

# **Acutime™2000 Synchronization Kit**

**User Guide**



**Part Number 45005-00-ENG  
Revision C  
May 2002**

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- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
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### **European Community (CE) Directive Conformance Statement**

The Acutime 2000 GPS Smart Antenna conforms with the essential requirements of the EMC Directive 89/336/EEC. A Declaration of Conformity indicating the requirements met has been signed at Trimble Navigation Limited, 645 North Mary Avenue, Sunnyvale, CA 94086, USA.

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# About This Manual

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Welcome to the *Acutime 2000 Synchronization Kit User Guide*. This manual describes how to integrate the Acutime 2000 smart antenna with your host system.

## Scope and Audience

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, Trimble recommends that you do one of the following:

- Read the booklet *GPS, A Guide to the Next Utility* (available from Trimble).
- Complete the GPS tutorial at:
  - [www.trimble.com/gps](http://www.trimble.com/gps)

The following sections provide you with a guide to this manual, as well as to other documentation that you may have received with this product.

## Organization

This manual contains the following:

- Chapter 1, Introduction, describes the Acutime 2000 GPS smart antenna.
- Chapter 2, Getting Started, describes how to quickly install, connect and operate the Acutime 2000.
- Chapter 3, Acutime 2000 Installation, provides general installation guidelines.
- Chapter 4, Acutime 2000 Connections, provides detailed interfacing guidelines for connecting the Acutime 2000 GPS smart antenna to the host system.
- Chapter 5, System Operation, describes the operating characteristics of the Acutime 2000 from power-up through the output of GPS information. GPS timing applications are also described.
- Appendix A, Trimble Standard Interface Protocol, defines the TSIP protocol and the structure of all message packets.
- Appendix B, Timing Receiver Monitor, describes the monitor program included on the Acutime 2000 CD-ROM.
- Appendix C, NMEA 0183, provides a brief description of the NMEA 0183 protocol and defines the structure of the NMEA message output by the Acutime 2000.
- Appendix D, Specifications and Drawings, includes the specifications and mechanical drawings for the Acutime 2000 GPS smart antenna interface cables.
- Appendix E, Theory of Operation, gives a more detailed technical description of many of the Acutime 2000 GPS smart antenna's operating characteristics. A brief overview of the system architecture is also presented.
- The Glossary contains definitions of GPS and technical terms used in this manual.

## Reader Feedback

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## Related Information

The following sections discuss other sources of information that introduce, extend, or update this manual.

### Update Notes

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### Technical Assistance

If you have a problem and cannot find the information you need in the product documentation, ***contact your sales representative.***

Alternatively, request technical support via email at [trimble\\_support@trimble.com](mailto:trimble_support@trimble.com) or by phone at 1-800-767-4822.

## Abbreviations

In this manual, the following abbreviations are used:

- TSIP - Trimble Standard Interface Protocol
- host system or host - the device or instrument connected to the Acutime 2000 smart antenna

The host system can be a PC, network equipment, or timing system, depending on the application.

## Document Conventions

*Italics* identify software menus, menu commands, dialog boxes, and the dialog box fields.

SMALL CAPITALS identify user commands, directories, filenames, and filename extensions.

Helvetica represents messages printed on the screen.

**Courier Bold** represents information that you must type in a software screen or window.

**Helvetica Bold** identifies a software command button.

**Ctrl** is an example of a hardware function key that you must press on a personal computer (PC). If you must press more than one of these at the same time, this is represented by a plus sign, for example,

**Ctrl** + **C**.

## Cautions and Notes

Cautions, notes, and tips draw attention to important information and indicate its nature and purpose.



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**Caution** – Cautions describe operating procedures and practices required for correct operation and alert you to situations that could cause hardware damage or malfunction or software error.

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**Note** – Notes give additional significant information about the subject to increase your knowledge, or guide your actions.

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**Warning** – Warnings alert you to situations that could cause personal injury or unrecoverable data loss. A warning precedes the text it references.

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# 1 Introduction

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This chapter provides an overview of the Acutime 2000 GPS smart antenna.

## 1.1 Overview

The Acutime 2000 is the latest in the Trimble family of GPS smart antennas. The smart antenna allows OEMs and systems integrators to add GPS capability to their product lines quickly and easily, without becoming GPS experts. The Trimble Acutime 2000 GPS smart antenna encompasses the experience of four product lines: Acutis™, Acutime™, Acutime™ II and Palisade™.

The Acutime 2000, using Trimble's latest GPS technology, is designed for wireless voice and data network synchronization. It offers precise PPS output, event input, and also supports long cable runs.

The Acutime 2000 is composed of a set of matched subsystems. This ensures optimal GPS performance, long-term reliability, ease of operation, and easy integration.

