USER GUIDE

Trimble® BD960 GNSS Receiver Module

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Legal Notices

Release Notice

This is the May 2011 release (Revision A) of the *BD960 GNSS Receiver Module User Guide*. It applies to version 4.40 of the receiver firmware.

Restriction of Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS)

This Trimble product complies in all material respects with DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) and Amendment 2005/618/EC filed under C(2005) 3143, with exemptions for lead in solder pursuant to Paragraph 7 of the Annex to the RoHS Directive applied.

Waste Electrical and Electronic Equipment (WEEE)

For product recycling instructions and more information, please go to www.trimble.com/ev.shtml.

Recycling in Europe: To recycle Trimble WEEE (Waste Electrical and Electronic Equipment, products that run on electrical power.), Call +31 497 53 24 30, and ask for the "WEEE Associate". Or, mail a request for recycling instructions to:

Trimble Europe BV
c/o Menlo Worldwide Logistics
Meerheide 45
5521 DZ Eersel, NL

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CHAPTER

1

Introduction

The *BD960 GNSS Receiver Module User Guide* describes how to set up and use the Trimble® BD960 GNSS receiver module. The BD960 receiver uses advanced navigation architecture to achieve real-time centimeter accuracies with minimal latencies.

Even if you have used other Global Positioning System (GPS) products before, Trimble recommends that you spend some time reading this manual to learn about the special features of this product. If you are not familiar with GPS, visit the Trimble website (www.trimble.com) for an interactive look at Trimble and GPS.

About the BD960 receiver

The BD960 receiver is used for a wide range of precise positioning and navigation applications. These uses include unmanned vehicles and port and terminal equipment automation, and any other application requiring reliable, centimeter-level, guidance at a high update rate and low latency.

The BD960 receiver offers centimeter-level accuracy based on RTK solutions and submeter accuracy code-phase solutions.

Automatic initialization and switching between positioning modes allow for the best position solutions possible. Low latency (< 20 msec) and high update rates (up to 20 Hz) give the response time and accuracy required for precise dynamic applications.

Designed for reliable operation in all environments, the BD960 receiver provides a positioning interface to an office computer, external processing device, or control system. The receiver can be controlled through a serial or Ethernet port using binary interface commands or web interface.

You can configure the BD960 receiver as an autonomous base station (sometimes called a reference station) or as a rover receiver (sometimes called a mobile receiver). Streamed outputs from the receiver provide detailed information, including the time, position, quality assurance (figure of merit) numbers, and the number of tracked satellites. The receiver also outputs a one pulse per second (1 PPS) strobe signal which lets remote devices precisely synchronize time.

Related information

The web browser interface includes help screens to assist you to quickly find the information you need.

Technical Support

If you have a problem and cannot find the information you need in the product documentation, contact your local dealer. Alternatively, go to the Support area of the Trimble website (www.trimble.com/support.shtml) and then select the product that you need information on. Product updates, documentation, and any support issues are available for download.

If you need to contact Trimble technical support, go to www.trimble.com/global-services/.

CHAPTER

2

Features and Functions

In this chapter:

BD960 receiver features

The BD960 receiver provides the following features:

- 72-channel L1/L2/L2C/L5 GPS plus L1/L2 GLONASS receiver
- OmniSTAR XP/HP/VBS service capable
- WAAS (Wide Area Augmentation System), EGNOS (European Geo-Stationary Navigation System), and MSAS (MTSAT Satellite-Based Augmentation System). Satellite Based Augmentation (SBAS) compatible
- Configuration and monitoring through the following methods:
  - Web interface
  - Networked or peer-to-peer Ethernet
  - Binary interface commands
- Choice of external GPS antenna for base station or rover operation
- –40 °C to +67 °C (–40 °F to +149 °F) operating temperature range
- 4.9 V to 28 V DC input power range, with over-voltage protection
- Moving baseline capability
- 5 Hz, 10 Hz, or 20 Hz measurement update rate
- RoHS compliant
- 1 pulse per second (1PPS) output
- Event marker input support
- Compact Euro card form factor
- LED support

Use and care

CAUTION – Operating or storing the receiver outside the specified temperature range can damage it. For more information, see Chapter 9, Specifications.

Always mount the BD960 receiver in a suitable casing.

Radio and radar signals

High-power signals from a nearby radio or radar transmitter can overwhelm the BD960 receiver circuits. This does not harm the instrument, but it can prevent the receiver electronics from functioning correctly. Avoid using the receiver within 400 m of powerful radar, television, or other transmitters. Low-power transmitters such as those used in portable phones and walkie-talkies normally do not interfere with the operation of the receivers.

COCOM limits

The U.S. Department of Commerce requires that all exportable GPS products contain performance limitations so that they cannot be used in a manner that could threaten the security of the United States. The following limitations are implemented on this product:

- Immediate access to satellite measurements and navigation results is disabled when the receiver velocity is computed to be greater than 1,000 knots, or its altitude is computed to be above 18,000 meters. The receiver GPS subsystem resets until the COCOM situation clears. As a result, all logging and stream configurations stop until the GPS subsystem is cleared.

CHAPTER

3

Installation

In this chapter:

The Trimble BD960 receiver delivers the highest performance capabilities of a GNSS receiver in a compact Eurocard form factor. This chapter describes how to install and operate the BD960 receiver.

Receiver setup

Figure 3.1 shows the setup for a BD960 receiver.

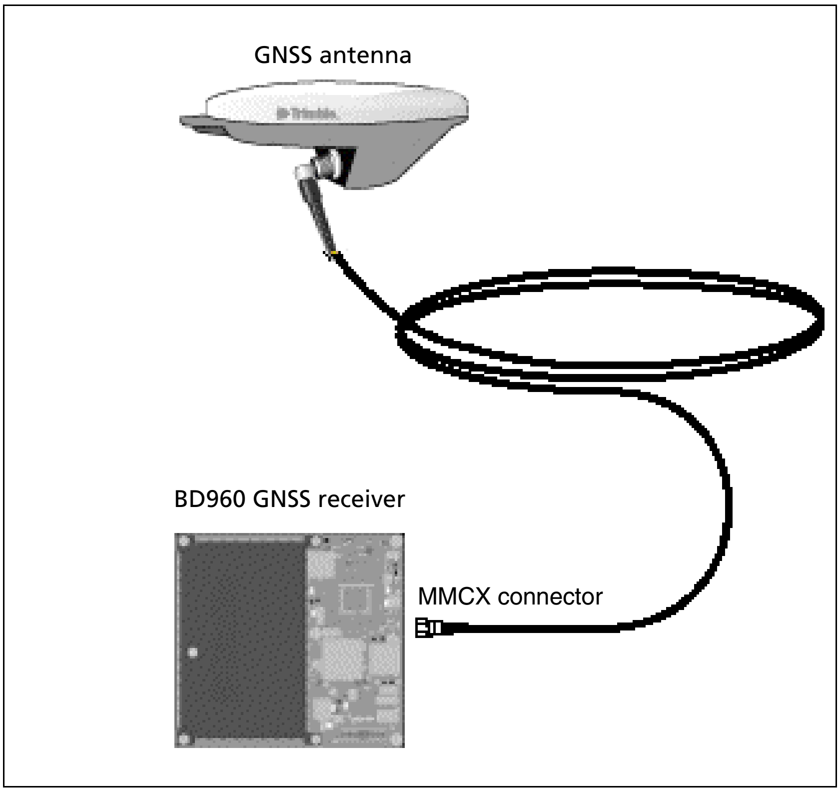


Figure 3.1 BD960 receiver on Eurocard PC board

Installing the BD960 receiver

Trimble recommends that you read this section ***before*** installing the BD960 receiver.

Unpacking and inspecting the shipment

Visually inspect the shipping cartons for any signs of damage or mishandling before unpacking the receiver. Immediately report any damage to the shipping carrier.

Shipment carton contents

The shipment will include one or more cartons. This depends on the number of optional accessories ordered. Open the shipping cartons and make sure that all of the components indicated on the bill of lading are present.

Reporting shipping problems

Report any problems discovered after you unpack the shipping cartons to both Trimble Customer Support and the shipping carrier.

Supported antennas

The BD960 receiver tracks six different GNSS frequencies: The Zephyr™ Model 2 antenna supports all these frequencies.

Other antennas may be used. However, ensure that the antenna you choose supports the frequencies you need to track and operates at either 3.3 or 7.1 volts with a greater than 40 dB signal at the board antenna port.

Installation guidelines

The BD960 receiver is designed to be standoff mounted. Use the appropriate hardware and the seven mounting holes. See Chapter D, Drawings.

Considering environmental conditions

Install the BD960 receiver in a location situated in a dry environment. Avoid exposure to extreme environmental conditions. This includes:

- Water or excessive moisture
- Excessive heat greater than 75 °C (167 °F)
- Excessive cold less than –40 °C (–38 °F)
- Corrosive fluids and gases

Avoiding these conditions improves the BD960 receiver's performance and long-term product reliability.

Mounting the antennas

Choosing the correct location for the antenna is critical to the installation. Poor or incorrect placement of the antenna can influence accuracy and reliability and may result in damage during normal operation. Follow these guidelines to select the antenna location:

- If the application is mobile, place the antenna on a flat surface along the centerline of the vehicle.
- Choose an area with clear view to the sky above metallic objects.
- ***Avoid*** areas with high vibration, excessive heat, electrical interference, and strong magnetic fields.
- ***Avoid*** mounting the antenna close to stays, electrical cables, metal masts, and other antennas.

- *Avoid* mounting the antenna near transmitting antennas, radar arrays, or satellite communication equipment.

Sources of electrical interference

Avoid the following sources of electrical and magnetic noise:

- gasoline engines (spark plugs)
- television and computer monitors
- alternators and generators
- electric motors
- propeller shafts
- equipment with DC-to-AC converters
- fluorescent lights
- switching power supplies

BD960 connections

An evaluation kit is available for testing the BD960 receiver. This includes an I/O board, which enables easy access to DB9 ports, the Ethernet port, and the power supply, as shown in Figure 3.2.

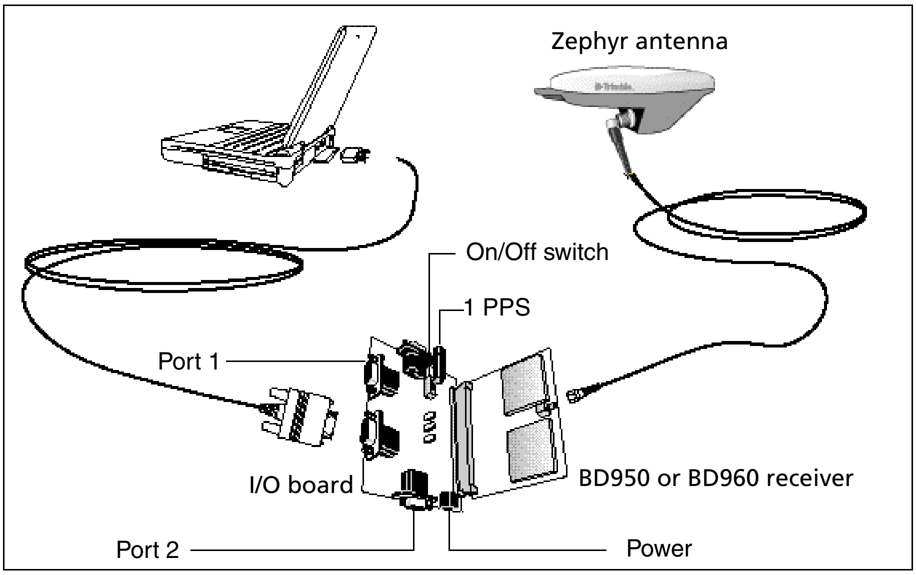


Figure 3.2 Typical I/O board setup

The computer connection provides a means to set up and configure the receiver.

Routing and connecting the antenna cable

1. Mount the antenna and then route the antenna cable from the GPS antenna to the BD960 receiver (see Figure 3.1). Avoid the following hazards when routing the antenna cable:
   - Sharp ends or kinks in the cable
   - Hot surfaces (such as exhaust manifolds or stacks)
   - Rotating or reciprocating equipment
   - Sharp or abrasive surfaces
   - Door and window jams
   - Corrosive fluids or gases
2. Connect the cable to the receiver. Use tie-wraps to secure the cable at several points along the route. For example, to provide strain relief for the antenna cable connection use a tie-wrap to secure the cable near the base of the antenna.

Note – *When securing the cable, start at the antenna and work towards the BD960 receiver.*

3. Coil any slack in the cable. Secure the coil with a tie-wrap and tuck it in a safe place.

On/Off switch

The I/O board contains an On/Off switch. When the receiver is shipped from the factory, this switch is disabled. To enable this feature, you must upgrade the software option; contact your sales representative.

LED functionality and operation

The BD960 receiver comes with three LEDs to indicate satellite tracking, RTK receptions, and power. The initial power-up sequence for a receiver lights all the three LEDs for about three seconds followed by a brief duration where all three LEDs are off. Thereafter, use the following table to confirm tracking of satellite signals or for basic troubleshooting:

Power LED	RTK LED	SV Tracking LED	Status
On (continuous)	Off	Off	The receiver is turned on, but not tracking satellites.
On (continuous)	Off	Blinking at 1 Hz[1] (5 seconds) followed by high frequency blinking burst[2]	The receiver is tracking satellites on both position (primary) and vector (secondary) antennas, but not receiving RTK corrections.
On (continuous)	Off	Blinking at 1 Hz[1]	The receiver is tracking satellites on the position (primary) antenna only. The vector antenna is not tracking.

Power LED	RTK LED	SV Tracking LED	Status
On (continuous)	Off	High frequency blinking burst every 5 seconds[2]	The receiver is tracking satellites on the vector (secondary) antenna only. The position antenna is not tracking.
On (continuous)	Blinking at 1 Hz	Blinking at 1 Hz[1]	The receiver is tracking satellites on the position (primary) antenna only (the vector antenna is not tracking) and receiving incoming RTK corrections.
On (continuous)	Blinking at 1 Hz	Blinking at 1 Hz[1] (5 seconds) followed by high frequency blinking burst[2]	The receiver is tracking satellites on both the position (primary) and vector (secondary) antennas and receiving incoming RTK corrections.
On (continuous)	Blinking at 1 Hz	High frequency blinking burst every 5 seconds[2]	The receiver is tracking satellites on the vector (secondary) antenna only (the position antenna not tracking), and receiving RTK corrections.
On (continuous)	Blinking at 1 Hz	Off	The receiver is receiving incoming RTK corrections, but not tracking satellites on either antenna.
On (continuous)	Blinking at 1 Hz	On (continuous)	The receiver is in Boot Monitor Mode. Contact technical support.

[1] High frequency rapid flash (blinking) indicates less than five satellites tracked.

2 Only available in receivers running firmware version 4.40 or later.

CHAPTER

4

Positioning Modes

In this chapter:

The BD960 receiver is designed for high-precision navigation and location. The receiver uses Real-Time Kinematic (RTK) techniques to achieve centimeter-level positioning accuracy. This chapter provides background information on terminology and describes the capabilities and limitations of the BD960 receiver.

What is RTK?

Real-Time Kinematic (RTK) positioning is positioning that is based on at least two GPS receivers—a base receiver and one or more rover receivers. The base receiver takes measurements from satellites in view and then broadcasts them, together with its location, to the rover receiver(s). The rover receiver also collects measurements to the satellites in view and processes them with the base station data. The rover then estimates its location relative to the base. Typically, base and rover receivers take measurements at regular 1-second epochs (events in time) and produce position solutions at the same rate.

The key to achieving centimeter-level positioning accuracy with RTK is the use of the GPS carrier phase signals. Carrier phase measurements are like precise tape measures from the base and rover antennas to the satellites. In the BD960 receiver, carrier phase measurements are made with millimeter-precision. Although carrier phase measurements are highly precise, they contain an unknown bias, termed the *integer cycle ambiguity*, or *carrier phase ambiguity*. The BD960 rover has to resolve, or initialize, the carrier phase ambiguities at power-up and every time that the satellite signals are interrupted.

Carrier phase initialization

The BD960 receiver can automatically initialize the carrier phase ambiguities as long as at least five common satellites are being tracked at base and rover sites. *Automatic initialization* is sometimes termed *On-The-Fly (OTF)* or *On-The-Move*, to reflect that no restriction is placed on the motion of the rover receiver throughout the initialization process.

The BD960 receiver uses L1 and L2 carrier-phase measurements plus precise code range measurements to the satellites to automatically initialize the ambiguities. The initialization process takes approximately 10 seconds.

As long as at least four common satellites are continuously tracked after a successful initialization, the ambiguity initialization process does not have to be repeated.

Tip – Initialization time depends on baseline length, multipath, and prevailing atmospheric errors. To minimize the initialization time, keep reflective objects away from the antennas, and make sure that baseline lengths and differences in elevation between the base and rover sites are as small as possible.

Update rate and latency

The number of position fixes delivered by an RTK system per second also defines how closely the trajectory of the rover can be represented and the ease with which position navigation can be accomplished. The number of RTK position fixes generated per second defines the *update rate*. Update rate is quoted in Hertz (Hz). For the BD960 receiver, the maximum update rate is 20 Hz.

Solution latency refers to the lag in time between when the position was valid and when it was displayed. For precise navigation, it is important to have prompt position estimates, not values from 2 seconds ago. Solution latency is particularly important when guiding a moving vehicle. For example, a vehicle traveling at 25 km/h moves approximately 7 m/s. Thus, to navigate to within 1 m, the solution latency must be less than 1/7 (= 0.14) seconds. For the BD960 receiver, the latency is less than 0.02 seconds.

Data link

The base-to-rover data link serves an essential role in an RTK system. The data link must transfer the base receiver carrier phase, code measurements, plus the location and description of the base station, to the rover.

The BD960 receiver supports two data transmission standards for RTK positioning: the Compact Measurement Record (CMR) format and the RTCM/RTK messages. The CMR format was designed by Trimble and is supported across all Trimble RTK products.

CAUTION – Mixing RTK systems from different manufacturers usually results in degraded performance.

Factors to consider when choosing a data link include:

- Throughput capacity
- Range
- Duty cycle
- Error checking/correction
- Power consumption

The data link must support at least 4800 baud, and preferably 9600 baud throughput. Your Trimble representative (see Technical Support, page 8) can assist with questions regarding data link options.

Moving Baseline RTK positioning

In most RTK applications, the reference receiver remains stationary at a known location, and the rover receiver can move. However, Moving Baseline RTK is an RTK positioning technique in which both reference and rover receivers can move.

Moving Baseline RTK is useful for GPS applications that require vessel orientation. The reference receiver broadcasts CMR data every epoch, while the rover receiver performs a synchronized baseline solution at 10 Hz. The resulting baseline solution has centimeter-level accuracy. To increase the accuracy of the absolute location of the two antennas, the Moving Reference receiver can use differential corrections from a static source, such as a shore-based reference station.

Critical factors affecting RTK accuracy

The following sections present system limitations and potential problems that could be encountered during RTK operation.

Base station receiver type

CAUTION – Trimble recommends that you always use a Trimble base station with a BD960 rover. Using a non-Trimble base receiver can result in suboptimal initialization reliability and RTK performance.

The BD960 receiver uses a state-of-the-art tracking scheme to collect satellite measurements. Optimal RTK performance is achieved when using BD960 receivers at base and rover sites. The BD960 receiver is compatible with all other Trimble RTK-capable systems.

Base station coordinate accuracy

The base station coordinates should be known to within 10 m in the WGS-84 datum for optimal system operation. Incorrect or inaccurate base station coordinates degrade the rover position solution. It is estimated that every 10 m of error in the base station coordinates introduces one part per million error in the baseline vector. This means that if the base station coordinates have a height error of 50 m, and the baseline vector is 10 km, then the error in the rover location is approximately 5 cm. One second of latitude represents approximately 31 m on the earth surface; therefore, a latitude error of 0.3 seconds equals a 10 m error on the earth's surface. If the baseline vector is 10 km, then the error in the rover location is approximately 1 cm.

Number of visible satellites

A GNSS position fix is similar to a distance resection. Satellite geometry directly impacts on the quality of the position solution estimated by the BD960 receiver. The Global Positioning System is designed so that at least five satellites are above the local horizon at all times. For many times throughout the day, as many as eight or more satellites might be above the horizon. Because the satellites are orbiting, satellite geometry changes during the day, but repeats from day-to-day.

A minimum of four satellites are required to estimate user location and time. If more than four satellites are tracked, then an overdetermined solution is performed and the solution reliability can be measured. The more satellites, the greater the solution quality and integrity.

The Position Dilution Of Precision (PDOP) provides a measure of the prevailing satellite geometry. Low PDOP values, in the range of 4.0 or less, indicate good satellite geometry, whereas a PDOP greater than 7.0 indicates that satellite geometry is weak.

Even though only four satellites are needed to form a three-dimensional position fix, RTK initialization demands that at least five common satellites must be tracked at base and rover sites. Furthermore, L1 and L2 carrier phase data must be tracked on the five common satellites for successful RTK initialization. Once initialization has been gained, a minimum of four continuously tracked satellites must be maintained to produce an RTK solution.

Elevation mask

The elevation mask stops the BD960 receiver from using satellites that are low on the horizon. Atmospheric errors and signal multipath are largest for low elevation satellites. Rather than attempting to use all satellites in view, the BD960 receiver uses a default elevation mask of 10 degrees. By using a lower elevation mask, system performance may be degraded.

If you are using an OmniSTAR satellite for differential corrections, the receiver starts using this satellite at eight degrees of elevation.

Environmental factors

Environmental factors that impact GPS measurement quality include:

- Ionospheric activity
- Tropospheric activity
- Signal obstructions
- Multipath
- Radio interference

High ionospheric activity can cause rapid changes in the GPS signal delay, even between receivers a few kilometers apart. Equatorial and polar regions of the earth can be affected by ionospheric activity. Periods of high solar activity can therefore have a significant effect on RTK initialization times and RTK availability.

The region of the atmosphere up to about 50 km is called the troposphere. The troposphere causes a delay in the GPS signals that varies with height above sea level, prevailing weather conditions, and satellite elevation angle. The BD960 receiver includes a tropospheric model that attempts to reduce the impact of the tropospheric error. If possible, try to locate the base station at approximately the same elevation as the rover.

Signal obstructions limit the number of visible satellites and can also induce signal multipath. Flat metallic objects located near the antenna can cause signal reflection before reception at the GPS antenna. For phase measurements and RTK positioning, multipath errors are about 1 to 5 cm. Multipath errors tend to average out when the roving antenna is moving while a static base station may experience very slowly changing biases. If possible, locate the base station in a clear environment with an open view of the sky. If possible use an antenna with a ground plane to help minimize multipath.

The BD960 receiver provides good radio interference rejection. However, a radio or radar emission directed at the GPS antenna can cause serious degradation in signal quality or complete loss of signal tracking. Do not locate the base station in an area where radio transmission interference can become a problem.

Operating range

Operating range refers to the maximum separation between base and rover sites. Often the characteristics of the data link determine the RTK operating range. The initialization performance of the BD960 receiver is optimized for an operating range up to 20 km. Degraded initialization time and reliability are likely to result if RTK is attempted beyond the 20 km operating range specification.

DGPS

The receiver supports output and input of differential GPS (DGPS) corrections in the RTCM SC-104 format. This allows position accuracies of less than 1 meter to be achieved using the L1 frequencies of GPS and GLONASS.

SBAS

The receiver supports SBAS (satellite based augmentation systems) that conform to RTCA/DO-229C, such as WAAS. The reciever can use the WAAS (Wide Area Augmentation System) set up by the Federal Aviation Administration (FAA). WAAS was established for flight and approach navigation for civil aviation. WAAS improves the accuracy, integrity, and availability of the basic GPS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico.

SBAS can be used in surveying applications to improve single point positioning when starting a reference station, or when the RTK radio link is down. SBAS corrections should be used to obtain greater accuracy than autonomous positioning, not as an alternative to RTK positioning.

The SBAS system provides correction data for visible satellites. Corrections are computed from ground station observations and then uploaded to two geostationary satellites. This data is then broadcast on the L1 frequency, and is tracked using a channel on the BD960 receiver, exactly like a GPS satellite.

For more information on WAAS, refer to the FAA home page at http://gps.faa.gov.

OmniSTAR

OmniSTAR is a wide-area differential GPS service, using satellite broadcast techniques. For the sub-meter service, data from many widely-spaced reference stations is used in a proprietary multi-site solution over most land areas worldwide. The high-accuracy HP solution uses more sophisticated data from these reference sites and XP uses satellite orbit and clock correction data, which is independent of reference site location. For more information visit www.omnistar.com.

CHAPTER

5

Configuring the BD960 Receiver Using Trimble Software Utilities

In this chapter:

- Configuration Toolbox software
- Trimble MS Controller software

Configuration Toolbox software

The Configuration Toolbox software is a Windows® application that provides a graphical user interface to help you configure selected Trimble GPS receivers.

The Configuration Toolbox software lets you:

- create and edit application files
- transfer application files to and from the receiver
- manage application files stored in the receiver

Creating and editing application files

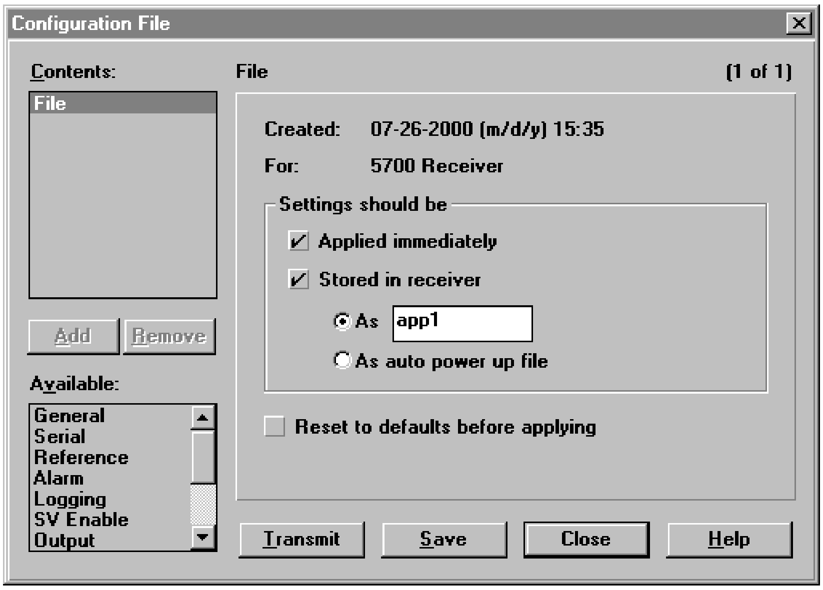
You can create an application file and transfer it to the receiver in several different ways. The general workflow includes the following steps:

1. Create and save the application file in the Configuration Toolbox software.
2. Connect the receiver to the computer and apply power.
3. Open the desired application file in the Configuration Toolbox software.
4. Transfer this application file to the receiver.
5. Check that the receiver is using the transferred application file.

To create and save an application file to the receiver:

1. To start the Configuration Toolbox software and then click **Start**. Then select *Programs* / *Trimble* / *Configuration Toolbox* / *Configuration Toolbox*.
2. Select *File* / *New* / *Any Receiver*.
3. Specify the receiver settings (for specific information, refer to the Configuration Toolbox documentation).

4. Select *File* / *Save As* to save the application file:



To transfer the application file to the receiver:

1. Connect a data cable to any port on the BD960 receiver.
2. Connect the other end of the data cable to a serial (COM) port on the computer.
3. Select *File* / *Open* to open the desired application file.
4. With the file open and the *Configuration File* dialog open, select *Communications* / *Transmit File*.

   A message appears stating that the application file has been successfully transferred. If an error occurs, select *Communications* / *Transmit File* again. This overrides any incompatibility in baud rates and enables successful communication.

5. To check whether the transfer was successful, close the *Configuration File* dialog and then select *Communications* / *Get File*.

   A list of all application files in the BD960 receiver appears. If you selected **Apply Immediately** in the application file, the Current application file will contain the settings in the new file.

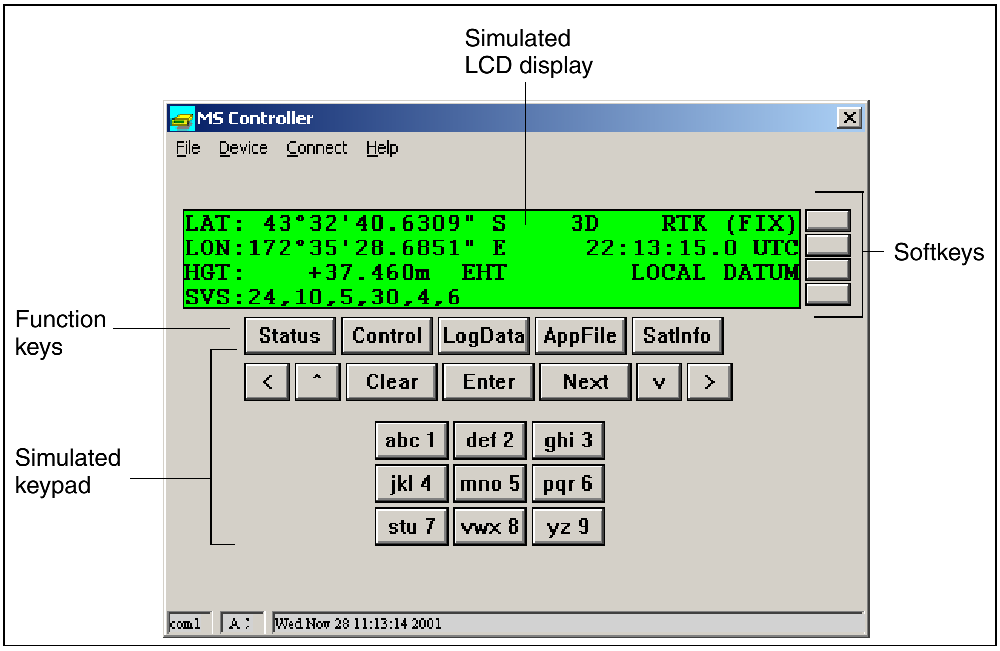
6. To apply a different file, select the file you require from the list and then repeat this procedure.

