the **$PASHS,SBA,RTC** command to convert the SBAS corrections to RTCM SC-104. See **$PASHS,SBA,RTC** on page 320 for more information.

The number of SBAS channels used for the conversion depends on the $PASHS,SBA,CDU setting.

Utilizing SBAS Corrections in DGPS Solution

The full SBAS set of corrections include:

- fast corrections—Satellite clock corrections
- long term or slow corrections—Satellite ephemeris and long term satellite clock corrections
- ionosphere corrections

Use the **$PASHS,RTC,SLC,SBA** and **$PASHS,RTC,REM,ON** commands to utilize SBAS corrections in the DGPS solution.

SBAS message types 6, 8 and 10 are not used in position computation using SBAS corrections. These messages help determine and report the quality of the corrections/solution, but do not to allow or disallow position computation.

Use the **$PASHS,SBA,PAR,OFF** command if you do not want a differential position output without the whole of correction set of fast, slow, and iono components. The default is ON: partial corrections are allowed.

After a cold start, the first solution is corrected with all components but the ionosphere and subsequent position fixes are corrected with all components.

The number of SBAS channels used for the utilization of SBAS corrections depends on the $PASHS,SBA,CDU setting.

Utilizing Integrity Information

You can use the **$PASHS,SBA,INT,ON/OFF** command to enable or disable the integrity information available. The default is ON.

The number of SBAS channels used as a source of integrity information depends on the $PASHS,SBA,CDU setting.

Ranging signal utilization in navigation solution

This function will be available to the user by means of **$PASHS,USP,SBA,Y/N** command. Default is Y.

SBAS ranging information shall be available in BOTH MCA and MBN format so the SBAS satellite can be used seamlessly in the navigation solution by raw data users.

The number of SBAS channels used for ranging information depends on the $PASHS,SBA,CDU setting.

Saving SBAS Settings

You can save any SBAS parameters you set using the **$PASHS,SAV,Y**

command.

Beacon Operation

The DG14 two-channel scanning beacon receiver has two modes of operation: automatic or fixed. In both modes, the beacon receiver can provide corrections from one or two beacon stations.

The DG14 beacon receiver outputs in RTCM SC-104 differential correction format.

The DG14 has several modes of beacon operation Use the **$PASHS,BCN,MOD** command to set the beacon operation mode:

- Automatic Mode—the receiver determines which beacon station(s) to use
  - Single Automatic Mode
  - Dual Automatic Mode
- Manual Mode—you manually set which beacon station(s) to use
  - Single Manual Mode
  - Dual Manual Mode

The default Beacon mode is Single Automatic. On power up, the DG14 remembers the last beacon stations used, and begins searching with those frequencies.

Automatic Modes

In Automatic mode, the beacon receiver automatically determines the MSK bit rate(s), and it utilizes its own position information in conjunction with a Beacon Station Location Table (stored in memory) to identify the nearest beacon stations and begin searching for these stations. On power up, the beacon receiver remembers the last used beacon ID's and begin searching for these frequencies.

You can view the default beacon directory using the **$PASHQ,BCN,DIR** command. The beacon directory in the receiver is similar to, but usually larger than, the beacon almanac received in RTCM Type 7. The receiver beacon directory is updated by both RTCM Type 7 and what you add manually with the **$PASHS,BCN,DIR,ADD** command. The last received record (RTCM Type 7 or user entry) overrides any preceding entries. Therefore, to avoid overwriting your entries with RTCM type 7 update information, disable RTCM Type 7 processing using the **$PASHS,BCN,RT7,N** command.

A beacon station is identified by latitude, longitude, range, frequency, health, Station ID, bit rate, Modulation code, Sync type, and Broadcast Coding.

In Automatic Mode, you can mark a frequency to "never be used" using the

$PASHS,BCN,NVR command.

Single Automatic Mode

In Single Automatic Mode, the beacon receiver automatically detects all available radio beacon signals and select the best one station, switching automatically as the user moves from one coverage area to another. Channel 1 tracks the best available beacon signal and sends the demodulated DGPS corrections to the DG14 receiver. Channel 2 scans for other available DGPS beacon signals, maintaining a DGPS beacon directory in a battery-backed memory.   The beacon almanac/directory is automatically saved.

The quality of the beacon signal tracked on Channel 1 (signal strength, etc.) is continuously compared to a quality threshold. When the quality of the signal on Channel 1 is worse than the quality threshold, the beacon receiver checks the quality of the signal on Channel 2. If Channel 2 signal is better than Channel 1, the beacon receiver switches to it. If, on the other hand, the signal on Channel 1 drops below the threshold and the signal on Channel 2 is no better or no beacon signal is available, the DG14 continues to use and track the beacon signal on Channel 1.

Use the **$PASHS,BCN,MOD,AUT,SNG** command to set the DG14 to operate in Single Automatic Mode.

Use the **$PASHS,BCN,OUT** command to output the demodulated Beacon data from Channel 1 to the serial port.

The best beacon signal is determined based collectively on the SNR, continuity of signal reception, etc.

Dual Automatic Mode

In Dual Automatic Mode, the beacon receiver shall automatically detect all available radio beacon signals and select the best station, which shall be tracked by Channel 1. After completing a scan of all available frequencies, Channel 2 shall track the second-best available station. Since there is no other beacon channel, the beacon receiver has no capability to continue to scan for other, better signals. Therefore, the beacon receiver shall continue to track these two stations so long it is able. Should the signal on one of the channels be lost, this channel shall scan the available frequencies to determine the best signal available for tracking.

Use the **$PASHS,BCN,MOD,AUT,DUA** command to set the DG14 to operate in Dual Automatic Mode.

Use the **$PASHS,BCN,OUT** command to output the demodulated beacon data from Channel 1 or Channel 2 to the serial port.

The best beacon signal is determined based collectively on the SNR, continuity of signal reception, etc.

Manual Modes

In Manual Beacon mode, the DG14 tracks the beacon station(s) you specify. You can specify either one or two beacon stations for either Single Manual Mode or Dual Manual Mode. You must enable the Manual mode with the **$PASHS,BCN,MOD,MAN** command and then assign frequencies to the channels.

Single Manual Mode

In Single Manual Beacon mode, the DG14 tracks the specified beacon signal on Channel 1. After enabling Manual mode with the **$PASHS,BCN,MOD,MAN** command, use the **$PASHS,BCN,CHN** command to assign a frequency to Channel 1.

Use the **$PASHS,BCN,OUT** command to output the demodulated beacon data from Channel 1 to the serial port.

Dual Manual Mode

In Dual Manual Beacon Mode, the DG14 tracks the two specified beacon signals on Channel 1 and Channel 2, respectively. After enabling Manual mode with the **$PASHS,BCN,MOD, MAN** command, use the **$PASHS,BCN,CHN** command to assign a frequency to Channel 1, and enter the command a second time to assign a frequency to Channel 2.

Use the **$PASHS,BCN,OUT** command to output the demodulated beacon data from Channel 1 or Channel 2.

Working with the Beacon Directory

The DG14 beacon directory is similar to, but usually larger than, the beacon almanac received in the RTCM Type 7 message. The Type 7 message contains information about a specific network of reference stations, and the receiver directory contains the same information for all stations. The receiver beacon directory contains:

- Default list of stations kept in ROM
- List of stations received from RTCM Type 7
- User entered stations

After a cold start the beacon directory consists of the default list of stations kept in ROM.

The beacon directory is kept in BBU. It can be erased with the

$PASHS,BCN,DIR,CLR command. You can reset the beacon directory to the default list of stations kept in ROM only with the **$PASHS,BCN,DIR,INI** command.

Blocking RTCM Type 7 Message

The most recently received record (RTCM Type 7 or user entry) may override preceding entries in the beacon directory. Use the **$PASHS,BCN,RT7,Y/N** command to prevent the overwriting entries with RTCM type 7 information. The default is Y, overwrite information.

If you enable RTCM type 7 information, and receive RTCM type 7 from a station located within 30 km from any station in the beacon directory, then the existing station is replaced with the one received from RTCM Message 7 in the beacon directory. If the RTCM type 7 information received is from a station more than 30 km from any station in the Beacon directory then the new station will be added to the beacon directory.

Adding Stations to the Beacon Directory

To add a new station to the beacon directory manually, you need the following information:

- Latitude—required
- Longitude—required
- Range—optional
- Frequency—required
- Health—optional
- Station ID—required
- Bit Rate —required
- Modulation Code—optional
- Sync Type —optional
- Broadcast Coding—optional

Use the **$PASHS,BCN,DIR,ADD,f1,c1,f2,c2,f3,d1,d2[,d3,d4,d5,d6,d7]** command to add a new station to the beacon directory, where Table 8.5 outlines the parameters.

To replace a station, or delete some parameters, you must delete the station and then to add a new one.

Table 8.5. $PASHS.BCN,DIR,ADD Parameters

Parameter	Description
f1	Latitude
c1	North (N) or South (S)

<p style="text-align:center">Table 8.5. $PASHS.BCN,DIR,ADD Parameters</p>

Parameter	Description
f2	Longitude
c2	East (E) or West (W)
f3	Frequency
d1	Station ID
d2	Bit Rate
d3	Range (Kilometers)
d4	Health
d5	Modulation Code
d6	Sync Type
d7	Broadcast Coding

Deleting Stations from the Beacon Directory

When deleting a station from beacon directory you need to specify the frequency, and optionally Station ID.

You can delete a station from the beacon directory with the **$PASHS,BCN,DIR,DEL,f1[,d1]** command where f1 is the frequency and d1 is the Station ID. If Station ID is not specified then all stations with matching Frequencies are deleted from the beacon directory.

If the station you want to delete is locked, then deleting station from the beacon directory will not remove this station from lock. See 'Working with Never Used Frequencies' on page 292 to have an immediate effect on the locked stations.

Listing the Current Beacon Directory

You can list current directory with the **$PASHQ,BCN,DIR** command. The response message consists of a series of **$PASHR,BCN,DIR** messages, one at each output interval. The message output is in the format:

`$PASHR,BCN,DIR,n1,n2,s1,f1,f2,c2,f3,d1,d2,d3,d4,d5,d6,d7`

where Table 8.6 outlines the response format:

<p style="text-align:center">Table 8.6. $PASHR,BCN,DIR Format</p>

Parameter	Description
n1	Total number of DIR messages (stations) in the response
n2	Number of messages remaining in output

Table 8.6. $PASHR,BCN,DIR Format

Parameter	Description
s1	Source of information DEF—Default list, RTC—from RTCM message 7, USR—user defined
f1	Latitude
c1	North (N) or South (S)
f2	Longitude
c2	East (E) or West (W)
f3	Frequency
d1	Station ID
d2	Bit Rate
d3	Range (Kilometers)
d4	Health
d5	Modulation Code
d6	Sync Type
d7	Broadcast Coding

If the information for a field is not available, then the field is set to the factory default.

You can use the following options to specify which part of the beacon directory you wish to list:

- **$PASHQ,BCN,DIR**— view the whole directory
- **$PASHQ,BCN,DIR,USR**— view the user entered stations only
- **$PASHQ,BCN,DIR,RTC**— view stations from RTCM Type 7 message only
- **$PASHQ,BCN,DIR,DEF**— view stations from the default list

Saving and Resetting the Beacon Directory

Beacon directory is automatically saved in BBU. The **$PASHS,IN**I, **$PASHS,RST**, and **$PASHS,SAV** commands will not affect beacon directory. Table 8.7 summarizes the commands for saving, editing, and deleting the beacon directory.

Table 8.7. Saving and Resetting Beacon Directory Commands

Command	Task
$PASHS,BCN,DIR,ADD	Add a station to the directory
$PASHS,BCN,DIR,DEL	Delete a station from the directory

Table 8.7. Saving and Resetting Beacon Directory Commands (Continued)

Command	Task
$PASHS,BCN,DIR,CLR	Clear the directory – delete all records
$PASHS,BCN,DIR,INI	Restore the directory from FLASH to factory defaults

Working with Never Used Frequencies

In Automatic Modes, you can mark a frequency to "never be used" using the **$PASHS,BCN,NVR, f1** command where f1 is the frequency.