The Acutime 2000 houses the GPS receiver, antenna, power supply, interface and other support circuitry in a single enclosure that mounts like an antenna. As a sealed, shielded, self-contained unit with a digital interface, the Acutime 2000 eliminates most of the difficulties associated with integrating GPS. Once power is applied, the Acutime 2000 self-initializes, acquires satellite signals, and computes position and time, automatically outputting this data to the host system.

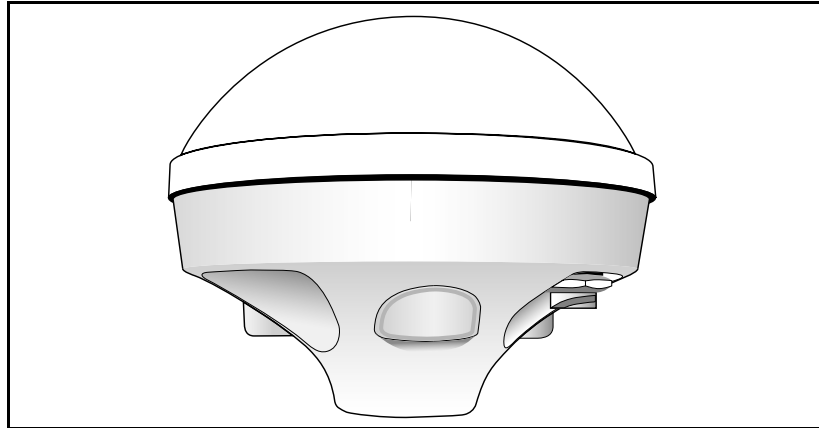
To integrate the Acutime 2000, the OEM only needs to add a standard serial interface port on the host system and develop a software interface. Commonly used interface protocols, such as NMEA 0183, and the software interface tool (the Timing Receiver Monitor), simplify this task, minimizing the engineering costs associated with integrating the Acutime 2000.

## 1.2 Acutime 2000 GPS Smart Antenna Features

The Acutime 2000 has many features common to previous products in the Trimble family of smart antennas, including:

- an 8 to 36-volt DC power supply with protection against reverse polarity.
- Trimble's advanced multi-channel GPS receiver architecture, including:
  - the reference oscillator
  - the synthesizer and IF circuits
  - the digital signal processing hardware
  - a microprocessor
  - the serial interface circuitry
- a patch GPS antenna with a proprietary pre-amp design for excellent performance against jamming signals.
- a sealed, waterproof connector supporting both the power and interface connections.

- a waterproof, UV-resistant, plastic (polycarbonate) enclosure with a proven epoxy seal.  
(The enclosure is illustrated in Figure 1-1).



**Figure 1-1 Acutime 2000 GPS Smart Antenna Enclosure**

Acutime 2000 generates a PPS synchronized to UTC within 50 nanoseconds (one sigma). This level of precision is obtained using an overdetermined time solution, an 80-nanosecond pulse steering resolution and a T-RAIM (Time-Receiver Autonomous Integrity Monitor) algorithm. The Acutime 2000's PPS conforms to RS-422, which supports long cable runs. The Acutime 2000 outputs a comprehensive time packet after each PPS on a dedicated serial port. It also features an automatic operating mode that requires no user or host intervention. The Acutime 2000 accepts an event input and reports time stamps in response to an external event signal.

The Acutime 2000 is available in the following configurations:

- Acutime 2000 with RS-422 Interface and 8-channel receiver
- Acutime 2000 with RS-232 Interface and 8-channel receiver

### 1.3 Starter Kit

The Acutime 2000 Synchronization Kit includes the following:

- Acutime 2000 with RS-422 interface and 8-channel receiver
- Acutime 2000 User Guide
- 100' interface cable with DB25 connectors
- RS-422 to RS-232 converter
- Timing Receiver Monitor software
- Power Supply

For information about Acutime 2000 interface cables, see Chapter 4, Acutime 2000 Connections.

For information about part numbers, refer to:

- [www.trimble.com/products/acutime2000](http://www.trimble.com/products/acutime2000)

## 2 Getting Started

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This chapter describes how to quickly install, connect and communicate with the Acutime 2000 GPS Smart Antenna.



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**Note** – For permanent installations, see the instructions in Chapter 3.

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You will need the following items:

- a PC running Windows
- the Timing Receiver Monitor software for Windows (also available on the web site)
- an interface cable for the smart antenna
- an RS-422 to RS-232 converter (included in the Acutime 2000 Starter Kit)

You may require this if you are using an Acutime 2000 with an RS-422 interface. In many cases, however, a PC's communication port is flexible enough to accept an RS-422 signal without a converter.

- connectors/adapters for connecting the interface cable to the PC's communication port

The interface cable included in the Acutime 2000 Starter Kit is terminated with a DB25 connector. The standard interface cables are not terminated with connectors.