Trimble MS Controller software

The Trimble MS Controller software that is supplied with the BD960 receiver serves as a virtual keypad and display screen for the receiver.

To use the MS Controller software, you need to connect one of the receiver's I/O ports to one of the serial ports on an IBM-compatible office computer. The software runs under the Windows operating system and manages the communications link between the computer and the BD960 receiver.

The simulated keypad and display for the MS Controller software are shown below:



Simulated LCD display

The simulated LCD display shows data about the current position or survey operation, the satellites tracked by the receiver, the internal status of the receiver, and a variety of other information.

The data shown on the simulated LCD display is called a screen and the various types of data are displayed in fields. Three types of fields are displayed on the simulated screens: Display-only fields, data-entry fields, and carousels. For more information about fields, see Working with screens and fields, page 32.

The simulated LCD display can display four lines of data at once. When more than four lines of data is available for display, double left arrows ( ) appear in the upper left corner of the display. To display another four lines of data, click the Next key.

Some screens appear solely for the purpose of viewing status information. For instance, the *SatInfo* screens show satellite tracking and status information.

Data-entry screens appear when you need to configure the receiver operation.

Many status and data-entry fields include menu options for displaying additional screens and these screens can contain menus for displaying more screens. Menu options appear on the right side of the screen, enclosed within angle brackets.

Softkeys

The four softkeys perform different functions, depending on the menu options displayed on the right side of the simulated display. Menu options (also called softkey options) appear on the screen enclosed within left and right angle brackets (**< >**). One softkey is provided for each of the four lines on the simulated LCD display: The first (top) softkey performs the action described by the menu option on the first line of the display, the second softkey performs the action associated with the menu option on the second screen line, and so on. When a menu option is not displayed on a screen for a specific screen line, the associated softkey performs no action.

In the sample screen below, one menu option (the **<HERE>** softkey) is displayed:

```
BASE STATION (CONTROL)          <HERE>
 [CMR]:[OFF   ]   ANT. HT.:00.000 m
 LAT: 00°00'0.00000" N NAME: 0000
 LON:000°00'00.00000" E HGT:+0000.000 m
```

The menu action associated with a softkey can be executed immediately, or the action can display another screen that might include additional menu options. In the sample screen above, press **<HERE>** to enter the current position as the coordinates for a base station.

Throughout this manual, softkey options are shown enclosed within angle brackets and in bold type.

Simulated keypad

Use the simulated keypad to enter alphanumeric and numeric data, and to select predefined values for data-entry fields:

Key/Symbol	Description
0 – 9	The numeric keys let you enter numeric data.
a – z	The alphabetic keys become active when a field can accept alphabetic data.
< – >	The side arrow keys let you move the cursor to data-entry fields before entering data or choosing options from carousel fields.
^ – v	The up and down arrow keys let you select options from carousel fields. Alternatively, you can select alphabetic and numeric data where appropriate.
Next	Pages through multiple screen lines, softkey options, or predefined field options.

Key/Symbol	Description
Enter	Accepts change entered into data fields. Click Enter from the last data field to accept all changes entered in all fields.
Clear	Returns to the previous screen without saving the changes made in any data fields.

Function keys

The six function keys display screens with options for showing status information and additional screens for controlling BD960 receiver functions and options:

Key	Shows ...
Status	The *Status* screen with options for displaying factory configuration information and receiver systems information.
SatInfo	The *SatInfo* screen with options for displaying satellite tracking and status information.
AppFile	The *AppFile* screen with options for displaying the application files directory, storing the current parameter settings as an application file, and options for warm booting the receiver.
Control	The *Control* screen with options for configuring the receiver setup parameters.
LogData	Not applicable.

Working with screens and fields

A summary of the keypad and display operations for the BD960 receiver with the MS Controller software appears below.

Key/Symbol	Description
Next	Pages through multiple screen lines, softkey options, or carousel data entry fields.
Enter	Accepts / changes data fields. Click Enter on the last data field to accept all changes.
Clear	Returns the screen to the previous menu level without changing the data fields.
[ ]	Indicates a carousel data field used to select from a limited options list.
Õ	Indicates that additional screen lines are accessible. Click Next.
< >	Indicates a softkey (menu option).
< and >	Moves the cursor between fields on the simulated screen.
^ and v	Selects from carousel data fields, or alphanumeric and numeric data.

Types of field

Three types of field appear on the simulated LCD display:

- Display-only fields
- Data-entry fields
- Carousels

Most fields include two parts—a field description and a reserved area for entering or selecting data.

Display-only fields

Display-only fields can appear on any screen. Some screens are composed entirely of display-only fields. For example, the *SatInfo* screens show satellite status and tracking information. A cursor is not displayed when a screen is composed entirely of display-only fields. If screens contain combinations of data-entry, carousels, and display-only fields, you cannot move the cursor into display-only fields.

Data-entry fields

Data-entry fields accept numeric or alphanumeric input from the keypad. For example, the fields for entering latitude, longitude, and height information accept numeric input from the keypad. Data-entry fields are usually displayed when you configure receiver operating parameters or when you enable receiver functions and options.

Carousels

Whenever square brackets [ ] appear around an item on the display, you can click the Next key to change the value to one of a set of options. The square brackets indicate a carousel data entry field.

Click Next to page through more screen lines. Because the simulated receiver display has only four lines, there are times when additional information needs to be accessed. For example, if you select the Control menu, four softkeys become active and the double left arrow symbol « appears in the top left corner of the screen. The double left arrow is the visual cue that selecting Next allows you to page through more screen information.

Entering data in fields

Carousels let you select from a limited set of options. For example, to choose a port number, you use carousels and Next. Some data fields involve alphanumeric entry through the keyboard.

Click Enter to accept the data field and move the cursor to the next input item. To accept all of the selections on the display, click Enter at the last data field. All of the data selections are ignored if you click Clear while in a data entry screen. Click Clear to move back up the menu structure after selections are entered and saved.

Use the < and > keys, on the left and right of the display respectively, to move between data entry fields without changing their values.

CHAPTER

6

Configuring the BD960 Receiver Using a Web Browser

In this chapter:

Configuring Ethernet settings

The receiver has an Ethernet port so that the receiver can connect to an Ethernet network. You can use the Ethernet network to access, configure, and monitor the receiver. No serial cable connection to the receiver is necessary.

The receiver requires the following Ethernet settings:

- IP setup: Static or DHCP
- IP address
- Netmask
- Broadcast
- Gateway
- DNS address
- HTTP port

The default setting for the HTTP port is 80. The HTTP port is not assigned by the network. HTTP port 80 is the standard port for web servers. This allows you to connect to the receiver by entering only the IP address of the receiver in a web browser. If the receiver is set up to use a port other than 80, you will need to enter the IP address followed by the port number in a web browser.

Example of connecting to the receiver using port 80: http://169.254.1.0

Example of connecting to the receiver using port 4000: http://169.254.1.0:4000

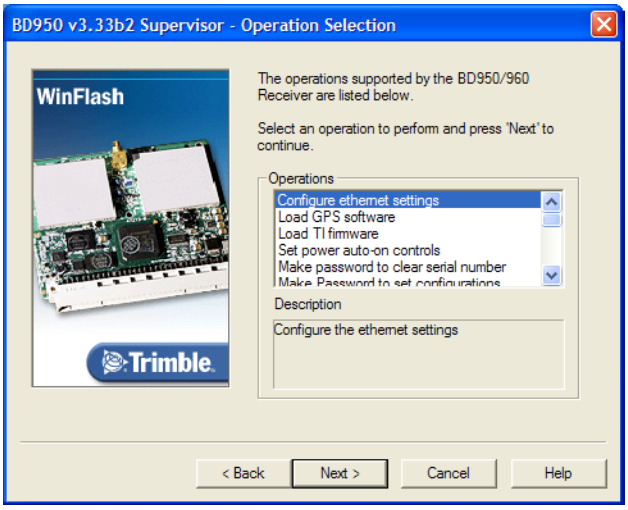
The default setting of the receiver is to use DHCP, which enables the receiver to automatically obtain the IP address, Netmask, Broadcast, Gateway, and DNS address from the network.

When a receiver is connected to a network using DHCP, the network assigns an IP address to the receiver. To verify the IP address of the receiver use the WinFlash software utility:

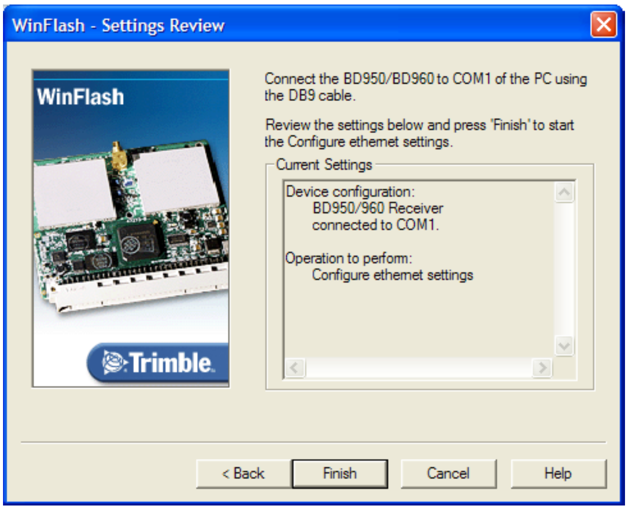
1. Connect the receiver to a computer running the WinFlash utility using the serial cable provided with the receiver.
2. Turn on the receiver.
3. On the computer, start the WinFlash utility.

4. From the *Device Configuration* screen, select *BD950/960 receiver.* From the *PC serial port* list, select the appropriate PC serial port. Click **Next**:

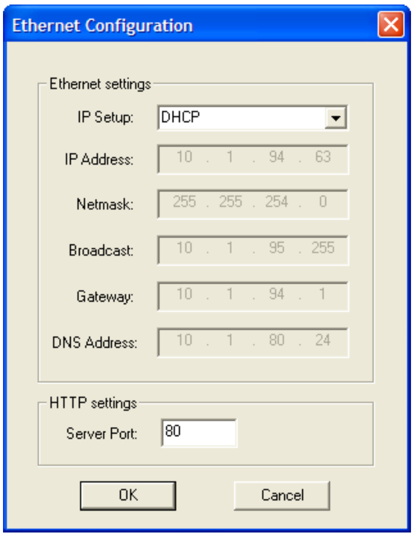
5. From the *Operation Selection* screen, select *Configure ethernet settings* and then click **Next**:



6. From the *Settings Review* screen, click **Finish**:



Note the IP Address displayed in the *Ethernet Configuration* dialog:



7. If your network installation requires the receiver to be configured with a static IP address, you can select a Static IP address and enter the settings given by your network administrator. The *Broadcast* setting is the IP address that is used to broadcast to all devices on the subnet. This is usually the highest address (usually 255) in the subnet.

Configuring the receiver using a web browser

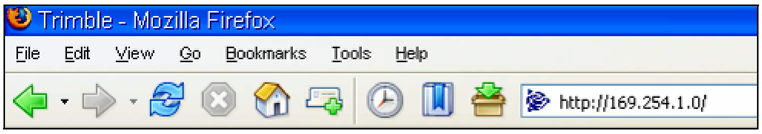
This section describes how to set up the receiver using a web browser.

Supported browsers

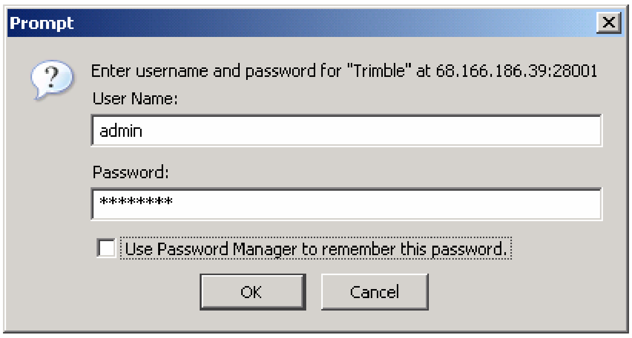
- Mozilla Firefox version 1.07 or later (version 2.00 or later is recommended for Windows, Macintosh, and Linux operating systems)
- Internet Explorer® internet browser version 7.00 or later for Windows operating systems

To connect to the receiver using a web browser:

1. Enter the IP address of the receiver into the address bar of the web browser as shown:



2. If security is enabled on the receiver, the web browser prompts you to enter a username and password:



The default login values for the receiver are:

– User Name: admin

– Password: password

If you cannot connect to the receiver, the password for the admin account may have been changed, or a different account may currently be in use. Contact your receiver administrator for the appropriate login information.

Once you are logged in, the welcome web page appears, see Figure 6.1.

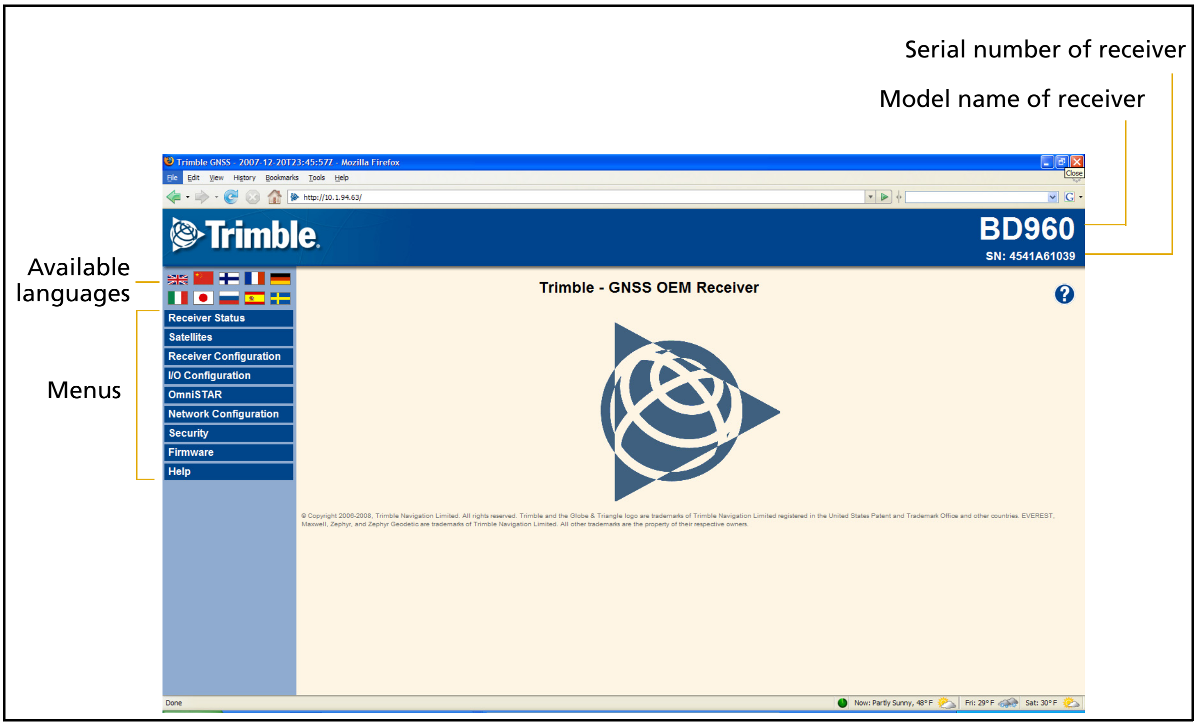


Figure 6.1 SPS GPS receiver Home webpage

Changing the settings

Use the webpage to configure the receiver settings. The web interface shows the configuration menus on the left of the browser window, and the settings on the right. Each configuration menu contains related submenus to configure the receiver and to monitor receiver performance.

***Note** – The configuration menus available vary based on the version of the receiver.*

A summary of each configuration menu is provided here. For more detailed information about each of the receiver settings, select the *Help* menu. The Help is available whenever your computer is connected to the Internet. It is also available at any time from the Trimble website (www.trimble.com/OEM_ReceiverHelp/V3.60/en/).

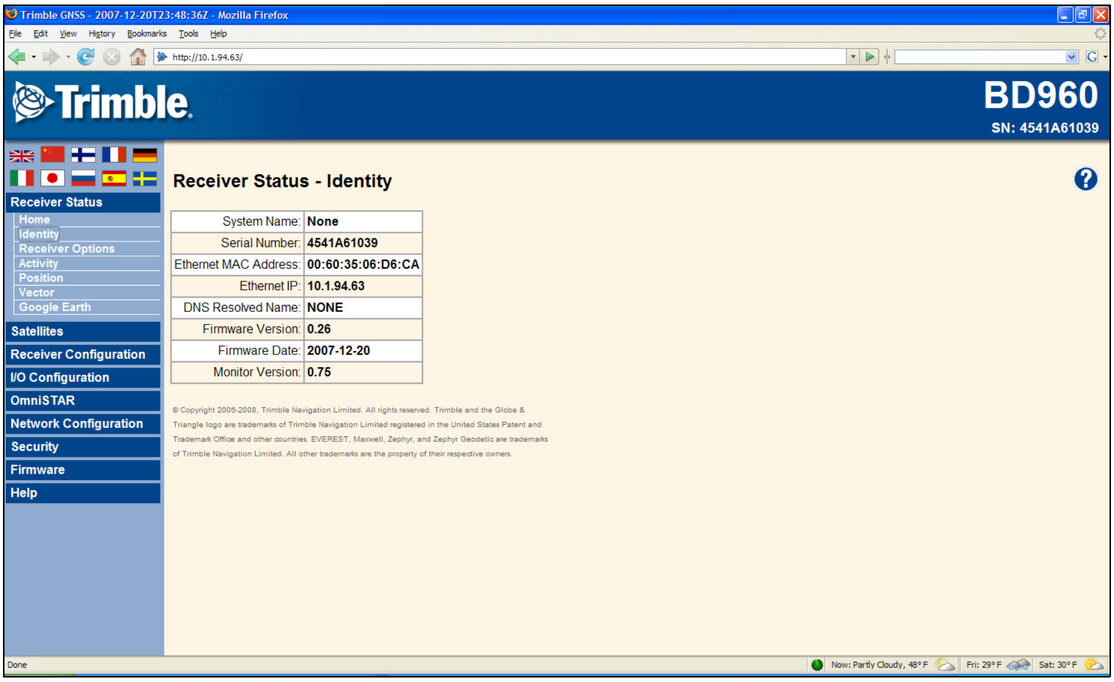
To display the web interface in another language, click the corresponding country flag. The web interface is available in the following languages:

- English (en)
- Chinese (zh)
- Finnish (fi)
- French (fr)
- German (de)
- Italian (it)
- Japanese (ja)
- Russian (ru)
- Spanish (es)
- Swedish (sv)

Receiver Status menu

The *Receiver Status* menu provides a quick link to review the receiver's available options, current firmware version, IP address, temperature, runtime, satellites tracked, current outputs, available memory, position information, and more.

This figure shows an example of the screen that appears when you select *Receiver Status / Identity*:

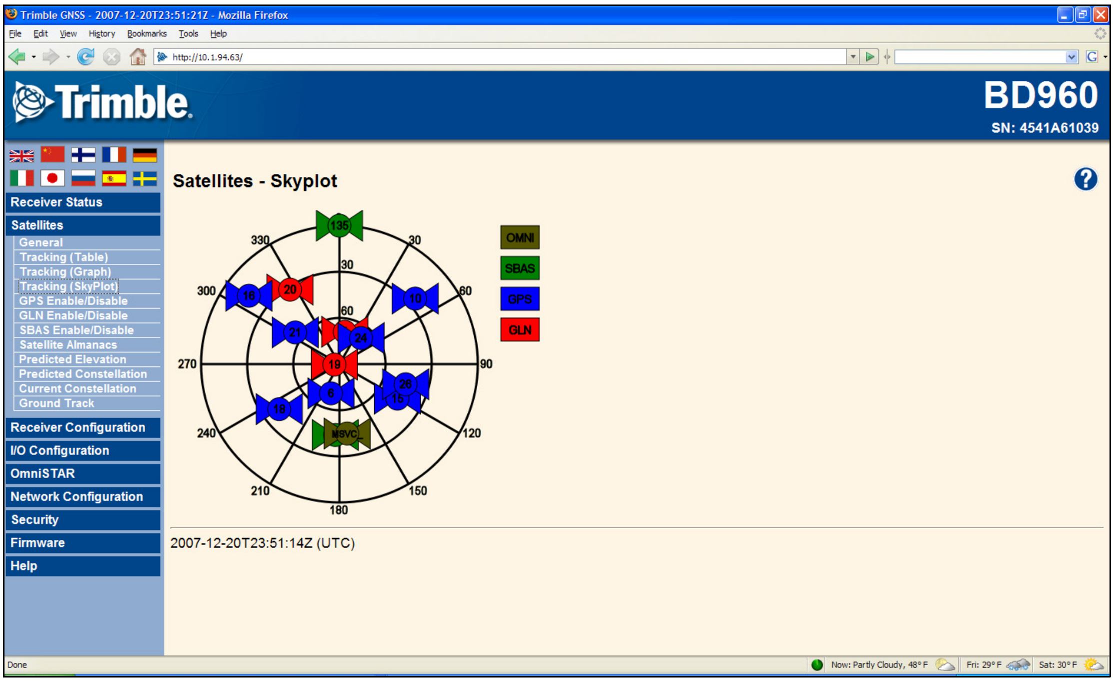


Satellites menu

Use the *Satellites* menu to view satellite tracking details and enable/disable GPS, GLONASS, and SBAS (WAAS/EGNOS/MSAS) satellites.

***Note** – To configure the receiver for OmniSTAR, use the OmniSTAR menu. See page 45.*

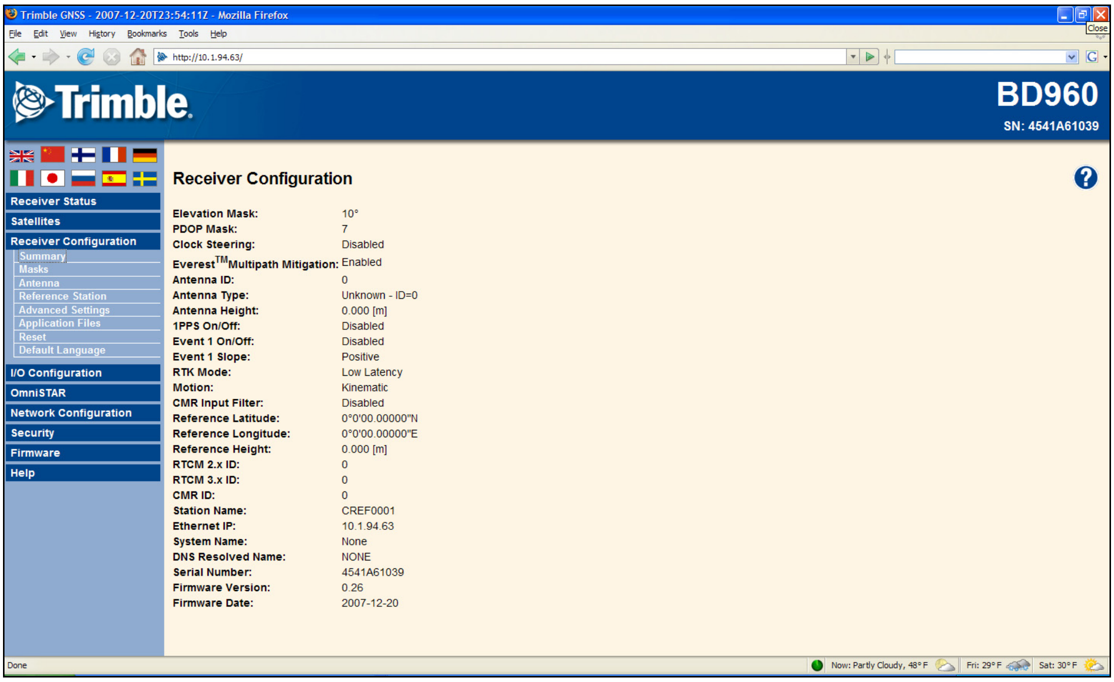
This figure shows an example of the screen that appears when you select *Satellite / Tracking (Sky Plot)*:



Receiver Configuration menu

Use the *Receiver Configuration* menu to configure such settings as elevation mask and PDOP mask, the antenna type and height, the reference station position, and the reference station name and code.

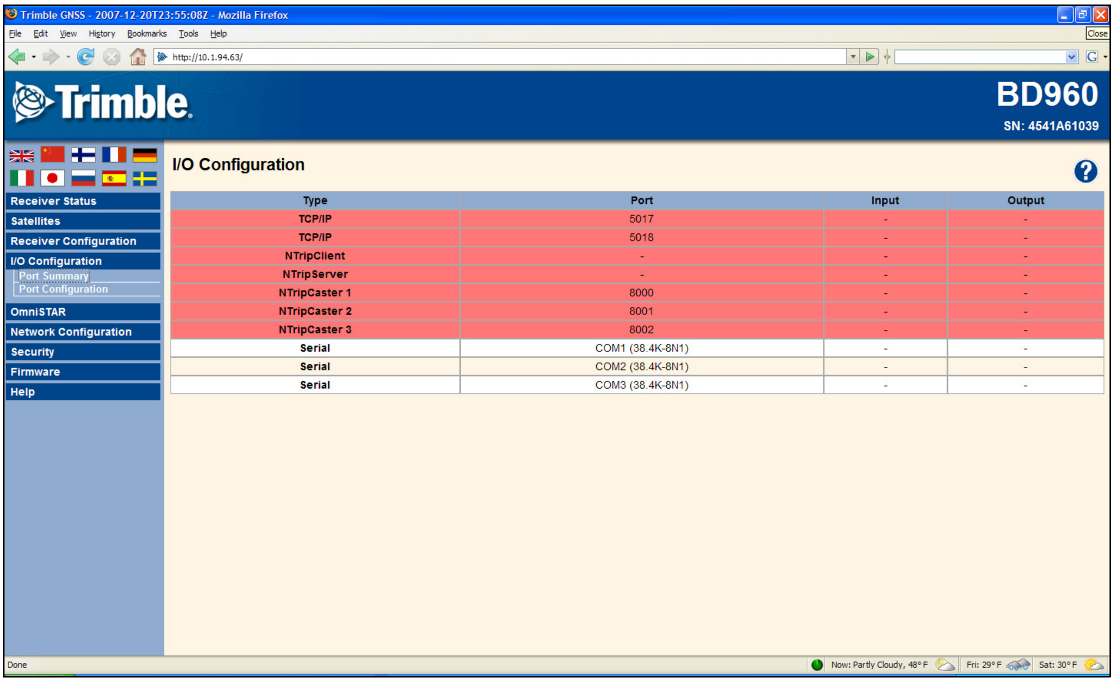
This figure shows an example of the screen that appears when you select *Receiver Configuration / Summary*:



I/O Configuration menu

Use the *I/O Configuration* menu to set up all outputs of the receiver. The receiver can output CMR, RTCM, NMEA, GSOF, RT17, or BINEX messages. These messages can be output on TCP/IP, UDP, or serial ports.