All stations with the specified frequency will not be searched for after issuing this command.

Use the **$PASHS,BCN,CLR,f1** command to clear the never-use mark for the specified frequency

Use the **$PASHQ,BCN,NVR** command to query frequencies currently marked as never-use. The response message lists all frequencies marked as never-use in the format:

$PASHR,BCN,NVR,d1,f1,f2,...

where

   d1 – the number of frequencies

   f1,f2,... – frequencies marked as never-use

Saving and Resetting Beacon Parameters

When you save the beacon parameters, the following are saved in BBU:

* current mode
* individual channel settings (in manual mode)
* never-use frequencies
* RTCM Type 7 message blockage setting

Table 8.8 outlines the commands you can use to save and reset the beacon parameters.

Table 8.8. Saving and Resetting Beacon Parameters Commands

Command or Action	Result
Power Cycle the DG14	All receiver and Beacon parameters are restored from battery backed-up memory.
$PASHS,RST	The receiver and Beacon restart. All Beacon parameters are restored to defaults.
$PASHS,BCN,RST	The Beacon restarts. All Beacon parameters are restored to defaults.

Table 8.8. Saving and Resetting Beacon Parameters Commands (Continued)

Command or Action	Result
$PASHS,SAV,Y	All receiver and Beacon parameters saved to battery backed-up memory.
$PASHS,BCN,SAV	All Beacon parameters saved to battery backed-up memory.
$PASHS,INI,x,x,3 or $PASHS,INI,x,x,1	The receiver and Beacon restart. All receiver and Beacon parameters are restored to defaults.
$PASHS,INI,x,x,0 or $PASHS,INI,x,x,2	The receiver and Beacon restart. All receiver and Beacon parameters are restored from battery backed-up memory.
$PASHS,BCN,BBU	The Beacon restarts. All Beacon parameters are restored from battery backed-up memory.

Output Beacon Data to Serial Ports

You can output the beacon data to any of DG14 serial ports using the **$PASHS,BCN,OUT,d1,c1,s1** command where d1 is Beacon Channel (1 or 2), c1 is receiver port (A or B or C), and s1 is ON or OFF.

Beacon Tracking Signal Strength:

$PASHQ,BCN,STA

or

$PASHS,BCN,STA,A,ON

will cause output of $PASHR,BCN,STA message. This is a status message of the following format:

```
$PASHR,BCN,STA,n1,{d1,d2,d3,f1,d4,d5,d6}...
```

Table 8.9. $PASHR,BCN,STA Format

Parameter	Description
n1	Number of structures (stations) in this message (always 2 for DG14). The structure would contain the following parameters obtained from each Beacon channel:
d1	In Threshold Flag, (0 or 1)
d2	Out Threshold Flag (0 or 1)

Table 8.9. $PASHR,BCN,STA Format

Parameter	Description
d3	Channel task: 1-Stopped 2-FFT 3-Wide Band Search 4-PLL Lock
f1	Frequency (applicable only if Channel Task is 2 or 4) in kHz
d4	Bit rate
d5	SNR in this channel
d6	Auto Gain Control scale value

Example:

```
$PASHR,BCN,STA,2,1,1,4,287.0,100,266,1268,1,1,4,314.0,200,274,1
261*4D
```

This message should be output when locked or not locked to a station. When not locked, the last good parameters will be output.

AGC is the coefficient that the input signal is multiplied by before further processing. The stronger the input signal the smaller AGC scale value. The weaker the input signal the bigger AGC scale value. This AGC scale value is not SNR - it is the input signal+noise strength.

Integrated Differential Optimization

You can specify the source(s) of differential corrections and how these corrections are utilized. Use the **$PASHS,RTC,SLC** command to specify the source(s) of corrections used in the navigation solution. You can choose either a single or multiple sources of corrections: SBAS, Beacon and Serial corrections (individually or in any combination/order). The default is a single source of serial corrections.

Regardless of the source of differential corrections (beacon, serial, or SBAS (full or partial) corrections), the DGPS position flag is set if any types of differential corrections are used in the navigation solution.

Utilization of Differential Corrections

If you have chosen multiple sources of corrections to be used in the navigation solution, you need to specify the method of utilization: Multi-Base

Processing, or Primary-Secondary Scenario. The default is Primary-Secondary. Use the **$PASHS,RTC,SLC** command to list the sources in the order of preference, separated by commas.

Primary-Secondary Scenario

The navigation solution always utilizes a single source of corrections. The Primary-Secondary option has two modes: manual and automatic.

Manual Primary-Secondary

The first source in the list of corrections, specified in the **$PASHS,RTC,SLC** command, is used as the primary source of corrections and the remaining sources listed are used as backup or 'secondary sources in the order they are listed. When the Primary source is not available, the DG14 switches to the first secondary source available. Use the **$PASHS,RTC,SLC** command to set the Primary and Secondary sources of corrections.

If the SBAS or beacon is set to Dual Mode, the corrections provided on Channel 1 serve as Primary and Channel 2 serves as the Secondary set of corrections.

If you have multiple serial corrections available, the first set of corrections successfully decoded by the DG14 will be Primary and all other corrections marked with reference station ID's are Secondary.

Automatic Primary-Secondary:

This mode operates similarly to the Manual operation except that the DG14 automatically chooses the primary and secondary sources of corrections based on an internal set of criteria for the "best" correction source. Use the **$PASHS,RTC,SLC,WGH** command to set the receiver in Automatic-Primary mode.

When the DG14 switches from one correction source to another, there can be decimeter-level position jumps due to change in "quality" of corrections. Any reference clock offset differences between the old and new correction sources, however, will be absorbed by the NavT/NavTdot solution parameter without reflecting on the position/velocity solution. The "Quality" of corrections includes accuracy of corrections, latency of corrections, frequency of corrections, age of corrections, baseline length and network coverage, etc...

Integrated Differential Optimization (U and D Options Required)

The DG14 offers the following options in processing correction data:

- Nearest base station
- Base station solution yielding solution with lowest RMS
- Weighted multi-base solution (weight factors include: age of correction, distance to base, satellite elevation at base, etc.) (WGH)

If the SBAS or beacon is set to Dual Mode, each Channel serves as a separate source of corrections. If multiple serial corrections are available, each set of corrections (based on reference station ID) serves as a separate source of corrections.

Multi-Base Differential Processing (U and M Options Required)

The Multi-Base feature is capable of receiving up to 8 individual correction streams (8 Ref IDs) on each serial port, for a total of 24 correction streams. The base station can be as far as 1500 km from the remote receiver. The maximum update rate is 10 Hz. This feature cannot be used in conjunction with SBAS or Internal Beacon corrections.

9

Differential Commands

This chapter contains the receiver commands for the following applications:

- **RTCM Commands**, on page 298
- **SBAS Commands**, on page 313
- **Beacon Commands**, on page 324

RTCM Commands

RTCM commands allow you control and monitor operation in differential mode. RTCM commands are available if the differential options are installed. If only the base station option [B] is installed, only commands controlling base station parameters are available when setting the receiver for differential operation. If only the remote differential option [U] is installed, only commands controlling remote station parameters are available when setting the receiver for differential operation. Both options must be installed in order for base station commands and remote station commands to be available to the receiver. The RTCM mode is off by default.

All but one of the RTCM commands are set commands. The set commands allow you to enable and modify a variety of parameters affecting differential operation. There is only one query command: **$PASHQ,RTC**. This command is used to monitor differential parameters and status. Table 9.1 lists the RTCM commands.

Table 9.1. RTCM Commands

Function	Command	Description	Default	Page
Base station parameters	$PASHS,RTC,BAS	Set receiver to operate as differential base station		300
	$PASHS,RTC,FMT	Set differential output format		300
	$PASHS,RTC,IOD	Set ephemeris data update for RTCM base		300
	$PASHS,RTC,MSG	Defines RTCM type 16 message (base to remote)		301
	$PASHS,RTC,QAF	Set quality percentage mask	100	302
	$PASHS,RTC,SPD	Set baud rate of base station		308
	$PASHS,RTC,STH	Set health of reference station		309
	$PASHS,RTC,TYP	Enable/disable RTCM message types	3	311

Table 9.1. RTCM Commands (Continued)

Function	Command	Description	Default	Page
Remote station parameters	$PASHS,RTC,AUT	Turns auto differential mode on or off	Y	299
	$PASHS,RTC,MAX	Set maximum age of RTCM differential corrections	60	301
	$PASHS,RTC,REM	Set receiver to operate as differential remote station		303
	$PASHQ,RTC,RPS	Query remote station parameters		303
	$PASHS,RTC,SEQ	Check sequence number of received messages	N	307
	$PASHS,RTC,SLC	Select RTCM corrections type for navigational solution		308
	$PASHS,RTC,UDR	Set UDRE acceptance threshold		312
General parameters	$PASHS,RTC,OFF	Disable differential mode		302
	$PASHQ,RTL	Query RTCM and user entered information		306
	$PASHS,RTC,STI	Set station identification of base or remote	0000	310
	$PASHQ,RTC	Request base or remote differential mode parameters and status		304
	$PASHS,RTC,TAG	Set RTCM SC-104 version	V22	310

AUT: Automatic Differential Mode

$PASHS,RTC,AUT,s1

This command enables or disables automatic differential mode, where s1 is Y (enabled) or N (disabled). When auto differential mode is enabled, the receiver outputs raw positions automatically if differential corrections are older than the maximum age setting, or when differential corrections are not available. When auto differential mode is disabled, the receiver stops outputting positions when the age of the differential correction exceeds the maximum age setting or when differential corrections are not available, and does not resume position output until it receives RTCM corrections with age values lower than the maximum or differential mode is disabled. The automatic differential setting applies to remote differential stations only. You can view the current automatic differential setting by entering the **$PASHQ,RTC** command and checking the AUT field.

Example

Enter the following command to turn auto differential mode on:

$PASHS,RTC,AUT,Y

DEFAULT SETTING
RTC,AUT— Y

BAS: Set Receiver in Differential Base Station Mode

$PASHS,RTC,BAS,c1

This command sets the DG14 to operate as an RTCM differential base station, where c1 designates the output port (A or B) for differential corrections. You can view the current RTCM mode setting by entering the **$PASHQ,RTC** command and checking the MODE field.

Example

Enter the following command to set the receiver as an RTCM base station outputting differential corrections from port B:

$PASHS,RTC,BAS,B

FMT: Differential Output Format

$PASHS,RTC,FMT,s1

This command sets the differential output format to either RTCM or RTCA. s1 is either TCM or TCA.

RTCM and RTCA can also be used in place of TCM and TCA respectively.

IOD: Ephemeris Data Update Rate for RTCM Base Station

$PASHS,RTC,IOD,d

This command sets the time period before the RTCM base station switches to a new issue of the ephemeris data (IODE) where d is the time between 0 and 90 seconds. The default is 30 seconds.

This message is applicable to receivers in RTCM BASE mode only. A base receiver continues to transmit corrections on the old ephemeris in the navigation solution until it receives an ephemeris update. After receiving new ephemeris, the receiver waits for the offset period (d) before transmitting corrections using the new ephemeris (IODE).

$PASHQ,RTC,IOD,[c1]

This command queries for the time period for when the RTCM base station switches to a new issue of the ephemeris data, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,RTC,IOD

The response is in the format:

```
$PASHR,RTC,IOD,d*cc
```

where d is the set IOD switch period in seconds.

MAX: Maximum Age Threshold for Differential Corrections

$PASHS,RTC,MAX,d1

This command sets the maximum age for incoming RTCM differential corrections, where d1 is any number between 1 and 9999. The receiver ignores incoming corrections whose age exceeds the maximum age setting. The default value is 60. The maximum age setting applies to remote differential stations only. You can view the current maximum age setting by entering the query command **$PASHQ,RTC** and checking the MAX field.