- a DC power source

The Acutime 2000 accepts 8-36 V DC power, and draws approximately 110 milliamps at 12 volts.

- A mounting pole  
The Acutime 2000 accepts a standard 1"-14 straight thread.

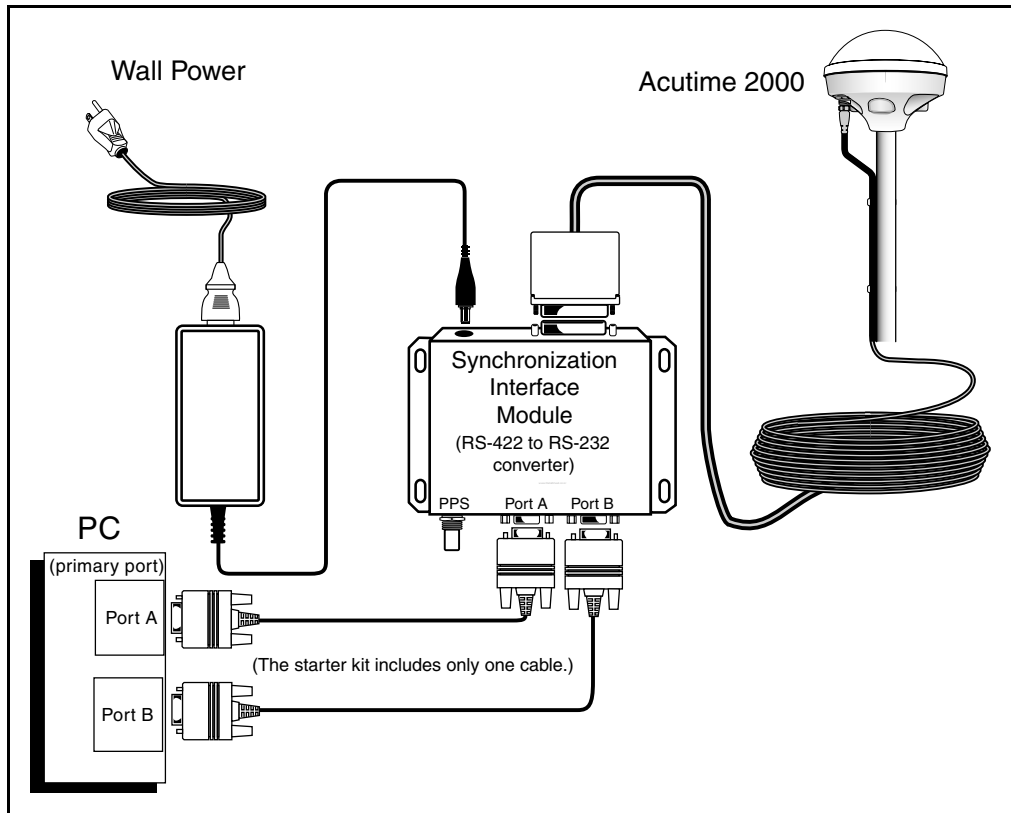
## 2.4 Connecting the Smart Antenna

The Acutime 2000 can be placed anywhere with a clear view of the sky.

Connect the interface cable to the smart antenna. The connector on the interface connector has a locking ring for securing the connection.

## 2.5 Connecting the Computer and Power Source

The connection instructions illustrated in Figure 2-1 assume use of the Trimble interface cable included in the Synchronization Kit. If you are using your own cable, modify the instructions accordingly.



**Figure 2-1 Connection Diagram**

## 2.6 Communicating with the Acutime 2000

When power is applied, the Acutime 2000 acquires a valid set of satellites and automatically transmits position and time messages. During the satellite acquisition process, the Acutime 2000 outputs periodic status messages.

To begin communicating with the Acutime 2000, start the Timing Receiver Monitor program. Data fields in the Timing Receiver Monitor program fill up as the data becomes available. For more information, see Appendix B, Timing Receiver Monitor.