This figure shows an example of the screen that appears when you select *I/O Configuration / Port Summary*:

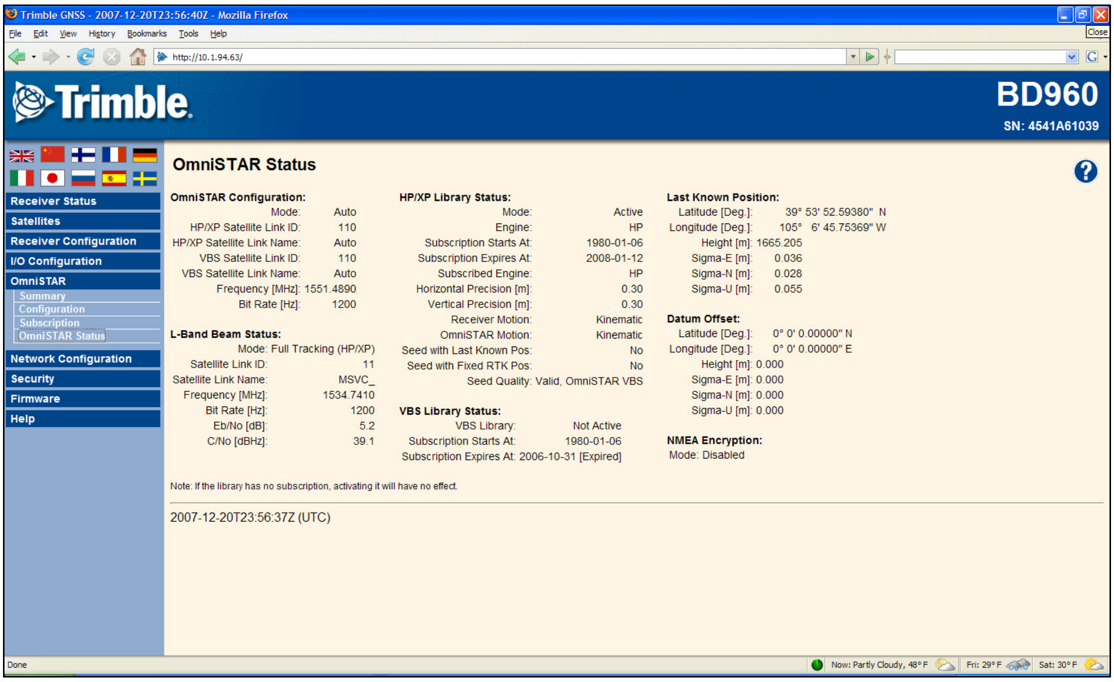


OmniSTAR menu

The BD960 receiver can receive OmniSTAR corrections. By default, OmniSTAR tracking is turned on in the receiver. To receive OmniSTAR corrections, you must set the receiver to track OmniSTAR satellites. The receiver must have a valid OmniSTAR subscription. To purchase a subscription for your receiver, contact OmniSTAR at:

www.OmniSTAR.com
North & South America: +1-888-883-8476 or +1-713-785-5850
Europe & Northern Africa, India, Pakistan: +31-70-317-0900
Australia & Asia: +61-8-9322 5295
Southern Africa: +27 21 552 0535

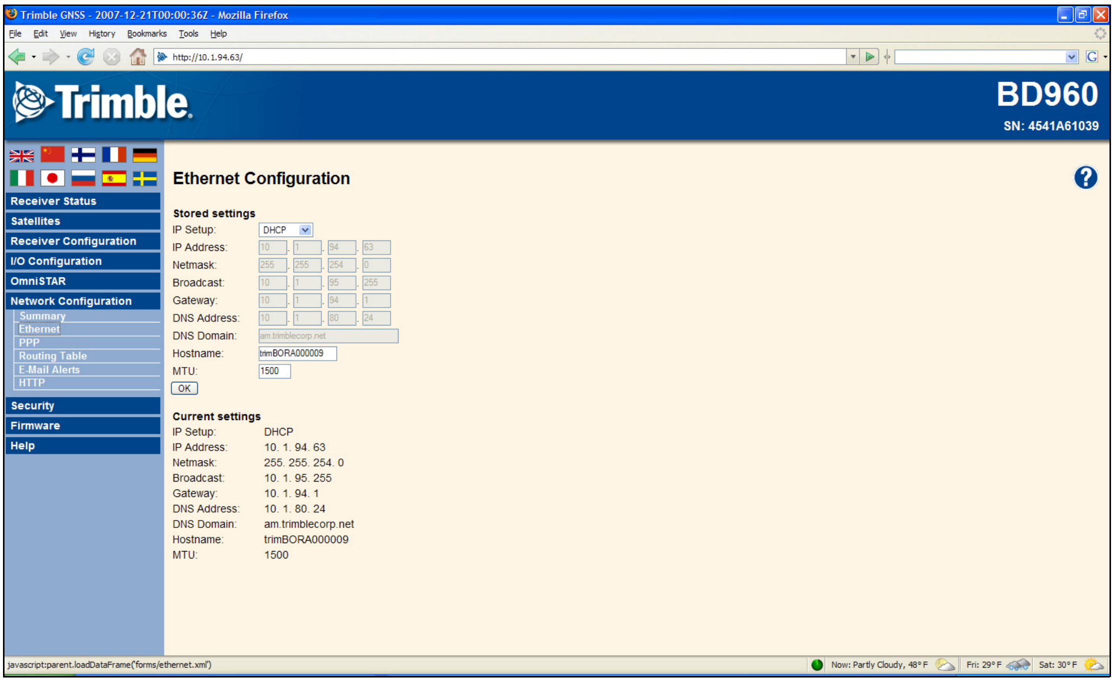
To receive an OmniSTAR activation, the receiver must be switched on, have a clear view to the south, and should be tracking an OmniSTAR satellite. This figure shows an example of the screen that appears when you select *OmniSTAR / Status:*



Internet Configuration menu

Use the *Internet Configuration* menu to configure Ethernet settings, email alerts, PPP connection, HTTP port, FTP port, and VFD port settings of the receiver. For information on the Ethernet settings, see Configuring Ethernet settings, page 36.

This figure shows an example of the screen that appears when you select *Network Configuration / Ethernet*:

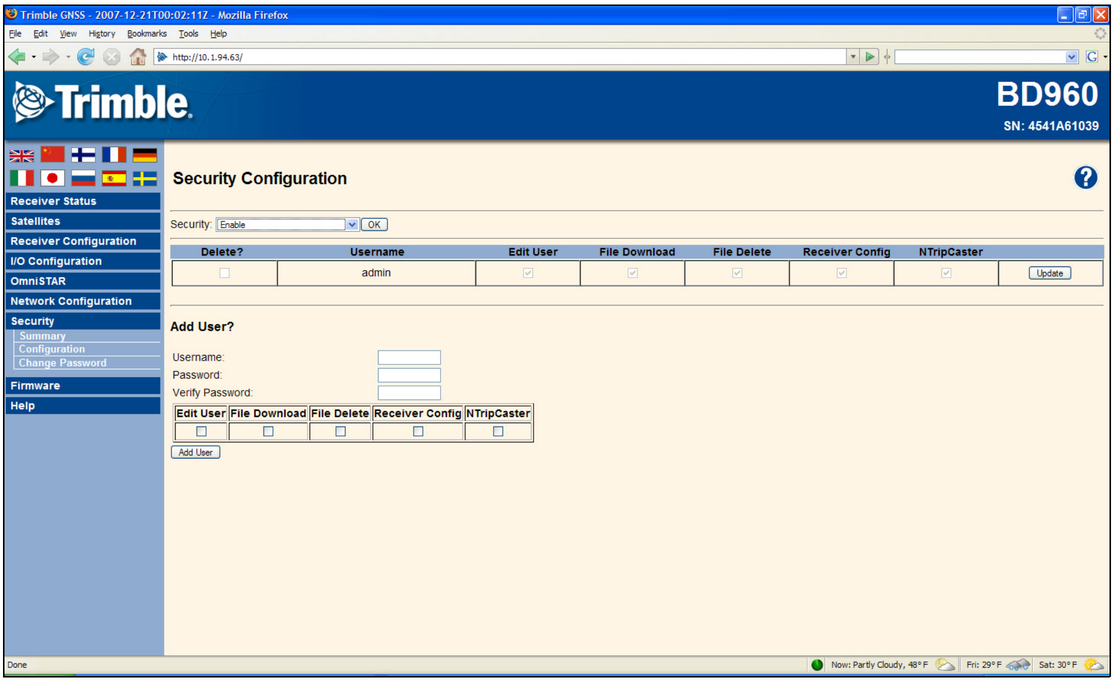


Security menu

Use the *Security* menu to configure the login accounts for all users who will be permitted to configure the receiver using a web browser. Each account consists of a username, password, and permissions. Administrators can use this feature to limit access to other users.

Security can be disabled for a receiver. However, Trimble discourages this as it makes the receiver susceptible to unauthorized configuration changes.

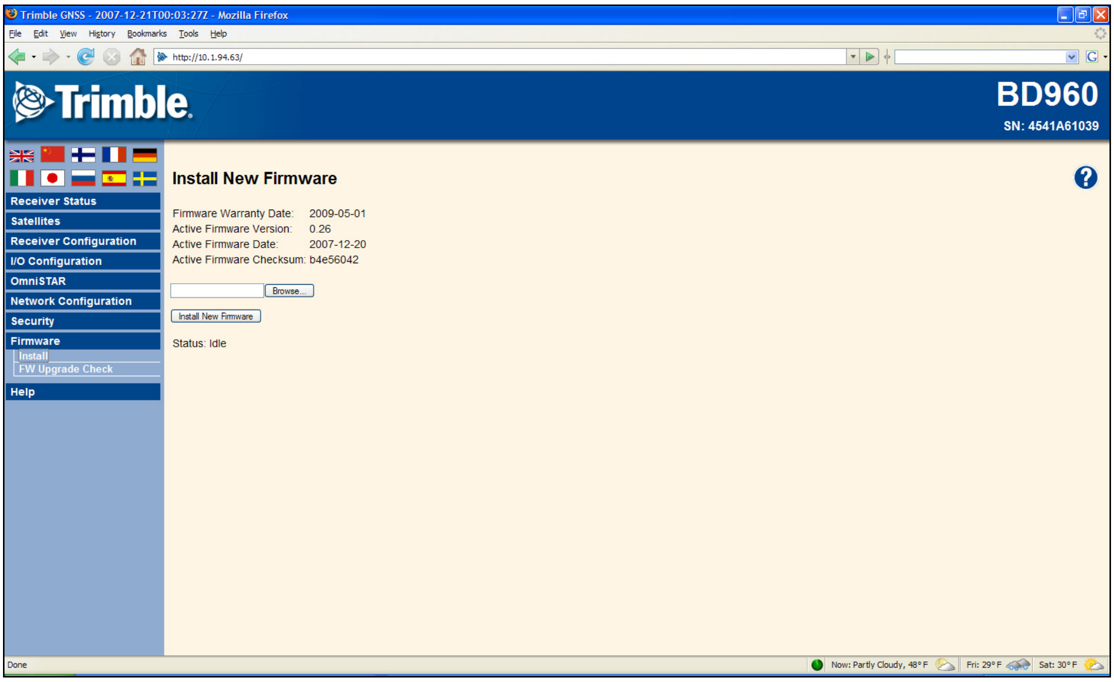
This figure shows an example of the screen that appears when you select *Security / Configuration*:



Firmware menu

Use the *Firmware* menu to verify the current firmware and load new firmware to the receiver. You can upgrade firmware across a network or from a remote location without having to connect to the receiver with a serial cable.

This figure shows an example of the screen that appears when you select *Firmware*:



Help Menu

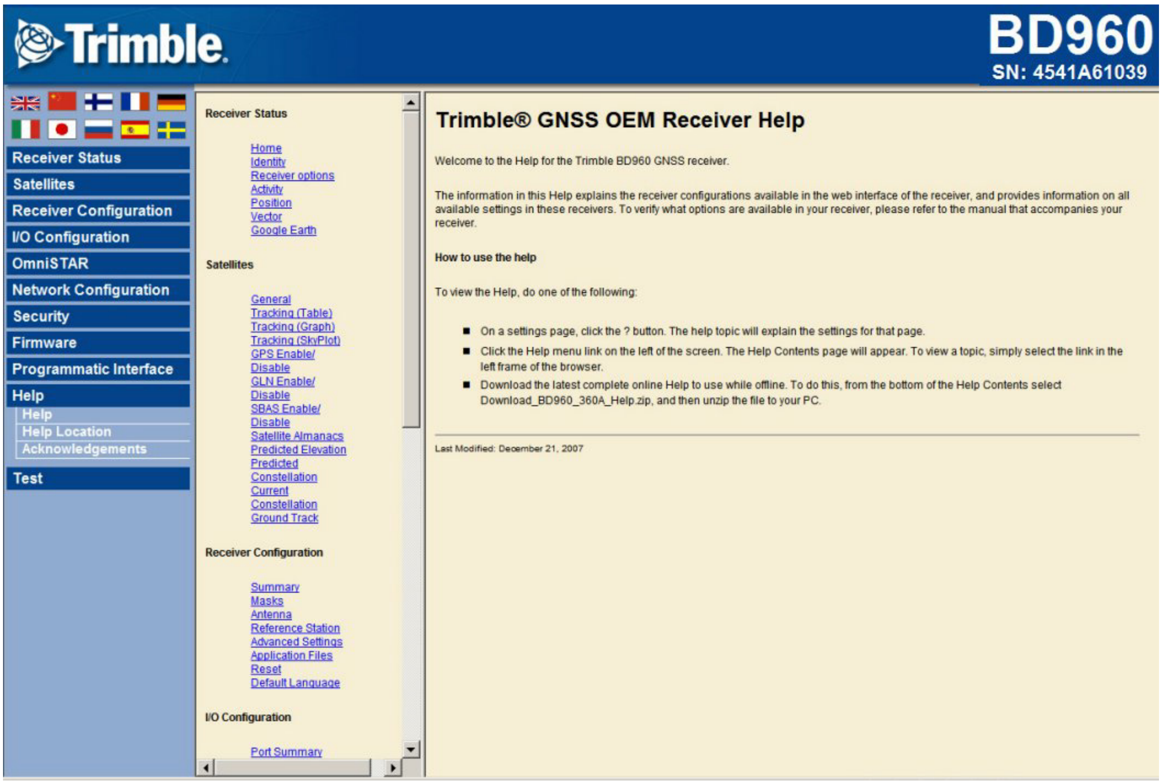
The *Help* menu provides information on each of the receiver settings available in a web browser. Selecting the *Help* menu opens new windows. Select the section of the Help that you want to view. The Help files are stored on the Trimble Internet site (www.trimble.com/OEM_ReceiverHelp/V3.60/en/) and are updated between firmware releases.

***Note –** For languages other than English, replace* **en** *with the appropriate two-letter country code, see page 40*

To access the Help, your computer must be connected to the Internet.

If you do not have access to the Internet, there is also a copy of the receiver Help files on the *Trimble SPS GPS Receiver CD*. (This copy shows the Help files as they were when the CD was published.)

This figure shows an example of the screen that appears when you select *Help*:



CHAPTER

7

Configuring the BD960 Receiver Using Binary Interface Commands

In this chapter:

This chapter documents the Data Collector Format packets that are used to configure the receiver settings and outputs.

RS-232 Serial Interface Specification

The RS-232 Serial Interface Specification enables a remote computing device to communicate with a BD960 receiver over an RS-232 connection, using Data Collector Format packets. The RS-232 Serial Interface Specification provides command packets for configuring the BD960 receiver for operation, and report packets for retrieving position and status information from the receiver.

Data Collector Format packets are similar to the data collector format packets which evolved with the Trimble Series 4000 receivers. The set of Data Collector Format command and report packets implemented on the receiver are simplified with a more flexible method for scheduling the output of data. For a detailed explanation of the streamed data output format, see 40h, GENOUT (General output record reports), page 79.

The receiver is configured for operation using application files. Application files include fields for setting all receiver parameters and functions. The default application file for the receiver includes the factory default values. Multiple application files can be transferred to the receiver for selection with command packets. Application files for specific applications can be developed on one receiver and downloaded to a computer for transfer to other BD960 receivers.

For a general description of application files, see To send application files to the receiver, use the Trimble Configuration Toolbox software or create the application files with a custom software program., page 60. For information about the structure of application files, see 64h, APPFILE (Application file record command), page 60.

Communications format

Supported data rates are: 2400, 4800, 9600, 19200, 38400, and 57600 baud and 115 kbaud. Any of these data rates ***can*** be used, however only 4800 baud or higher ***should*** be used. For example, a 20 Hz GGK string output requires the baud rate to be set to at least 19200. Only an 8-bit word format is supported, with Odd, Even, or No parity, and 1 stop bit. The default communications format for the receiver is 38400 baud, 8 data bits, no parity, and 1 stop bit.

Changes to the serial format parameter settings for all serial ports are stored in EEPROM (Electrically-Erasable Read-Only Memory) and remain in effect across power cycles until you change the parameter settings.

Testing the communications link

To determine whether the receiver can accept RS-232 commands, the protocol request ENQ (05h) is used. The response is either ACK (06h) or NAK (15h).

ENQ/ACK/NAK correspond to "Are you ready?", "I am ready", and "I am not ready". This quick 1-byte test can be sent by the remote device before any other command to make sure that the RS-232 line is clear and operational.

Communication errors

The receiver normally responds to a RS-232 Serial Interface Specification command packet within 500 milliseconds. If the receiver does not respond to the request or command, the external device can send numerous \0 characters (250) to cancel any partially received message before resending the previous message.

Data Collector Format packets

Command packets are sent from the remote device to the BD960 receiver when requesting data, sending commands, or when managing application files. The BD960 receiver acknowledges every command packet sent by the remote device. It does this by sending an associated report packet or by acknowledging the transaction with an ACK (06h) or NAK (15h) from the receiver.

Note – *The return of a NAK sometimes means that the receiver cannot fulfill the request. That is, the requested command is not supported.*

Packets are processed by the receiver on a first-in, first-out (FIFO) basis. External devices can send multiple packets without waiting for a response from each packet. The external device is responsible for matching expected responses with the actual response sent by the receiver.

Each message begins with a 4-byte header, followed by the bytes of data in the packet, and the packet ends with a 2-byte trailer. Byte 3 is set to 0 (00h) when the packet contains no data. Most data is transmitted between the receiver and remote device in binary format.

Data Collector Format packet structure

Every command and report packet, regardless of its source and except for protocol sequences, has the same format as shown in Table 7.1.

Table 7.1 Data Collector Format packet structure

Byte #	Message	Description
Begin packet header		
0	STX (02h)	Start transmission
1	STATUS	Receiver status code (see Table 7.2)
2	PACKET TYPE	Hexadecimal code assigned to the packet
3	LENGTH	Single byte # of data bytes, limits data to 255 bytes
Begin packet data		
4 to length	DATA BYTES	Data bytes
Begin packet trailer		
Length + 4	CHECKSUM	(status + type + length + data bytes) modulo 256
Length + 5	ETX (03h)	End transmission

Data Collector Format packet functions

WARNING – Virtually no range checking is performed by the receiver on the values supplied by the remote device. The remote device must adhere to the exact ranges specified within this document. ***Failure to do so can result in a receiver crash and/or loss of data.***

The functions of Data Collector Format command and report packets can be divided into the following categories:

- Information requests (command packets) and replies (report packets)
- Control functions (command packets) and RS-232 acknowledgments (ACK or NAK)
- Application file management

Requests for information, such as the Command Packet 4Ah (GETOPT), can be sent at any time. The expected reply (Report Packet 4Bh, RETOPT) is always sent. Some control functions may result in an RS-232 acknowledgment of NAK (15h) if one of the following conditions exists:

- The request is not supported (invalid) by the receiver (for example, a required option may not be installed on the receiver).
- The receiver cannot process the request.

The receiver STATUS byte

The status byte contains important indicators that usually require immediate attention by the remote device. The receiver never makes a request of the remote device. Each bit of the status byte identifies a particular problem. More than one problem may be indicated by the status byte. Table 7.2 lists the status byte codes.

Table 7.2 Status byte codes

Bit	Bit value	Meaning
Bit 0	1	Reserved
Bit 1	1	Low battery
Bit 2–7	0–63	Reserved

Reading binary values

The receiver stores numbers in Motorola format. The byte order of these numbers is the opposite of what personal computers expect (Intel format). To supply or interpret binary numbers (8-byte DOUBLES, 4-byte LONGS, and 2-byte INTEGERS), the byte order of these values must be reversed. A detailed description of the Motorola format used to store numbers in the receiver is provided in the following sections.

INTEGER data types

The INTEGER data types (CHAR, SHORT, and LONG) can be signed or unsigned. They are unsigned by default. All integer data types use two's complement representation. Table 7.3 lists the integer data types.

Table 7.3 Integer data types

Type	# of bits	Range of values (Signed)	(Unsigned)
CHAR	8	–128 to 127	0 to 255
SHORT	16	–32768 to 32767	0 to 65535
LONG	32	–2147483648 to 2147483647	0 to 4294967295

FLOATING-POINT data types

Floating-point data types are stored in the IEEE SINGLE and DOUBLE precision formats. Both formats have a sign bit field, an exponent field, and a fraction field. The fields represent floating-point numbers in the following manner:

```
Floating-Point Number = <sign> 1.<fraction field> x 2
(<exponent field> - bias)
```

- **Sign bit field**

  The sign bit field is the most significant bit of the floating-point number. The sign bit is 0 for positive numbers and 1 for negative numbers.

- **Fraction field**

  The fraction field contains the fractional part of a normalized number. Normalized numbers are greater than or equal to 1 and less than 2. Since all normalized numbers are of the form 1.XXXXXXXX, the 1 becomes implicit and is not stored in memory. The bits in the fraction field are the bits to the right of the binary point, and they represent negative powers of 2.

  For example:

  ```
  0.011 (binary) = 2-2 + 2-3 = 0.25 + 0.125 = 0.375
  ```

- **Exponent field**

  The exponent field contains a biased exponent; that is, a constant bias is subtracted from the number in the exponent field to yield the actual exponent. (The bias makes negative exponents possible.)

  If both the exponent field and the fraction field are zero, the floating-point number is zero.

- **NaN**

  A NaN (Not a Number) is a special value that is used when the result of an operation is undefined. For example, adding positive infinity to negative infinity results in a NaN.

FLOAT data type

The FLOAT data type is stored in the IEEE single-precision format which is 32 bits long. The most significant bit is the sign bit, the next 8 most significant bits are the exponent field, and the remaining 23 bits are the fraction field. The bias of the exponent is 127. The range of single-precision format values is from 1.18×10^{-38} to 3.4×10^{38}. The floating-point number is precise to 6 decimal digits.

31	30 … 23	22 … 0
S	Exp. + Bias	Fraction

```
0 000 0000 0 000 0000 0000 0000 0000 0000 = 0.0
0 011 1111 1 000 0000 0000 0000 0000 0000 = 1.0
1 011 1111 1 011 0000 0000 0000 0000 0000 = -1.375
1 111 1111 1 111 1111 1111 1111 1111 1111 = NaN
```

DOUBLE

The DOUBLE data type is stored in the IEEE double-precision format which is 64 bits long. The most significant bit is the sign bit, the next 11 most significant bits are the exponent field, and the remaining 52 bits are the fractional field. The bias of the exponent is 1023. The range of single precision format values is from 2.23×10^{-308} to 1.8×10^{308}. The floating-point number is precise to 15 decimal digits.

63	62 … 52	51 … 0
S	Exp. + Bias	Fraction

```
0 000 0000 0000 0000 0000 ... 0000 0000 0000 = 0.0
0 011 1111 1111 0000 0000 ... 0000 0000 0000 = 1.0
1 011 1111 1110 0110 0000 ... 0000 0000 0000 = -0.6875
1 111 1111 1111 1111 1111 ... 1111 1111 1111 = NaN
```

Data Collector Format Command Packets

Data Collector Format command packets are sent from the remote device to the receiver to execute receiver commands or to request data reports. The receiver acknowledges all command packets. It does this by sending a corresponding report packet or by acknowledging the completion of an action.

The following sections provide details for each command and report packet. Table 7.4 provides a summary of the command packets.

Table 7.4 Command Packet summary

ID, Command Packet	Action	Page
06h, GETSERIAL (Receiver and antenna information request)	06h, GETSERIAL (Receiver and antenna information request)	60

Table 7.4 Command Packet summary (continued)

ID, Command Packet	Action	Page
54h, GETSVDATA (Satellite information request)	54h, GETSVDATA (Satellite information request)	58
56h, GETRAW (Position or real-time survey data request)	56h, GETRAW (Position or real-time survey data request)	59
64h, APPFILE (Application file record command)	64h, APPFILE (Application file record command)	60
65h, GETAPPFILE (Application file request)	65h, GETAPPFILE (Application file request)	73
66h, GETAFDIR (Application file directory listing request)	66h, GETAFDIR (Application file directory listing request)	74
68h, DELAPPFILE (Delete application file data command)	68h, DELAPPFILE (Delete application file data command)	75
6Dh, ACTAPPFILE (Activate application file)	6Dh, ACTAPPFILE (Activate application file)	75
81h, KEYSIM (Key simulator)	81h, KEYSIM (Key simulator)	76
82h, SCRDUMP (Screen dump request)	82h, SCRDUMP (Screen dump request)	77

06h, GETSERIAL (Receiver and antenna information request)

Command Packet 06h requests receiver and antenna information. The receiver responds by sending the data in the Report Packet 07h:

Packet flow		
Receiver		**Remote**
	←	Command Packet 06h
Report Packet 07h	→	

Table 7.5 describes the packet structure.

Table 7.5 Command packet 06h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code
2	PACKET TYPE	CHAR	06h	Command Packet 06h
3	LENGTH	CHAR	00h	Data byte count
4	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value
5	ETX	CHAR	03h	End transmission

54h, GETSVDATA (Satellite information request)

Command Packet 54h requests satellite information. The request may be for an array of flags showing the availability of satellite information such as an ephemeris or almanac. In addition, satellites may be enabled or disabled with this command packet. Table 7.6 shows the packet structure. For additional information, see Data Collector Format packet structure, page 53.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 54h
Report Packet 55h or NAK	→	

***Note –** The normal reply to Command Packet 54h is usually Report Packet 55h. However, a NAK is returned if the SV PRN is out of range (except for SV FLAGS), if the DATA SWITCH parameter is out of range, or if the requested data is not available for the designated SV.*

Table 7.6 Command packet 54h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	00h	Receiver status code
2	PACKET TYPE	CHAR	54h	Command Packet 54h
3	LENGTH	CHAR	03h	Data byte count
4	DATA SWITCH	CHAR	See Table 7.7, page 58	Selects type of satellite information downloaded from receiver or determines whether a satellite is enabled or disabled
5	SV PRN #	CHAR	01h–20h	Pseudorandom number (1–32) of satellite (ignored if SV Flags or ION/UTC is requested)
6	RESERVED	CHAR	00h	Reserved (set to zero)
7	CHECKSUM	CHAR	See Table 7.2, page 54	Checksum value
8	ETX	CHAR	03h	End transmission

Table 7.7 DATA SWITCH byte values

Byte value		Meaning
Dec	**Hex**	
0	00h	SV Flags indicating Tracking, Ephemeris and Almanac, Enable/Disable state
1	01h	Ephemeris
2	02h	Almanac
3	03h	ION/UTC data
4	04h	Disable Satellite
5	05h	Enable Satellite
The Enable and Disable Satellite data switch values always result in the transmission of a RETSVDATA message as if the SV Flags are being requested.		

56h, GETRAW (Position or real-time survey data request)

Command Packet 56h requests raw satellite data in *.DAT Record 17 format or Concise format. The request may specify if Real-Time attribute information is required. The receiver responds by sending the data in Report Packet 57h. Alternatively, the packet can be used to request receiver position information in *.DAT record 11 format. Table 7.8 describes the packet structure. For additional information, see 57h, RAWDATA (Position or real-time survey data report), page 114.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 56h
Report Packet 57h or NAK	→	

Note – *The reply to this command packet is usually a Report Packet 57h. A NAK is returned if the Real-Time Survey Data Option (RT17) is not installed on the receiver.*

Table 7.8 Command packet 56h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code
2	PACKET TYPE	CHAR	56h	Command Packet 56h
3	LENGTH	CHAR	03h	Data byte count
4	TYPE RAW DATA	CHAR	See Table 7.9, page 59	Identifies the requested type of raw data
5	FLAGS	CHAR	See Table 7.10, page 59	Flag bits for requesting raw data
6	RESERVED	CHAR	00h	Reserved; set to zero
7–8	CHECKSUM	SHORT	See Table 7.1, page 53	Checksum value
9	(03h) ETX	CHAR	03h	End transmission

Table 7.9 TYPE RAW DATA values

Byte value		Meaning
Dec	Hex	
0	00h	Real-Time Survey Data Record (Record Type 17)
1	01h	Position Record (Record Type 11)

Table 7.10FLAGS bit values

Bit	Meaning
0	Raw Data Format 0: Expanded *.DAT Record Type 17 format 1: Concise *.DAT Record Type 17 format
1	Enhanced Record with real-time flags and IODE information 0: Disabled – record data not enhanced 1: Enabled – record data is enhanced
2–7	Reserved (set to zero)

64h, APPFILE (Application file record command)

To send application files to the receiver, use the Trimble Configuration Toolbox software or create the application files with a custom software program.

Application files contain a collection of individual records that fully prescribe the operation of the receiver. Application files are transferred using the standard Data Collector Format packet format.

Each application file can be tailored to meet the requirements of separate and unique applications. Up to 10 application files can be stored within the receiver for activation at a later date.

The two important application files in the receiver are explained in Table 7.11.

Table 7.11Important application files and their functions

Name	Function
DEFAULT	Permanently stored application file containing the receiver's factory default settings. This application file is used when the receiver is reset to the factory default settings.
CURRENT	Holds the current settings of the receiver.

Individual records within an existing application file can be updated using the software tools included with the receiver. For example, the OUTPUT MESSAGES record in an application file can be updated without affecting the parameter settings in other application file records.

Application files can be started immediately and/or the files can be stored for later use.

Once applications files are transferred into memory, command packets can be used to manage the files. Command packets are available for transferring, selecting, and deleting application files.

If any part of the application record data is invalid, then the receiver ignores the entire record. The receiver reads a record using the embedded length. Any extraneous data is ignored. This allows for backward compatibility when the record length is increased to add new functions.

If you are concerned about application files producing the same results on future receivers, make sure that the application records do not contain extraneous data.

Command Packet 64h is sent to create, replace, or report on an application file. The command packet requests the application file by System File Index.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 64h
ACK	→	

For detailed information about BD960 Application Files and for guidelines about using application files to control remote devices, see Report Packet 64h, APPFILE (Application file record report), page 123.