Enter the following command to set the maximum age to 30 seconds:

$PASHS,RTC,MAX,30

DEFAULT SETTING
RTC,MAX— 60

MSG: Define RTCM Type 16 Message

$PASHS,RTC,MSG,s1

This command defines an ASCII message of up to 90 characters which can be enabled for broadcast by the RTCM base station. The contents of this message can be obtained in different ways depending on whether the receiver is configured as a base station or a remote station. In the case of the base station, you can issue

the commands **$PASHQ,RTC** or **$PASHQ,MSG**. The type 16 message must be enabled for output in order to use the MSG query to get the contents of the type 16 message when the receiver is configured as a base station. In the case of the remote station, only the MSG query can be used to obtain the contents of a type 16 message broadcasted from a base station.

Example

Enter the following command to create a type 16 message stating, "This is a test message":

$PASHS,RTC,MSG,THIS IS A TEST MESSAGE

OFF: Disable Differential Operation

$PASHS,RTC,OFF

This command disables differential operation, whether the receiver is set as a base station or a remote station. You can view the current RTCM mode setting by entering the **$PASHQ,RTC** command and checking the MODE field.

QAF: Quality Factor

$PASHS,RTC,QAF,c1

This command sets the number of received differential correction frames in RTCM differential mode above which where c_1 ranges from 0 and 999. When the total number of received messages reaches the c_1, c_1 resets to 100. **$PASHS,RTC,QAF** is used only in REMOTE mode.

c_1 is used to compute the QA value, where: QA = # of good messages/QAF. The QA parameter allows you to evaluate the communication quality between the base and remote stations.

Example

Enter the following command to set the quality percentage mask to 99%:

$PASHS,RTC,QAF,99

DEFAULT SETTING
RTC,QAF—100

REM: Set Receiver in Differential Remote Station Mode

$PASHS,RTC,REM,c1

This command sets the DG14 to operate as an RTCM differential remote station. The c1 parameter designates the input port (A or B) for differential corrections. You can view the current RTCM mode setting by entering the **$PASHQ,RTC** command and checking the MODE field.

Example

Enter the following command to set receiver as a differential remote station with port B designated as the input port for RTCM differential corrections:

$PASHS,RTC,REM,B

RPS: Rover Parameters

$PASHQ,RTC,RPS,c1

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

$PASHR,RPS

The response is in the format:

```
$PASHR,RTC,RPS,h1,h2,h3,h4,h5,h6,h7
```

where Table 9.2 outlines the parameters

Table 9.2. $PASHR,RTC,RPS Response Format

Parameter	Description	Range
h1	Mode of operation	0—Base Mode 1—Remote Mode
h2	Port used fro RTCM input	A, B, or C
h3	Remote Station ID	0 to 1027
h4	Auto-differential	N or Y
h5	QA factor setting	0 to 99
h6	Maximum age setting	0 to 999
h7	Sequence checking	N or Y

RTC: Query RTCM Operating Parameters and Status

$PASHQ,RTC,[c1]

This command queries for differential parameter settings and status, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

The response message has a free-form Ashtech format. Like the PAR response message, the RTC response message does not have a header or message identifier as shown in the following example:

```
STATUS:
SYNC:   TYPE:00 STID:0000 STHE:0
AGE:+999 QA:000.00% OFFSET:00
SETUP:
MODE:OFF PORT: A SOURCE:SLC,EXT AUT:N FMT:RTCM
SPD:0300 STI:0000 STH:0 IOD:20
MAX:0060 QAF:100 SEQ:N RTCM:V22
TYP:1  2  3  6   7  9  16 18 19
FRQ:99 00 00 OFF 00 00 00 00 00
BASE:   LAT:0000.00000,N LON:00000.00000,E ALT:+00000.00 W84
MSG:
```

Table 9.3 describes the items in the RTC response message:

Table 9.3. RTC Response Format

Parameter	Description	Range
STATUS	This subsection of the RTC response contains status information related to the performance of the remote differential station, such as message synchronization status, the type of message being received, the ID number of base station broadcasting the corrections, etc. SYNC, TYPE, STID, STHE, AGE, QA, and OFFSET fall into this subsection.	
SYNC:	An asterisk (*) appearing in this field indicates that synchronization between base and remote has been established. Synchronization has not been established if this field is blank. This field applies to remote differential mode only.	*
TYPE:	Indicates RTCM message type received by the remote station.	1, 2, 3, 6, 9, 16
STID:	The ID number of the differential base station. This ID number is received from the base station.	0000 to 1023
STHE:	This code number indicates the health of the base station.	0 to 7

Table 9.3. RTC Response Format (Continued)

Parameter	Description	Range
AGE:	In base station mode, this field indicates the elapsed time in seconds between the transmission of Type 1 or 9 messages. In remote station mode, this field indicates the age of the received messages in seconds.	1 to 999
QA:	The communication quality factor between base and remote. Defined as (number of good messages received/total number of messages) x 100 total number of messages. This field applies to remote differential mode only.	000.0% to 100.0%
OFFSET	The number of bits from the beginning of the RTCM byte (in case of a bit slippage).	
SETUP	This subsection of the RTC response message contains status information related to RTCM parameter settings, such as the operating mode, the RTCM messages enabled for output, the port assigned to receive or transmit differential corrections, etc. MODE, PORT, AUT, SPD, STI, STH, MAX, QAF, SEQ, TYP, FRQ, BASE, and MSG fall into this subsection.	
MODE	The current differential mode. The default setting is OFF.	BAS, REM, OFF
PORT	The port used for receiving or transmitting RTCM corrections.	A, B, C (optional) or All
SOURCE	The source of the RTCM corrections.	SLC with any combination of EXT, BCN, or SBA -OR- WGH
AUT	Indicates whether automatic differential mode is enabled (Y) or disabled (N). The default setting is N. This field applies to remote station mode only.	Y, N
FMT	The data format for the corrections.	RTCM, RTCA
SPD	Indicates the current rate of output for RTCM corrections in bits per second (bps). The default output rate is 300 bps. This field applies to base station mode only.	25 to 1500
STI	The differential station ID number. The ID number is a user-entered parameter. A remote station with an ID number of 0000 can receive corrections from any RTCM base station. Otherwise, the remote station must be programmed with the same ID number as the base station the in order to receive corrections from that base station. The default ID number is 0000.	0000 to 1023
STH	Code number indicating the health of the base station. This code number is a user-entered parameter. This field applies to base station mode only.	0 to 7
IOD	Offset setting for the latest issue of ephemeris data. Applicable to the base only.	0 to 90

Differential Commands

Table 9.3. RTC Response Format (Continued)

Parameter	Description	Range
MAX	The maximum age (seconds) of a received differential correction, above which the remote station will not use the correction. The maximum age setting is a user-entered parameter. The default setting is 60 seconds. This field applies to remote station mode only.	1 to 1199
QAF	The multiplier value used to calculate the QA value. Always 100. This field applies to remote station mode only.	100
SEQ	Indicates whether the remote station is checking (Y) or not checking (N) the sequence numbers of the received RTCM correction messages. When SEQ is enabled, the remote station will not output corrected positions until is receives two sequential corrections. The default setting is N. This field applies to remote station mode only.	Y, N
RTCM	Indicates the RTCM version used by the receiver.	V22 for version 2.2 V21 for Version 2.1
TYP	The RTCM message types supported by the DG14.	1, 2, 3, 6, 9, 16, 18, 19
FRQ	Indicates the output interval setting for each RTCM message except for the type 6 message, which is either ON or OFF. Zero (0) indicates the message is disabled; 99 indicates continuous output. The output interval unit of measure for message types 1 and 9 is seconds; the output interval for unit of measure for message types 2, 3, and 16 is minutes. The default output interval setting is 99 for the type 1 message, OFF for the type 6 message, and 00 for all other RTCM messages.	0 to 99; ON, OFF
BASE	The base station reference position, used to calculate corrections. The reference position is entered the POS command set commands. If no position has been entered, this field displays all zeroes. This field applies to base station mode only.	Latitude: 0° to 90° Longitude: 0° to 180° Altitude: -3000.00 to +3000.00 m
MSG	This field contains the text entered for the type 16 message. The text in the type 16 message is entered by the user through the $PASHS,RTC,MSG command. This field applies to base station mode only.	Up to 90 characters

RTL: User Entered Position Information

$PASHQ,RTL[c1]

This command queries the RTCM and user entered position information, where c1 is the optional port designator for the output of the response. If a port is not specified, the receiver sends the response to the current port.

$PASHR,RTL,f1,c2,f3,c4,f5,d6,c7,d8,c9,d10,d11,d12*hh

The response is in the format:

`$PASHR,RTL,f1,c2,f3,c4,f5,d6,c7,d8,c9,d10,d11,d12*hh`

where Table 9.4 outlines the response format.

Table 9.4. $PASHR,RTL Response Format

Parameter	Description	Range
f1	User entered latitude	ddmm.mmmm
c2	Latitude direction	N or S
f3	User entered Longitude	ddmm.mmmm
c4	Longitude direction	E or W
f5	User entered altitude in meters	
d5	Differential mode	0 = Off 1 = Base 2 = Remote
c7	Auto differential flag	N = Off y = On
d8	Station ID	0 to 1023
c9	Differential port	A, B, optional C or All
d10	Index of baud rate for the differential port	0 to 9
d11	Maximum age	0 to 1199
d12	RTCM speed index	0 to 9
*hh	hexidecimal checksum	

SEQ: Verify RTCM Message Sequence

$PASHS,RTC,SEQ,c1

This command enables or disables a check on the sequence number of received RTCM correction messages, where c1 is Y (on) or N (off). When SEQ is enabled, the remote station must receive two sequential RTCM correction messages before it starts applying the corrections. This condition is in effect only at beginning of differential operation, and applies to remote station mode only. You can see whether message sequence monitoring is enabled or disabled by entering the **$PASHQ,RTC** command and checking the SEQ field.

Example

Enter the following command to enable a check of RTCM message sequence:

$PASHS,RTC,SEQ,Y

DEFAULT SETTING
RTC,SEQ— N

SLC: Navigational Solution

$PASHS,RTC,SLC,s1,[s1],[s1]

This command sets the corrections type to use in the navigational solution. You may select more than one type to use in the solution. s1 is the type of correction: EXT (Serial Port), BCN (Beacon), SBA (SBAS), or WGH (Weighted Multi-base Solutions).

SPD: Baud Rate for RTCM Message Output

$PASHS,RTC,SPD,d1

This command sets the base station's output rate for RTCM messages in bits per second (bps), where d1 is a code number between 0 and 8. Table 9.5 lists the available bit rates and corresponding codes. The default output bit rate is 300 bps. This command applies to base station mode only. You can view the current output bit rate setting by entering the **$PASHQ,RTC** command and checking the SPD field.

Table 9.5. Available Output Bit Rates for RTCM Messages

Code	Rate
0	25
1	50
2	100
3	110
4	150
5	200
6	250
7	300

Table 9.5. Available Output Bit Rates for RTCM Messages

Code	Rate
8	1500
9	Burst

DEFAULT SETTING
RTC,SPD - Burst = to port BAUD Rate

Example

Enter the following command to set the output bit rate for RTCM messages to 1500 bits per second:

$PASHS,RTC,SPD,8

STH: Differential Base Station Health

$PASHS,RTC,STH,d1

This command sets the health of the base station, where d1 is a code number between 0 and 7. The health states and the corresponding codes are listed in Table 9.6. This command applies to base station mode only. You can view the current base station health setting by entering the **$PASHQ,RTC** command and checking the STH field.

Table 9.6. $PASHS,RTC Health of Reference

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

Differential Commands

Example

Enter the following command to set the base station health code to indicate that the base station is not working:

$PASHS,RTC,STH,7

DEFAULT SETTING
RTC,STH— 0

STI: Differential Base/Remote Station ID

$PASHS,RTC,STI,d1

This command sets differential station identification numbers, where d1 is any number between 0000 and 1023. A remote station with the ID number 0000 can receive corrections from any RTCM base station; otherwise, the remote station must be programmed with the same ID number as the base station in order to receive corrections from that base station.