# 3 Acutime 2000 Installation

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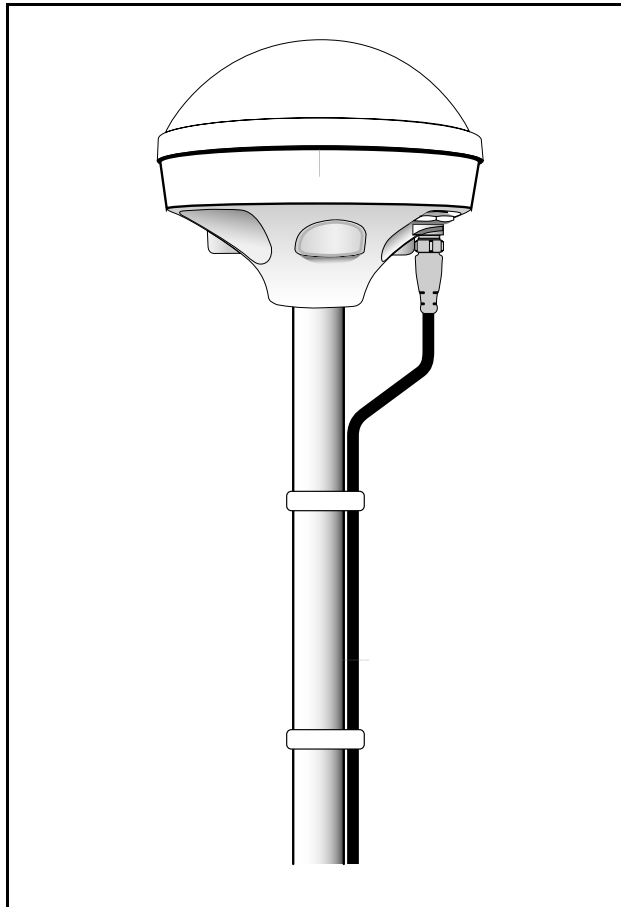
This chapter provides installation guidelines for the Acutime 2000 GPS smart antenna. Installation of the Acutime 2000 requires four steps:

1. Choosing a location.
2. Mounting the smart antenna.
3. Routing and securing the interface cable.
4. Connecting the host system.

Each of these installation steps is described on the following pages.

## 3.1 Choosing a Location

Select an outdoor location for the antenna (such as the roof of your building) that has a relatively unobstructed view of the sky. Consider the length of the cable run and the length of the interface cable when selecting a location. The Acutime 2000 GPS smart antenna is designed for a pole mount. (The mounting pole is not included with the Acutime 2000.) Pole mounting is illustrated in Figure 3-1.



**Figure 3-1 Mounted Antenna**

The antenna can receive satellite signals through glass, canvas, and thin fiberglass, but dense wood, concrete and metal structures shield the antenna from satellite signals.

The Acutime 2000 GPS smart antenna contains an active antenna. For optimal performance, place it as far as possible from transmitting antennas, including radars, satellite communication equipment and cellular transmitters. When locating the antenna near a radar

installation, ensure that the antenna is positioned outside of the radar's cone of transmission. When installing the antenna near satellite communication equipment, follow the same guideline. For best results, mount the antenna below and at least ten feet away from satellite communication equipment.

For installations exposed to shock or vibration exceeding the limits specified in Appendix D, Specifications and Drawings, use a mounting scheme that isolates the Acutime 2000 from the excessive shock or vibration.

## 3.2 Mounting the Smart Antenna

The smart antenna is designed for a pole mount, as illustrated in Figure 3-1. The threaded socket in the base of the antenna accepts a standard 1"-14 straight thread. A wide variety of 1"-14 pole mounts are available from marine hardware suppliers.

After obtaining an appropriate mounting pole, follow these simple steps to install the Acutime 2000 GPS smart antenna.

1. Secure the mounting pole to a solid structure so that it is oriented vertically.
2. Thread the smart antenna onto the pole or pipe and hand-tighten until snug.



---

**Caution** – Do not over-tighten the smart antenna on the pole or use a tool—this could damage the threaded socket in the base of the antenna. Also, do not use a thread-locking compound because it can damage the plastic housing.

---

3. Connect the interface cable to the smart antenna.

The connector on the interface connector has a locking ring for securing the connection.



---

**Caution** – Do not over-tighten the locking ring—this can strip the connector.

---

### 3.3 Routing and Securing the Interface Cable

After the smart antenna is mounted:

1. Route the interface cable from the smart antenna to the host location.



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**Note** – The interface cable is a digital cable, so it can be spliced and extended, if necessary.

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Choose the most direct path to the host system, while avoiding the following hazards:

- sharp bends or kinks in the cable
  - hot surfaces (exhaust manifolds or stacks)
  - rotating or reciprocating equipment
  - sharp or abrasive surfaces
  - door and window jambs
  - corrosive fluids or gases
2. When you have established the ideal cable routing, secure the cable along the routing using tie-wraps.

When securing the cable, start at the antenna and work towards the host system. To provide strain relief for the interface cable connections, ensure that the cable is secured at points close to the smart antenna and the host system.



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**Note** – Additional protection (for example, heat-shrink tubing) may be required to protect the cable jacket at points where the cable enters or exits bulkheads, especially if the opening is rough or sharp.

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3. Once the cable is secured, the host end of the cable can be cut to an appropriate length (if necessary).

Leave enough slack to allow for easy connection to the host and normal movement (for example, rack, gimbal or swivel mounts).