Packet paging

Since an application file contains a maximum of 2048 bytes (all records are optional) of data and exceeds the byte limit for RS-232 Serial Interface Specification packets, Command Packet 64h is divided into several subpackets called pages. The PAGE INDEX byte (byte 5) identifies the packet page number and the MAXIMUM PAGE INDEX byte (byte 6) indicates the maximum number of pages in the report.

The first and subsequent pages are filled with a maximum of 248 bytes consisting of 3 bytes of page information and 245 bytes of application file data. The application file data is split wherever the 245 byte boundary falls. Therefore the remote device sending the Command Packet pages must construct the application file using the 248 byte pages before sending the file to the receiver.

To prevent data mismatches, each report packet is assigned a Transmission Block Identifier (byte 4) which gives the report pages a unique identity in the data stream. The software on the remote device can identify the pages associated with the report and reassemble the application file using bytes 4–6.

Table 7.12 shows the structure of the report packet containing the application file.

Table 7.12Command packet 64h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	00h	Receiver status code.
2	PACKET TYPE	CHAR	64h	Command Packet 64h.
3	LENGTH	CHAR	00h	Data byte count.
4	TX BLOCK IDENTIFIER	CHAR	00h–FFh	A Transmission Block Identifier, ranging between 0–255, that must remain the same for all pages of an application file transfer.
5	PAGE INDEX	CHAR	00h–FFh	Index number (0–255) assigned to the current page.
6	MAXIMUM PAGE INDEX	CHAR	00h–FFh	Index number (0–255) assigned to the last page of the packet.
FILE CONTROL INFORMATION BLOCK The FILE INFORMATION CONTROL BLOCK must be sent in the first page of the report containing the application file. The second page and consecutive pages must not include a FILE CONTROL INFORMATION BLOCK.				
7	APPLICATION FILE SPECIFICATION VERSION	CHAR	03h	Always 3 for this version of the specification.
8	DEVICE TYPE	CHAR	See Table 7.13, page 65	Unique identifier for every receiver/device type that supports the application file interface.
9	START APPLICATION FILE FLAG	CHAR	See Table 7.14, page 65	Determines whether the application file is activated immediately after records are sent to receiver.
10	FACTORY SETTINGS FLAG	CHAR	See Table 7.15, page 65	Determines whether the receiver is reset to factory default settings before activating the records in the application file.

Table 7.12Command packet 64h structure (continued)

Byte #	Item	Type	Value	Meaning
				Insert Appfile Records here. (See Below)
Length +4	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
Length +5	ETX	CHAR	03h	End transmission.
APPLICATION FILE RECORDS The records listed below (for example, FILE STORAGE RECORD, GENERAL CONTROLS RECORD) are subtypes of the FILE CONTROL INFORMATION BLOCK.				
FILE STORAGE RECORD The FILE STORAGE RECORD indicates the application file creation date and time and provides identification information required to store the file in memory. When included in the application file, this record must be the first record within the file.				
0	RECORD TYPE	CHAR	00h	File Storage Record.
1	RECORD LENGTH	CHAR	0Dh	Number of bytes in record, excluding bytes 0 and 1.
2–9	APPLICATION FILE NAME	CHARs	*ASCII text A...Z, a...z, _ (underscore)*	Eight-character name for the application file.
10	YEAR OF CREATION	CHAR	00h–FFh	Year when application file is created, ranging from 00–255 (1900 = 00).
11	MONTH OF CREATION	CHAR	01h–0Ch	Month when application file is created (01–12).
12	DAY OF CREATION	CHAR	00h–1Fh	Day of the month when application file is created (00–31).
13	HOUR OF CREATION	CHAR	00h–17h	Hour of the day when application file is created (00-23).
14	MINUTES OF CREATION	CHAR	00h–3Bh	Minutes of the hour when application file is created (00–59).
GENERAL CONTROLS RECORD The GENERAL CONTROLS RECORD sets general GPS operating parameters for the receiver, including the elevation mask, measurement rate, PDOP (Position Dilution of Precision) mask, and the positioning mode.				
0	RECORD TYPE	CHAR	01h	General controls record.
1	RECORD LENGTH	CHAR	08h	Number of bytes in record, excluding bytes 0 and 1.
2	ELEVATION MASK	CHAR	00h–5Ah	Elevation mask in degrees (0–90).
3	MEASUREMENT RATE	CHAR	See Table 7.16, page 66	Frequency rate at which the receiver generates measurements.
4	PDOP MASK	CHAR	00h–FFh	Position Dilution of Precision mask (0–255).
5	RESERVED	CHAR	00h	Reserved (set to zero).
6	RESERVED	CHAR	00h	Reserved (set to zero).
7	RTK POSITIONING MODE	CHAR	See Table 7.20, page 67	Sets the RTK positioning mode.
8	POSITIONING SOLUTION SELECTION	CHAR	See Table 7.17, page 66	Controls use of DGPS and RTK solutions.

Table 7.12Command packet 64h structure (continued)

Byte #	Item	Type	Value	Meaning
9	RESERVED	CHAR	00h	Reserved (set to zero).
SERIAL PORT BAUD/FORMAT RECORD The SERIAL PORT BAUD RATE/FORMAT RECORD is used to set the communication parameters for the serial ports. Individual serial ports are identified within the record by the SERIAL PORT INDEX number.				
0	RECORD TYPE	CHAR	02h	Serial Port Baud Rate/Format Record.
1	RECORD LENGTH	CHAR	04h	Number of bytes in the record, excluding bytes 0 and 1.
2	SERIAL PORT INDEX.	CHAR	00h–03h	The number of the serial port to configure.
3	BAUD RATE	CHAR	See Table 7.18, page 66	Data transmission rate.
4	PARITY	CHAR	See Table 7.19, page 66	Sets the parity of data transmitted through the port. The eight data bits and one stop bit are always used, regardless of the parity selection.
5	FLOW CONTROL	CHAR	See Table 7.21, page 67	Flow control.
REFERENCE (BASE) NODE RECORD The REFERENCE NODE RECORD is an optional record for providing LLA (Latitude, Longitude, Altitude) coordinates for base station nodes.				
0	RECORD TYPE	CHAR	03h	Reference Node Record.
1	RECORD LENGTH	CHAR	25h	Data bytes in the record, excluding bytes 0 and 1.
2	FLAG	CHAR	00h	Reserved (set to zero).
3	NODE INDEX	CHAR	00h	Reserved (set to zero).
4–11	NAME	CHAR	ASCII text	Eight-character reference node description.
12–19	REFERENCE LATITUDE	DOUBLE	radians	Latitude of reference node, $\pm\pi/2$.
20–27	REFERENCE LONGITUDE	DOUBLE	radians	Longitude of reference node, $\pm \pi$.
28–35	REFERENCE ALTITUDE	DOUBLE	meters	Altitude of reference node, $-9999.999 \le h \le +9999.999$.
36–37	STATION ID	SHORT	0000h–03FFh	Reference Node Station ID for RTCM output.
38	RTK STATION	CHAR	00h–1Fh	Reference Station ID for RTK output.
SV ENABLE/DISABLE RECORD The SV ENABLE/DISABLE RECORD is used to enable or disable a selection of the 32 GPS satellites. By default, the receiver is configured to use all satellites which are in good health. This record is useful for enabling satellites which are not in good health. Once enabled, the health condition of the satellite(s) is ignored, and the GPS signal transmissions from the satellite(s) are considered when computing position solutions.				
0	RECORD TYPE	CHAR	06h	SV Enable/Disable Record.
1	RECORD LENGTH	CHAR	20h	Number of bytes in record, excluding bytes 0 and 1.
2–33	SV ENABLE/DISABLE STATES	CHARs	See Table 7.22, page 67	Array of Enable/Disable flags for the 32 SVs. The first byte sets the required Enable/Disable status of SV1, the second sets the status of SV2, etc.

Table 7.12Command packet 64h structure (continued)

Byte #	Item	Type	Value	Meaning
OUTPUT MESSAGE RECORD				
The OUTPUT MESSAGE RECORD selects the outputs for a specified serial port, the frequency of message transmissions, the integer second offset from the scheduled output rate, and output specific flags. Bytes 0 through 5 are included in all records, regardless of the output message type. The remaining bytes in the record (byte 6...) are dependent on the output message type.				
0	RECORD TYPE	CHAR	07h	Output Message Record.
1	RECORD LENGTH	CHAR	04h, 05h or 06h	Number of bytes in the record, excluding bytes 0 and 1. The number of bytes is dependent on the number of output specific flags.
2	OUTPUT MESSAGE TYPE	CHAR	See Table 7.23, page 67	Type of message or packet.
3	PORT INDEX	CHAR	00h–03h	Serial port index number.
4	FREQUENCY	CHAR	See Table 7.24, page 69	Frequency of message transmissions.
5	OFFSET	CHAR	00h–FFh	Integer second offset (0–255 seconds) from scheduled output rate. (Only valid when frequency is < 1 Hz or >1 second.)
***Note –** The remaining bytes depend on the output message type (Byte 2). One or two flag bytes can be sent, but two are always stored in the receiver.*				
OUTPUT MESSAGE RECORD TYPE 10 (GSOF)				
6	GSOF SUBMESSAGE TYPE	CHARs	See Table 7.32, page 73	GSOF message number.
7	OFFSET	CHAR	0–255	Integer second offset from scheduled frequency.
OUTPUT MESSAGE RECORD TYPE 2 (RTK-CMR)				
6	CMR MESSAGE TYPE FLAGS	CHAR	See Table 7.25, page 69	CMR message types.
OUTPUT MESSAGE RECORD TYPE 3 (RTCM)				
6	RTCM FLAGS	CHAR	See Table 7.27, page 70	Bit settings for RTCM output flags.
OUTPUT MESSAGE RECORD TYPE 4 (RT17)				
6	REAL-TIME 17 MESSAGE FLAGS	CHAR	See Table 7.26, page 70	RT17 (Real Time 17) flags.
ANTENNA RECORD				
The ANTENNA RECORD identifies the Antenna Type and the true vertical height of antenna above the ground mark.				
0	RECORD TYPE	CHAR	08h	Reference Node record.
1	RECORD LENGTH	CHAR	0Ch	Number of bytes in record, excluding bytes 0 and 1.
2–9	ANTENNA HEIGHT	DOUBLE	meters	Vertical height of antenna, in meters.
10–11	ANTENNA TYPE	SHORT	See Table 7.28, page 71	Defines the type of antenna connected to the receiver.
12	RESERVED	CHAR	00h	Reserved (set to zero).
13	RESERVED	CHAR	00h	Reserved (set to zero).

Table 7.12Command packet 64h structure (continued)

Byte #	Item	Type	Value	Meaning
DEVICE CONTROL RECORD				
The DEVICE CONTROL RECORD contains configuration parameters for controlling some external devices and the operation of some receiver options. The number of bytes contained in the record and the length of the record are determined by the DEVICE TYPE entry. The table subheadings identify different devices				
0	RECORD TYPE	CHAR	09h	Device Control record.
1	RECORD LENGTH	CHAR	02h or 0Dh	Number of bytes in record, excluding bytes 0 and 1.
2	DEVICE TYPE	CHAR	See Table 7.29, page 72	Type of device.
For 1 PPS Output Only				
3	1 PPS CONTROL	CHAR	See Table 7.30, page 72	Enables or disables 1 PPS output; byte 2 is set to 2.
STATIC/KINEMATIC RECORD				
The bytes value in the STATIC/KINEMATIC RECORD determine whether the receiver is operating in Static or Kinematic mode.				
0	RECORD TYPE	CHAR	0Ah	Static/Kinematic record.
1	RECORD LENGTH	CHAR	01h	Number of bytes in record, excluding bytes 0 and 1.
2	STATIC/KINEMATIC MODE	CHAR	See Table 7.31, page 72	Configures receiver for static or kinematic operation.

Table 7.13DEVICE TYPE byte values

Byte value		Meaning
Dec	Hex	
0	00h	All Devices
2–5	02h–05h	Reserved
66	42h	BD960 receiver

Table 7.14START APPLICATION FILE FLAG byte values

Byte value		Meaning
Dec	Hex	
0	00h	Do ***not*** apply the application file parameter settings to the active set of parameters when the transfer is complete.
1	01h	Apply application file records immediately.

Table 7.15FACTORY SETTINGS byte values

Byte value		Meaning
Dec	Hex	
0	00h	Alter receiver parameters only as specified in the application file. Leave unspecified settings alone.
1	01h	Set all controls to factory settings prior to applying the application file.

Table 7.16MEASUREMENT RATE byte values

Byte value		Meaning
Dec	Hex	
0	00h	1 Hz
1	01h	5 Hz
2	02h	10 Hz

Table 7.17POSTITIONING SOLUTION SELECTION values

Byte value		Meaning
Dec	Hex	
0	00	Use best available solution.
1	01	Produce DGPS and Autonomous solutions.
2	02	Produce DGPS, RTK Float, and Autonomous solutions. On-the-fly RTK initialization is disabled, therefore no RTK Fix solutions are generated.
3	03	Produce RTK Fix, DGPS, and Autonomous solutions (no RTK Float solutions).

Table 7.18BAUD RATE byte values

Byte value		Meaning
Dec	Hex	
0	00h	9600 baud (default)
1	01h	2400 baud
2	02h	4800 baud
3	03h	9600 baud
4	04h	19.2K baud
5	05h	38.4K baud
6	06h	57.6K baud
7	07h	115.2K baud
8	08h	300 baud
9	09h	600 baud
10	0Ah	1200 baud
11	0Bh	230,000 baud
12	0Ch	460,000 baud

Table 7.19PARITY byte values

Byte value		Meaning
Dec	Hex	
0	00h	No Parity (10-bit format)
1	01h	Odd Parity (11-bit format)
2	02h	Even Parity (11-bit format)

Table 7.20RTK POSITIONING MODE byte values

Byte value		Meaning
Dec	Hex	
0	00h	Synchronous positioning
1	01h	Low Latency positioning

Table 7.21FLOW CONTROL byte values

Byte value		Meaning
Dec	Hex	
0	00h	None
1	01h	CTS

Table 7.22SV ENABLE/DISABLE STATES flag values

Byte value		Meaning
Dec	Hex	
0	00h	Heed health (default)
1	01h	Disable the satellite
2	02h	Enable the satellite regardless of whether the satellite is in good or bad health

Table 7.23OUTPUT MESSAGE TYPE byte values

Byte value	Meaning
0xFF	Turn off ***all*** outputs on ***all*** ports. Frequency must also be 'Off' for this to work.
0	Turn off ***all*** outputs on the given port only. Frequency must be 'Off' for this to work
1	Not used.
2	CMR Output
3	RTCM Output
4	RT17 Output
5	Not used.
6	NMEA_GGA
7	NMEA_GGK
8	NMEA_ZDA
9	Reserved
10	GSOF
11	1PPS
12	NMEA_VTG
13	NMEA_GST
14	NMEA_PJK
15	NMEA_PJT
16	NMEA_VGK

Table 7.23OUTPUT MESSAGE TYPE byte values (continued)

Byte value	Meaning
17	NMEA_VHD
18	NMEA_GSV
19	NMEA_TSN
20	NMEA_TSS
21	NMEA_PRC
22	NMEA_REF
23	NMEA_GGK_SYNC
24	J1939_VehPos
25	J1939_Time
26	J1939_VehSpd
27	J1939_ImpPos
28	J1939_ImpSpd
29	NMEA_AVR
30	Reserved
31	NMEA_HDT
32	NMEA_ROT
33	NMEA_ADV
34	NMEA_PIO
35	NMEA_BETA
36	Reserved
37	NMEA_VRSGGA
38	NMEA_GSA
39	Binex
40	NMEA_RMC
41	NMEA_BPQ
42	Reserved
43	Reserved
44	NMEA_GLL
45	NMEA_GRS
46	Reserved
47	NMEA_LDG

Table 7.24FREQUENCY byte values

Byte value		Meaning
Dec	Hex	
0	00h	Off
1	01h	10 Hz
2	02h	5 Hz
3	03h	1 Hz
4	04h	2 seconds
5	05h	5 seconds
6	06h	10 seconds
7	07h	30 seconds
8	08h	60 seconds
9	09h	5 minutes
10	0Ah	10 minutes
11	0Bh	2 Hz
12	0Ch	15 seconds
13	0Dh	20 Hz
15	0Fh	50 Hz
255	FFh	Once only, immediately
Certain message output types may not support >1 Hz output.		

Table 7.25CMR MESSAGE TYPE byte values

Byte value		Meaning
Dec	Hex	
0	00h	Standard (CMR, CMR+™).
1	01h	High speed CMR (5 or 10 Hz).
2	02h	Compatible with Trimble 4000 receivers.

Table 7.26REAL-TIME 17 MESSAGE bit values

Bit	Meaning
7 (msb)	Reserved (set to zero)
6	Reserved (set to zero)
5	Reserved (set to zero)
4	Position Only 0: Disabled 1: Enabled
3	Streamed Position 0: Disabled 1: Enabled
2	Streamed Ephemeris 0: Disabled 1: Enabled
1	RT (Real-Time) Enhancements 0: Disabled 1: Enabled
0	(lsb) Compact Format 0: Disabled 1: Enabled

Table 7.27RTCM Flag bit values

Bit	Meaning
0	Invalid value
1	Output RTK RTCM packets (Type 18 & 19)
2	Output DGPS RTCM packets (Type 1)
3	Output RTK and DGPS RTCM packets (Types 1, 18, and 19)
4	Output Type 9 Groups of 3 Bit 3 (Use RTCM version 2.2) 0: Off 1: On (Multiple message bit turned on in Types 18 and 19) Bit 4 (Use RTCM version 2.3) 0: Off 1: On (Output Types 23 & 24)
5–7	Invalid values

If Flags are invalid, the record is not applied. (However, the Appfile may be accepted.)

Table 7.28ANTENNA TYPE byte values

Byte value		Meaning
Dec	**Hex**	
0	00h	Unknown External
1	01h	4000ST Internal
2	02h	4000ST Kinematic Ext
3	03h	Compact Dome
4	04h	4000ST L1 Geodetic
5	05h	4000SST L1 L2 Geodetic
6	06h	4000SLD L1 L2 Square
7	07h	4000SX Helical
8	08h	4000SX Micro Square
9	09h	4000SL Micro Round
10	0Ah	4000SE Attachable
11	0Bh	4000SSE Kinematic L1 L2
12	0Ch	Compact L1 L2 with Groundplane
13	0Dh	Compact L1 L2
14	0Eh	Compact Dome with Init
15	0Fh	L1 L2 Kinematic with Init
16	10h	Compact L1 L2 with Init
17	11h	Compact L1 with Init
18	12h	Compact L1 with Groundplane
19	13h	Compact L1
20	14h	Permanent L1 L2
21	15h	4600LS Internal
22	16h	4000SLD L1 L2 Round
23	17h	Dorne Margolin Model T
24	18h	Ashtech L1 L2 Geodetic L
25	19h	Ashtech Dorne Margolin
26	1Ah	Leica SR299 External
27	1Bh	Trimble Choke Ring
28	1Ch	Dorne Margolin Model R
29	1Dh	Ashtech Geodetic L1 L2 P
30	1Eh	Integrated GPS Beacon
31	1Fh	Mobile GPS Antenna
32	20h	GeoExplorer Internal
33	21h	Topcon Turbo SII
34	22h	Compact L1 L2 with Groundplane with Dome
35	23h	Permanent L1 L2 with Dome
36	24h	Leica SR299/SR399 External Antenna
37	25h	Dorne Margolin Model B

Table 7.28ANTENNA TYPE byte values (continued)

Byte value		Meaning
Dec	Hex	
38	26h	4800 Internal
39	27h	Micro Centered
40	28h	Micro Centered with Groundplane
47	29h	Rugged Micro Centered with 13-inch Groundplane
85	55	Zephyr (KZ)
86	56	Zephyr Geodetic™ (GZ)

Table 7.29DEVICE TYPE byte values

Byte value		Meaning
Dec	Hex	
0	00h	Reserved
1	01h	Reserved
2	02h	1 PPS (Pulse per second) output
3	03h	Reserved
4	04h	Reserved
5	05h	Reserved
6	06h	Reserved
7	07h	Reserved

Table 7.301 PPS CONTROL byte values

Byte value		Meaning
Dec	Hex	
0	00h	1 PPS output is off
1	01h	1 PPS output is on

Table 7.31STATIC/KINEMATIC MODE byte values

Byte value		Meaning
Dec	Hex	
0	00h	Kinematic
1	01h	Static
2–255	02h–FFh	Reserved

Table 7.32Output message record type

Record Number	Description
1	POSITION TIME
2	LAT, LONG, HEIGHT
3	ECEF POSITION
4	LOCAL DATUM POSITION
5	LOCAL ZONE POSITION
6	ECEF DELTA
7	TANGENT PLANE DELTA
8	VELOCITY DATA
9	PDOP INFO
10	CLOCK INFO
11	POSITION VCV INFO
12	POSITION SIGMA INFO
13	SV BRIEF INFO
14	SV DETAILED INFO
15	RECEIVER SERIAL NUMBER
16	CURRENT TIME
26	POSITION TIME UTC
27	ATTITUDE INFO*+
41	BASE POSITION AND QUALITY INDICATOR
33	ALL SV BRIEF INFO
34	ALL SV DETAILED INFO
35	RECEIVED BASE INFO

65h, GETAPPFILE (Application file request)

A specific application file can be downloaded from the receiver by sending the Command Packet 65h. If the request is valid, a copy of the application file is downloaded to the remote device in Report Packet 64h.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 65h
Report Packet 64h or NAK	→	

The receiver can store multiple application files (including a default application file, containing the factory default parameter settings) in the Application File directory. Each application file is assigned a number to give the file a unique identity within the directory. The application file containing the factory default values is assigned a System File Index code of zero (0).

Table 7.33 shows the packet structure. For more information, see 64h, APPFILE (Application file record report), page 123.

Table 7.33Command Packet 65h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status indicator
2	PACKET TYPE	CHAR	65h	Command Packet 65h
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count
4–5	SYSTEM FILE INDEX	SHORT	0–*n*	Unique number (ID code) assigned to each of the application files stored in the Application File directory
6	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value
7	ETX	CHAR	03h	End transmission

66h, GETAFDIR (Application file directory listing request)

Command Packet 66h is used to request a directory listing of the application files stored in receiver memory. The receiver responds by sending the directory listing in Report Packet 67h.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 66h
Report Packet 67h	→	

Table 7.34 describes the packet structure. For more information, see 67h, RETAFDIR (Directory listing report), page 123.

Table 7.34Command Packet 66h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code
2	PACKET TYPE	CHAR	66h	Command Packet 66h
3	LENGTH	CHAR	0h	Data byte count
4	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value
5	ETX	CHAR	03h	End transmission

68h, DELAPPFILE (Delete application file data command)

Command Packet 68h deletes the data for a specified application file. The application file is selected by specifying the System File Index assigned to the file.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 68h
ACK or NAK	→	

Table 7.35Command Packet 68h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status indicator.
2	PACKET TYPE	CHAR	68h	Command Packet 68h.
3	LENGTH	CHAR	01h	Data byte count.
4–5	SYSTEM FILE INDEX	SHORT	0–*n*	Unique number assigned to each of the application files stored in the Application File directory.
6	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum.
7	ETX	CHAR	03h	End transmission.

6Dh, ACTAPPFILE (Activate application file)

Command Packet 6Dh is used to activate one of the application files stored in the Application File directory. The application file with the specified System File Index is activated.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 6Dh
ACK or NAK	→	

Each application file is assigned a System File Index. The application file containing the factory default values is assigned a System File Index of zero (0), allowing this command to be used to reset the receiver to the factory default conditions. Table 7.36 describes the packet structure.

Table 7.36Command Packet 6dh structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status indicator
2	PACKET TYPE	CHAR	6Dh	Command Packet 6Dh
3	LENGTH	CHAR	01h	Data byte count

Table 7.36Command Packet 6dh structure (continued)

Byte #	Item	Type	Value	Meaning
4–5	SYSTEM FILE INDEX	SHORT	0–*n*	Unique number assigned to each of the application files stored in the Application File directory
6	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum
7	ETX	CHAR	03h	End transmission

81h, KEYSIM (Key simulator)

Command Packet 81h simulates any front panel key press.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 81h
ACK	→	

Table 7.37Command Packet 81h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code
2	PACKET TYPE	CHAR	81h	Command Packet 81h
3	LENGTH	CHAR	01h	Data byte count
4	KEY ID	CHAR	See Table 7.38, page 76	Key scan code ID
5	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum values
6	ETX	CHAR	03h	End transmission

Table 7.38Key ID codes

Scan Code	Receiver Key	ASCII Character
7Fh	CLEAR	Del <del>
0Dh	ENTER	Enter <carriage return>
41h	Softkey Choice 1	<A>
42h	Softkey Choice 2	<B>
43h	Softkey Choice 3	<C>
44h	Softkey Choice 4	<D>
1Dh	<	—
1Ch	>	—
30h	0	<0>
31h	1	<1>
32h	2	<2>
33h	3	<3>
34h	4	<4>
35h	5	<5>

Table 7.38Key ID codes (continued)

Scan Code	Receiver Key	ASCII Character
36h	6	<6>
37h	7	<7>
38h	8	<8>
39h	9	<9>
4Ch	STATUS	<L>
4Ah	SESSION	<J>
4Bh	SAT INFO	<K>
4Fh	LOG DATA	<O>
4Dh	CONTROL	<M>
50h	ALPHA	<P>
4Eh	MODIFY	<N>
1Bh	POWER	—

82h, SCRDUMP (Screen dump request)

Command Packet 82h has two forms—a command packet and report packet. Both packets are assigned the same hexadecimal code (82h).

Packet Flow		
Receiver		**Remote**
	←	Command Packet 82h
Report Packet 82h	→	

Command Packet 82h requests an ASCII representation of a BD960 simulated display screen. In response, Report Packet 82h sends the data used that is used to display the screen to the remote device in ASCII format.

Table 7.39 shows the command packet structure. For more information, see 82h, SCRDUMP (Screen dump), page 128.

Table 7.39Command packet 82h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code
2	PACKET TYPE	CHAR	82h	Command Packet 82h
3	LENGTH	CHAR	0h	Data bytes count
4	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value
5	ETX	CHAR	03h	End transmission

Data Collector Format Report Packets

Data Collector Format report packets are usually sent in response to a command packet. The prime exception is Report Packet 40h (GSOF) which streams a selection of data reports to the remote device at intervals defined in the current application file.

Report packets are generated immediately after the request is received. The receiver always responds to requests for reports, even in cases where a report cannot be transmitted for some reason or the transmission of a report is not necessary. In these cases, the receiver sends an ACK or NAK to acknowledge the request.

Report Packet summary

The following sections provide details for each command and report packet. Table 7.40 lists a summary of the report packets.

Table 7.40Report Packet summary

ID (Hex)	Name	Function	Page
07h	07h, RSERIAL (Receiver and antenna information report)	07h, RSERIAL (Receiver and antenna information report)	78
40h	40h, GENOUT (General output record reports)	40h, GENOUT (General output record reports)	79
55h	55h, RETSVDATA (Satellite information reports)	55h, RETSVDATA (Satellite information reports)	108
57h	57h, RAWDATA (Position or real-time survey data report)	57h, RAWDATA (Position or real-time survey data report)	114
64h	64h, APPFILE (Application file record report)	64h, APPFILE (Application file record command)	123
67h	67h, RETAFDIR (Directory listing report)	67h, RETAFDIR (Directory listing report)	123
6Eh	6Eh, BREAKRET (Break sequence return)	6Eh, BREAKRET (Break sequence return)	125
82h	82h, SCRDUMP (Screen dump)	82h, SCRDUMP (Screen dump request)	128

07h, RSERIAL (Receiver and antenna information report)

Report Packet 07h is sent in response to the Command Packet 06h. The report returns the receiver and antenna serial number, antenna type, software processor versions, and the number of receiver channels.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 06h
Report Packet 07h	→	

Table 7.41 describes the packet structure. For more information, see 06h, GETSERIAL (Receiver and antenna information request), page 57.

Table 7.41Report Packet 07h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code.
2	PACKET TYPE	CHAR	??h	Report Packet 07h.
3	LENGTH	CHAR	2Dh	Data byte count.
4–11	RECEIVER SERIAL #	CHAR	ASCII text	Receiver serial number.
12–19	RECEIVER TYPE	CHARs	"BD960"	Receiver model designation (padded with three spaces).
20–24	NAV PROCESS VERSION	CHARs	ASCII text	Version number of NAV Processor software.
25–29	SIG PROCESS VERSION	CHARs	ASCII text (00000)	Not applicable.
30–34	BOOT ROM VERSION	CHARs	ASCII text (00000)	Not applicable.
35–42	ANTENNA SERIAL #	CHARs	ASCII text (8 spaces)	Not used.
43–44	ANTENNA TYPE	CHAR	ASCII text (2 spaces)	Not used.
45–46	# CHANNELS	CHAR	12h	There are 18 receiver channels.
47–48	# CHANNELS L1	CHAR	09h	Nine (9) L1 receiver channels.
49 - 58	LONG SERIAL NUMBER	CHARValue	ASCII text (10 spaces)	This is the serial number that should be used for newer receivers like the BD960.
59 - 89	LOCAL LONG ANT SERIAL	CHAR	ASCII text (31 spaces)	Not Applicable
90 - 120	BASE LONG ANT SERIAL	CHAR	ASCII text (31 spaces)	Not Applicable
121 - 151	BASE NGS ANT DESCRIPTOR	CHAR	ASCII text (31 spaces)	Not Applicable
152-153	# USABLE CHANNELS	CHAR		Maximum usable channels with the current option set.
154-155	# PHYSICAL CHANNELS	CHAR		Number of hardware channels.
156	# SIMULTANEOUS CHANNELS	CHAR		How many satellites can be tracked at once.
157-161	Reserved	N/A	N/A	N/A
162	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
163	ETX	CHAR	03h	End transmission.