Example

Enter the following command to set the differential station ID number to 0001:

$PASHS,RTC,STI,0001

DEFAULT SETTING
RTC,STI— 0000

TAG: RTCM SC-104 Version

$PASHS,RTC,TAG,s1

This command sets the RTCM SC-104 version used by the receiver. s1 is either V21 (RTCM SC-104 version 2.1), or V22 (RTCM SC-104 version 2.2).

DEFAULT SETTING
RTC,TAG— V22

TYP: Enable/Disable Output of RTCM Message Types

$PASHS,RTC,TYP,d1,d2

This command enables or disables the output of specific RTCM message types as well as the message output interval, where d1 is the type number and d2 is value of the output interval. This command applies to base station mode only. Table 9.7 lists the available message types and range of the output interval setting.

Table 9.7. $PASHS,RTC,TYP Message Types

Type	Range
01	0-99 seconds, where 0 is disabled and 99 is generated continuously
02	0-99 minutes, where 0 is disabled and 99 is generated continuously
03	0-99 minutes, where 0 is disabled and 99 is generated continuously
06	1 = ON, 0 = OFF Default = OFF
09	0-99 seconds, where 0 is disabled and 99 is generated continuously
16	0-99 minutes, where 0 is disabled and 99 is generated continuously
18	0-99 seconds, where 0 is disabled and 99 is generated continuously
19	0-99 seconds, where 0 is disabled and 99 is generated continuously

All messages, except for 01 and 09, can be enabled simultaneously with any output period setting. Default for type 6 is OFF, type 1 is 99, and all others are set to 00 (disabled).

RTCM type 1 correction with a UDRE (User Differential Range Error) field set to 3 (one-sigma differential error > 8 meters) are no longer used.

Type 18 and 19 are not available in the current release (DD00).

Example

Enter the following command to enable the type 1 message once per second:

$PASHS,RTC,TYP,1,1

DEFAULT SETTING		
RTC,TYP	Type 1	99
	Type 2	00
	Type 3	00
	Type 6	OFF
	Type 9	00
	Type 16	00
	Type 18	00
	Type 19	00

UDR: UDRE Acceptance Threshold

$PASHS,RTC,UDR,d1

This commands sets the UDRE acceptance threshold where d1 is 0, 1, 2, or 3. All RTCM corrections with UDRE flags equal to or less than the threshold are accepted. All incoming RTCM corrections are checked against the UDRE flag before they are incorporated into the navigation solution.

DEFAULT SETTING
RTC,UDR— 3

SBAS Commands

SBAS commands allow you control and specify usage of WAAS, EGNOS, and MSAS functionality. These commands are available only if the SBAS option [Y] is installed. When the [Y] option is installed, 2 channels are made available for tracking SBAS satellites. If you did not purchase this option, and you want to now, please call your Magellan GNSS Board Sales Representative. See **Receiver Options**, on page 15 for more information on the available receiver options

The receiver can track two geostationary SBAS satellites at a time and includes the ranging, ephemeris and SBAS differential correction data messages over the RS232 output ports. The DG14 can process SBAS corrections for DGPS positioning. SBAS corrections are converted to RTCM SC-104 corrections and output through the serial ports.

In the GPS+SBAS mode, the DG14 retains all standard functionality, including high data output rates (raw and navigation).

The DG14 has several modes of SBAS operation:

- Automatic Mode—the receiver determines which SBAS satellite(s) to use
  - Single Automatic Mode
  - Dual Automatic Mode
- Manual Mode—you manually set which SBAS satellite(s) to use
  - Single Manual Mode
  - Dual Manual Mode

The default SBAS mode is Single.

Table 9.8 outlines the SBAS commands.

Table 9.8. SBAS Commands

Function	Command	Description	Default	Page
SBAS Mode	$PASHS,SBA,SAM	Enable Single Automatic SBAS Mode		321
	$PASHS,SBA,DAM	Enable Dual Automatic SBAS mode		316
	$PASHS,SBA,MAN,xx	Enable Single Manual mode		319
	$PASHS,SBA,MAN,xx,yy	Enable Dual Manual mode		319
	$PASHS,SBA,OFF	Disable the SBAS mode		319
	$PASHS,SBA,SSO	Set SBAS satellite search order		321
SBAS Ephemeris and Almanac	$PASHS,RAW,SAW	Enable or disable SBAS almanac data		187
	$PASHQ,SAW	Query the SBAS almanac data		187
	$PASHS,RAW,SNW	Enable or disable SBAS ephemeris data		190
	$PASHQ,SNW	Query the SBAS ephemeris data		191

Table 9.8. SBAS Commands

Function	Command	Description	Default	Page
SBAS Data and Information	$PASHQ,SBA	Query SBAS parameters		314
	$PASHS,SBA,CDU	Select the SBAS channels to use	BTH	315
	$PASHS,SBA,DAT	Enable the SBAS output messages		316
	$PASHQ,SBA,DAT	Queries the SBAS output messages		317
	$PASHS,SBA,INF	Enable or disable the SBAS information messages		317
	$PASHS,SBA,INT	Enable or disable the integrity information	ON	318
	$PASHS,SBA,PAR	Enable or Disable Partial SBAS corrections		320
	$PASHS,SBA,RTC	Set SBAS to RTCM message information		320
	$PASHS,USE,SBA	Include or exclude all SBAS satellites for tracking		322
	$PASHS,USP,SBA	Include or exclude all SBAS satellites in the position computation	No	322

SBA: Query SBAS Parameters

$PASHQ,SBA,[c1]

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

Example

Enter the following command to query the SBAS parameters.

$PASHQ,SBA

```
MOD:OFF
INF:0
CDU:BTN PAR:ON INT:ON RNG:ON
RTCM:   1   2   3   6   9
PRTA: OFF OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF OFF
SBA:  INF DAT SNW SAW
PRTA: OFF OFF OFF OFF
PRTB: OFF OFF OFF OFF
PRTC: OFF OFF OFF OFF
```

Table 9.9 outlines the parameters in the response message.

Table 9.9. $PASHQ,SBA Response Parameters

Parameter	Description
MOD	Current SBAS Mode: OFF, single automatic, dual automatic, single manual, or dual manual
INF	Currently assigned SBAS satellites (See **$PASHS,SBA,INF,c1,s1,[f1]**, on page 317)
CDU	Channel Data Utilization: **BTH**—both, **BCP**—Use channel 1 data when available and Channel 2 data only as backup, **CH1**—use Channel 1 data only
PAR	Use partial SBAS corrections. ON or OFF
INT	Use SBAS integrity information. ON or OFF
RNG	Use SBAS ranging information. ON or OFF
RTCM	Current SBAS to RTCM conversion and output settings
PRTA	Port A output status ON or OFF
PRTB	Port B output status ON or OFF
PRTC	Port C output status ON or OFF
SBA	Status of the SBAS related messages output (INF, DAT, SNW, and SAW)
PRTA	Port A output status ON or OFF
PRTB	Port B output status ON or OFF
PRTC	Port C output status ON or OFF

CDU: Channel Data Utilization

$PASHS,SBA,CDU,c1

This command selects the SBAS channels to use where c1 is outlined the Table 9.10.

Table 9.10. $PASHS,SBA,CDU parameter

c1 Value	Description
CH1	Use Channel data only

Table 9.10. $PASHS,SBA,CDU parameter

c1 Value	Description
BCP	Use Channel 1 data when available, and Channel 2 data as a backup. Use this option when the DG14 is in dual mode or operation.
BTH	Use data from both channels simultaneously. Use this option when the DG14DG14 is in dual mode or operation.

You must use the $PASHS,SAV command to save the parameters set in this command to memory.

DEFAULT SETTING
SBA,CDU—BTH

DAM: Dual Automatic Mode

$PASHS,SBA,DAM

This command sets the DG14 to Dual Automatic mode.

This command sets the receiver to track SBAS satellites on Channel 1 and Channel 2 and use this data in the navigation solution.

In Dual Automatic SBAS mode the DG14 automatically detects all available SBAS signals and selects the best two satellites. Channel 1 tracks the best satellite available, and Channel 2 tracks the second-best available satellite. In this mode, the DG14 has no capability to continue to scan for other, better SBAS signals. Therefore, once selected, the DG14 continues to track these two selected SBAS satellites so long it is able. If the signal on one of the channels is lost, the DG14 scans the available frequencies to find another SBAS satellite.

The best SBAS satellite is determined based collectively on the satellite SNR, elevation angle, continuity of signal reception, etc.

DAT: SBAS Output Message

$PASHS,SBA,DAT,c1,s1,[f1]

This command enables or disables the output of the SBAS messages on the specified port. c1 is Port A, B, or C to where the messages output, s1 is ON or OFF, and f1 is the optional frequency setting for the output ranging from 0.05 to 999

seconds depending on the measurement update rate option installed. If the command is set without a period, the DG14 uses the period set in the $PASHS,NME,PER command.

Example:

Enter the following command to enable the SBAS messages to port B.

$PASHS,SBA,DAT,B,ON

$PASHQ,SBA,DAT,<c1>

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

$PASHR,SBA,DAT

The response is in the format:

```
$PASHR,SBA,DAT,d1,d2,d3,s4*hh
```

Table 9.11 outlines the response parameters.

Table 9.11. $PASHR,SBA,DAT Response Message

Parameter	Description	Range
d1	Satellite ID number	33 to 64
d2	RTCA message ID	0 to 63
d3	Error flags (in HEX): bit0—preamble error, bit1—parity error	0 to 3
s4	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.	

INF: SBAS Information Message

$PASHS,SBA,INF,c1,s1,[f1]

This command enables or disables the output of the SBAS information message on the specified port. c1 is Port A, B, or C to where the messages output, s1 is ON or OFF, and f1 is the optional frequency setting for the output ranging from 0.05 to 999 seconds depending on the measurement update rate option installed. If the command is set without a period, the DG14 uses the period set in the $PASHS,NME,PER command.

$PASHR,SBA,INF

The response is in the format:

```
$PASHR,SBA,INF,d1,{d2,d3,d4}*hh
```

Table 9.12 outlines the response parameters.

Table 9.12. $PASHR,SBA,INF Response Message

Parameter	Description	Range
d1	Number of satellite assigned	0 or 2
d2	Satellite ID number	33 to 64
d3	Satellite signal-to-noise ratio	0 to 99
d4	Satellite state in HEX • bit0—Energy is found • bit1—PLL is locked • bit2—500 HZ data are synchronized • bit3—Viterbi decoder (250 Hz data) synchronized • bit4—Message preamble is found • bit5—Parity is OK	0 to 3F
*cc	Checksum	

Examples

Enable the SBAS information message on port A:

$PASHS,SBA,INF,A,ON

Disable the SBAS information message on port B.

$PASHS,SBA,INF,B,OFF

NOTE: Satellite ID numbers 33 to 64 correspond to SBAS PRN numbers 120-138. The offset from SBAS SVID to SBAS PRN number is 87. Add 87 to SVID to derive SBAS PRN number.

INT: Integrity Information

$PASHS,SBA,INT,s1

This command enables or disables the integrity information where s1 is ON (enable) or OFF (disable).

The DG14 will use one or two SBAS channels as a source for integrity information depending on the $PASHS,SBA,CDU setting.

You must use the $PASHS,SAV command to save the parameters set in this command to memory.

DEFAULT SETTING
SBA,INT— ON

MAN: Single Manual SBAS Mode

$PASHS,SBA,MAN,s1

This command sets the DG14 to Single Manual SBAS mode and has the DG14 search for and track the SBAS satellite you specify for Channel 1. s1 is the 2-digit SBAS ID number (33 to 64), which will be tracked on Channel 1.

Channel 2 automatically searches for and tracks the best available SBAS signal. If the best signal is selected for Channel 1, the DG14 uses the next best signal for Channel 2.

In single mode, the demodulated SBAS data from Channel 1 are available for output and used in the navigation solution.