### **3.4 Connecting the Host System**

The final step, if applicable, is the installation of the connector on the host end of the cable. The connector installation instructions depend on the type of connector required by the host system.

For information on pin-outs, see Chapter 4, Acutime 2000 Connections.



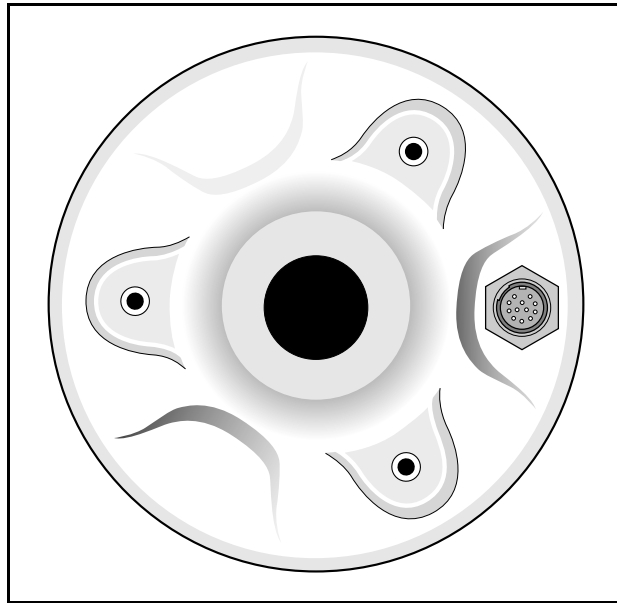
# 4 Acutime 2000 Connections

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This chapter provides instructions on connecting the Acutime 2000 to the host system and power source.

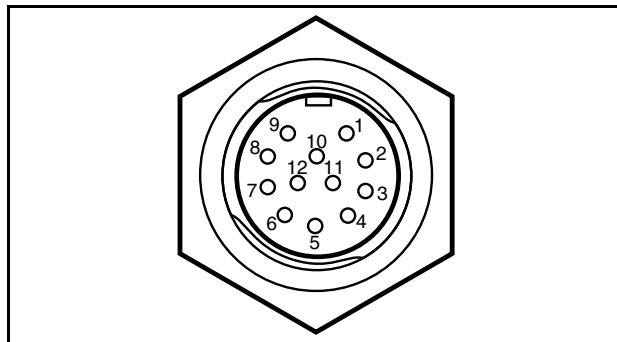
## 4.1 Interface and Power Connections

The black plastic connector located in the base of the Acutime 2000 supports both the interface and power connections. The Acutime 2000 uses a 12-pin connector. Figure 4-1 illustrates the location of the connector.



**Figure 4-1 Acutime 2000 Interface Connector**

Figure 4-2 illustrates the pin arrangement for this connector.



**Figure 4-2 Acutime 2000 12-pin Connector format**



## 4.2 Interface Cables and Connectors

Interface cables for the Acutime 2000 are available in the following standard lengths.

- 50' (15-meter)
- 100' (30-meter)
- 200' (60-meter)
- 400' (120-meter)

Contact Trimble for custom-length cables up to 300 m.

For a list of part numbers, refer to:

- [www.trimble.com/products/acutime2000](http://www.trimble.com/products/acutime2000)

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**Note** – The standard interface cables offered by Trimble are not terminated on the host end, so the appropriate connector must be installed before connecting the cable to the host system.

---

For OEMs and integrators who want to produce their own interface cables, Table 4-3 specifies the source and part number of the mating cable connectors for the 12-pin connector.

**Table 4-1 Mating Connectors**

Antenna Connector	Mating Connector	Manufacturer	Description
MMP Series #68001-2212P1	MMP Series #26C-2212S1	Deutsch Commercial Products 5733 W. Whittier Avenue Hemet, California 92545 Phone: (909) 765-2200 Fax: (909) 922-1544	Connector body (requires a molded backshell)

## 4.2.1 Pin-Outs

Table 4-2 lists the pin-out descriptions and color codes for the standard interface cables.

**Table 4-2 Acutime 2000 RS-422 Cable Pin-Out**

Signal Description	Wire Color	Protocol	Acutime 2000 Connector
DC Power (+8 to +36 Volts DC)	Red	+8 to 36 V	Pin 1
Port B: RS-422 / Receive	Violet	TSIP RS422	Pin 2
Port B: RS-422 / Receive +	Orange	TSIP RS422	Pin 3
Port B: RS-422 / Transmit -	Brown	TSIP RS422	Pin 4
Port B: RS-422 / Transmit +	Yellow	TSIP RS422	Pin 5
Port A: RS-422 / Receive -	White	Event Input / RTCM RS422	Pin 6
Port A: RS-422 / Receive +	Gray	Event Input/ RTCM RS422	Pin 7
Port A: RS-422 / Transmit -	Green	NMEA / TSIP RS422	Pin 8
DC Ground	Black	Ground	Pin 9
Port A: RS-422 / Transmit +	Blue	NMEA / TSIP RS422	Pin 10
One PPS: Transmit +	Orange w/ White stripe	RS422	Pin 11
One PPS: Transmit -	Black w/ White stripe	RS422	Pin 12