40h, GENOUT (General output record reports)

When scheduled, Report Packet 40h is continuously output at the FREQUENCY specified by the current application file. The GENOUT report contains multiple sub-records as scheduled by the application file (subtype = 10, GSOF).

For information about controlling the record types included in Report Packet 40h, see command packet 64h Appfile.

Packet Flow		
Receiver		**Connected computer**
(02h) STX	→	
(??h) STATUS	→	
(40h) TYPE	→	
(??h) LENGTH	→	
1 (byte) TRANSMISSION NUMBER	→	
1 (byte) PAGE INDEX	→	
1 (byte) MAX PAGE INDEX	→	
Various record types		
1 (byte) OUTPUT RECORD TYPE	→	
1 (byte) RECORD LENGTH	→	
Various fields dependant on RECORD TYPE.	→	
There can be multiple records in one GENOUT packet. There could be multiple GENOUT packets per epoch. Records may be split over two consecutive packets.		
(??h) CHECKSUM	→	
(03h) ETX	→	

Where:

- TRANSMISSION NUMBER is a unique number assigned to a chapter of pages indicating that the pages are from the same group.
- PAGE INDEX is the page number of this page in a sequence (chapter) of pages and is zero based.
- MAX PAGE INDEX is the index of the last page in the chapter.
- RECORD LENGTH is the length of data in the record (excluding type and size).

Page Numbering *– The Page Index and Max Page Index fields are 0-based, so for example the first transmission of a 2-page set will be 0/1 (PAGE/MAX PAGE) and the 2nd (last) page will be 1/1. The total number of pages is MAX PAGE INDEX + 1.*

GSOF record types

Table 7.42 GSOF record types

Record number	Description	Page
1	POSITION TIME	82
2	LAT, LONG, HEIGHT	84

Table 7.42 GSOF record types

Record number	Description	Page
3	ECEF POSITION	85
4	LOCAL DATUM POSITION	86
5	LOCAL ZONE POSITION	87
6	ECEF DELTA	88
7	TANGENT PLANE DELTA	89
8	VELOCITY DATA	90
9	PDOP INFO	91
10	CLOCK INFO	92
11	POSITION VCV INFO	93
12	POSITION SIGMA INFO	94
13	SV BRIEF INFO	95
14	SV DETAILED INFO	96
15	RECEIVER SERIAL NUMBER	98
16	CURRENT TIME	99
26	POSITION TIME UTC	100
27	ATTITUDE INFO*+	102
33	ALL SV BRIEF INFO	104
34	ALL SV DETAILED INFO	105
35	RECEIVED BASE INFO	107
41	BASE POSITION AND QUALITY INDICATOR	108

GSOF 1: GSOF 1 (01h) POSITION TIME

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 1	→	
1 (byte) RECORD LENGTH	→	
4 (long) GPS TIME (ms)	→	
2 (int) GPS WEEK NUMBER	→	
1 (byte) NUMBER OF SVS USED	→	
1 (byte) POSITION FLAGS 1	→	
1 (byte) POSITION FLAGS 2	→	
1 (byte) INITIALIZATION NUMBER	→	

Where:

- OUTPUT RECORD TYPE = 1.
- RECORD LENGTH is the length of this sub-record.
- GPS TIME is in milliseconds of the GPS week.
- GPS WEEK NUMBER is the week count since January 1980.
- NUMBER OF SVS USED is the number of satellites used to determine the position.
- POSITION FLAGS 1 reports position attributes and is defined as follows:
  - bit 0 SET: New Position
  - bit 1 SET: Clock fix calculated this position
  - bit 2 SET: Horizontal coordinates calculated this position
  - bit 3 SET: Height calculated this position
  - bit 4 reserved: Always SET (was "Weighted position")
  - bit 5 SET: Least squares position
  - bit 6 reserved: Always CLEAR (was "Iono-free position")
  - bit 7 SET: Position uses Filtered L1 pseudoranges
- POSITION FLAGS 2 reports position attributes and is defined as follows:
  - bit 0 SET: Position is a differential solution. RESET: Position is autonomous or WAAS solution.
  - bit 1 SET: Differential position is phase including RTK (float, fixed or location), HP or XP Omnistar (VBS is not derived from phase). RESET: Differential position is code.

  - bit 2 SET: Differential position is fixed integer phase position (RTK-fixed). Uncorrected position is WAAS (if bit 0 is 0). RESET: Differential position is RTK-float, RTK-location or code phase (DGPS), Uncorrected position is Autonomous (if bit 0 is 0).
  - bit 3 SET: OmniSTAR differential solution (including HP, XP, and VBS.) RESET: Not OmniSTAR solution.
  - bit 4 SET: Position determined with STATIC as a constraint.
  - bit 5 SET: Position is Network RTK solution.
  - bit 6 SET: RTK-Location.
  - bit 7 SET: Beacon DGPS.
- INITIALIZATION NUMBER is a rollover counter to indicate when re-initializations have taken place.

GSOF 2: GSOF 2 (02h) LAT, LONG, HEIGHT

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 2	→	
1 (byte) RECORD LENGTH	→	
8 (double) LATITUDE	→	
8 (double) LONGITUDE	→	
8 (double) HEIGHT	→	

Where:

- OUTPUT RECORD TYPE = 2.
- RECORD LENGTH is the length of this sub-record.
- LATITUDE is the WGS-84 latitude in radians.
- LONGITUDE is the WGS-84 longitude in radians.
- HEIGHT is the WGS-84 height in meters.

GSOF 3: GSOF 3 (03h) ECEF POSITION

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 3	→	
1 (byte) RECORD LENGTH	→	
8 (double) X	→	
8 (double) Y	→	
8 (double) Z	→	

Where:

- OUTPUT RECORD TYPE = 3.
- RECORD LENGTH is the length of this sub-record.
- X is the earth-centered earth-fixed X axis WGS-84 coordinate of the position in meters.
- Y is the earth-centered earth-fixed Y axis WGS-84 coordinate of the position in meters.
- Z is the earth-centered earth-fixed Z axis WGS-84 coordinate of the position in meters.

GSOF 4: GSOF 4 (04h) LOCAL DATUM POSITION.

Back to: 40h GENOUT

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 4	→	
1 (byte) RECORD LENGTH	→	
8 (char) LOCAL DATUM ID	→	
8 (double) LOCAL DATUM ECEF LATITUDE	→	
8 (double) LOCAL DATUM LONGITUDE	→	
8 (double) LOCAL DATUM HEIGHT	→	
1 (byte) OUTPUT RECORD TYPE = 4	→	

Where:

- OUTPUT RECORD TYPE = 4.
- RECORD LENGTH is the length of this sub-record.
- LOCAL DATUM IDENTIFIER is an ASCII string that identifies the coordinate datum.
- LOCAL DATUM LATITUDE is the latitude in the local datum (radians).
- LOCAL DATUM LONGITUDE is the longitude in the local datum (radians).
- LOCAL DATUM HEIGHT is the height in the local datum (meters).

GSOF 5: GSOF 5 (05h) LOCAL ZONE POSITION

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 5	→	
1 (byte) RECORD LENGTH	→	
8 (char) LOCAL DATUM ID	→	
8 (char) LOCAL ZONE ID	→	
8 (double) LOCAL ZONE NORTH	→	
8 (double) LOCAL ZONE EAST	→	
8 (double) LOCAL DATUM HEIGHT	→	

Where:

- OUTPUT RECORD TYPE = 5.
- RECORD LENGTH is the length of this sub-record.
- LOCAL DATUM IDENTIFIER is an ASCII string that identifies the coordinate datum.
- LOCAL ZONE IDENTIFIER is an ASCII string that identifies the coordinate zone.
- LOCAL ZONE NORTH is the local zone north coordinate (meters).
- LOCAL ZONE EAST is the local zone east coordinate (meters).
- LOCAL DATUM HEIGHT is the height in the local datum (meters).

GSOF 6: GSOF 6 (06h) ECEF DELTA

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 6	→	
1 (byte) RECORD LENGTH	→	
8 (double) DELTA X	→	
8 (double) DELTA Y	→	
8 (double) DELTA Z	→	

Where:

- OUTPUT RECORD TYPE = 6.
- RECORD LENGTH is the length of this sub-record.
- DELTA X is the ECEF X axis delta between the rover and base positions (rover - base) in meters.
- DELTA Y is the ECEF Y axis delta between the rover and base positions (rover - base) in meters.
- DELTA Z is the ECEF Z axis delta between the rover and base positions (rover - base) in meters.

GSOF 7: GSOF 7 (07h) TANGENT PLANE DELTA

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 7	→	
1 (byte) RECORD LENGTH	→	
8 (double) DELTA EAST	→	
8 (double) DELTA NORTH	→	
8 (double) DELTA UP	→	

Where:

- OUTPUT RECORD TYPE = 7.
- RECORD LENGTH is the length of this sub-record.
- DELTA EAST is the east component of a vector from the base to the rover projected onto a plane tangent to the WGS-84 ellipsoid at the base. Units: meters.
- DELTA NORTH is the north component of the tangent plane vector.
- DELTA UP is the difference between the ellipsoidal height of the tangent plane at the base and a plane parallel to this passing through the rover point.

GSOF 8: GSOF 8 (08h) VELOCITY DATA

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 8	→	
1 (byte) RECORD LENGTH	→	
1 (byte) VELOCITY FLAGS	→	
4 (float) VELOCITY	→	
4 (float) HEADING	→	
4 (float) VERTICAL VELOCITY	→	

Where:

- OUTPUT RECORD TYPE = 8.
- RECORD LENGTH is the length of this sub-record.
- VELOCITY FLAGS indicate attributes of the velocity information. Defined values are:
  - bit 0 SET: Velocity data valid. RESET: Velocity data not valid
  - bit 1 SET: Velocity computed from consecutive measurements. RESET: Velocity computed from Doppler
  - bits 2-7: RESERVED
- VELOCITY is the horizontal velocity in meters per second.
- HEADING is the WGS-84 referenced true north heading in radians.
- VERTICAL VELOCITY is the velocity in the vertical direction in meters per second.

GSOF 9: GSOF 9 (09h) PDOP INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 9	→	
1 (byte) RECORD LENGTH	→	
4 (float) PDOP	→	
4 (float) HDOP	→	
4 (float) VDOP	→	
4 (float) TDOP	→	

Where:

- OUTPUT RECORD TYPE = 9.
- RECORD LENGTH is the length of this sub-record.
- PDOP is the positional dilution of precision.
- HDOP is the horizontal dilution of precision.
- VDOP is the vertical dilution of precision.
- TDOP is the time dilution of precision.

Note – *When an RTK system is placed in the Static (measuring) mode, these values become Relative DOP values, and as such tend to diminish with elapsed time spend static.*

GSOF 10: GSOF 10 (0Ah) CLOCK INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 10	→	
1 (byte) RECORD LENGTH	→	
1 (byte) CLOCK FLAGS	→	
8 (double) CLOCK OFFSET	→	
8 (double) FREQUENCY OFFSET	→	

Where:

- OUTPUT RECORD TYPE = 10.
- RECORD LENGTH is the length of this sub-record.
- CLOCK FLAGS indicates information relation of the clock fix process. Defined values are:
  - bit 0 SET: Clock offset is valid
  - bit 1 SET: Frequency offset is valid
  - bit 2 SET: Receiver is in anywhere fix mode
  - bit 3-7: RESERVED
- CLOCK OFFSET is the current clock offset in milliseconds.
- FREQUENCY OFFSET is the offset of the local oscillator from the nominal GPS L1 frequency in parts per million.

GSOF 11: GSOF 11 (0Bh) POSITION VCV INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 11	→	
1 (byte) RECORD LENGTH	→	
4 (float) POSITION RMS	→	
4 (float) VCV xx	→	
4 (float) VCV xy	→	
4 (float) VCV xz	→	
4 (float) VCV yy	→	
4 (float) VCV yz	→	
4 (float) VCV zz	→	
4 (float) UNIT VARIANCE	→	
2 (short) NUMBER OF EPOCHS	→	

Where:

- OUTPUT RECORD TYPE = 11.
- RECORD LENGTH is the length of this sub-record.
- RANGE RESIDUAL RMS is the square root of (the sum of the squares of the range residuals divided by the number of degrees of freedom in the solution).
- VCVxx .. VCVzz is the variance-covariance matrix. This contains the positional components of the inverted normal matrix of the position solution in a ECEF WGS-84 reference.
- UNIT VARIANCE is the unit variance of the position solution.
- NUMBER OF EPOCHS indicates the number of measurements used to compute the position. It may be greater than 1 for positions subjected to a STATIC constraint.

GSOF 12: GSOF 12 (0Ch) POSITION SIGMA INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 12	→	
1 (byte) RECORD LENGTH	→	
4 (float) POSITION RMS	→	
4 (float) SIGMA EAST	→	
4 (float) SIGMA NORTH	→	
4 (float) COVAR. EAST-NORTH	→	
4 (float) SIGMA UP	→	
4 (float) SEMI MAJOR AXIS	→	
4 (float) SEMI-MINOR AXIS	→	
4 (float) ORIENTATION	→	
4 (float) UNIT VARIANCE	→	
2 (short) NUMBER EPOCHS	→	

Where:

- OUTPUT RECORD TYPE = 12.
- RECORD LENGTH is the length of this sub-record.
- RANGE RESIDUAL RMS is the square root of (the sum of the squares of the range residuals divided by the number of degrees of freedom in the solution).
- SIGMA EAST, NORTH, UP are in meters.
- COVARIANCE EAST-NORTH is dimensionless.
- SEMI-MAJOR/MINOR AXES of the error ellipse is in meters.
- ORIENTATION of the semi-major axis is in degrees from clockwise from True North.
- UNIT VARIANCE is valid only for over determined solutions. It should tend towards 1.0. A value less than 1.0 indicates that the apriori variances were too pessimistic.
- NUMBER OF EPOCHS indicates the number of measurements used to compute the position. It may be greater than 1 for positions subjected to a STATIC constraint.

GSOF 13: GSOF 13 (0Dh) SV BRIEF INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 13	→	
1 (byte) RECORD LENGTH	→	
1 (byte) NUMBER OF SVS	→	
repeated for number of svs		
1 (byte) PRN	→	
1 (byte) SV FLAGS1	→	
1 (byte) SV FLAGS2	→	

Where:

- OUTPUT RECORD TYPE = 13.
- RECORD LENGTH is the length of this sub-record.
- NUMBER OF SVS is the number of tracked satellites reported in this record.
- PRN is the PRN number of the satellite which the following flags refer to.
- SV FLAGS1 indicate conditions relating to satellites. Defined values are:
  - bit 0 SET: Above horizon
  - bit 1 SET: Currently assigned to a channel (trying to track)
  - bit 2 SET: Currently tracked on L1 frequency
  - bit 3 SET: Currently tracked on L2 frequency
  - bit 4 SET: Reported at Base on L1 frequency
  - bit 5 SET: Reported at Base on L2 frequency
  - bit 6 SET: Used in Position
  - bit 7 SET: Used in current RTK process (search, propagate, fix solution)
- SV FLAGS2 indicate conditions relating to satellites. Defined values are:
  - bit 0 SET: Tracking P Code on L1
  - bit 1 SET: Tracking P Code on L2
  - bit 2 SET: Tracking CS on L2
  - bits 3-7: RESERVED

GSOF 14: GSOF 14 (0Eh) SV DETAILED INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 14	→	
1 (byte) RECORD LENGTH	→	
1 (byte) NUMBER OF SVS	→	
repeated for number of svs		
1 (byte) PRN	→	
1 (byte) SV FLAGS1	→	
1 (byte) SV FLAGS2	→	
1 (signed byte) ELEVATION	→	
2 (short) AZIMUTH	→	
1 (byte) SNR L1*4	→	
1 (byte) SNR L2*4	→	

Where:

- OUTPUT RECORD TYPE = 14.
- RECORD LENGTH is the length of this sub-record.
- NUMBER OF SVS is the number of tracked satellites reported in this record.
- PRN is the PRN number of the satellite which the following information refers to.
- SV FLAGS1 indicate conditions relating to satellites. Defined values are:
  - bit 0 SET: Above horizon
  - bit 1 SET: Currently assigned to a channel (trying to track)
  - bit 2 SET: Currently tracked on L1 frequency
  - bit 3 SET: Currently tracked on L2 frequency
  - bit 4 SET: Reported at Base on L1 frequency
  - bit 5 SET: Reported at Base on L2 frequency
  - bit 6 SET: Used in Position
  - bit 7 SET: Used in current RTK process (search, propagate, fix solution)
- SV FLAGS2 indicate conditions relating to satellites. Defined values are:
  - bit 0 SET: Tracking P Code on L1
  - bit 1 SET: Tracking P Code on L2
  - bit 2 SET: Tracking CS on L2
  - bits 3-7: RESERVED
- ELEVATION is the angle of the satellite above the horizon in degrees.

- AZIMUTH is the azimuth of the satellite form true north in degrees.
- SNR L1 is the signal-to-noise ratio of the L1 signal (multiplied by 4). 0 for SVs not tracked on this frequency.
- SNR L2 is the signal-to-noise ratio of the L2 signal (multiplied by 4). 0 for SVs not tracked on this frequency.

GSOF 15: GSOF 15 (0Fh) RECEIVER SERIAL NUMBER

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 15	→	
1 (byte) RECORD LENGTH	→	
4 (long) SERIAL NUMBER	→	

Where:

- OUTPUT RECORD TYPE = 15.
- RECORD LENGTH is the length of this sub-record.
- RECEIVER SERIAL NUMBER is the full serial number of the receiver.

GSOF 16: GSOF 16 (10h) CURRENT TIME

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 16	→	
1 (byte) RECORD LENGTH	→	
4 (long) GPS MILLISEC OF WEEK	→	
2 (short) GPS WEEK NUMBER		
2 (short) UTC OFFSET		
1 (byte) FLAGS		

Where:

- OUTPUT RECORD TYPE = 16.
- RECORD LENGTH is the length of this sub-record.
- GPS MILLISECONDS OF WEEK is the time that the message was sent from the receiver.
- GPS WEEK NUMBER is the full week number since start of GPS time.
- UTC OFFSET is the current GPS to UTC time offset in integer seconds.
- FLAGS indicate the validity of the time and UTC offset parameters. Defined values are:
  - bit 0 SET: Time information (week and milliseconds of week) valid
  - bit 1 SET: UTC Offset is valid

GSOF 26: GSOF 26 (1Ah) POSITION TIME UTC

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 26	→	
1 (byte) RECORD LENGTH	→	
4 (long) MILLISECONDS OF WEEK	→	
2 (short) GPS WEEK NUMBER	→	
1 (byte) NUMBER OF SVS USED	→	
1 (byte) POSITION FLAGS 1	→	
1 (byte) POSITION FLAGS 2	→	
1 (byte) INITIALIZATION NUMBER	→	

Where:

- OUTPUT RECORD TYPE = 26.
- RECORD LENGTH is the length of this sub-record.
- MILLISECONDS OF WEEK is the GPS time since the start of the GPS week.
- GPS WEEK NUMBER is the week count since January 1980.
- NUMBER OF SVS USED is the number of satellites used to determine the position.
- POSITION FLAGS 1 reports position attributes and is defined as follows:
  - bit 0 SET: New Position
  - bit 1 SET: Clock fix calculated this position
  - bit 2 SET: Horizontal coordinates calculated this position
  - bit 3 SET: Height calculated this position
  - bit 4 reserved: Always SET (was "Weighted position")
  - bit 5 SET: Least squares position
  - bit 6 reserved: Always CLEAR (was "Iono-free position")
  - bit 7 SET: Position uses Filtered L1 pseudoranges
- POSITION FLAGS 2 reports position attributes and is defined as follows:
  - bit 0 SET: Position is a differential solution. RESET: Position is autonomous or WAAS solution.
  - bit 1 SET: Differential position is phase (RTK, or HP Omnistar). RESET: Differential position is code.
  - bit 2 SET: Differential position is fixed integer phase position (RTK). Uncorrected position is WAAS (if bit 0 is 0). RESET: Differential position is RTK-float or code phase (DGPS). Uncorrected position is Autonomous (if bit 0 is 0).

  - bit 3 SET: HP / Omnistar differential solution. RESET: HP / Omnistar not active.
  - bit 4 SET: Position determined with STATIC as a constraint
  - bit 5 SET: Position is Network RTK solution
  - bits 6-7: RESERVED
- INITIALIZATION NUMBER is a rollover counter to indicate when re-initializations have taken place.

GSOF 27: GSOF 27 (1Bh) ATTITUDE INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 27	→	
1 (byte) RECORD LENGTH	→	
4 (unsigned long) GPS TIME	→	
1 (byte) FLAGS	→	
1 (byte) NUMBER OF SVS	→	
1 (byte) CALCULATION MODE	→	
1 (byte) RESERVED	→	
8 (double) PITCH	→	
8 (double) YAW	→	
8 (double) ROLL	→	
8 (double) MASTER-SLAVE RANGE	→	
2 (word) PDOP	→	
Record length = 42, up to and including PDOP (does not include type and length bytes)		
4 (float) PITCH VARIANCE	→	
4 (float) YAW VARIANCE	→	
4 (float) ROLL VARIANCE	→	
4 (float) MASTER-SLAVE RANGE VARIANCE	→	
Record length = 70 up to and including Master Slave Range Variance		

Where:

- OUTPUT RECORD TYPE = 27.
- RECORD LENGTH is the length of this sub-record.
- GPS TIME is time of position in milliseconds of GPS week.
- FLAGS indicate the following:
  - bit 0: Calibrated
  - bit 1: Pitch Valid
  - bit 2: Yaw Valid
  - bit 3: Roll Valid
  - bit 4: Scalar Valid
  - bit 5 - Bit 7: Reserved
  - bit 5: Diagnostic Valid

- bit 6: Slave Static
- bit 7: Error Stats valid

- NUMBER OF SVS.
- CALCULATION MODE is one of the following values:
  - 0: None
  - 1: Autonomous
  - 2: RTK/Float
  - 3: RTK/Fix
  - 4: DGPS
- RESERVED is currently unused.
- PITCH is the forward dive/climb angle (radians).
- YAW is the horizontal turn (left or right) (radians).
- ROLL is the side-to-side roll angle (radians).
- MASTER-SLAVE RANGE is the distance between master and slave antennas, in meters.
- PDOP is the current position PDOP in tenths.

  Subsequent elements are not implemented in firmware versions prior to GNSS version 4.20. The error stats valid flag is also set when these elements are implemented.
- PITCH VARIANCE is the expected variance of error of the pitch estimate (radians^2).
- YAW VARIANCE is the expected variance of error of the yaw estimate (radians^2).
- ROLL VARIANCE is the expected variance of error of the roll estimate (radians^2).
- PITCH-YAW COVARIANCE is the expected covariance of errors of the pitch and yaw estimates (radians^2).
- PITCH-ROLL COVARIANCE is the expected covariance of errors of the pitch and roll estimates (radians^2).
- YAW-ROLL COVARIANCE is the expected covariance of errors of the yaw and roll estimates (radians^2).
- MASTER-SLAVE RANGE VARIANCE is the expected variance of error of the master-slave range estimate, in meters^2.

GSOF 33: GSOF 33 (21h) ALL SV BRIEF INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 33	→	
1 (byte) RECORD LENGTH	→	
1 (byte) NUMBER OF SVs	→	
Repeated for number of SVs		
1 (byte) PRN	→	
1 (byte) SV System	→	
1 (byte) SV FLAGS1	→	
1 (byte) SV FLAGS2	→	

Where:

- OUTPUT RECORD TYPE = 33.
- RECORD LENGTH is the length of this sub-record.
- NUMBER OF SVS is the number of tracked satellites reported in this record.
- PRN is the PRN number of the satellite which the following flags refer to. This will be the ACTUAL PRN number given by the SV (not ranged due to SV system) due to the next field:
- SV System is the system that the SV belongs to.
  - 0 = GPS
  - 1 = SBAS
  - 2 = GLONASS
  - 3 = GALILEO
  - 4 - 255: RESERVED
- SV FLAGS1 indicate conditions relating to satellites.
  - bit 0 set: Above horizon
  - bit 1 set: Currently assigned to a channel (trying to track)
  - bit 2 set: Currently tracked on L1/G1 frequency
  - bit 3-7: RESERVED
- SV FLAGS2 indicate conditions relating to satellites.
  - bits 0-7: RESERVED

GSOF 34: GSOF 34 (22h) ALL SV DETAILED INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 34	→	
1 (byte) RECORD LENGTH	→	
1 (byte) NUMBER OF SVS	→	
Repeated for number of SVs		
1 (byte) PRN	→	
1 (byte) SV SYSTEM	→	
1 (byte) SV FLAGS1	→	
1 (byte) SV FLAGS2	→	
1 (signed byte) ELEVATION	→	
2 (short) AZIMUTH	→	
1 (byte) SNR L1*4	→	
1 (byte) SNR L2*4	→	
1 (byte) SNR L5*4 OR G1P SNR OR Galileo SNR	→	

Where:

- OUTPUT RECORD TYPE = 34.
- RECORD LENGTH is the length of this sub-record.
- NUMBER OF SVS is the number of tracked satellites reported in this record.
- PRN is the PRN number of the satellite which the following flags refer to. This will be the ACTUAL PRN number given by the SV (not ranged due to SV system) due to the next field.
- SV SYSTEM is the system that the SV belongs to.
  - 0: GPS
  - 1: SBAS
  - 2: GLONASS
  - 3 - 9: RESERVED
  - 10: OMNISTAR
  - 11 - 255: RESERVED
- SV FLAGS1 is a bitmap field having the following values:
  - bit 0 Set: Above horizon
  - bit 1 Set: Currently assigned to a channel (trying to track)
  - bit 2 Set: Currently tracked on L1/G1 frequency
  - bit 3 Set: Currently tracked on L2/G2 frequency

  - bit 4 Set: Reported at base on L1/G1 frequency
  - bit 5 Set: Reported at base on L2/G2 frequency
  - bit 6 Set: Used in current position
  - bit 7 Set: Used in the current RTK solution.
- SV FLAGS2 is a bitmap variable having the following values:
  - bit 0 Set: Tracking P-Code on L1/G1
  - bit 1 Set: Tracking P-Code on L2
- IF GPS SV:
  - bit 2 Set: Tracking CS on L2
  - bit 3 Set: Tracking L5 Signal
  - Bits 4-7 are reserved
- If GLONASS SV:
  - bit 2 Set: Glonass SV is "M" SV
  - bit 3 Set: Glonass SV is "K" SV
  - Bits 4-7 are reserved
- ELSE
  - Bits 2-7 are reserved
- ELEVATION is the angle of the satellite above the horizon in degrees.
- AZIMUTH is the azimuth of the satellite form true north in degrees.
- SNR L1 is the signal-to-noise ratio of the L1 signal (multiplied by 4). 0 for SVs not tracked on this frequency.
- SNR L2 is the signal-to-noise ratio of the L2 signal (multiplied by 4). 0 for SVs not tracked on this frequency.
- IF GPS SNR L5 is the signal-to-noise ratio of the L5 signal (multiplied by 4). 0 for SVs not tracked on this frequency.
- IF GLONASS G1P SNR is the signal-to-noise ratio of the G1P signal (multiplied by 4). 0 for SVs not tracked on this frequency.
- IF Galileo, E1 SNR or E5A SNR or E5B SNR or E5AltBOC SNR
- ELSE This last byte is RESERVED.

GSOF 35: GSOF 35 (23h) RECEIVED BASE INFO

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 35	→	
1 (byte) RECORD LENGTH	→	
1 (Byte) FLAGS and VERSION OF MESSAGE	→	
8 (chars) BASE NAME	→	
2 (bytes) BASE ID	→	
8 (double) BASE LATITUDE	→	
8 (double) BASE LONGITUDE	→	
8 (double) BASE HEIGHT	→	

Where:

- OUTPUT RECORD TYPE = 35.
- RECORD LENGTH is the length of this sub-record.
- FLAGS specifies a few attributes about the BASE (and ONLY the base, since there are status flags about RTK in other messages). Defined values:
  - Bits 0 - 2 specify a “version number” for this message.
  - Bit 3 if SET specifies that the base info given is valid.
  - Bits 4 - 7 are currently RESERVED.
- BASE NAME is the short base name received from the base. In the case of the base being RTCM (with no base name), the field is set to all 0s.
- BASE ID is the ID# of the base being used. This field is big-endian, so the first byte will always be set to 0 if the base is a CMR base.
- BASE LATITUDE is the WGS-84 latitude of the base in radians.
- BASE LONGITUDE is the WGS-84 longitude of the base in radians.
- BASE HEIGHT is the WGS-84 height of the base in meters.