MAN: Dual Manual SBAS Mode

$PASHS,SBA,MAN,s1,s2

This command sets the DG14 to Dual Manual SBAS mode and has the DG14 search for and track the SBAS satellite you specify for Channel 1 and 2. s1 is the 2-digit SBAS ID number (33 to 64), which will be tracked on Channel 1. s2 s the 2-digit SBAS ID number (33 to 64), which will be tracked on Channel 2.

In dual mode, the demodulated SBAS data from both channels are available for output and used in the navigation solution.

OFF: Disable SBAS Mode

$PASHS,SBA,OFF

This command disables the SBAS mode. After entering this command, the DG14 will no longer track SBAS satellites, and will track 14 GPS satellites.

To reactivate the SBAS mode, issue either the **$PASHS,SBA,DAM** or **$PASHS,SBA,MAN** command to enable either the Automatic or Manual SBAS mode.

If you issue the $PASHS,SBA,OFF command to disable the SBAS satellites, you can revert the DG14 to 12 GPS channels by entering the $PASHS,GPS,CHN,12 command.

PAR: Partial SBAS Corrections

$PASHS,SBA,PAR, s1

This command enables or disables the partial output of SBAS corrections where s1 is ON (enable) or OFF (disable).

If you enable partial SBAS corrections, the DG14 will output a differential position without the whole set of fast, slow, and ionospheric components.

If you want the entire set of fast, slow, and ionospheric components along with the differential solution be sure that this command is set to OFF.

You must use the $PASHS,SAV command to save the parameters set in this command to memory.

RTC: SBAS to RTCM Interface

$PASHS,SBA,RTC,c1,d1,d2

This command sets the interface parameters for SBAS based RTCM messages. Table 9.13 defines the parameters for this command.

Table 9.13. $PASHS,SBA,RTC Parameters

Parameter	Description	Range
c1	Receiver port from which the SBAS RTCM messages output	A, B, or C (optional port)
d1	RTCM Message Type	1, 2, 3, 6, 9
d2	Output interval	• 0—No message generated • 99—Message Output Continuously • 1 to 98 time interval between messages • Use 0 to disable the SBAS to RTCM conversion

Message Type 3 contains the current GPS/DGPS position of the receiver (if in Stand-alone or Remote mode).

Examples

Enable the SBAS based RTCM message 1 from port A at 1Hz:

$PASHS,SBA,RTC,A,1,1

Disable the SBAS based RTCM message 1 on port A:

$PASHS,SBA,RTC,A,1,0

SAM: Single Automatic Mode

$PASHS,SBA,SAM

This command sets the DG14 to Single Automatic mode. The demodulated SBAS data from Channel 1 are used in the navigation solution.

In Single Automatic SBAS mode, the DG14 automatically detects all available SBAS signals and selects the best ONE satellite, switching automatically as you move from one coverage area to another. The automatic selection uses both SBAS channels. Channel 1 tracks the best available SBAS signal and Channel 2 scans for another available SBAS satellite signals, maintaining a SBAS satellite directory in a battery-backed memory. The quality of the SBAS satellite tracked on Channel 1 (signal strength, elevation, etc.) is continuously compared to the quality threshold. When the quality of the signal on Channel 1 is less than the quality threshold, the DG14 checks the quality of the signal of the Channel 2 satellite. If Channel 2 satellite has a better signal, the DG14 switches to it. If, on the other hand, the signal on Channel 1 drops below the threshold and the signal on Channel 2 is no better or no SBAS satellite, The DG14 continues to use and track the satellite on Channel 1.

SSO: SBAS Satellite Search Order

$PASHS,SBA,SSO,s1[,s2,...]

This command sets the order the receiver searches for SBAS satellites where s1, s2,... are the SBAS satellite ID numbers ranging from 33 to 64, which are searched for first. The remaining satellites after the specified SBAS satellites.

The numbers 33 to 64 are used for SBAS satellites. The SBAS system PRN numbers range from 120 to 138. The offset from SBAS SV ID to SBAS PRN number is 87. Add 87 to the SV ID to derive the SBAS PRN number.

Example

The following command sets SBAS PRN 122 and 134 as the first in the search list. SBAS satellite 122 has a satellite ID number 35, and SBAS satellite 134 has a satellite ID number 47.

$PASHS,SBA,SSO,35,47

DEFAULT SETTING
SSO—Search Order Satellite IDs 35, 33, 47, 51, 34, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 48, 49, 50

USE: SBAS Satellites for Acquisition

$PASHS,USE,SBA,c1

This command includes or excludes all SBAS satellites simultaneously, where c1 is Y (include) or N (exclude). In a case where several satellites were excluded from being tracked with the **$PASHS,USE** command, this shortcut command once again includes all SBAS satellites for tracking.

To enable or disable the tracking of all GPS satellites, use the **$PASHS,USE** command. See **USE: Satellites for Acquisition**, on page 149 for a description of this command.

This command does not change the current GPS/SBAS configuration.

USP: SBAS Satellites Used in Position Computation

$PASHS,USP,SBA,s1

This command includes or excludes all SBAS satellites used in the position computation, where s1 is YES to included all or NO to exclude all. In a case where several satellites were excluded from the position computation with the **$PASHS,USP** command, this shortcut command once again includes all SBAS satellites in the position computation.

DEFAULT SETTING
USP,SBA— NO (exclude all)

To enable or disable using all GPS satellites in the position computation, use the **$PASHS,USP** command. See **USP: Satellites Used in Position Computation**, on page 150 for a description of this command.

If the receiver is set to single mode, the DG14 uses only the range information from Channel 1 in the navigation solution. If the receiver is set to dual mode, the DG14 uses the range information from both channels depending on the **$PASHS,SBA,CDU** setting.

The SBAS ranging information is available in both the MCA and MBN formatted messages so that the SBAS satellite can be used seamlessly in a navigation solution.

You must use the $PASHS,SAV command to save the parameters set in this command to memory.

Differential Commands

Beacon Commands

The DG14 two-channel scanning beacon receiver has two modes of operation: automatic or fixed. In both modes, the beacon receiver can provide corrections from one or two beacon stations. The beacon commands are only available with the Beacon option (N) installed. See **Receiver Options**, on page 15 for more information on available receiver options.

The DG14 beacon receiver outputs in RTCM SC-104 differential correction format.

The DG14 has several modes of beacon operation Use the **$PASHS,BCN,ddd** command to set the beacon operation mode:

- Automatic Mode—the receiver determines which beacon station(s) to use
  - Single Automatic Mode
  - Dual Automatic Mode
- Manual Mode—you manually set which beacon station(s) to use
  - Single Manual Mode
  - Dual Manual Mode

The default Beacon mode is Single Automatic. On power up, the DG14 remembers the last beacon stations used, and begins searching with those frequencies.

Table 9.14 outlines the Beacon commands.

Table 9.14. Beacon Commands

Function	Command	Description	Default	Page
Beacon Mode	$PASHS,BCN,MOD,AUT,DUA	Set Dual Automatic mode		331
	$PASHS,BCN,MOD,AUT,SNG	Set Single Automatic mode		331
	$PASHS,BCN,MOD,MAN	Set Manual mode		330
	$PASHS,BCN,CHN	Specify stations to track in Manual Mode		327
	$PASHQ,BCN,MOD	Query the Beacon mode		330

Table 9.14. Beacon Commands

Function	Command	Description	Default	Page
Beacon Directory and Channel	$PASHS,BCN,CHN,OFF	Disable specified channel		328
	$PASHS,BCN,CLR	Clear the Never-use mark for the specified frequency		328
	$PASHS,BCN,DIR,ADD	Add a specified Beacon station to the directory		326
	$PASHS,BCN,DIR,CLR	Erase the beacon directory		329
	$PASHS,BCN,DIR,DEL	Delete the specified frequency and bit rate entry in the beacon directory		330
	$PASHS,BCN,DIR,INI	Restore the Beacon directory from Flash- return to factory default		330
	$PASHQ,BCN,DIR	Query the Beacon directory		328
	$PASHQ,BCN,DIR,DEF	Query the Beacon directory for stations from the default list		328
	$PASHQ,BCN,DIR,RTC	Query Beacon directory for RTCM message Type 7 stations		328
	$PASHQ,BCN,DIR,USR	Query the Beacon directory for user entered stations		329
	$PASHS,BCN,NVR	Mark a frequency to never use in Automatic mode		331
	$PASHQ,BCN,NVR	Query the frequencies set to never use in Automatic mode		331
	$PASHS,BCN,RT7	Enable RTCM message type 7overwrite blocking	Y	332
Beacon Memory and Almanac	$PASHS,BCN,ALM	Enable/disable internal almanac message		327
	$PASHQ,BCN,ALM	Query for internal almanac message		327
	$PASHS,BCN,RST	Reset all Beacon parameters		332
	$PASHS,BCN,SAV	Save the Beacon parameters		333
Output	$PASHS,BCN,OUT	Set the serial port for output		332

ADD: Add Frequency

$PASHS,BCN,DIR,ADD,f1,c1,f2,c2,f3,d1,d2,[d3,d4,d5,d6,d7]

This command adds a specified Beacon station to the beacon directory. Table 9.15 outlines the parameters.

Table 9.15. $PASHS,BCN,DIR,ADD Parameters

Parameter	Description	Range
f1	Latitude	0 to 90.0000
c1	Direction of latitude	N or S
f2	Longitude	0 to 180.0000
c2	Direction of Longitude	E or W
f3	Beacon frequency, KHz	283.5 to 325.0
d1	Station ID	0 to 1023
d2	Bit rate	25, 50, 100, 200, none, autodetect
d3	Optional. Range in Km	
d4	Optional. Health	
d5	Optional. Modulation code	
d6	Optional. Synchronization type	
d7	Optional. Broadcast coding	

The **$PASHS,BCN,DIR,ADD** command will be NAKed if you enter a station that is located less than 30 Km from an existing station in the Beacon directory. To replace a station, or edit one or more station parameters, you must delete the station and add a new station with the new parameters.

Example

Enter the following command to add the Beacon station at Pigeon Point, CA to the Beacon directory.

$PASHS,BCN,DIR,ADD,3711.33,N,122.2366,W,287.0,883,100

ALM: Internal Almanac Message

$PASHS,BCN,ALM,c1,s1

This command enables the Beacon to output the internal almanac message where c1 is the output port (A, B, or optional C) and s1 is ON or OFF.

$PASHQ,BCN,ALM

This command queries for the internal almanac messages.

$PASHR,BCN,ALM,n1,(f1,c1,f2,c2,f3,d1)…

The response is in the format `$PASHR,BCN,ALM,n1,(f1,c1,f2,c2,f3,d1)...`

Table 9.16 outlines the parameters of the response message.

Table 9.16. $PASHR,BCN,ALM Response Message Parameters

Parameter	Description
n1	Number of station in the message. The remaining parameters are repeated for each message.
f1	Latitude
c1	Latitude hemisphere N or S
f2	Longitude
c2	Longitude hemisphere E or W
f3	Frequency
d1	Range in Km

CHN: Assign Beacon Station Channel

$PASHS,BCN,CHN,d1,f1,[d2],[d3]

This command assigns the specified Beacon station frequency to the DG14 channel. You can only use this command when the Beacon receiver is in Manual mode. Table 9.17 outlines the parameters.

Table 9.17. $PASHS,BCN,CHN Parameters

Parameter	Description	Range
d1	Channel number	1 or 2
f1	Frequency in KHz	283.5 to 325.0

Table 9.17. $PASHS,BCN,CHN Parameters

Parameter	Description	Range
d2	Radio Beacon broadcast ID (station ID)	0 to 1023
d3	Bit Rate	25, 50, 100, 200

$PASHS,BCN,CHN,d1 OFF

This command disables the specified channel, where d1 is the channel 1 or 2.

Examples

Enter the following command to set Channel 1 to track the Beacon Station at Pigeon Point, CA

$PASHS,BCN,CHN,1,287,883,100

Enter the following command to disable Channel 1.