**Table 4-3 Acutime 2000 RS-232 Cable Pin-Out**

Signal Description	Wire Color	Protocol	Acutime 2000 Connector
DC Power	Red	+8 to +36V	Pin 1
Port B: RS-232 Receive	Violet	TSIP RS232	Pin 2
Not Used	Orange	Not Used	Pin 3
Port B: RS-232 Transmit	Brown	TSIP RS232	Pin 4
Not Used	Yellow	Not Used	Pin 5
Port A: RS-232 Receive	White	Event Input/RTCM	Pin 6
Port A: RS-232 Transmit	Gray	TSIP RS232	Pin 7
Vback	Green	Battery Backup	Pin 8
DC Ground	Black	Ground	Pin 9
Not Used	Blue	Not Used	Pin 10
One PPS: Transmit +	Orange/White	RS422	Pin 11
One PPS: Transmit -	Black/White	RS422	Pin 12




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**Note** – The cable color codes listed in this table apply only if you are using the Trimble interface cable.

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**Note** – Receive and Transmit are with respect to the Acutime 2000 GPS smart antenna. The host Transmit should be connected to the Acutime 2000's Receive, and vice versa.

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**Note** – The Acutime 2000 with an RS-232 interface is designed especially for short cable runs (usually under 50 feet). For longer cable runs, an RS-422 interface is recommended.

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## 4.3 Connection Instructions

This section provides detailed information for connecting the Acutime 2000's power, timing pulse and data packet lines.

### 4.3.1 Power Connection (Red and Black Wires)

The red wire (Acutime 2000 pin #1) and black wire (Acutime 2000 pin #9) in the interface cable support the power and ground connections, respectively. The Acutime 2000 features a switching DC power supply, which accepts from 8 to 36 volts. The Acutime 2000 is protected against reverse polarity and brief over-voltage conditions; however, sustained over-voltage conditions can cause permanent damage.



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**Warning** – Voltages exceeding 36 volts can cause permanent damage to the Acutime 2000's power supply.

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The typical power consumption of the Acutime 2000 at an input voltage of 12 volts is 110 milliAmps, or 1.3 watts.



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**Note** – The Acutime 2000 requires a minimum of 8 volts at the interface connector. When specifying the supply voltage, line losses in the interface cable must be considered. To account for line loss, the supply voltage may need to exceed 8 volts to satisfy the minimum voltage at the Acutime 2000.

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### 4.3.2 Timing Pulse Connections

The Acutime 2000 outputs a timing pulse for use in timing and synchronization applications. The timing pulse is generated using an RS-422 line driver circuit (pins #11 and #12). The leading edge of the PPS output pulse is synchronized to UTC. The width of the pulse's leading edge is 20 nanoseconds or less. The exact width and shape of the pulse depends on the distributed capacitance in the interface cable.

For more information on using the timing pulse, see Chapter 5, System Operation.

### 4.3.3 Serial Port Connections

The recommended use of the serial ports on the Acutime 2000 for most users is as follows:

- Use Port B to configure the Acutime 2000 as necessary.
- Disable the automatic output packets on Port B using command packet 8E-A5.
- Use Port B to transmit the desired timing packet.
- Use Port B to query for specific satellite data as needed.
- Use the Port A receive line to time-tag external events or input RTCM data.

If you have two serial ports, use ports A and B on the Acutime 2000 as follows:

- Use Port B to configure the Acutime 2000 as necessary.
- Use Port A to transmit the desired timing packet.
- Use Port B to query for specific satellite data as needed.
- Use the Port A receive line to time-tag external events or input RTCM data.

#### Port B

Port B is the primary serial port for the Acutime 2000. You can send commands, receive command replies, and query for and receive a variety of satellite data (for example, ephemeris, tracking information, signal levels, and so on) using Port B. You can also receive timing packets that are synchronized with the PPS output on Port B.

TSIP timing packets 8F-0B, 8F-AB and 8F-AC (which work together as a pair of packets) or 8F-AD can be enabled on Port B using command packet 8E-A5. These packets are sent within 30 milliseconds after the PPS pulse when enabled.

By default, the Acutime 2000 automatically sends a variety of satellite data packets on Port B that you may not need. You can disable these automatic output packets with command packet 8E-A5 so that only the timing packets are sent. You can also choose to receive these timing packets on Port A, which serves as a dedicated transmit port for timing packets, and use Port B to send commands and receive satellite data.