GSOF 41: GSOF 41 (29h) BASE POSITION AND QUALITY INDICATOR

Packet Flow		
Receiver		**Connected computer**
1 (byte) OUTPUT RECORD TYPE = 41	→	
1 (byte) RECORD LENGTH	→	
4 (long) GPS TIME (ms)	→	
2 (int) GPS WEEK NUMBER	→	
8 (double) LATITUDE	→	
8 (double) LONGITUDE	→	
8 (double) HEIGHT	→	
1 (byte) QUALITY INDICATOR	→	

Where:

- OUTPUT RECORD TYPE = 41.
- RECORD LENGTH is the length of this sub-record.
- GPS TIME is in milliseconds of the GPS week.
- GPS WEEK NUMBER is the week count since January 1980.
- LATITUDE is the base WGS-84 latitude in radians.
- LONGITUDE is the base WGS-84 longitude in radians.
- HEIGHT is the base WGS-84 height in meters.
- QUALITY INDICATOR shows the quality of the base position:
  - 0 - Fix not available or invalid
  - 1 - Autonomous
  - 2 - Differential, SBAS or OmniSTAR VBS
  - 4 - RTK Fixed
  - 5 - OmniSTAR XP, OmniSTAR HP, RTK Float, or RTK Location

55h, RETSVDATA (Satellite information reports)

Report Packet 55h is sent in response to Command Packet 54h. The report includes either the ephemeris or almanac information for a specific satellite, or ION/UTC data, the Enabled/Disabled state and Heed/Ignore Health state of all satellites, or the condition of satellite status flags for one satellite or all satellites.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 54h
Report Packet 55h	→	

Only the satellite information, requested by Command Packet 54h, is sent in the report packet. As a result, several forms of the Report Packet 55h can be requested.

Table 7.43 through Table 7.47 describe the structure of the report packets.

Returns a NAK if the GETSVDATA request meets one of the following criteria:

- SV PRN is out of range 1–32 (except for SV flags)
- Data Switch is out of range
- Data is not available for the requested SV

SV FLAGS report

The SV FLAGS report is sent when Command Packet 54h is used to request the status of the SV Flags for one satellite or all satellites. The Command Packet 54h DATA SWITCH byte (byte 4) is set to zero (0) when requesting the report. Table 7.43 describes the packet structure.

Table 7.43Report Packet 55h SV flags report structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status.
2	PACKET TYPE	CHAR	55h	Report Packet 55h.
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count.
4	DATA TYPE INDICATOR	CHAR	00h	SV FLAGS Report.
5	SV PRN #	CHAR	00h–20h	Pseudorandom number of satellite (1–32) or zero when requesting flag status of all satellites.
6–9	EPHEMERIS FLAGS	LONG	32 flag bits	For all 32 satellites, the flags show availability of Ephemeris data when set to one.[1]
10–13	ALMANAC FLAGS	LONG	32 flag bits	For all 32 satellites, the flags show availability of Almanac data when set to one.[1]
14–17	SVS DISABLED FLAGS	LONG	32 flag bits	Flags show Enabled or Disabled status of all satellites. When set to one, satellite is disabled.[1]
18–21	SVS UNHEALTHY FLAGS	LONG	32 flag bits	Flags show the health of satellites. When set to one, satellite is currently unhealthy.[1]
22–25	TRACKING L1 FLAGS	LONG	32 flag bits	Flags show satellites tracked on L1 when set to one.[1]
26–29	TRACKING L2 FLAGS	LONG	32 flag bits	Flags show satellites tracked on L2 when set to one.[1]
30–33	Y-CODE FLAGS	LONG	32 flag bits	Flags show satellites with Anti-Spoofing turned on when set to one.[1]

[1] Bit 0 = PRN 1

Table 7.43Report Packet 55h SV flags report structure (continued)

Byte #	Item	Type	Value	Meaning
34–37	P-CODE ON L1 FLAGS	LONG	32 flag bits	Flags show satellites which are tracking P-code on the L1. Flags are not set for satellites not tracked on L1.[1]
38–41	RESERVED	LONG	32 flag bits	Reserved (set to zero).
42–45	RESERVED	LONG	32 flag bits	Reserved (set to zero).
46–49	RESERVED	LONG	32 flag bits	Reserved (set to zero).
50–53	RESERVED	LONG	32 flag bits	Reserved (set to zero).
54	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
55	ETX	CHAR	03h	End transmission.

[1] Bit 0 = PRN 1

EPHEMERIS report

The EPHEMERIS report is sent when Command Packet 54h is used to request the Ephemeris for one satellite or all satellites. The GETSVDATA DATA SWITCH byte (byte 4) is set to one (1) to request the report. Table 7.44 describes the packet structure.

The Ephemeris data follows the standard defined by GPS ICD-200 except for CUC, CUS, CIS, and CIC. These values need to be multiplied by π to become the units specified in the GPS ICD-200 document. The Ephemeris Flags are described in Table 7.45.

Table 7.44Report Packet 55h ephemeris report structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status.
2	PACKET TYPE	CHAR	55h	Report Packet 55h.
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count.
4	DATA TYPE INDICATOR	CHAR	01h	Ephemeris report.
5	SV PRN #	CHAR	00h–20h	Pseudorandom number of satellite (1–32) or 0 when data is for all satellites.
6–7	EPH WEEK #	SHORT	GPS ICD-200[1]	Ephemeris Week Number.
8–9	IODC	SHORT	GPS ICD-200[1]	
10	RESERVED	CHAR	GPS ICD-200[1]	Reserved (set to zero).
11	IODE	CHAR	GPS ICD-200[1]	Issue of Data Ephemeris.
12–15	TOW	LONG	GPS ICD-200[1]	Time of week.
16–19	TOC	LONG	GPS ICD-200[1]	
20–23	TOE	LONG	GPS ICD-200[1]	
24–31	TGD	DOUBLE	GPS ICD-200[1]	
32–39	AF2	DOUBLE	GPS ICD-200[1]	
40–47	AF1	DOUBLE	GPS ICD-200[1]	
48–55	AF0	DOUBLE	GPS ICD-200[1]	

Table 7.44Report Packet 55h ephemeris report structure (continued)

Byte #	Item	Type	Value	Meaning
56–63	CRS	DOUBLE	GPS ICD-200[1]	
64–71	DELTA N	DOUBLE	GPS ICD-200[1]	
72–79	M SUB 0	DOUBLE	GPS ICD-200[1]	
80–87	CUC	DOUBLE	GPS ICD-200[1]	
88–95	ECCENTRICITY	DOUBLE	GPS ICD-200[1]	
96–103	CUS	DOUBLE	GPS ICD-200[1]	
104–111	SQRT A	DOUBLE	GPS ICD-200[1]	
112–119	CIC	DOUBLE	GPS ICD-200[1]	
120–127	OMEGA SUB 0	DOUBLE	GPS ICD-200[1]	
128–135	CIS	DOUBLE	GPS ICD-200[1]	
136–143	I SUB 0	DOUBLE	GPS ICD-200[1]	
144–151	CRC	DOUBLE	GPS ICD-200[1]	
152–159	OMEGA	DOUBLE	GPS ICD-200[1]	
160–167	OMEGA DOT	DOUBLE	GPS ICD-200[1]	
168–175	I DOT	DOUBLE	GPS ICD-200[1]	
176–179	FLAGS	LONG	See Table 7.45, page 111	Shows status of Ephemeris Flags.
180	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
181	ETX	CHAR	03h	End transmission.

[1] For detailed information, refer to the U.S. Government document GPS ICD-200.

Table 7.45Ephemeris flags

Bit(s)	Description	Location
0	Data flag for L2 P-code	Sub 1, word 4, bit 1
1–2	Codes on L2 channel	Sub 1, word 3, bits 11–12
3	Anti-spoof flag: Y-code on: from ephemeris	Sub 1–5, HOW, bit 19
4–9	SV health: from ephemeris	Sub 1, word 3, bits 17–22
10	Fit interval flag	Sub 2, word 10, bit 17
11–14	URA: User Range Accuracy	Sub 1, word 3, bits 13–16
15	URA may be worse than indicated Block I: Momentum Dump flag	Sub 1–5, HOW, bit 18
16–18	SV Configuration: SV is Block I or Block II	Sub 4, page 25, word and bit depends on SV.
19	Anti-spoof flag: Y-code on	Sub 4, page 25, word and bit depends on SV.

ALMANAC report

The ALMANAC report is sent when Command Packet 54h is used to request the Almanac for one satellite or all satellites. The Command Packet 54h DATA SWITCH byte (byte 4) is set to zero (2) when requesting the report. Data follows the format specified by GPS ICD-200.

Table 7.46 describes the packet structure.

Table 7.46Command Packet 55h almanac report structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status.
2	PACKET TYPE	CHAR	55h	Report Packet 55h.
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count.
4	DATA TYPE INDICATOR	CHAR	02h	Almanac data
5	SV PRN #	CHAR	00h–20h	Pseudorandom number of satellite (1–32) or 0 when data is for all satellites.
6–9	ALM DECODE TIME	LONG		Full GPS seconds from the start of GPS time.
10–11	AWN	SHORT	GPS ICD-200[1]	
12–15	TOA	LONG	GPS ICD-200[1]	
16–23	SQRTA	DOUBLE	GPS ICD-200[1]	
24–31	ECCENT	DOUBLE	GPS ICD-200[1]	
32–39	ISUBO	DOUBLE	GPS ICD-200[1]	
40–47	OMEGADOT	DOUBLE	GPS ICD-200[1]	
48–55	OMEGSUBO	DOUBLE	GPS ICD-200[1]	
56–63	OMEGA	DOUBLE	GPS ICD-200[1]	
64–71	MSUBO	DOUBLE	GPS ICD-200[1]	
72	ALM HEALTH	CHAR	GPS ICD-200[1]	
73	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
74	ETX	CHAR	03h	End transmission.

[1] For detailed information, refer to the U.S. Government document GPS ICD-200.

RETSVDATA UTC/ION report

The UTC/ION report is sent when Command Packet 54h is used to request the UTC (Universal Time Coordinated) and Ionospheric data. The Command Packet 54h DATA SWITCH byte (byte 4) is set to three (3) when requesting the report.

Data follows the standard defined within GPS ICD-200 except that some parameters are expanded. A NAK is returned if Command Packet 54h DATA SWITCH values is out of range.

Table 7.47 describes the packet structure.

Table 7.47RETSVDATA UTC/ION packet structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status
2	PACKET TYPE	CHAR	55h	Report Packet 55h
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count
4	DATA TYPE INDICATOR	CHAR	03h	UTC/ION Report
5	SV PRN #	CHAR	00h	Data for all satellites
[1] For detailed information, refer to the U.S. Government document GPS ICD-200.				
Begin UTC Data				
6–13	ALPHA 0	DOUBLE	GPS ICD-200[1]	
14–21	ALPHA 1	DOUBLE	GPS ICD-200[1]	
22–29	ALPHA 2	DOUBLE	GPS ICD-200[1]	
30–37	ALPHA 3	DOUBLE	GPS ICD-200[1]	
38–45	BETA 0	DOUBLE	GPS ICD-200[1]	
46–53	BETA 1	DOUBLE	GPS ICD-200[1]	
54–61	BETA 2	DOUBLE	GPS ICD-200[1]	
62–69	BETA 3	DOUBLE	GPS ICD-200[1]	
Begin Ionospheric Data				
70–77	ASUB0	DOUBLE	GPS ICD-200[1]	
78–85	ASUB1	DOUBLE	GPS ICD-200[1]	
86–93	TSUB0T	DOUBLE	GPS ICD-200[1]	
94–101	DELTATLS	DOUBLE	GPS ICD-200[1]	
102–109	DELTATLSF	DOUBLE	GPS ICD-200[1]	
110–117	IONTIME	DOUBLE	GPS ICD-200[1]	
118	WNSUBT	CHAR	GPS ICD-200[1]	
119	WNSUBLSF	CHAR	GPS ICD-200[1]	
120	DN	CHAR	GPS ICD-200[1]	
121–126	RESERVED	CHARs	GPS ICD-200[1]	Reserved (set to zero)
127	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value
128	ETX	CHAR	03h	End transmission
[1] For detailed information, refer to the U.S. Government document GPS ICD-200.				

57h, RAWDATA (Position or real-time survey data report)[1]

Report Packet 57h is sent in response to one of the following requests:

- Command Packet 56h
- Real-Time Survey Data streaming is enabled in the application file with Command Packet 64h
- A simulated front panel command

Packet Flow		
Receiver		**Remote**
	←	Command Packet 56h or RT Survey Data Request or Front Panel Command
Report Packet 57h or NAK	→	

A NAK is returned if the Real-Time Survey Data option (RT17) is not installed and the application file is configured to stream real-time survey data.

Report Packet 57h can contain one of the following types of raw data, depending on options selected in Command Packet 56h:

- Expanded Format (*.DAT Record Type 17 style data) raw satellite measurements
- Concise Format (*.DAT Record Type 17 style data) raw satellites measurements
- Position data (*.DAT Record Type 11)

The Expanded and Concise records can also include Enhanced record data, including Real-Time Flags and IODE information if these options are enabled in the application file. For more information, see Report Packet 56h, GETRAW (Position or real-time survey data request), page 59.

Packet paging and measurement counting

The Raw satellite data responses follow either the Expanded or the Concise format and usually exceed the byte limit for RS-232 Serial Interface Specification packets. To overcome the packet size limitation, the data is included in several subpackets called pages. The PAGE INDEX byte (Byte 4) identifies the packet page index and the maximum page index included for the measurement epoch (0 of 2, 1 of 2, 2 of 2).

The first and subsequent packet pages are filled with a maximum of 248 bytes consisting of 4 bytes of page and flag information and 244 bytes of raw satellite data. The raw satellite data is split wherever the 244 byte boundary falls, regardless of internal variable boundaries. Therefore the external device receiving the multiple pages must reconstruct the raw satellite record using the 244 byte pages before parsing the data. This format is maintained for the position record, even though it never extends beyond 244 bytes.

1. This record only contains raw measurement information from the GPS satellites. For raw information from additional constellations (GLONASS and so on), contact Trimble technical support. See Technical Support, page 8.

Determining the LENGTH byte of records

The total length of the Raw Satellite Data (ignoring the protocol framing and the paging bytes) may be computed as follows:

Expanded Format: LENGTH = 17 + N*48 + M*24 + N*J*12

Concise Format: LENGTH = 17 + N*27 + M*13 + N*J*3

where:

- N is the number of satellites
- M is the number of satellites with L2 data
- J is either 1 if REAL-TIME DATA is ON, or 0 if REAL-TIME DATA is OFF.

Expanded record format

Table 7.48 shows the structure of Report Packet 57h when Expanded Record format is enabled with Command Packet 56h.

Table 7.48Report Packet 57h structure (expanded format)

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status.
2	PACKET TYPE	CHAR	57h	RAWDATA.
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count.
4	RECORD TYPE	CHAR	See Table 7.50, page 118	Raw data record type.
5	PAGING INFO	CHAR	See Table 7.51, page 118	b7–b4 is the current page number b3–b0 is the total pages in this epoch (1 of 3, 2 of 3, 3 of 3).
6	REPLY #	CHAR	00h–FFh	Roll-over counter which is incremented with every report but remains constant across pages within one report. This value should be checked on the second and subsequent pages to ensure that report pages are not mismatched with those from another report.
7	FLAGS	CHAR	See Table 7.52, page 118	Bit 0 must be set to 0 to enable Expanded Record format.
Begin Expanded Format Record Header (17 bytes)				
8–15	RECEIVE TIME	DOUBLE	msecs	Receive time within the current GPS week (common to code and phase data).
16–23	CLOCK OFFSET	DOUBLE	msecs	Clock offset value. A value of 0.0 indicates that clock offset is not known.
24	# OF SVS IN RECORD	CHAR		Number of SV data blocks included in record.

Table 7.48Report Packet 57h structure (expanded format) (continued)

Byte #	Item	Type	Value	Meaning
Begin data for first satellite in constellation *(repeated for up to n SVs)*				
Begin Real-Time Survey Data *(48 bytes * n)*				
	SV PRN #	CHAR	01h–20h	Pseudorandom number of satellite (1–32).
	FLAGS1	CHAR	See Table 7.53, page 119	First set of status flags.
	FLAGS2	CHAR	See Table 7.54, page 119	Second set of status flags.
	FLAG STATUS	CHAR	See Table 7.55, page 120	Determines whether the bit values for FLAGS1 and FLAGS2 are valid.
	ELEVATION ANGLE	SHORT	degrees	Satellite elevation angle (negative or positive value).
	AZIMUTH	SHORT	degrees	Satellite azimuth.
Begin L1 Data				
	L1 SNR	DOUBLE	*dB*	Measure of satellite signal strength.
	FULL L1 C/A CODE PSEUDORANGE	DOUBLE	*meters*	Full L1 C/A code or P-code pseudorange (see bit 0 of FLAGS2).
	L1 CONTINUOUS PHASE	DOUBLE	*L1 cycles*	L1 Continuous Phase. Range-Rate sign convention: When pseudorange is increasing, the phase is decreasing and the Doppler is negative.
	L1 DOPPLER	DOUBLE	*Hz*	L1 Doppler.
	RESERVED	DOUBLE	0.0	Reserved.
Begin L2 Data *(available if bit 0 of FLAGS1 is set to 1) (24 bytes * n)*				
	L2 SNR	DOUBLE	*dB*	Measure of satellite signal strength
	L2 CONTINUOUS PHASE	DOUBLE	*L2 cycles*	L2 Continuous Phase is in L2 cycles if bit 5 of FLAGS1 = 1
	L2 P-CODE - L1 C/A CODE P-RANGE	DOUBLE	*meters*	L2 P-Code or L2 Encrypted Code (see bit 1 and bit 2 of FLAGS2) — L1 C/A-Code or P-code (see bit 0 of FLAGS2) pseudorange (valid only if bit 5 of FLAGS1 = 1)
Begin Enhanced Record[1] **if bit 1 of the FLAGS byte set to 1** *(12 bytes * n)*				
	IODE	CHAR	00h–FFh	Issue of Data Ephemeris
	L1 SLIP COUNTER	CHAR	00h–FFh	Roll-over counter is incremented for each occurrence of detected cycle-slips on L1 carrier phase
	L2 SLIP COUNTER	CHAR	00h–FFh	Roll-over counter is incremented for each occurrence of detected cycle-slips on the L2 carrier phase. The counter always increments when L2 changes from C/A code to Encrypted code and vice versa.
	RESERVED	CHAR	—	Reserved (set to zero)
	L2 DOPPLER	DOUBLE	*Hz*	L2 Doppler
Repeat previous bytes for remaining satellites in constellation				
	CHECKSUM	SHORT	See Table 7.1, page 53	Checksum value
	ETX	CHAR	03h	End transmission

[1]To be compatible with Trimble software, this data must be stripped off before record 17 is stored in a *.DAT file.

Concise record format

Table 7.49 shows the structure of Report Packet 57h when Concise Record format is enabled with Command Packet 56h.

Table 7.49Report Packet 57h structure (concise format)

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status
2	PACKET TYPE	CHAR	57h	RAWDATA
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count
4	RECORD TYPE	CHAR	See Table 7.50, page 118	Raw data record type
5	PAGING INFO	CHAR	See Table 7.51, page 118	b7–b4 is the current page number. b3–b0 is the total pages in this epoch (1 of 3, 2 of 3, 3 of 3).
6	REPLY #	CHAR	00h–FFh	Roll-over counter is incremented with every report but remains constant across pages within one report. This value should be checked on second and subsequent pages to avoid mismatching report pages with those of another report.
7	FLAGS	CHAR	See Table 7.52, page 118	Bit 0 must be set to 1 to enable Concise Record format
Begin Concise Record Header *(17 bytes)*				
8–15	RECEIVE TIME	DOUBLE	*msecs*	Receive time within current GPS week (common to code and phase data)
16–23	CLOCK OFFSET	DOUBLE	*msecs*	Clock offset value. A value of 0.0 indicates that clock offset is not known.
24	# OF SVS IN RECORD	CHAR	*blocks*	Number of SV data blocks included in record
Begin data for first satellite in constellation (repeated for up to n SVs)				
Begin Real-Time Survey Data (27 bytes * n)				
	SV PRN #	CHAR	01h–20h	Satellite pseudorandom number (1–32)
	FLAGS1	CHAR	See Table 7.53, page 119	First set of satellite status flags
	FLAGS2	CHAR	See Table 7.54, page 119	Second set of satellite status flags
	ELEVATION ANGLE	CHAR	*degrees*	Satellite elevation angle (negative or positive).
	AZIMUTH	SHORT	*degrees*	Azimuth of satellite
Begin L1 Data				
	L1 SNR	CHAR	*dB * 4*	Measure of satellite signal strength. The value needs to be divided by 4.
	FULL L1 C/A CODE PSEUDORANGE	DOUBLE	*meters*	Full L1 C/A code or P-code pseudorange (see bit 0 of FLAGS2)
	L1 CONTINUOUS PHASE	DOUBLE	*L1 cycles*	L1 continuous phase. Range-Rate sign convention: When pseudorange is increasing, the phase is decreasing and the Doppler is negative.
	L1 DOPPLER	FLOAT	*Hz*	L1 Doppler

Table 7.49Report Packet 57h structure (concise format) (continued)

Byte #	Item	Type	Value	Meaning
Begin L2 Data if bit 0 of FLAGS1 set to 1 *(13 bytes * n)*				
	L2 SNR	CHAR	*dB * 4*	Measure of satellite signal strength. The value needs to be divided by 4.
	L2 CONTINUOUS PHASE	DOUBLE	*L2 cycles*	L2 continuous phase is in L2 cycles if bit 5 of FLAGS1 = 1.
	L2 P-CODE[1] - L1 C/A CODE[2] P-RANGE	FLOAT	*meters*	Valid if bit 5 of FLAGS1 is set to 1.
[1] L2 encrypted. See bit 1 and bit 2 of FLAGS2. [2] P-code. See bit 0 of FLAGS2.				
Begin Enhanced Record[1] if bit 1 of the FLAGS byte is set to 1 *(3 bytes * n)*				
	IODE	CHAR	00h–FFh	Issue of Data Ephemeris.
	L1 SLIP COUNTER	CHAR	00h–FFh	Roll-over counter is incremented for each occurrence of detected cycle-slips on L1 carrier phase.
	L2 SLIP COUNTER	CHAR	00h–FFh	Roll-over counter is incremented for each occurrence of detected cycle-slips on the L2 carrier phase. The counter always increments when L2 changes from C/A code to Encrypted code and vice versa.
Repeat previous bytes for remaining satellites in constellation				
	CHECKSUM	SHORT	See Table 7.1, page 53	Checksum value
	ETX	CHAR	03h	End transmission

[1]To be compatible with Trimble software, this data must be stripped off before record 17 is stored in a *.DAT file.

Table 7.50RECORD TYPE byte values

Byte Value		Meaning
Dec	Hex	
0	00h	Real-Time Survey Data
1	01h	Position Data

Table 7.51PAGE INFO bit values

Bit Value	Meaning
0–3	Total page count
4–7	Current page number

Table 7.52FLAGS bit values

Bit	Meaning
Real-Time Survey Data	
0	Raw Data Format 0: Expanded *.DAT Record Type 17 format 1: Concise *.DAT Record Type 17 format

Table 7.52FLAGS bit values (continued)

Bit	Meaning
1	Enhanced Record with real-time flags and IODE information 0: Disabled-record data is not enhanced 1: Enabled-record data is enhanced
2–7	Reserved (set to zero)

Table 7.53FLAGS1 bit values

Bit	Meaning
0	L2 Data Loaded and Phase Valid (also see bit 6) 0: Off 1: On
1	L1 Cycle-slip (since last record 17 write) 0: Off 1: On
2	L2 Cycle-slip (since last record 17 write) 0: Off 1: On
3	L1 Phase Lock Point (redundant, for diagnostics) 0: Off 1: On
4	L1 Phase valid (lock-point valid) 0: Off 1: On
5	L2 Pseudorange (reset = squared - L2 phase) 0: Off (always for the receiver) 1: On
6	L1 Data Valid (non-zero but bytes always present) (also see bit 4), reset = only L2 data loaded (also see FLAG STATUS in Table 7.55, page 120) 0: Off 1: On
7	New Position Computed during this Receiver Cycle 0: Off 1: On

Table 7.54FLAGS2 bit values

Bit	Meaning
0	L1 Tracking Mode 0: C/A code 1: P-code
1	L2 Tracking Mode 0: C/A code (or encrypted P-code) 1: P-code
2	L2 Tracking Encryption Code 0: Off 1: On

Table 7.54FLAGS2 bit values (continued)

Bit	Meaning
3	Filtered L1 Band Pseudorange Corrections 0: Off 1: On
4–7	Reserved (bits set to zero)

Table 7.55FLAG STATUS bit values

Bit	Meaning
0	Validity of FLAGS1 and FLAGS2 Bit Values 0: Bit 6 of FLAGS1 and bit 0–7 of FLAGS2 are undefined 1: Bit 6 of FLAGS1 and bit 0–7 of FLAGS2 are valid (always set for RAWDATA)
2–7	Reserved (bits set to zero)

Position record (Record Type 11)

Table 7.56 shows the structure of Report Packet 57h when the Position Record is enabled with Command Packet 56h.

$$\text{Position Record Length} = 78 + N * 2$$

where N is the number of satellites.

Table 7.56Position record (record type 11) structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status
2	PACKET TYPE	CHAR	57h	RAWDATA
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count
4	RECORD TYPE	CHAR	See Table 7.50, page 118	Raw data record type
5	PAGE COUNTER	CHAR	This byte is split into two sections of 4 bits allowing for 15 pages. Bits 0-3 : Page total Bits 4-7 : Current Page number For example, 0x23 indicates page 2 of 3.	Indicates how many pages there are for this epoch and what this page number is (e.g., 1 of 3, 2 of 3, 3 of 3).
6	REPLY NUMBER	CHAR	00h–FFh	Roll-over counter which is incremented with every report but remains constant across pages within one report. This value should be checked on the second and subsequent pages to ensure that report pages are not mismatched with those from another report.
7	Record Interpretation Flags	Char	Real-Time Survey Data: • Bit 0: Set Concise format • Bit 1: SetEnhanced Record with real-time flags and IODE information • Bits 2-7: Reserved Position Data, Event Mark, MET3, WAAS, and all other record types: Not Defined	RECORD INTERPRETATION FLAGS indicates special attributes of the record that must be used in parsing values.
Begin Position Record *(Record 11) (78 + (nSVs * 2) bytes)*				
8–15	LATITUDE	DOUBLE		Latitude in semi-circles
16–23	LONGITUDE	DOUBLE		Longitude in semi-circles
24–31	ALTITUDE	DOUBLE	*meters*	Altitude
32–39	CLOCK OFFSET	DOUBLE	*meters*	Clock offset
40–47	FREQUENCY OFFSET	DOUBLE	*Hz*	Frequency offset from 1536*1.023 MHz
48–55	PDOP	DOUBLE		PDOP (dimensionless)
56–63	LATITUDE RATE	DOUBLE	*radians per second*	Latitude rate

Table 7.56Position record (record type 11) structure (continued)

Byte #	Item	Type	Value	Meaning
64–71	LONGITUDE RATE	DOUBLE	*radians per second*	Longitude rate
72–79	ALTITUDE RATE	DOUBLE	*meters per second*	Altitude rate
80–83	GPS MSEC OF WEEK	LONG	msecs	Position time tag
84	POSITION FLAGS	CHAR	See Table 7.57, page 122	Position status flags
85	# OF SVS	CHAR	00h–0Ch	Number of satellites used to compute position solution (0–12)
	The next 2 bytes are repeated for each satellite used to compute position			
	CHANNEL #	CHAR		Channel used to acquire satellite measurement. Zero is reported for RTK solutions.
	PRN #	CHAR	01–20h	PRN number of satellite (1–32)
	CHECKSUM	SHORT	See Table 7.1, page 53	Checksum value
	ETX	CHAR	03h	End transmission

Table 7.57POSITION FLAGS bit values

Bit	Meaning
0–2	Position flag and position type definition 0: 0-D position fix (clock-only solution) (1+ SVs) (if # of SVs used is non-zero) 1: 1-D position fix (height only with fixed latitude/longitude) (2+ SVs) 2: 2-D position fix (fixed height and clock) (2+ SVs) 3: 2-D position fix (fixed height) (3+ SVs) 4: 3-D solution (4+ SVs) 5: 3D Solution (4+ SVs) Wide Area/Network RTK
3	RTK Solution: if set, position is fixed RTK, else float RTK 0: Floating integer ambiguity 1: Fixed integer ambiguity
4	DGPS Differential Corrections 0: No DGPS corrections are used in position computation 1: DGPS corrections are used to compute position
5	Reserved (set to zero)
6	RTK Solution: if set, position is from RTK (including Location RTK) 0: False 1: True
7	Position Derived While Static (RTK only) 0: False 1: True
Bit combinations	
• Bit 4 and 6 are set if the solution type is SBAS • Bit 5 and 4 are set if the solution type is OmniSTAR HP/XP	

64h, APPFILE (Application file record report)

Report Packet 64h is sent to the remote device when Command Packet 65h is sent to request a specific application file. Command Packet 65h requests the application file by System File Index.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 65h
Report Packet 64h	→	

For more information about BD960 Application Files and guidelines for using application files to control remote devices, see Report Packet 64h, APPFILE (Application file record command), page 60.