$PASHS,BCN,CHN,1,OFF

CLR: Clear Never-Use Mark

$PASHS,BCN,CLR,p1

This command clears the never-use mark for the specified frequency. p1 is the frequency ranging from 283.5 to 325 KHz.

Example

Enter the following command to clear 287 KHz from the never-use frequency mark list.

$PASHS,BCN,CLR,287.0

DIR: Beacon Directory

$PASHQ,BCN,DIR

This command queries for the entire current Beacon directory.

$PASHQ,BCN,DIR,DEF

This command queries for the Beacon directory of the stations only in the default list.

$PASHQ,BCN,DIR,RTC

This command queries for the Beacon directory of the stations with only RTCM message type 7.

$PASHQ,BCN,DIR,USR

This command queries for the Beacon directory for only the user entered stations.

$PASHR,BCN,DIR,n1,n2,s1,f1,f2,c2,f3,d1,d2,d3,d4,d5,d6,d7

The response is in the format

```
$PASHR,BCN,DIR,n1,n2,s1,f1,f2,c2,f3,d1,d2,d3,d4,d5,d6,d7*hh
```

Table 9.18 outlines the response parameters.

Table 9.18. $PASHR,BCN,DIR Response Message Parameters

Parameter	Description
n1	Total number of DIR messages (stations) in the response
n2	Number of messages remaining to output (countdown)
s1	Source of the information DEF—Default list, RTC—RTCM Type 7 message, USR—User entered
f1	Latitude
c1	Latitude hemisphere N or S
f2	Longitude
c2	Longitude hemisphere E or W
f3	Frequency
d1	Station ID
d2	Bit Range
d3	Range in Km
d4	Health
d5	Modulation code
d6	Synchronization type
d7	Broadcast code
*hh	Checksum

DIR,CLR: Erase Beacon Directory

$PASHS,BCN,DIR,CLR

This command erases the contents of the beacon directory from memory. Upon a cold start, the DG14 Beacon directory consists of the default list kept in ROM only. The Beacon Directory can also be reset to the default list of stations with the **$PASHS,BCN,DIR,INI** command.

DIR,DEL: Delete Beacon Station from Beacon Directory

$PASHS,BCN,DIR,DEL,f1,[d1]

This command deletes the specified Beacon station from the Beacon directory where f1 is the frequency, in KHz, and d1 is the Station ID.

If you do not specify a Station ID, then all stations with the frequency specified are deleted from the Beacon directory.

If you specify both a frequency and Station ID, the frequency must match the frequency for the specified Station ID, or no Beacon station will be deleted from the Beacon directory.

If you specify a Station that is locked, then deleting the Station from the Beacon directory will not remove the Never-Use lock from the station. You must use the **$PASHS,BCN,CLR** to remove the Never-Use lock.

DIR,INI: Reset Beacon Directory

$PASHS,BCN,DIR,INI

This command restores the Beacon directory from FLASH to the factory defaults.

MAN: Manual Mode

$PASHS,BCN,MOD,MAN

This command sets the DG14 Beacon functionality to Manual mode. For more information on the Beacon Manual mode, see **Manual Modes**, on page 288.

After manual mode is set, both Beacon channels stop operating until the channels are assigned specific stations/frequencies with the **$PASHS,BCN,CHN** command (For more information on the **$PASHS,BCN,CHN** command, see page **CHN: Assign Beacon Station Channel**, on page 327).

MOD: Query Beacon Mode

$PASHQ,BCN,MOD

This command queries the mode that the Beacon functionality is currently in.

$PASHR,BCN,MOD

The response is in the format:

```
$PASHR,BCN,MOD,s1,s2
```

where s1 is indicates automatic (AUT) or manual (MAN) and s2 indicates single (SNG) or dual (DUA) mode.

MOD,AUT,SNG: Set Single Automatic Mode

$PASHS,BCN,MOD,AUT,SNG

This command sets the Beacon receiver to single automatic mode. For more information on the Single Automatic mode, see **Single Manual Mode**, on page 288.

MOD,AUT,DUA: Set Dual Automatic Mode

$PASHS,BCN,MOD,AUT,DUA

This command sets the Beacon receiver to dual automatic mode. For more information on the Dual Automatic mode, see **Dual Automatic Mode**, on page 287.

NVR: Never Use Frequency

$PASHS,BCN,NVR,f1

This command marks a frequency to never be used in automatic or manual modes. f1 is the frequency, in KHz, ranging from 283.5 to 325.0 KHz. All stations with the specified frequency are not searched after you issue this command.

Use the **$PASHS,BCN,CLR** to remove the Never-Use lock from a station.

$PASHQ,BCN,NVR

This command queries for the frequencies marked as Never-Use.

$PASHR,BCN,NVR,d1,f1,f2

The response is in the format `$PASHR,BCN,NVR,d1,f1,f2....` Table 9.19 outlines the response message parameters.

Table 9.19. $PASHR,BCN,NVR Response Parameters

Parameter	Description
d1	Number of frequencies marked as Never-Use
f1,f2,...	Beacon frequencies, in KHz, marked as Never-Use

OUT: Serial Port for Output

$PASHS,BCN,OUT,d1,c1,s1

This command directs the Beacon output to the specified serial port. d1 is the Beacon channel (1 or 2), c1 is the receiver port (A, B, or optional C), and s1 is ON or OFF.

Example

Enter the following command to direct the Beacon output for Channel 1 to port B.

$PASHS,BCN,OUT,1,B,ON

RST: Reset Beacon Parameters

$PASHS,BCN,RST

This command resets the Beacon parameters to the saved or default settings.

Table 9.20 lists the different methods you can restart the Beacon receiver and the differences between the methods.

Table 9.20. Restarting the Beacon Receiver

Reset Command or Action	Description
Power Cycle the DG14	All receiver and Beacon parameters are restored from battery backed-up memory.
$PASHS,RST	The receiver and Beacon restart. All Beacon parameters are restored to defaults.
$PASHS,BCN,RST	The Beacon restarts. All Beacon parameters are restored to defaults.
$PASHS,INI,x,x,3 or $PASHS,INI,x,x,1	The receiver and Beacon restart. All receiver and Beacon parameters are restored to defaults.
$PASHS,INI,x,x,0 or $PASHS,INI,x,x,2	The receiver and Beacon restarts All receiver and Beacon parameters are restored from battery backed-up memory.
$PASHS,BCN,BBU	The Beacon restarts. All Beacon parameters are restored from battery backed-up memory.

RT7: Blocking RTCM Message Type 7

$PASHS,BCN,RT7,s1

This command blocks the RTCM message type 7 from overwriting the preceding user entered Beacon stations in the Beacon directory where s1 is Y or N.

If RTCM message type 7 information is enabled, and received from an RTCM type 7 station located within 30 km of any station in the Beacon directory, then the station in the Beacon directory is replaced with the newly received information.

If information is received from RTCM type 7 station located more than 30 km from any station in the Beacon directory, then the station is added to the Beacon directory.

Example

Enter the following command to block RTCM message type 7 from overwriting in the preceding Beacon stations in the Beacon directory.

$PASHS,BCN,RT7,N

Enter the following command to enable RTCM message type 7 overwriting in the Beacon directory.

$PASHS,BCN,RT7,Y

DEFAULT SETTING
BCN,RT7—ON (Y)

SAV: Save Beacon Parameters

$PASHS,BCN,SAV

This command saves the current channel tuning and mode selection in the battery-backed memory. The saved parameters will be used after a power cycle or after a reset.

10

RAIM & HLP Features

Introduction & Definitions

Two new features have recently been implemented in the DG14:

- RAIM: Receiver Autonomous Integrity Monitoring (complying with RTCA/DO-208 guidelines)
- HLP: Horizontal Protection Level.
  HLP is defined as the radius of a circle in the horizontal plane, centered at the true aircraft position, that is assured to contain the indicated horizontal position, with a given probability of missed detection and false alert. The HPL value should be similar to the one output in ARINC label 130. Note that HPL computation algorithm will NOT strictly conform to the HPL definition in DO-229C as it is a document that was published at a later date.

The following important assumptions were made when implementing the RAIM algorithm in the DG14:

- DG14's RAIM does not include WAAS satellites as RTCA/DO-208 does not include them
- DG14's RAIM is supposed to work only in standalone mode and with standard LMS positioning
- WAAS integrity information will not affect DG14's RAIM.

RAIM Option

The [I] option is needed to use the RAIM operation features RAIM and HLP. If the RAIM option is not installed, then the commands used to enable these features will have no effect.

The RAIM feature is available on firmware DD00 and later versions.

Combining RAIM with Other DG14 Modes

RAIM Versus Differential

The RAIM option can only be used in standalone mode. Consequently, the receiver will not allow you to use the RAIM and a differential mode at the same time.

The RAIM feature has therefore been implemented as follows:

1. If one of the differential modes (from port, from SBAS, or from Beacon) is currently enabled in the board, then the command used to enable RAIM is intentionally made unusable.

2. If RAIM is currently enabled and a command is issued to enable one of the differential modes, then RAIM is automatically disabled. When the user chooses to return to the standalone mode, RAIM is automatically re-enabled.

RAIM Versus WAAS/EGNOS Satellites

The DG14's RAIM is supposed to work only with GPS satellites. But it is also necessary that the set of satellites used in the position solution and the set of satellites used by RAIM be exactly the same. As a consequence, the DG14 should not use WAAS/EGNOS satellites in the position solution while RAIM is enabled.

This is implemented in the following way: By default, WAAS/EGNOS satellites are always used in the position solution. When the command to enable RAIM is issued, all WAAS/EGNOS satellites are automatically rejected from the position solution. After RAIM is disabled, all WAAS/EGNOS satellites will automatically be re-used in the position solution.

If the enabling of the RAIM feature is the reason why WAAS/EGNOS satellites are not used in the position solution, then these satellites should be marked with the letter "R" in SAT messages when SUI=ON.

RAIM Versus KFP Mode

The DG14's RAIM is supposed to work only in standalone mode with standard LMS positioning. Actually RTCA/DO-208 requires that the position computation algorithm be LMS. It means that RAIM is not compatible with KFP positioning. Therefore RAIM and KFP cannot be used at the same time.

This is implemented in the following way:

The DG14's implementation is the following.

1. If the KFP mode is currently enabled, then the command used to enable RAIM is intentionally made unsable
2. Conversely, if the RAIM feature is currently enabled, then the command used to enable the KFP mode is intentionally made unsable.

RAIM Algorithm

RAIM (Receiver Autonomous Integrity Monitoring) provides the detection of anomalous satellite pseudorange error with miss detection probability 0.999 and false alarm probability 0.002 per hour (requirements from RTCA/DO-208) under given horizontal alarm limit in range 200 m to 2 nautical miles.

In addition, RAIM isolates wrong satellite and corrects position and velocity errors. RAIM includes three procedures that are called every epoch. The first one is Availability Check which checks current satellites constellation available to determine the possibility of anomalous error detection with given alarm threshold, false alarm and miss detection probabilities. Availability percentage depends on alarm threshold value, satellites number and their position. The less alarm threshold is, the less availability percentage will be.

For example, if 7 satellites with good PDOP are in view and alarm threshold is the one nautical mile (terminal mode), detection is always available. If only 4 satellites are visible, detection is impossible.

If detection is available then Detection procedure is called. Detection algorithm compares the residuals with threshold depending upon the number of redundant satellites in view. If the threshold is exceeded then anomalous error is detected.

RAIM is a snapshot type algorithm, so detection usually takes place at the first epoch after the alarm limit being exceeded. If error is detected and at least 6 satellites with good PDOP are in view, then the Exclusion And Correction algorithm is called.

The Exclusion And Correction algorithm determines the number of "wrong" satellites by maximal normalized residual, after that the position and velocity are corrected by exclusion of that "wrong" satellite. To avoid possible incorrect isolation, the rest of the satellites' set is tested by Availability Check and Detection algorithm. If the rest of the satellites' set is available and no error is detected, it means the successful correction of position and velocity.

The procedures above can be executed recursively. It provides the possibility of more than one simultaneously wrong satellite exclusion.