Port B can also be configured to transmit NMEA packets, but these packets are not guaranteed to be sent within 30 milliseconds after the PPS output.

### **Port A**

By default, the Port A receive line is used to receive external event inputs as described below; however, Port A can also receive serial RTCM (differential corrections.) When you enable RTCM messages on Port A (by sending command packets on Port B), the event input mechanism is automatically disabled. When RTCM messages are off (the default state), the event input mechanism is automatically enabled.

#### **4.3.4 Event Input**

The Acutime 2000 accepts an external event input in the form of an RS-422 pulse. The external event pulse input is supported on Port A (pins #6 and #7). The Acutime 2000 transmits a TSIP time packet (8Fx0B or 8FxAD) in response to the event input. The TSIP packet increments the event count field for each event received.

The event time stamp is generated within 320 nanoseconds of arrival at the Acutime 2000's interface connector. The precision of the time stamp is subject to Selective Availability.



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**Note** – These Port A pins are shared between the external event input and serial RTCM message inputs. When differential GPS is enabled, this input is set up to receive RTCM messages. When differential GPS is off, this input is set up to receive external event signals.

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# 5 System Operation

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This chapter describes the operating characteristics of the Acutime 2000 GPS smart antenna, including start-up, satellite acquisition, operating modes, serial data communication, and the timing pulse. The Acutime 2000 acquires satellites and computes position and time solutions. It outputs data in the TSIP (or NMEA) protocol through its serial ports.

For more technical information on system operation, see Appendix F, Theory of Operation .

## 5.1 Start-Up

At power-up, the Acutime 2000 automatically begins to acquire and track GPS satellite signals. It typically obtains its first fix in under two minutes.

During the satellite acquisition process, the Acutime 2000 outputs periodic TSIP status messages on Port B. These status messages confirm that the receiver is working.



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**Note** – The Acutime 2000 has no provision for external backup power and always begins operation from a cold start unless a warm start is forced by uploading almanac data and time.

---

## 5.2 Automatic Operation

When the Acutime 2000 has acquired and locked onto a set of satellites that pass the mask criteria listed below, and has obtained a valid ephemeris for each satellite, it performs a self-survey. After a number of position fixes, lasting approximately 40 minutes, the self-survey is complete. At that time, the Acutime 2000 automatically switches to a time-only mode and periodic outputs of navigation information cease.

### 5.2.1 Satellite Masks

The Acutime 2000 continuously tracks and uses up to eight satellites in an overdetermined clock solution. The satellites must pass the mask criteria to be included in the solution.

Table 5-1 lists the default satellite masks used by the Acutime 2000. These masks serve as the screening criteria for satellites used in fix computations and ensure that solutions meet a minimum level of accuracy. The satellite masks can be adjusted using the TSIP protocol described in Appendix A, Trimble Standard Interface Protocol.

**Table 5-1 Default Satellite Mask Settings**

Mask	Setting	Notes
Elevation	10°	SV elevation above horizon
SNR	4	Signal strength
DOP	8	Self-survey only

#### Elevation Mask

Satellites below 10° elevation are not used in the solution. Generally, signals from low-elevation satellites are of poorer quality than signals from higher elevation satellites. These signals travel farther through the ionospheric and tropospheric layers and undergo distortion due to these atmospheric conditions.

### SNR Mask

Although the Acutime 2000 is capable of tracking signals with SNRs as low as 2, the default SNR mask is set to 4 to eliminate poor quality signals from the fix computation. Low SNR values can result from:

- low-elevation satellites
- partially obscured signals (for example, dense foliage)
- multi-reflected signals (multipath)

Multi-reflected signals, also known as multipath, can degrade the position solution. Multipath is most commonly found in urban environments with many tall buildings and a preponderance of mirrored glass. Multi-reflected signals tend to be weak (low SNR value), since each reflection diminishes the signal. Setting the SNR mask to 4 or higher minimizes the impact of multi-reflected signals.

### PDOP Mask

Position Dilution of Position (PDOP) is a measure of the error caused by the geometric relationship of the satellites used in the position solution. Satellite sets that are tightly clustered or aligned in the sky have a high PDOP and contribute to a lower position accuracy. For most applications, a PDOP mask of 8 offers a satisfactory trade-off between accuracy and GPS coverage. With worldwide GPS coverage, the PDOP mask can be lowered even more for many applications without sacrificing coverage.



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**Note** – PDOP is only applicable during self-survey or whenever the receiver is performing position fixes.

---

## 5.2.2 Tracking Modes

The Acutime 2000 operates in one of two main fix modes:

- Self-Survey (Position fix mode)
- Overdetermined Clock mode

After establishing a reference position in Self-Survey mode, the Acutime 2000 automatically switches to Overdetermined (OD) Clock mode.