The Application File Record Report format is identical to the format used for Command Packet 64h. For more information, see Packet paging, page 61.

67h, RETAFDIR (Directory listing report)

Report Packet 67h sends a listing of the application files in the application file directory. The report is requested with Command Packet 66h. For more information, see 66h, GETAFDIR (Application file directory listing request), page 74.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 66h
Report Packet 67h	→	

Report Packet 67h can exceed the maximum data byte limit (248 bytes of data) for RS-232 Serial Interface Specification packets, depending on the number of application files stored in memory. Each application file directory entry occupies 16 bytes. Report Packet 67h is divided into subpackets called pages when the data byte limit is exceeded. The PAGE INDEX and MAXIMUM PAGE INDEX bytes are used to account for the pages included in the report (0 of 2, 1 of 2, 2 of 2).

The TX BLOCK IDENTIFIER uses a roll-over counter to assign a transaction number to the report packet pages. The TX BLOCK IDENTIFIER INDEX number is useful for preventing data mismatches when stream synchronization is lost.

Table 7.58 describes the packet structure.

Table 7.58Report packet 67h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code.
2	PACKET TYPE	CHAR	67h	Report Packet 67h.
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count.

Table 7.58Report packet 67h structure (continued)

Byte #	Item	Type	Value	Meaning
4	TX BLOCK IDENTIFIER	CHAR	00h–FFh	Unique number assigned to every application file transfer.
5	PAGE INDEX	CHAR	00h–FFh	Page index assigned to packet page.
6	MAXIMUM PAGE INDEX	CHAR	00h–FFh	Page index assigned to the last packet page.
Begin Directory List				
7	# APP FILES		00h–*n*	Number of application files in directory.
[1] The Date/Time fields should all be relative to UTC.				
First Application File Directory Record *The following record block (bytes 8–23) is repeated for every application file stored in directory. At least one application file exists (SYSTEM FILE INDEX number 0, the Default Application File). The receiver can store at least 10 user-defined application file records.*				
8	SYSTEM FILE INDEX	CHAR	See Table 7.59, page 124	Record number assigned to the file.
9–16	APP FILE NAME	CHARs	*ASCII text*	Name of application file (8 ASCII characters).
17	CREATION YEAR[1]	CHAR	00h–FFh	Year when file is created. Based on the years since 1900 (1900 = 00).
18	CREATION MONTH[1]	CHAR	01h–0Ch	Month of the year when file is created (1–12).
19	CREATION DAY[1]	CHAR	01h–1Fh	Day of the month when file is created (1–31).
20	CREATION HOUR[1]	CHAR	00h–17h	Hour when file is created (0–23).
21	CREATION MINUTES[1]	CHAR	00h–3Bh	Minutes of hour when file is created (0–59).
22–23	APP FILE SIZE	SHORT	*bytes*	Size of file.
Begin Second Application File Record Entry . . . *End with Last Application File Record Entry*				
Length +4	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
Length +5	ETX	CHAR	03h	End transmission.
[1] The Date/Time fields should all be relative to UTC.				

Table 7.59SYSTEM FILE INDEX values

Byte Value		Meaning
Dec	**Hex**	
0	00h	Application file record number of the default application file which contains factory default values.
1–*n*	01h–*n*h	Application file record number.

6Eh, BREAKRET (Break sequence return)

Command Packet 6Eh returns the receivers current serial port communication parameters, receiver version numbers and dates, and communication protocol settings when the remote device sends a 250 millisecond (minimum duration) break sequence.

Packet Flow		
Receiver		**Remote**
	←	Break sequence
Report Packet 6Eh	→	

Sending a break sequence

To initiate a break sequence return, the following events need to occur:

1. The remote device sends a break sequence with a minimum duration of 250 milliseconds to the receiver. For example, pressing Ctrl+Break from an office computer is equivalent to sending a break sequence.
2. The receiver detects the break signal and responds by setting the communication parameters for the serial port to 9600 baud, 8 data bits, no parity, and 1 stop bit.
3. The receiver outputs an Identity Message through the serial port to the remote device (see Table 7.60).

Table 7.60 describes the structure of Report Packet 6Eh.

Table 7.60Report packet 6eh structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission.
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status indicator.
2	PACKET TYPE	CHAR	6Eh	Report Packet 6Eh.
3	LENGTH	CHAR	See Table 7.1, page 53	Data byte count.
	PRODUCT	CHARs	comma delimited ASCII string	Comma-delimited ASCII string indicating the receiver product family name. For more information, see PRODUCT, page 126.
	PORT SETTING	CHARs	comma delimited ASCII string	Comma-delimited ASCII string indicating the serial port settings and the break sequence acknowledgment code. For more information, see PORT, page 126.
	PORT STATUS	CHARs	'FIX' / 'ADJ'	FIX: Port settings cannot be changed. ADJ: Port settings can be changed.
	VERSION	CHARs	comma delimited ASCII string	Comma-delimited ASCII string indicating the software version number and version release date. For more information, see VERSION, page 127.

Table 7.60Report packet 6eh structure (continued)

Byte #	Item	Type	Value	Meaning
	COMM PROTOCOL	CHARs	comma delimited ASCII string	Comma-delimited ASCII string indicating the communication protocols supported on serial portm serial number, and Ethernet IP address. For more information, see COMM, page 127. SERIAL: Receiver serial number NOT SET'ETHIP: Receiver Ethernet IP address in xxx.xxx.xxx.xxx format or 0.0.0.0 if not found.
	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value.
	ETX	CHAR	03h	End transmission.

Identity message format

The following example shows the structure of an Identity Message:

<STX><0><0x6E><93>
PRODUCT,BD960;
PORT,1,38400,38400,8,1,N,F;
VERSION,4.30, 4/14/10,,;
COMM,DCOL,NMEA;
<CHECKSUM><ETX>

***Note –** The previous example shows the strings on separate lines for clarity, but the actual message is one continuous string of characters.*

Detailed information about the four parameter strings is described in the following sections.

PRODUCT

For the receiver, the PRODUCT string is always set to BD960. The string always begins with the word PRODUCT, followed by a comma, followed by the word BD960, and terminated with a semicolon as in the following example:

PRODUCT,BD960;

PORT

The PORT parameter is a comma-delimited string of ASCII characters describing the current input baud rate, output baud rate, data bits, stop bits, parity, and the break sequence status acknowledgment. The syntax of the comma delimited string is shown below:

PORT,*input baud rate,output baud rate,data bits,stop bits, parity,boolean acknowledgement;*

The string always begins with the word PORT, and the end of the string is always terminated with a semicolon character. Commas are used to delimit the other fields within the string.

The input and output protocols can be 2400, 4800, 9600, 19200, 38400, 57600, or 115k baud. The number of data bits is always set to 8, and the number of stop bits is always set to 1. The parity can be O (Odd), E (Even), or N (None). The string always identifies the current communication parameters defined for the port.

The final field in the string contains the boolean (T or F) code used to acknowledge the break sequence. A value of T (True) indicates that the communication parameters for the port are going to be set to 9600,8,N,1 for at least 5 seconds. A value of F (False) indicates that the receiver outputs the identity strings at 9600,8,N,1 and returns to the current port settings.

A sample string is shown below:

PORT,38400,38400,8,1,N,F;

VERSION

The VERSION parameter is a comma-delimited string of ASCII characters with the BD960 firmware and hardware version numbers and release dates. The end of the string is terminated with a semicolon. The syntax of the comma-delimited ASCII string is shown below:

VERSION,*software version number,version date,hardware version,version date;*

The string always begins with the word VERSION, followed by the software version number and date and two commas (,). The slash character (/) is used to separate the month, day, and year in date fields. The string is always terminated with a semicolon character. The following example shows a sample string:

VERSION,2.21,11/21/98,,;

COMM

The COMM parameter is a comma-delimited string of communication protocols supported on the connected serial port. The string has the following syntax:

COMM,first protocol,...last protocol;

The string always begins with the word COMM and a comma, followed by the comma-delimited list of protocols. The string is terminated with a semicolon character. Table 7.61 identifies the ASCII codes assigned to the various protocols supported by the receiver.

Table 7.61COMM

Protocol	Meaning
DCOL	Data Collector Format
NMEA	Outputs a subset of NMEA-0183 messages
RTCM	Radio Technical Commission for Maritime Services protocol specification RTCM SC-104

For example, the comma-delimited ASCII string for the connected serial port which supports DCOL and RTCM is shown below:

COMM,DCOL,RTCM;

82h, SCRDUMP (Screen dump)

Command Packet 82h has two forms—a command packet and report packet. Both packets are assigned the same hexadecimal code (82h). For more information, see 82h, SCRDUMP (Screen dump request), page 77.

Packet Flow		
Receiver		**Remote**
	←	Command Packet 82h
Report Packet 82h	→	

Report Packet 82h is sent in response to Command Packet 82h. The receiver generates an ASCII representation (a dump) of a BD960 display screen, and sends the dump to the remote device in Report Packet 82h. Table 7.62 shows the packet structure.

Table 7.62Report packet 82h structure

Byte #	Item	Type	Value	Meaning
0	STX	CHAR	02h	Start transmission
1	STATUS	CHAR	See Table 7.2, page 54	Receiver status code
2	PACKET TYPE	CHAR	82h	Report Packet 82h
3	LENGTH	CHAR	A1h	Data byte count
4–163	ASCII DATA	CHARs		ASCII data
164	CURSOR POSITION	CHAR		Position of the cursor
165	CHECKSUM	CHAR	See Table 7.1, page 53	Checksum value
166	ETX	CHAR	03h	End transmission

CHAPTER

8

Default Settings

In this chapter:

All settings are stored in application files. The default application file, Default.cfg, is stored permanently in the receiver, and contains the factory default settings. Whenever the receiver is reset to its factory defaults, the current settings (stored in the current application file, Current.cfg) are reset to the values in the default application file.

Default receiver settings

These settings are defined in the default application file.

Function		Factory default
SV Enable		All SVs enabled
General Controls:	Elevation mask	10°
	PDOP mask	7
	RTK positioning mode	Low Latency
	Motion	Kinematic
Ports:	Baud rate	38,400
	Format	8-None-1
	Flow control	None
Input Setup:	Station	Any
NMEA/ASCII (all supported messages)		All ports Off
Streamed output		All types Off Offset = 00
RT17/Binary		All ports Off
Reference position:	Latitude	0°
	Longitude	0°
	Altitude	0.00 m HAE (Height above ellipsoid)
Antenna:	Type	Unknown
	Height (true vertical)	0.00 m
	Measurement method	Antenna Phase Center
1 PPS		Disabled

CHAPTER

9

Specifications

In this chapter:

- Physical specifications
- Performance specifications
- Electrical specifications
- Communication specifications

This chapter details the specifications for the receiver.

Specifications are subject to change without notice.

Physical specifications

Feature	Specification
Dimensions (L x W x H)	100 mm x 106.7 mm x 12.7 mm
Temperature	
Operating	–40 °C to +75 °C (–40 °F to +167 °F)
Storage	–55 °C to +85 °C (–40 °F to +176 °F)
Vibration	MIL810F, tailored Random 6.2 gRMS operating Random 8 gRMS survival
Mechanical shock	MIL810D ±40 g operating ±75 g survival
I/O Connector	34-pin header (Samtec FTSH-117-01-L-DV-K-A-P-TR); mating connectors are a ribbon cable (Samtec FFSD) and a receptacle (Samtec FLE) for a board-to-board connection.
Antenna Connector	MMCX receptacle (Huber-Suhner 82MMCX-50-0-1/111); mating connectors are MMCX plug (Suhner 11MMCX-50-2-1C) or right-angle plug (Suhner 16MMCX-50-2-1C, or 16MMCX-50-2-10)

Performance specifications

Feature	Specification
Measurements	• Advanced Trimble Maxwell Custom Survey GNSS technology • High precision multiple correlator for GNSS pseudorange measurements • Unfiltered, unsmoothed pseudorange measurements data for low noise, low multipath error, low time domain correlation and high dynamic response • Very low receiver noise GNSS carrier phase measurements with <1 mm precision in a 1 Hz bandwidth • Signal-to-Noise ratios reported in dB-Hz • 72 Channels: - GPS L1 C/A Code, L2C, L1/L2/L51 Full Cycle Carrier - GLONASS L1 C/A Code, L1 P Code,L2 C/A2, L2 P Code, - 4 additional channels for SBAS WAAS/EGNOS/MSAS support - L-Band OmniSTAR VBS,HP, and XP
Code differential GPS positioning[1]	
3D	Typically, <1 m
SBAS (WAAS/EGNOS/MSAS)	
Horizontal accuracy[2]	Typically <1 m
Vertical accuracy[2]	Typically <5 m
OmniSTAR positioning	
VBS service accuracy	Horizontal <1 m
XP service accuracy	Horizontal 20 cm, Vertical 30 cm
HP service accuracy	Horizontal 10 cm, Vertical 15 cm

Feature	Specification
RTK positioning	
Horizontal accuracy	±(8 mm + 1 ppm) RMS
Vertical accuracy	±(15 mm + 1 ppm) RMS
Initialization time	Typically, 10 seconds
Initialization reliability[3]	Typically >99.9%

[1]Accuracy and reliability may be subject to anomalies such as multipath, obstructions, satellite geometry, and atmospheric conditions. Always follow recommended practices. RTK accuracy values are measured at 1 sigma level, when using Zephyr Model 2 antennas.

[2] Depends on WAAS, EGNOS, and MSAS system performance.

[3] May be affected by atmospheric conditions, signal multipath, and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

Electrical specifications

Feature	Specification
Power	4.9 V to 28 V DC external power input with over-voltage protection
Power consumption	Typically, 2.1 W at 5 V DC (L1/L2 GPS)

Communication specifications

Feature	Specification
Communications	
1 LAN port	• Supports links to 10BaseT/100BaseT networks. • All functions are performed through a single IP address simultaneously—including web interace access and data streaming.
3 x RS232 ports	Baud rates up to 115,200.
Receiver position update rate	1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz positioning
Correction data input	CMR, CMR+, RTCM 2.0 (select RTCM 2.1), RTCM 2.1–2.3, RTCM 3.0.
Correction data output	CMR, CMR+, RTCM 2.0 DGPS (select RTCM 2.1), RTCM 2.1–2.3, RTCM 3.0.
Data outputs	1PPS, NMEA, Binary GSOF, ASCII Time Tags.
Event Marker Input support	

APPENDIX

A

NMEA-0183 Output

In this appendix:

This appendix describes the formats of the subset of NMEA-0183 messages that are available for output by the receivers. For a copy of the NMEA-0183 Standard, go to the National Marine Electronics Association website at www.nmea.org.

To enable NMEA messages, see the configuration methods described in:

- Chapter 5, Configuring the BD960 Receiver Using Trimble Software Utilities
- Chapter 6, Configuring the BD960 Receiver Using a Web Browser
- Chapter 7, Configuring the BD960 Receiver Using Binary Interface Commands

NMEA-0183 message overview

When NMEA-0183 output is enabled, a subset of NMEA-0183 messages can be output to external instruments and equipment connected to the receiver serial ports. These NMEA-0183 messages let external devices use selected data collected or computed by the GPS receiver.

All messages conform to the NMEA-0183 version 3.01 format. All begin with $ and end with a carriage return and a line feed. Data fields follow comma (,) delimiters and are variable in length. Null fields still follow comma (,) delimiters but contain no information.

An asterisk (*) delimiter and checksum value follow the last field of data contained in an NMEA-0183 message. The checksum is the 8-bit exclusive of all characters in the message, including the commas between fields, but not including the $ and asterisk delimiters. The hexadecimal result is converted to two ASCII characters (0–9, A–F). The most significant character appears first.

The following table summarizes the set of NMEA messages supported by the receiver, and shows the page that contains detailed information about each message.

Message	Function	Page
ADV	Position and Satellite information for RTK network operations	138
GGA	Time, position, and fix related data	139
GSA	GPS DOP and active satellites	140
GST	Position error statistics	141
GSV	Number of SVs in view, PRN, elevation, azimuth, and SNR	142
HDT	Heading from True North	143
PTNL,AVR	Time, yaw, tilt, range, mode, PDOP, and number of SVs for Moving Baseline RTK	144
PTNL,GGK	Time, position, position type and DOP values	145
PTNL,PJK	Local coordinate position output	146
PTNL,VGK	Time, locator vector, type and DOP values	147
PTNL,VHD	Heading Information	148
RMC	Position, Velocity, and Time	149
ROT	Rate of turn	150
VTG	Actual track made good and speed over ground	151
ZDA	UTC day, month, and year, and local time zone offset	152

To enable or disable the output of individual NMEA messages, do one of the following:

- Create an application file in the GPS Configurator software that contains NMEA output settings and then send the file to the receiver.
- Add NMEA outputs in the *Serial outputs* tab of the GPS Configurator software and then apply the settings. (You cannot use the GPS Configuration software to load application files to the SPSx50 Modular GPS receivers.)
- For SPSx50 and SPSx51 Modular GPS receivers, set up the NMEA output using the keypad and display or a web browser.

Common message elements

Each message contains:

- a message ID consisting of *$GP* followed by the message type. For example, the message ID of the GGA message is *$GPGGA*.
- a comma
- a number of fields, depending on the message type, separated by commas
- an asterisk
- a checksum value

Below is an example of a simple message with a message ID ($GPGGA), followed by 13 fields and a checksum value:

$GPGGA,172814.0,3723.46587704,N,12202.26957864,W,2,6,1.2,18.893,M,-25.669,M,2.0,0031*4F

Message values

NMEA messages that the receiver generates contains the following values.

Latitude and longitude

Latitude is represented as *ddmm.mmmm* and longitude is represented as *dddmm.mmmm*, where:

- *dd* or *ddd* is degrees
- *mm.mmmm* is minutes and decimal fractions of minutes

Direction

Direction (north, south, east, or west) is represented by a single character: *N*, *S*, *E*, or *W*.

Time

Time values are presented in Universal Time Coordinated (UTC) and are represented as *hhmmss.cc*, where:

- *hh* is hours, from 00 through 23
- *mm* is minutes
- *ss* is seconds
- *cc* is hundredths of seconds

NMEA messages

When NMEA-0183 output is enabled, the following messages can be generated.

ADV Position and Satellite information for RTK network operations

An example of the ADV message string is shown below. Table A.1 and Table A.2 describe the message fields. The messages alternate between subtype 110 and 120.

$PGPPADV,110,39.88113582,-105.07838455,1614.125*1M

Table A.1 ADV subtype 110 message fields

Field	Meaning
0	Message ID $PPGPADV
1	Message sub-type 110
2	Latitude
3	Longitude
4	Ellipsoid height
6	Elevation of second satellite, in degrees, 90° maximum
7	Azimuth of second satellite, degrees from True North, 000° through 359°
8	The checksum data, always begins with *

$PGPPADV,120,21,76.82,68.51,29,20.66,317.47,28,52.38,276.81,22,42.26,198.96*5D

Table A.2 ADV subtype 120 message fields

Field	Meaning
0	Message ID $PPGPADV
1	Message sub-type 120
2	First SV PRN number
3	Elevation of first satellite, in degrees, 90° maximum
4	Azimuth of first satellite, degrees from True North, 000° through 359°
5	Second SV PRN number
6	Elevation of second satellite, in degrees, 90° maximum
7	Azimuth of second satellite, degrees from True North, 000° through 359°
8	The checksum data, always begins with *

GGA Time, Position, and Fix Related Data

An example of the GGA message string is shown below. Table A.3 describes the message fields.

Note – *The following data string exceeds the NMEA standard length.*

$GPGGA,172814.0,3723.46587704,N,12202.26957864,W,
2,6,1.2,18.893,M,-25.669,M,2.0,0031*4F

Table A.3 GGA message fields

Field	Meaning
0	Message ID $GPGGA
1	UTC of position fix
2	Latitude
3	Direction of latitude: N: North S: South
4	Longitude
5	Direction of longitude: E: East W: West
6	GPS Quality indicator: 0: Fix not valid 1: GPS fix 2: Differential GPS fix 4: Real Time Kinematic, fixed integers 5: Real Time Kinematic, float integers
7	Number of SVs in use, range from 00 through 12
8	HDOP
9	Orthometric height (MSL reference)
10	M: unit of measure for orthometric height is meters
11	Geoid separation
12	M: geoid separation is measured in meters
13	Age of differential GPS data record, Type 1 or Type 9. Null field when DGPS is not used.
14	Reference station ID, ranging from 0000 through 1023. A null field when any reference station ID is selected and no corrections are received.
15	The checksum data, always begins with *

GSA GPS DOP and active satellites

An example of the GSA message string is shown below. Table A.4 describes the message fields.

$GPGSA,<1>,<2>,<3>,<3>,,,,,<3>,<3>,<3>,<4>,<5>,<6>*<7><CR><LF>

Table A.4 GSA message fields

Field	Meaning
0	Message ID $GPGSA
1	Mode 1, M = manual, A = automatic
2	Mode 2, Fix type, 1 = not available, 2 = 2D, 3 = 3D
3	PRN number, 01 through 32, of satellite used in solution, up to 12 transmitted
4	PDOP-Position dilution of precision, 0.5 through 99.9
5	HDOP-Horizontal dilution of precision, 0.5 through 99.9
6	VDOP-Vertical dilution of precision, 0.5 through 99.9
7	The checksum data, always begins with *

GST Position Error Statistics

An example of the GST message string is shown below. Table A.5 describes the message fields.

$GPGST,172814.0,0.006,0.023,0.020,273.6,0.023,0.020,0.031*6A

Table A.5 GST message fields

Field	Meaning
0	Message ID $GPGST
1	UTC of position fix
2	RMS value of the pseudorange residuals; includes carrier phase residuals during periods of RTK(float) and RTK(fixed) processing
3	Error ellipse semi-major axis 1 sigma error, in meters
4	Error ellipse semi-minor axis 1 sigma error, in meters
5	Error ellipse orientation, degrees from true north
6	Latitude 1 sigma error, in meters
7	Longitude 1 sigma error, in meters
8	Height 1 sigma error, in meters
9	The checksum data, always begins with *

GSV Satellite Information

The GSV message string identifies the number of SVs in view, the PRN numbers, elevations, azimuths, and SNR values. An example of the GSV message string is shown below. Table A.6 describes the message fields.

$GPGSV,4,1,13,02,02,213,,03,-3,000,,11,00,121,,14,13,172,05*67

Table A.6 GSV message fields

Field	Meaning
0	Message ID $GPGSV
1	Total number of messages of this type in this cycle
2	Message number
3	Total number of SVs visible
4	SV PRN number
5	Elevation, in degrees, 90° maximum
6	Azimuth, degrees from True North, 000° through 359°
7	SNR, 00–99 dB (null when not tracking)
8–11	Information about second SV, same format as fields 4 through 7
12–15	Information about third SV, same format as fields 4 through 7
16–19	Information about fourth SV, same format as fields 4 through 7
20	The checksum data, always begins with *

HDT Heading from True North

The HDT string is shown below, and Table A.7 describes the message fields.

$GPHDT,123.456,T*00

Table A.7 Heading from true north fields

Field	Meaning
0	Message ID $GPHDT
1	Heading in degrees
2	T: Indicates heading relative to True North
3	The checksum data, always begins with *

PTNL,AVR

Time, Yaw, Tilt, Range for Moving Baseline RTK

The PTNL,AVR message string is shown below, and Table A.8 describes the message fields.

$PTNL,AVR,181059.6,+149.4688,Yaw,+0.0134,Tilt,,,60.191,3,2.5,6*00

Table A.8 AVR message fields

Field	Meaning
0	Message ID $PTNL,AVR
1	UTC of vector fix
2	Yaw angle in degrees
3	Yaw
4	Tilt angle in degrees
5	Tilt
6	Reserved
7	Reserved
8	Range in meters
9	GPS quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: Differential carrier phase solution RTK (Float) 3: Differential carrier phase solution RTK (Fix) 4: Differential code-based solution, DGPS
10	PDOP
11	Number of satellites used in solution
12	The checksum data, always begins with *

PTNL,GGK

Time, Position, Position Type, DOP

An example of the PTNL,GGK message string is shown below. Table A.9 describes the message fields.

$PTNL,GGK,172814.00,071296,3723.46587704,N,12202.26957864,W,3,06,1.7,EHT-6.777,M*48

Table A.9 PTNL,GGK message fields

Field	Meaning
0	Message ID $PTNL,GGA
1	UTC of position fix
2	Date
3	Latitude
4	Direction of latitude: N: North S: South
5	Longitude
6	Direction of Longitude: E: East W: West
7	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D Network solution 7: RTK Fixed 3D Network solution 8: RTK Float 2D in a Network solution 9: RTK Fixed 2D Network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
8	Number of satellites in fix
9	DOP of fix
10	Ellipsoidal height of fix
11	M: ellipsoidal height is measured in meters
12	The checksum data, always begins with *

Note – *The PTNL,GGK message is longer than the NMEA-0183 standard of 80 characters.*

PTNL,PJK

Local Coordinate Position Output

An example of the PTNL,PJK message string is shown below. Table A.10 describes the message fields.

$PTNL,PJK,010717.00,081796,+732646.511,N,+1731051.091,E,1,05,2.7,EHT-28.345,M*7C

Table A.10 PTNL,PJK message fields

Field	Meaning
0	Message ID $PTNL,PJK
1	UTC of position fix
2	Date
3	Northing, in meters
4	Direction of Northing will always be N (North)
5	Easting, in meters
6	Direction of Easting will always be E (East)
7	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D network solution 7: RTK Fixed 3D network solution 8: RTK Float 2D network solution 9: RTK Fixed 2D network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
8	Number of satellites in fix
9	DOP of fix
10	Ellipsoidal height of fix
11	M: ellipsoidal height is measured in meters
12	The checksum data, always begins with *

Note – *The PTNL,PJK message is longer than the NMEA-0183 standard of 80 characters.*

PTNL,VGK

Vector Information

An example of the PTNL,VGK message string is shown below. Table A.11 describes the message fields.

$PTNL,VGK,160159.00,010997,-0000.161,00009.985,-0000.002,3,07,1,4,M*0B

Table A.11 PTNL,VGK message fields

Field	Meaning
0	Message ID $PTNL,VGK
1	UTC of vector in hhmmss.ss format
2	Date in mmddyy format
3	East component of vector, in meters
4	North component of vector, in meters
5	Up component of vector, in meters
6	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D network solution 7: RTK Fixed 3D network solution 8: RTK Float 2D network solution 9: RTK Fixed 2D network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
7	Number of satellites if fix solution
8	DOP of fix
9	M: Vector components are in meters
10	The checksum data, always begins with *

PTNL,VHD

Heading Information

An example of the PTNL,VHD message string is shown below. Table A.12 describes the message fields.

$PTNL,VHD,030556.00,093098,187.718,-22.138,-76.929,-5.015,0.033,0.006,3,07,2.4,M*22

Table A.12 PTNL,VHD message fields

Field	Meaning
0	Message ID $PTNL,VHD
1	UTC of position in hhmmss.ss format
2	Date in mmddyy format
3	Azimuth
4	ΔAzimuth/ΔTime
5	Vertical Angle
6	ΔVertical/ΔTime
7	Range
8	ΔRange/ΔTime
9	GPS Quality indicator: 0: Fix not available or invalid 1: Autonomous GPS fix 2: RTK float solution 3: RTK fix solution 4: Differential, code phase only solution (DGPS) 5: SBAS solution – WAAS, EGNOS, MSAS 6: RTK Float 3D network solution 7: RTK Fixed 3D network solution 8: RTK Float 2D network solution 9: RTK Fixed 2D network solution 10: OmniSTAR HP/XP solution 11: OmniSTAR VBS solution
10	Number of satellites used in solution
11	PDOP
12	The checksum data, always begins with *

RMC Position, Velocity, and Time

The RMC string is shown below, and Table A.13 describes the message fields.

$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A

Table A.13 GPRMC message fields

Field	Meaning
0	Message ID $GPRMC
1	UTC of position fix
2	Status A=active or V=void
3	Latitude
4	Longitude
5	Speed over the ground in knots
6	Track angle in degrees (True)
7	Date
8	Magnetic variation in degrees
9	The checksum data, always begins with *

ROT Rate and Direction of Turn

The ROT string is shown below, and Table A.14 describes the message fields.

$GPROT,35.6,A*4E

Table A.14 ROT message fields

Field	Meaning
0	Message ID $GPROT
1	Rate of turn, degrees/minutes, "–" indicates bow turns to port
2	A: Valid data V: Invalid data
3	The checksum data, always begins with *

VTG Track Made Good and Speed Over Ground

An example of the VTG message string is shown below. Table A.15 describes the message fields.

$GPVTG,,T,,M,0.00,N,0.00,K*4E

Table A.15 VTG message fields

Field	Meaning
0	Message ID $GPVTG
1	Track made good (degrees true)
2	T: track made good is relative to true north
3	Track made good (degrees magnetic)
4	M: track made good is relative to magnetic north
5	Speed, in knots
6	N: speed is measured in knots
7	Speed over ground in kilometers/hour (kph)
8	K: speed over ground is measured in kph
9	The checksum data, always begins with *

ZDA UTC Day, Month, And Year, and Local Time Zone Offset

An example of the ZDA message string is shown below. Table A.16 describes the message fields.