However, in some cases where not enough satellites are available or too many errors are detected, the probability requirement cannot be met because of statistical limitations.

RAIM Flowchart

Tracked Satellites
Coordinates

HPL
Calculation

HPL < Alarm Limit ? —No→ FDE is not invoked
RAIM status is 3 (not available)
Position is output

Yes

Measured Satellite Data
True Positions → FDE Algorithm

Error Detected ? —No→ RAIM status is 0 (no error)
Position is output

Yes

Can Error be
Excluded ? —No→ RAIM status is 2 (error
detected, can not exclude)
Position is NOT output

Yes

Re-compute HPL w/o
excluded satellite

New HPL < Alarm
Limit ? —No→ RAIM status is 4 (error detected,
rest of SVs is not available)
Position is NOT output

Yes

Exclude failed satellite
from position solution

RAIM status is 1 (error detected
and corrected)
Position is output

A

Quick Start Commands

Set Remote SBAS

Use the following commands to set the receiver in remote mode to use SBAS corrections.

$PASHS,SBA,DAM /* Set receiver to dual automatic SBAS mode */

$PASHS,RTC,SLC,SBA /* Select SBAS corrections for use in differential solution */

$PASHS,RTC,REM,ON /* Set receiver in remote differential mode */

Set Remote Beacon

Use the following commands to set the receiver in remote mode to use beacon corrections.

$PASHS,BCN,MOD,AUT,DUA/* Set receiver to dual automatic beacon mode */

$PASHS,RTC,SLC,BCN /* Select beacon corrections for use in differential solution */

$PASHS,RTC,REM,ON /* Set receiver in remote differential mode */.

Set Remote External Serial Port

Use the following commands to set the receiver in remote mode to use external serial port corrections.

$PASHS,RTC,REM,B (or A or C)/* Set receiver in remote differential mode and select serial port to use*/, where A, B or C is the serial port through which the remote receives corrections.

OR

$PASHS,RTC,SLC,EXT /* Select serial port corrections for use in differential solution */

$PASHS,RTC,REM,ON /* Set receiver in remote differential mode */

In this case, the receiver automatically detects and uses corrections available on all serial ports. If corrections are received on more than one port, the corrections are combined and then applied to the position solution.

Set Remote, Two Sources

Use the following commands to set the receiver in remote mode to use corrections from two sources.

Serial or SBAS

Use the commands below to set the receiver in remote mode to use serial port corrections if available, or switch to SBAS if corrections are not available on serial port.

$PASHS,SBA,DAM /* Set receiver to dual automatic SBAS mode */

$PASHS,RTC,SLC,EXT,SBA /* Select serial port as primary and SBAS as secondary source of corrections*/

$PASHS,RTC,REM,ON /* Set receiver in remote differential mode */

Serial or Beacon

Use the commands below to set the receiver in remote mode to use serial port corrections if available, or switch to beacon if corrections are not available on the serial port.

$PASHS,BCN,MOD,AUT,DUA /* Set receiver to dual automatic beacon mode*/

$PASHS,RTC,SLC,EXT,BCN /* Select serial port as primary and beacon as secondary source of corrections*/

$PASHS,RTC,REM,ON /* Set receiver in remote differential mode */To open an existing UDM Utility project:

Beacon or SAS

Use the commands below to set the receiver in remote mode to use beacon corrections if available or switch to SBAS if no beacon is available.

$PASHS,BCN,MOD,AUT,DUA /* Set receiver to dual automatic beacon mode */

$PASHS,SBA,DAM /* Set receiver to dual automatic SBAS mode */

$PASHS,RTC,SLC,BCN,SBA /* Select beacon as primary and SBAS as secondary source of corrections*/

$PASHS,RTC,REM,ON /* Set receiver in remote differential mode */

Set Remote, Multiple Sources

Use the following commands to set the receiver in remote mode to use corrections from multiple sources.

Serial or Beacon or SBAS

Use the commands below to set the receiver in remote mode to use serial port corrections if available, or switch to beacon or SBAS if corrections are not available on the serial ports.

$PASHS,BCN,MOD,AUT,DUA   /*Set receiver to dual automatic Beacon mode*/

$PASHS,SBA,DAM   /* Set receiver to dual automatic SBAS mode */

$PASHS,RTC,SLC,EXT,BCN,SBA/* Select serial port as primary and beacon as secondary and SBAS as a third source of corrections*/

$PASHS,RTC,REM,ON   /* Set receiver in remote differential mode */

Weighted Multi-Base

Use commands below to set the receiver in Weighted Multi-Base mode.

$PASHS,BCN,MOD,AUT,DUA/* Set receiver to dual automatic beacon mode */

$PASHS,SBA,DAM   /* Set receiver to dual automatic SBAS mode */

$PASHS,RTC,SLC,WGH   /* Select weighted multi-base solution*/

$PASHS,RTC,REM,ON   /* Set receiver in remote differential mode */

In this mode the receiver selects or combines all available corrections to provide the best differential solution.

B

UDM Utility

If you have purchased the User Defined Messaging option [X], then you can use the UDM Utility program to create the script file which defines the custom messages. You can use the custom message feature to set the receiver to output only the information you need in a single message. This can save you from sending several receiver commands.

Installing UDM Utility

UDM Utility is designed for 32-bit operating systems: Windows 95, 98, 2000, or NT4.0, with a 486/66 computer or better.

To install the UDM Utility program, perform the following steps:

1. Insert the UDM Utility installation disk.
2. Click on the Windows Start menu and select "Run".
3. Type in "a:\setup.exe", where the "a:" is the letter of your CD-ROM drive.
4. Follow the instructions of the installation program.

Introduction

UDM Utility is intended to create the format of a receiver command. Receiver commands are used to output various operating/solution parameters such as elevation mask, latitude of antenna, and operating mode. UDM Utility allows the user to create commands to output solution or receiver parameters. The user can construct a project with output commands, then compile this project and upload to the GPS receiver.

Components of UDM Utility

When using UDM Utility, you create and edit a project file. Within the project file are the following file types:

- *.rdf—Receiver Definition File contains variables available for a specific receiver and used to create messages. Each receiver type has the own receiver definition file.
- *.ash—GPS receiver data file with the Ashtech commands for a specific receiver. Each receiver type has a unique *.ash file
- *.mdf—Message Definition File contains user-defined messages uploaded and saved to the receiver.
- *.prj—Project file

When you open a project, UDM utilizes the *.rdf and *.ash files for the receiver. The *.mdf file is created when you save the project. Figure 1 shows the relationships between the different components of UDM.

Figure A.1. Component of UDM

Operation

You can start UDM Utility from your Windows desktop.

To start UDM Utility, from the **Start** menu **Programs** folder, select **UDM Utility** from the **UDM Utility** folder. The UDM Utility main window opens.

Creating a New Project

To create a new UDM Utility project:

1. Select **New Project** from the **Project** menu.

   The **New Project** dialog box opens.

2. Enter the filename for the new project in the **File Name** field. The program automatically adds `.prj` extension to the filename.

3. Click **Open**.

   The **New Project** dialog box closes and the **Attach Receiver** data files dialog box opens.

4. Navigate to the directory which contains the `.rdf` file you want to attach to the project, and double-click file or click **Open**.

   UDM Utility creates a new project and displays the project name on the title bar of the main window.

Opening an Existing Project

To open an existing UDM Utility project:

1. Select **Open Project** from the **Project** menu.

   The **New Project** dialog box opens.

2. Double-click the .**prj** file you want to open or type the filename in the File name field.

3. Click **Open**.

Understanding UDM Utility Environment

When you start UDM Utility, you can see the three distinct windows of the program environment:

- The Folder list
- The Message Parameters pane
- The Warning window

If you do not see the Warning window, drag up the pane separator at the bottom of the main window.

Folder List

The **Folder** list (Figure 2) contains the all messages of the project. To view the message variables and parameters for a given message, double-click on the command.

Figure A.2. Folder List

Message Parameters Pane

The **Message Parameters** pane (Figure 3) contains information on the variables if the message already exists or allows you to define new variables when you create a new message.

Figure A.3. Message Parameter Pane

Table A-1 outlines the fields and list box in the **Message Parameters** pane.

Table A.1 Message Parameter Pane

Item	Description
Header	Ashtech or Other. If Ashtech is selected in the first field, there is PASHR in the second field. If Other is selected, the second field can be PASHR, blank, or any word.
Title	Alphabetical characters. A maximum of 3 characters.
Type	ASCII, Binary
Description	Place for comments
Message variables	Contains variables of the selected message.
Up button	Moves the variable up in the list.
Down button	Moves the variable down in the list.
Remove button	Deletes the variable from the list.
Optional check box	If you mark the check box, the variable is included in square brackets and can be missed.
Convert to:	Select the variable type you want the message variable converted to. The list of types varies variable selected.
Format	The format of the message variable. The type varies with the variable selected.
Max Digits Before Decimal	You can enter the maximum number of digits before decimal point.
Max Digits After Decimal	You can enter the maximum number of digits after decimal point.
Mandatory Sign	Requires to necessarily output the sign '+' or '-'. For example +12.1234 with "Mandatory Sign" and 12.1234 without.
Multiplier	You can enter a number to multiply the value. The response message displays the value multiplied by the Multiplier. This function is useful for converting measurement units. For example, if you would like the output message to display in meters, but the response is in feet, use a multiplier value of 0.3048 to convert the output value to meters.
Available Variables	Contains variables of the appropriated GPS receiver divided into several groups.
Tree	If you mark the radio button, you will see the variables in tree-view structure.
List	if you mark the radio button, you will see the variables in alphabetical order.
Insert to Parameter List button	Inserts the selected parameter in the Message Variables list.
Type	Displays the type of the variable. It can be Integer, Real, Text String, etc.

Item	Description
Description	Displays a brief description of the selected variable.
Request and Response	
Messages format	Displays the messages view.
Query Command	Displays the query command. If the message header is **Ashtech**, the query command format is $PASHQ,NEW, when NEW is the message title. If the message header is **Other**, the query command format is NEW, when NEW is the message title.
Set Command	Displays the set command. If the message header is **Ashtech**, the set command format is $PASHS,UDM,NEW, when NEW is the message title. If the message header is **Other**, the query command format is NEW, when NEW is the message title.
Request Confirmation (ACK, NAK)	You can mark the check box to get confirmation.
Save	Saves changes.
Cancel	Restores the last saved state.

Warning Window

The **Warning** window reflects errors and warnings. These messages appear during the files reading and writing, compiling or uploading of a project, etc. and informs you about ending of some long-run processes, such as the end of uploading.

Creating a Custom Message

To create a new message:

1. Open the project.
2. Click in the left pane.
3. Select **Add New Message** from the **Edit** menu.
4. Start to fill the field of the Message Parameter pane.
5. Select **Save Project** from the **File** menu to save the new message.

You can copy, paste from the clipboard, and delete the selected message by using the corresponding commands in the Edit **menu.**

Editing Message

To assign new variables to or edit an existing messages:

1. Select the message you want to edit.
2. Double-click the message or select **Edit Message** from the **Edit** menu. The fields of the **Message Parameter** pane populate.
3. Enter the new variables of the message.
4. Select **Save Project** from the **File** menu to save the edited message.

Defining Message Parameters

When you create a custom message, you must fill out the information in the **Message Parameter** pane.

1. Enter a three letter title for the message in the **Title** field. The title must not be in use by the receiver.
2. Enter a brief description for the message in the **Description** field.
3. Select **Ashtech** or **Other** in the **Header** field for the message prefix. If you selected **Other**, select **PASHR** or type in any word.
4. Select **ASCII** or **Binary** in the **Message Type** field to correspond to if you want your message output in ASCII or binary format.
5. Select the **Tree** radio button to view the available variables by function.
6. Click on the message group you want to add to your message (such as Communication) **in the Available Variables** list.

   The available variables for the group appear beneath the message group. Variables from the Miscellaneous group can be added anywhere in the custom message.
7. Double-click on a group or variable, or select a group or variable and press the **Add to Parameter** list button.