$GPZDA,172809,12,07,1996,00,00*45

Table A.16 ZDA message fields

Field	Meaning
0	Message ID $GPZDA
1	UTC
2	Day, ranging between 01 and 31
3	Month, ranging between 01 and 12
4	Year
5	Local time zone offset from GMT, ranging from 00 through ±13 hours
6	Local time zone offset from GMT, ranging from 00 through 59 minutes
7	The checksum data, always begins with *

Fields 5 and 6 together yield the total offset. For example, if field 5 is –5 and field 6 is +15, local time is 5 hours and 15 minutes earlier than GMT.

APPENDIX

B

Upgrading the Receiver Firmware

In this appendix:

The GPS receiver is supplied with the latest version of the receiver firmware already installed. If a later version of the firmware becomes available, use the WinFlash utility to upgrade the firmware on your receiver.

You can also upgrade the receiver through the web interface (see Configuring the receiver using a web browser, page 39). If your receiver has access to the Internet, then whenever Trimble releases new firmware your receiver will check and display the new firmware version number in the Web browser. You can then decide to install the newer firmware from the Web browser.

Firmware updates are available to download from the Trimble website. Go to www.trimble.com/support.shtml and select the link to the receiver that you need updates for and then click Downloads.

The WinFlash utility

The WinFlash utility communicates with Trimble products to perform various functions including:

- installing software, firmware, and option upgrades
- running diagnostics (for example, retrieving configuration information)
- configuring radios

For more information, online help is also available when using the WinFlash utility.

***Note** – The WinFlash utility runs on Windows 95, 98, Windows NT®, 2000, Me, or XP operating systems.*

Installing the WinFlash utility

You can install the WinFlash utility from the Trimble website.

The WinFlash utility guides you through the firmware upgrade process, as described below. For more information, refer to the WinFlash Help.

Upgrading the receiver firmware

1. Start the WinFlash utility. The *Device Configuration* screen appears.
2. From the *Device type* list, select your receiver.
3. From the *PC serial port* field, select the serial (COM) port on the computer that the receiver is connected to.
4. Click **Next**.

   The *Operation Selection* screen appears. The *Operations* list shows all of the supported operations for the selected device. A description of the selected operation is shown in the *Description* field.
5. Select *Load GPS software* and then click **Next**.

   The *GPS Software Selection* window appears. This screen prompts you to select the software that you want to install on the receiver.
6. From the *Available Software* list, select the latest version and then click **Next**.

   The *Settings Review* window appears. This screen prompts you to connect the receiver, suggests a connection method, and then lists the receiver configuration and selected operation.
7. If all is correct, click **Finish**.

   Based on the selections shown above, the *Software Upgrade* window appears and shows the status of the operation (for example, Establishing communication with <your receiver>. Please wait.).
8. Click **OK**.

The *Software Upgrade* window appears again and states that the operation was completed successfully.

9. To select another operation, click **Menu**; to quit, click **Exit**.

   If you click **Exit**, the system prompts you to confirm.

10. Click **OK**.

APPENDIX

C

Troubleshooting

In this appendix:

- Receiver issues

Use this appendix to identify and solve common problems that may occur with the receiver.

Please read this section before you contact Technical Support.

Receiver issues

This section describes some possible receiver issues, possible causes, and how to solve them.

Issue	Possible cause	Solution
The receiver does not turn on.	External power is too low.	Check that the input voltage is within limits.
The base station receiver is not broadcasting.	Port settings between reference receiver and radio are incorrect.	Check the settings on the radio and the receiver.
	Faulty cable between receiver and radio.	Try a different cable.
		Examine the ports for missing pins.
		Use a multimeter to check pinouts.
	No power to radio.	If the radio has its own power supply, check the charge and connections.
		Examine the ports for missing pins.
		Use a multimeter to check pinouts.
Rover receiver is not receiving radio.	The base station receiver is not broadcasting.	See the issue, The base station receiver is not broadcasting. above.
	Incorrect over air baud rates between reference and rover.	Connect to the rover receiver radio, and make sure that it has the same setting as the reference receiver.
	Incorrect port settings between roving external radio and receiver.	If the radio is receiving data and the receiver is not getting radio communications, check that the port settings are correct.
The receiver is not receiving satellite signals	The GPS antenna cable is loose.	Make sure that the GPS antenna cable is tightly seated in the GPS antenna connection on the GPS antenna.
	The cable is damaged.	Check the cable for any signs of damage. A damaged cable can inhibit signal detection from the antenna at the receiver.
	The GPS antenna is not in clear line of sight to the sky.	Make sure that the GPS antenna is located with a clear view of the sky.
		Restart the receiver as a last resort (turn off and then turn it on again).

APPENDIX

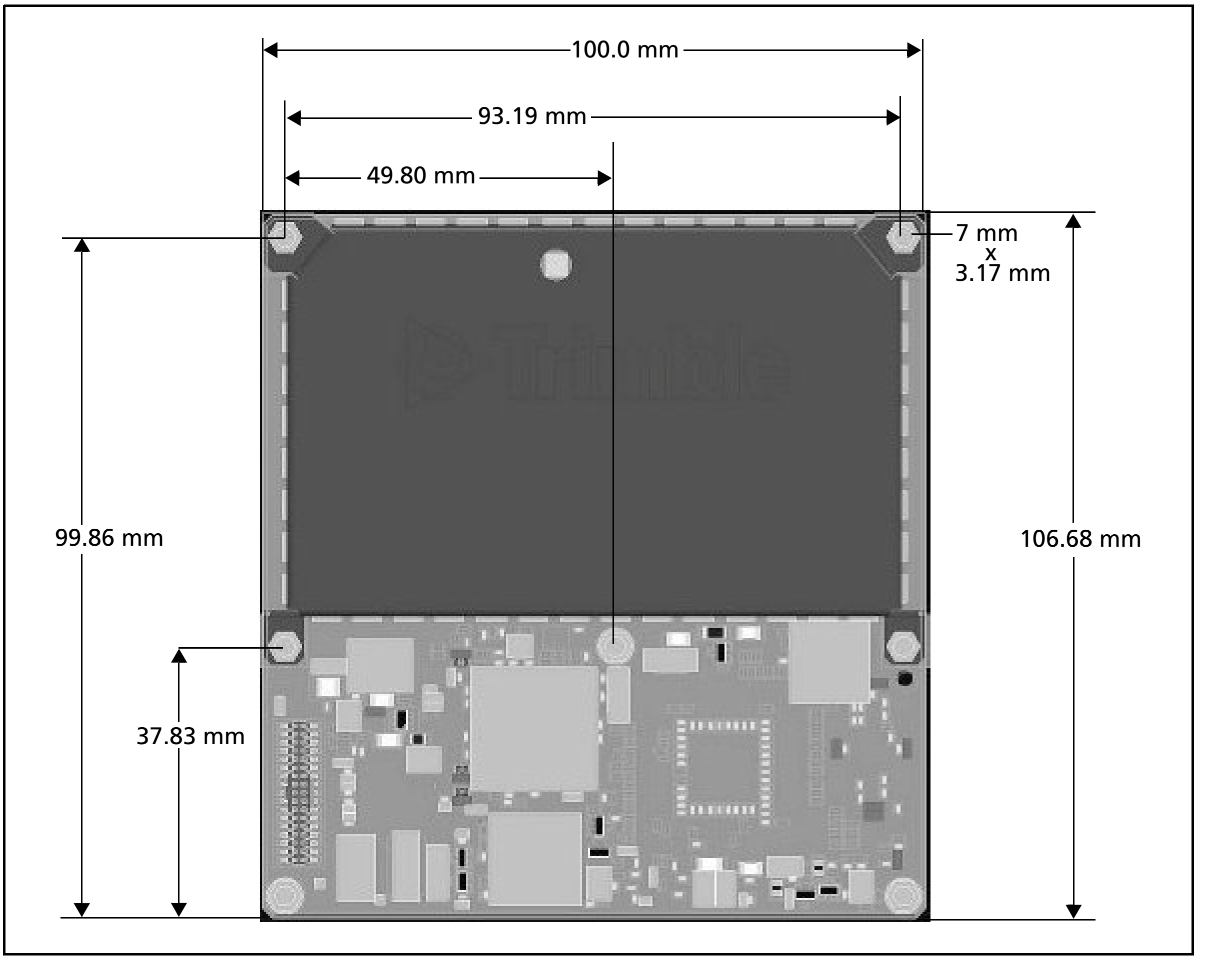
D

Drawings

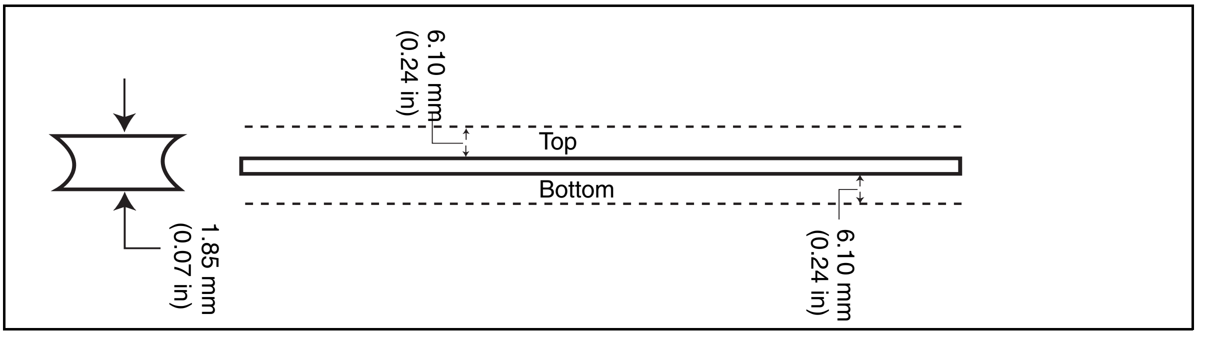
In this appendix:

The drawings in this appendix show the dimensions of the receiver. Refer to these drawings if you need to build mounting brackets and housings for the receiver.

Plan view



Edge view



APPENDIX

E

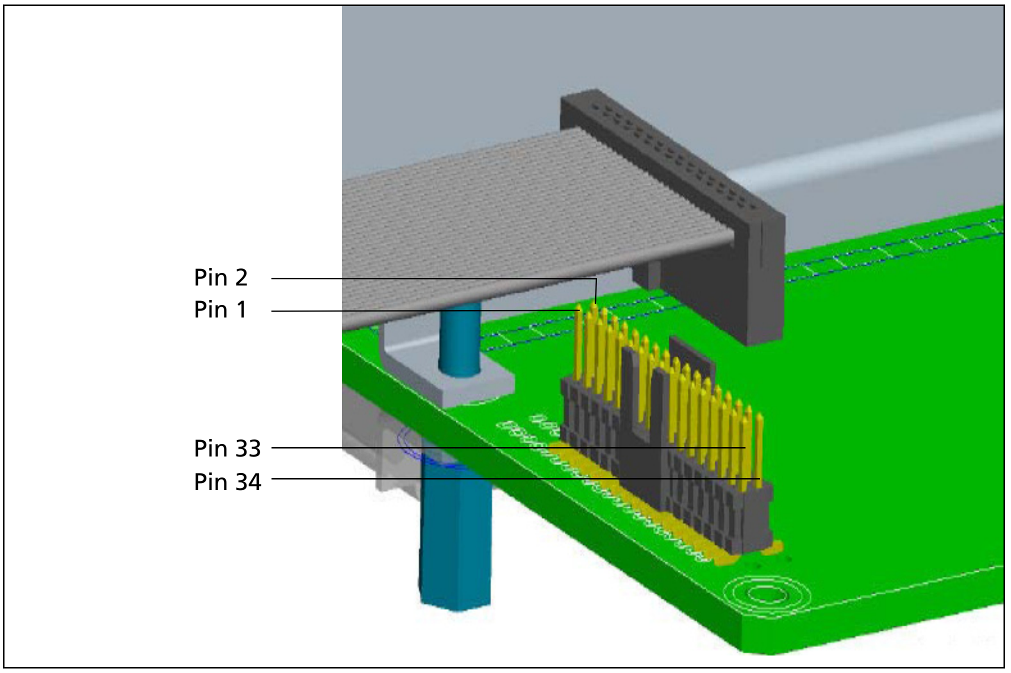
Receiver Connector Pinout Information

In this appendix:

The receiver has one connector—a 34-pin header (J1)

34-pin header

The 34-pin header (J1) has the following pinout.



Pin	Usage	Comment
1	GND	POWER- GROUND
2	GND	POWER- GROUND
3	BOOT_MONITOR	INPUT- hold low at boot up to boot into Monitor mode. Otherwise leave unconnected
4	Ethernet Receive Data -	INPUT – Ethernet Receive Minus.
5	LED 1*	Tracking SV
6	Ethernet Receive Data +	INPUT – Ethernet Receive Plus.
7	LED 2*	Receiving Corrections
8	Ethernet Transmit Data -	OUTPUT – Ethernet Transmit Minus.
9	LED 3*	Power
10	Ethernet Transmit Data +	OUTPUT – Ethernet Transmit Plus.
11	GND	POWER- GROUND
12	PPS	OUTPUT – Pulse per second; 3.3V TTL level
13	EVENT	INPUT –Event Markers
14	GND	POWER- GROUND
15	RS-232 - PORT1 TX	OUTPUT –Port 1 Serial port Transmit
16	RS-232 - PORT1 RX	INPUT–Port 1 Serial port Receive
17	GND	POWER- GROUND
18	RS-232 – PORT3 TX	OUTPUT – Port 3 Serial port Transmit
19	RS-232 – PORT3 RX	INPUT– Port 3 Serial port Receive
20	RS-232 – PORT3 CTS	INPUT –Port 3 Serial port Clear to send.

Pin	Usage	Comment
21	RS-232 – PORT3 RTS	OUTPUT– Port 3 Serial port Ring to Send.
22	GND	POWER- GROUND
23	RS-232 – PORT2 TX	OUTPUT –Port 2 Serial port Transmit
24	RS-232 – PORT2 RX	INPUT–Port 2 Serial port Receive
25	RS-232 – PORT2 CTS	INPUT –Port 2 Serial port Clear to send.
26	RS-232 – PORT2 RTS	OUTPUT–Port 2 Serial port Ring to Send.
27	ON_SWITCH	INPUT - ON_SWITCH When auto_on is enabled, NOT _USED When auto_on is disabled: - connect to ground to power unit on - No connect/ Float to turn on. Use open-drain or open-collector output to control the line.
28	Factory Use	Do not connect
29	DC Power In	POWER – Positive Power PIN, 5-28 VDC
30	DC Power In	POWER – Positive Power PIN, 5-28 VDC
31	DC Power In	POWER – Positive Power PIN, 5-28 VDC
32	DC Power In	POWER – Positive Power PIN, 5-28 VDC
33	GND	POWER- GROUND
34	GND	POWER- GROUND

* 3.3VTTL output pre-biased with a 100 Ohm resistor, current limited to 5 mA. Connect directly to the anode of an LED as long as your forward voltage is in the 2.0-2.8 V range. Application requiring brighter LEDs requiring more than 5mA should be buffered.

1PPS and ASCII time tag

The BD960 receiver can output a 1 pulse-per-second (1PPS) time strobe and an associated time tag message. The time tags are output on a user-selected port.

The leading edge of the pulse coincides with the beginning of each UTC second. The pulse is driven between nominal levels of 0.0 V and 3.3 V (see Figure E.1. The leading edge is positive (rising from 0 V to 3.3 V).

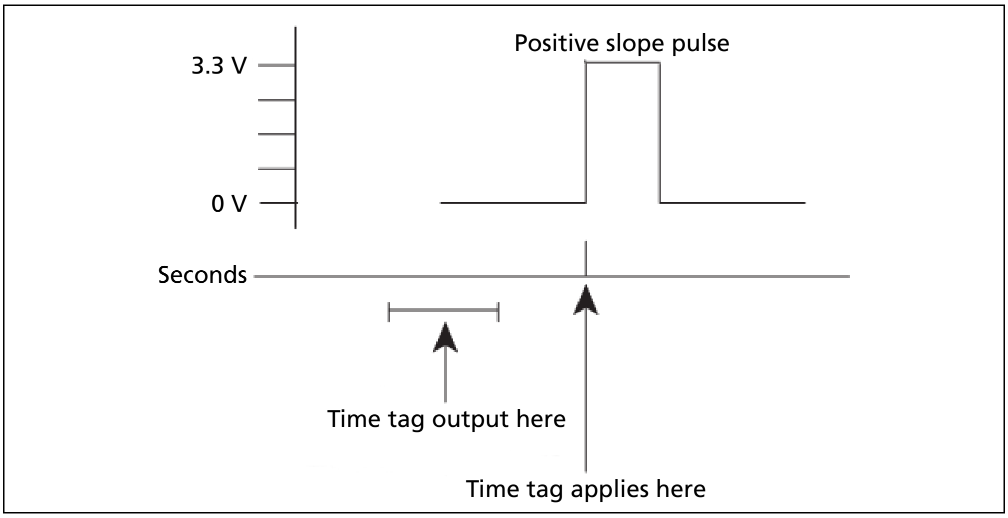


Figure E.1 Time tag relation to 1PPS wave form

The pulse is about 8 microseconds wide, with rise and fall times of about 100 nsec. Resolution is approximately 40 nsec, but the following external factor limits accuracy to approximately ±1 microsecond:

- Antenna cable length

  Each meter of cable adds a delay of about 2 nsec to satellite signals, and a corresponding delay in the 1PPS pulse.

ASCII time tag

Each time tag is output about 0.5 second before the corresponding pulse. Time tags are in ASCII format on a user-selected serial port. The format of a time tag is:

UTC *yy.mm.dd hh:mm:ss ab*

Where:

- UTC is fixed text.
- *yy.mm.dd* is the year, month, and date.
- *hh:mm:ss* is the hour (on a 24-hour clock), minute, and second. The time is in UTC, not GPS.
- *a* is an integer number representing the position-fix type:

  1 = time only
  2 = 1D & time
  3 = currently unused
  4 = 2D & time
  5 = 3D & time
- *b* is number of GPS satellites being tracked.
- Each time tag is terminated by a *carriage return, line feed* sequence. A typical printout looks like:

  UTC 02.12.21 20:21:16 56

  UTC 02.12.21 20:21:17 56

  UTC 02.12.21 20:21:18 56

Note – *If the receiver is not tracking satellites, the time tag is based on the receiver clock. In this case, a and b are represented by "??". The time readings from the receiver clock are less accurate than time readings determined from the satellite signals.*

Glossary

1PPS	Pulse-per-second. Used in hardware timing. A pulse is generated in conjunction with a time stamp. This defines the instant when the time stamp is applicable.
almanac	A file that contains orbit information on all the satellites, clock corrections, and atmospheric delay parameters. The almanac is transmitted by a GPS satellite to a GPS receiver, where it facilitates rapid acquisition of GPS signals when you start collecting data, or when you have lost track of satellites and are trying to regain GPS signals. The orbit information is a subset of the emphemeris / ephemerides data.
base station	Also called *reference station*. A base station in construction, is a receiver placed at a known point on a job site that tracks the same satellites as an RTK rover, and provides a real-time differential correction message stream through radio to the rover, to obtain centimeter level positions on a continuous real-time basis. A base station can also be a part of a virtual reference station network, or a location at which GPS observations are collected over a period of time, for subsequent postprocessing to obtain the most accurate position for the location.
carrier	A radio wave having at least one characteristic (such as frequency, amplitude, or phase) that can be varied from a known reference value by modulation.
carrier frequency	The frequency of the unmodulated fundamental output of a radio transmitter. The GPS L1 carrier frequency is 1575.42 MHz.
carrier phase	Is the cumulative phase count of the GPS or GLONASS carrier signal at a given time.
cellular modems	A wireless adaptor that connects a laptop computer to a cellular phone system for data transfer. Cellular modems, which contain their own antennas, plug into a PC Card slot or into the USB port of the computer and are available for a variety of wireless data services such as GPRS.
CMR **CMR+**	Compact Measurement Record. A real-time message format developed by Trimble for broadcasting corrections to other Trimble receivers. CMR is a more efficient alternative to RTCM.
covariance	A statistical measure of the variance of two random variables that are observed or measured in the same mean time period. This measure is equal to the product of the deviations of corresponding values of the two variables from their respective means.
datum	Also called *geodetic datum*. A mathematical model designed to best fit the geoid, defined by the relationship between an ellipsoid and, a point on the topographic surface, established as the origin of the datum. World geodetic datums are typically defined by the size and shape of an ellipsoid and the relationship between the center of the ellipsoid and the center of the earth. Because the earth is not a perfect ellipsoid, any single datum will provide a better model in some locations than in others. Therefore, various datums have been established to suit particular regions. For example, maps in Europe are often based on the European datum of 1950 (ED-50). Maps in the United States are often based on the North American datum of 1927 (NAD-27) or 1983 (NAD-83). All GPS coordinates are based on the WGS-84 datum surface.
deep discharge	Withdrawal of all electrical energy to the end-point voltage before the cell or battery is recharged.
DGPS	See real-time differential GPS.

differential correction Differential correction is the process of correcting GPS data collected on a rover with data collected simultaneously at a base station. Because the base station is on a known location, any errors in data collected at the base station can be measured, and the necessary corrections applied to the rover data.

Differential correction can be done in real-time, or after the data has been collected.

differential GPS See real-time differential GPS.

DOP Dilution of Precision. A measure of the quality of GPS positions, based on the geometry of the satellites used to compute the positions. When satellites are widely spaced relative to each other, the DOP value is lower, and position accuracy is greater. When satellites are close together in the sky, the DOP is higher and GPS positions may contain a greater level of error.

PDOP (Position DOP) indicates the three-dimensional geometry of the satellites. Other DOP values include HDOP (Horizontal DOP) and VDOP (Vertical DOP), which indicate the accuracy of horizontal measurements (latitude and longitude) and vertical measurements respectively. PDOP is related to HDOP and VDOP as follows: $PDOP^2 = HDOP^2 + VDOP^2$

dual-frequency GPS A type of receiver that uses both L1 and L2 signals from GPS satellites. A dual-frequency receiver can compute more precise position fixes over longer distances and under more adverse conditions because it compensates for ionospheric delays.

EGNOS European Geostationary Navigation Overlay Service. A satellite-based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. EGNOS is the European equivalent of WAAS, which is available in the United States.

elevation mask The angle below which the receiver will not track satellites. Normally set to 10 degrees to avoid interference problems caused by buildings and trees, atmospheric issues, and multipath errors.

ellipsoid An ellipsoid is the three-dimensional shape that is used as the basis for mathematically modeling the earth's surface. The ellipsoid is defined by the lengths of the minor and major axes. The earth's minor axis is the polar axis and the major axis is the equatorial axis.

emphemeris / ephemerides A list of predicted (accurate) positions or locations of satellites as a function of time. A set of numerical parameters that can be used to determine a satellite's position. Available as broadcast ephemeris or as postprocessed precise ephemeris.

epoch The measurement interval of a GPS receiver. The epoch varies according to the measurement type: for real-time measurement it is set at one second; for postprocessed measurement it can be set to a rate of between one second and one minute. For example, if data is measured every 15 seconds, loading data using 30-second epochs means loading every alternate measurement.

feature A feature is a physical object or event that has a location in the real world, which you want to collect position and/or descriptive information (attributes) about. Features can be classified as surface or non-surface features, and again as points, lines/breaklines, or boundaries/areas.

firmware The program inside the receiver that controls receiver operations and hardware.

GLONASS Global Orbiting Navigation Satellite System. GLONASS is a Soviet space-based navigation system comparable to the American GPS system. The operational system consists of 21 operational and 3 non-operational satellites in 3 orbit planes.

GNSS Global Navigation Satellite System.

GSOF	General Serial Output Format. A Trimble proprietary message format.
HDOP	Horizontal Dilution of Precision. HDOP is a DOP value that indicates the accuracy of horizontal measurements. Other DOP values include VDOP (vertical DOP) and PDOP (Position DOP). Using a maximum HDOP is ideal for situations where vertical precision is not particularly important, and your position yield would be decreased by the vertical component of the PDOP (for example, if you are collecting data under canopy).
L1	The primary L-band carrier used by GPS and GLONASS satellites to transmit satellite data.
L2	The secondary L-band carrier used by GPS and GLONASS satellites to transmit satellite data.
L2C	A modernized code that allows significantly better ability to track the L2 frequency.
L5	The third L-band carrier used by GPS satellites to transmit satellite data. L5 will provide a higher power level than the other carriers. As a result, acquiring and tracking weak signals will be easier.
Moving Base	Moving Base is an RTK positioning technique in which both reference and rover receivers are mobile. Corrections are sent from a “base” receiver to a “rover” receiver and the resultant baseline (vector) has centimeter-level accuracy.
MSAS	MTSAT Satellite-Based Augmentation System. A satellite-based augmentation system (SBAS) that provides a free-to-air differential correction service for GPS. MSAS is the Japanese equivalent of WAAS, which is available in the United States.
multipath	Interference, similar to ghosts on an analog television screen, that occurs when GPS signals arrive at an antenna having traversed different paths. The signal traversing the longer path yields a larger pseudorange estimate and increases the error. Multiple paths can arise from reflections off the ground or off structures near the antenna.
NMEA	National Marine Electronics Association. NMEA 0183 defines the standard for interfacing marine electronic navigational devices. This standard defines a number of 'strings' referred to as NMEA strings that contain navigational details such as positions. Most Trimble GPS receivers can output positions as NMEA strings.
OmniSTAR	The OmniSTAR HP/XP service allows the use of new generation dual-frequency receivers with the OmniSTAR service. The HP/XP service does not rely on local reference stations for its signal, but utilizes a global satellite monitoring network. Additionally, while most current dual-frequency GPS systems are accurate to within a meter or so, OmniSTAR with XP is accurate in 3D to better than 30 cm.
PDOP	Position Dilution of Precision. PDOP is a DOP value that indicates the accuracy of three-dimensional measurements. Other DOP values include VDOP (vertical DOP) and HDOP (Horizontal Dilution of Precision). Using a maximum PDOP value is ideal for situations where both vertical and horizontal precision are important.

real-time differential GPS	Also known as *real-time differential correction* or *DGPS*. Real-time differential GPS is the process of correcting GPS data as you collect it. Corrections are calculated at a base station and then sent to the receiver through a radio link. As the rover receives the position it applies the corrections to give you a very accurate position in the field. Most real-time differential correction methods apply corrections to code phase positions. While DGPS is a generic term, its common interpretation is that it entails the use of single-frequency code phase data sent from a GPS base station to a rover GPS receiver to provide sub-meter position accuracy. The rover receiver can be at a long range (greater than 100 kms (62 miles)) from the base station.
rover	A rover is any mobile GPS receiver that is used to collect or update data in the field, typically at an unknown location.
RTCM	Radio Technical Commission for Maritime Services. A commission established to define a differential data link for the real-time differential correction of roving GPS receivers. There are three versions of RTCM correction messages. All Trimble GPS receivers use Version 2 protocol for single-frequency DGPS type corrections. Carrier phase corrections are available on Version 2, or on the newer Version 3 RTCM protocol, which is available on certain Trimble dual-frequency receivers. The Version 3 RTCM protocol is more compact but is not as widely supported as Version 2**.**
RTK	real-time kinematic. A real-time differential GPS method that uses carrier phase measurements for greater accuracy.
SBAS	Satellite-Based Augmentation System. SBAS is based on differential GPS, but applies to wide area (WAAS/EGNOS and MSAS) networks of reference stations. Corrections and additional information are broadcast via geostationary satellites.
signal-to-noise ratio	SNR. The signal strength of a satellite is a measure of the information content of the signal, relative to the signal's noise. The typical SNR of a satellite at 30° elevation is between 47 and 50 dBHz.
skyplot	The satellite skyplot confirms reception of a differentially corrected GPS signal and displays the number of satellites tracked by the GPS receiver, as well as their relative positions.
SNR	See signal-to-noise ratio.
triple frequency GPS	A type of receiver that uses three carrier phase measurements (L1, L2, and L5).
UTC	Universal Time Coordinated. A time standard based on local solar mean time at the Greenwich meridian.

WAAS Wide Area Augmentation System. WAAS was established by the Federal Aviation Administration (FAA) for flight and approach navigation for civil aviation. WAAS improves the accuracy and availability of the basic GPS signals over its coverage area, which includes the continental United States and outlying parts of Canada and Mexico.

The WAAS system provides correction data for visible satellites. Corrections are computed from ground station observations and then uploaded to two geostationary satellites. This data is then broadcast on the L1 frequency, and is tracked using a channel on the GPS receiver, exactly like a GPS satellite.

Use WAAS when other correction sources are unavailable, to obtain greater accuracy than autonomous positions. For more information on WAAS, refer to the FAA website at http://gps.faa.gov.

The EGNOS service is the European equivalent and MSAS is the Japanese equivalent of WAAS.

WGS-84 World Geodetic System 1984. Since January 1987, WGS-84 has superseded WGS-72 as the datum used by GPS.

The WGS-84 datum is based on the ellipsoid of the same name.

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