   The selected variable appears in the **Message Variables** list with **(empty)** as a sub-heading.
8. Check the **Optional** check box if you want the group or variable to be optional.
9. Select the type you want to convert the variable to in the **Convert** to field.
10. Select a format for the variable display in the **Format** field.
11. Enter the maximum number of digits you want to appear before the decimal point for the variable in the **Max Digits Before** field.
12. Enter the maximum number of digits you want to appear after the decimal point for the variable in the **Max Digits After** field.

13. If the variable requires a positive or negative indicator, check the **Mandatory Sign** check box.

14. If you want the variable displayed using a multiplier, enter t multiplier in the **Multiplier** field.

15. Click the **Save Message** button to save your changes to the message.

16. Select (empty).

17. Repeat steps 6 to 16 for each group or variable you want to add to the **Message Variable** list.

18. To save project and message, select **Save** from the **File** menu.

Uploading Messages to a Receiver

After you have created and saved a custom message, you need to upload the user-defined data file to your receiver.

1. Verify that your receiver is connected to your PC and that you can communicate with your receiver.

2. Open the project file with the message formats you wish to upload to your receiver.

3. Select **Upload** from the **File** menu.

4. In the **Port Settings** dialog box, select the COM port that your receiver is connected.

5. Change the baud rate, if necessary.

6. Click **OK**.

   UDM initiates communication with your receiver and uploads the message formats to your receiver. The status bar in the dialog box shows the progression of the data upload.

7. Click .

UDM uploads the message formats in the background. You can continue to work in the project file while the upload progresses.

C

Floating Point Data Representation

The DG14 stores the floating point data types using the IEEE single and double precision format. The formats contain a **sign bit field**, an **exponent field**, and a **fraction field**. The value is represented in these three fields.

Sign Bit Field

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

Exponent Field

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

Fraction Field

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

1.xxxxxx (binary)

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

Because all floating point binary numbers begin with 1, the 1 becomes the implicit normalized bit and is omitted. It is the most significant bit of the fraction, and the binary point is located immediately to its right.   All bits after the binary point

represent values less than 1 (binary). For example, the number 1.625 (decimal) can be represented as:

1.101 (binary) which is equal to:

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

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

1.625 (decimal).

The Represented Value

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

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

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

Single-Precision Float

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

Table B.1. Single-Precision Format

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

In 1, the value 1.0 is calculated by the following method:

1.   The sign of the value is positive because the sign bit field is equal to 0.

2. The exponent field is equal to 7F (hexadecimal). The exponent is calculated by subtracting the bias value (7F) from the exponent field value. The result is 0.

    7F - 7F = 0

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

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

4. The value of the number is positive 1*1= 1.0 (decimal).

In 1, the value 0.75 is calculated by the following method:

1. The sign of the value is positive because the sign bit field is equal to 0.

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

    7E - 7F = -1

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

3. The fraction field is equal to .1 (binary). After adding the implicit normalized bit, the fraction is equal to 1.1 (binary). The fraction value is equal to $2^0 + 2^{-1}$ (decimal), which is equal to 1 + 0.5 (decimal), which is equal to 1.5 (decimal).

4. The value of the number is positive 0.5*1.5 = 0.75 (decimal).

Double-Precision Float

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

Table B.2 Double-Precision Format

63-60	59-56	55-62	51-48	47-44	43-40	...	15-12	11-8	7-4	3-0	
S EXPONENT FRACTION											VALUE
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.0
0011	1111	1111	0000	0000	0000	...	0000	0000	0000	0000	1.0
1111	1111	1111	1111	1111	1111	...	1111	1111	1111	1111	NAN (not a number)
0011	1111	1110	1000	0000	0000	...	0000	0000	0000	0000	0.75

In 2, the value 1 is calculated by the following method:

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

   3FF - 3FF = 0

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

In 2, the value 0.75 is calculated by the following method:

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

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

Glossary

A

Aerotriangulation (phototriangulation)

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

AFT

After

AGE

Age of Data

ALM

See **Almanac**

Almanac

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

(See **Ellipsoid**).

ALT

Altitude

Ambiguity

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

AMI

ATM Management Interface

ANT

Antenna

Antenna

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

Anti-Spoofing (AS)

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

ASCII

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

Atomic clock

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

Argument of latitude

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

Argument of perigee

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

Ascending node

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

Azimuth

A horizontal direction expressed as the angular distance between a fixed direction and the direction of the object.

AZM

See Azimuth

B

Bandwidth

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

Baseline

The measured distance between two receivers or two antennas

Bias

See **Integer bias terms**

BIN

Binary Index (file)

C

C/A

Coarse Acquisition

C/A code

A sequence of 1023 bits (0 or 1) that repeats every millisecond. Each satellite broadcasts a unique 1023-bit sequence that allows a receiver to distinguish between various satellites. The C/A-Code modulates only the L1 carrier frequency on GPS satellites. The C/A-Code allows a receiver to Carrier frequency
The basic frequency of an unmodulated radio signal. GPS satellite navigation signals are broadcast on two L-band frequencies, L1 and L2 is at 1575.42 Mhz, and L2 is at 1227.6 Mhz.

Carrier phase

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

CEP

See Circular error probable.

Channel

Refers to the hardware in a receiver that

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

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

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

Circular Error Probable
A circle's radius, centered at the true antenna position, containing 50% of the points in the horizontal scatter plot.

Clock offset
The difference in time between GPS time and a satellite clock or a sensor clock (less accurate).

COG
Course Over Ground

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

CTD
Course To Destination

Cycle slip
A loss of count of carrier cycles as they are being measured by a GPS receiver.

Loss of signal, ionospheric interference and other forms of interference cause cycle slips to occur.

D

DGPS
See Differential GPS

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

Differential processing
GPS measurements can be differenced between receivers, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS measurements is to take differences between receivers (single difference), then between satellites (double difference), then between measurement epochs (triple difference). A single-difference measurement between receivers is the instantaneous difference in phase of the signal from the same satellite, measured by two receivers simultaneously. A double-difference measurement is the difference for a chosen reference satellite. A triple-difference measurement is the difference between a double difference at one epoch and the same double difference at the previous epoch.

Differential (relative) positioning

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

Dilution of Precision (DOP)

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

DOP

Dilution of Precision

Doppler aiding

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

Doppler shift

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

Double difference

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

DTD

Distance to Destination

Dynamic positioning

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

E

Earth Centered, Earth Fixed (ECEF)

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

EDOP

Elevation Dilution of Precision

ELEV

Elevation

Elevation

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

Elevation mask

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

Elevation mask angle
That angle below which it is not advisable to track satellites. Typically the elevation mask is set to 5° to avoid interference problems caused by buildings and trees and multipath reflections.

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

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

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

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

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F

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FCC
Federal Communications Commission

Firmware
The coded instructions relating to receiver function, and (sometimes) data processing algorithms, embedded as integral portions of the internal circuitry.

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

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

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

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

Geoid

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

Geoidal height (geoidal separation; undulation)

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

GLL

Position Latitude/Longitude

GMST

Greenwich Mean Sidereal Time

GPS DIFF

Differential

GPS ICD-200

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

GPS week

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

Greenwich mean time (GMT)

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

H

HDOP

Horizontal Dilution of Precision. See Dilution of Precision.

HI

Height of Instrument

HTDOP

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

I

ID

Identification or Integrated Doppler

Integer bias terms

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

Integrated Doppler

A measurement of Doppler shift frequency or phase over time.

Ionosphere

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

Ionospheric delay

A wave propagating through the ionosphere [which is a nonhomogeneous (in space and time) and dispersive medium] experiences delay. Phase delay depends on electron content and affects carrier signals.

Group delay depends on dispersion in the ionosphere as well, and affects signal modulation (codes). The phase and group delay are of the same magnitude but opposite sign.

J

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

K

Kinematic surveying
A method which initially solves wavelength ambiguities and retains the resulting measurements by maintaining a lock on a specific number of satellites throughout the entire surveying period.

L

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

L-band
A nominal portion of the microwave electro-magnetic spectrum ranging from 390 MHz to 1.55 GHz.

LNA
Low-Noise Amplifier

M

MSG
RTCM Message

MSL
Mean Sea Level

Multichannel receiver
A receiver containing many independent channels. Such a receiver offers highest SNR because each channel tracks one satellite continuously.

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

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

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

Multiplexing channel
A receiver channel which is sequenced through several satellite signals (each from a specific satellite at a specific frequency) at a rate which is

synchronous with the satellite message bit-rate (50 bits per second, or 20 milliseconds per bit). Thus, one complete sequence is completed in a multiple of 20 milliseconds.

N

NMEA

National Marine Electronics Association

NV

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

O

Outage

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

P

Position Dilution of Precision (PDOP)

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

Photogrammetry

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

Point positioning

A geographic position produced from one receiver in a stand-alone mode. At best, position accuracy obtained from a stand-alone receiver is 5 meters to less than 1 meter, depending on the geometry of the satellites.

POS

Position

Post-processing

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

Precise Positioning System (PPS)

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

Pseudo-kinematic surveying

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

Pseudorandom noise (PRN)

The P(Y) and C/A codes are pseudo-random noise sequences which

modulate the navigation signals. The modulation appears to be random noise but is, in fact, predictable hence the term "pseudo" random. Use of this technique allows the use of a single frequency by all GPS satellites and also permits the satellites to broadcast a low power signal.

Pseudo-range

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

R

RAM

Random-Access Memory. A memory device whose data can be accessed at random, as approved to sequential access. RAM data is lost when power is removed.

Range rate

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

RDOP

Relative Dilution of Precision. See Dilution of Precision.

Reconstructed carrier phase

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

Real-time

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

Reference Network

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

Reference station

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

Relative positioning

The process of determining the relative difference in position between two points with greater precision than that to which

the position of a single point can be determined. Here, a receiver (antenna) is placed over each point and measurements are made by observing the same satellite at the same time. This technique allows cancellation (during computations) of all errors which are common to both observers, such as satellite clock errors, propagation delays, etc. See also Translocation and Differential Navigation.

RF

Radio Frequency

RFI

Radio Frequency Interference

RINEX

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

RMS

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

RTCM

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

RTCM SC-104 Format

A standard format used in the transmission of differential corrections.

S

Selective Availability (SA)

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

SEP

See Spherical Error Probable

Sidereal day

Time between two successive upper transits of the vernal equinox.

Sidereal time

The hour angle of the vernal equinox. Taking the mean equinox as the reference yields true or apparent Sidereal Time. Neither Solar nor Sidereal Time are constant, since angular velocity varies due to fluctuations caused by the Earth's polar moment of inertia as exerted through tidal deformation and other mass transports.

Single difference

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

Spherical Error Probable (SEP)

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

Spoofing

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

SPS

See Standard Positioning Service

Standard Positioning Service (SPS)

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

Static observations

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

Static positioning

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

SV

Satellite Vehicle, Satellite Visibility or Space Vehicle.

Switching channel

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

T

TDOP

Time Dilution of Precision. See Dilution of Precision.

TOW

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

Translocation

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

Tropospheric correction.

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

True anomaly

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

U

Universal Time Coordinated (UTC)

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

User Range Accuracy (URA)

The contribution to the range-measurement error from an individual error source (apparent clock and

ephemeris prediction accuracies), converted into range units, assuming that the error source is uncorrelated with all other error sources. Values less than 10 are preferred.

UT
Universal Time

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

V

VDC
Volts Direct Current

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

W

WGS
World Geodetic System

World Geodetic System 1984 (WGS-84)
A set of U.S. Defense Mapping Agency parameters for determining global geometric and physical geodetic relationships. Parameters include a geocentric reference ellipsoid; a coordinate system; and a gravity field model. GPS satellite orbital information in the navigation message is referenced to WGS-84.

World Geodetic System (WGS-72)
The mathematical reference ellipsoid previously used by GPS, having a semimajor axis of 6378.135 km and a flattening of 1/298.26.

Y

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

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

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