### Self-Survey Mode

At power-on, the Acutime 2000 performs a self-survey by averaging 2000 position fixes. The number of position fixes until survey completion is configurable using the 8E-4B or 8E-A9 command.

The default mode during self-survey is 3-D manual, where the receiver must obtain a 3-D solution with a PDOP below both the PDOP mask and PDOP switch. The PDOP mask and switch criteria can be set and queried using a TSIP packet. If fewer than four conforming satellites are visible, the Acutime 2000 suspends data output.

The highest accuracy fix mode is 3-D manual, where altitude is always calculated along with the latitude, longitude, and time. Obtaining a position requires four satellites with a PDOP below the PDOP mask. Depending on how the PDOP mask is set, 3-D mode can be restrictive when the receiver is subjected to frequent obscuration or when the geometry is poor due to an incomplete constellation.

If only a 2-D solution is desired, or if the exact altitude is known, 2-D manual should be requested. In this case, the receiver uses either the last altitude obtained in a 3-D fix, or the altitude supplied by the user. Any error in the assumed altitude affects the accuracy of the latitude and longitude solution. Use packet BB to set the desired position fix mode.



---

**Note** – Altitude and the fix mode are stored in non-volatile memory.

---

### **Overdetermined Clock Mode**

Overdetermined Clock Mode is used only in stationary timing applications. This is Acutime 2000's default mode. After the Acutime 2000 self-surveys its static reference position, it automatically switches to Overdetermined Clock Mode and determines the clock solution. The timing solution is qualified by a T-RAIM algorithm, which automatically detects and rejects faulty satellites from the solution.

In this mode, the Acutime 2000 does not navigate or update positions and velocities, but maintains the PPS output, solving only for the receiver clock error (bias) and error rate (bias rate).

### 5.2.3 PPS Output Options

The PPS (Pulse Per Second) output is the primary timing output generated by the Acutime 2000. In all configurations of the product, the PPS output is provided through a RS-422 differential driver. Although using a RS-422 differential receiver to receive the PPS provides the best noise immunity, you can use just one side of the differential signal for single-ended applications.

You can program the characteristics of the PPS output using TSIP packets. Packet 0x8E-4A allows you to enable or disable (turn it on or off), control the polarity, select the time base (GPS or UTC) and set the offset (control the cable delay compensation) of the PPS output. Packet 0x8E-4E allows you to set an accuracy criterion for the generation of the PPS signal based on the number of usable satellites. The accuracy of the PPS output depends to some degree on the number of satellites used in the solution that determine the placement of the PPS output. In some systems, it is preferable to have the PPS generated only when it meets the highest levels of accuracy and to leave it off if these accuracy levels are not met. Packet 0x8E-4F allows you to select the width of the PPS output from 10 us to 500 ms.



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**Note** – For a complete description of the packets described here, see Appendix A, Trimble Standard Interface Protocol.

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### 5.2.4 PPS Quantization Error

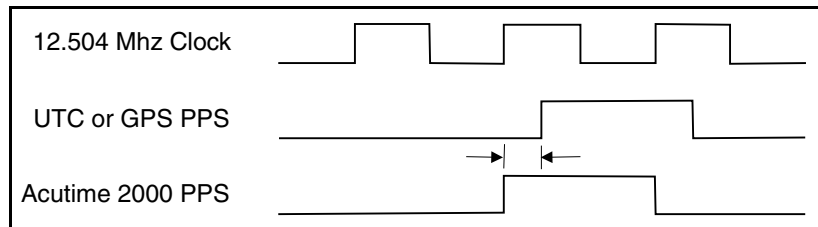
The Acutime 2000 uses a high-precision, fixed-frequency oscillator as the timing source to down-convert and decode the GPS signal and to generate the PPS output signal. Since a fixed-frequency oscillator is used, the Acutime 2000 must place the PPS output on the clock edge that it determines is closest to UTC or GPS. This situation results in a quantization error on the placement of the PPS whose magnitude is equal to one-half the period of the fixed frequency oscillator. The oscillator frequency is 12.504 MHz, which is equivalent to a period just under 80 nanoseconds; therefore, the quantization error on the PPS output is between +/-40ns.

Figure 5-1 illustrates quantization error.

The top waveform represents the 12.504 MHz clock.

The Acutime 2000 PPS output must be placed on one of the rising edges of this clock. The middle waveform represents the UTC/GPS on-time mark as determined by the Acutime 2000's GPS receiver electronics.

The bottom waveform represents the Acutime 2000's PPS output, which is output on the clock edge closest to the actual UTC/GPS on-time mark.



**Figure 5-1 PPS Quantization Error**

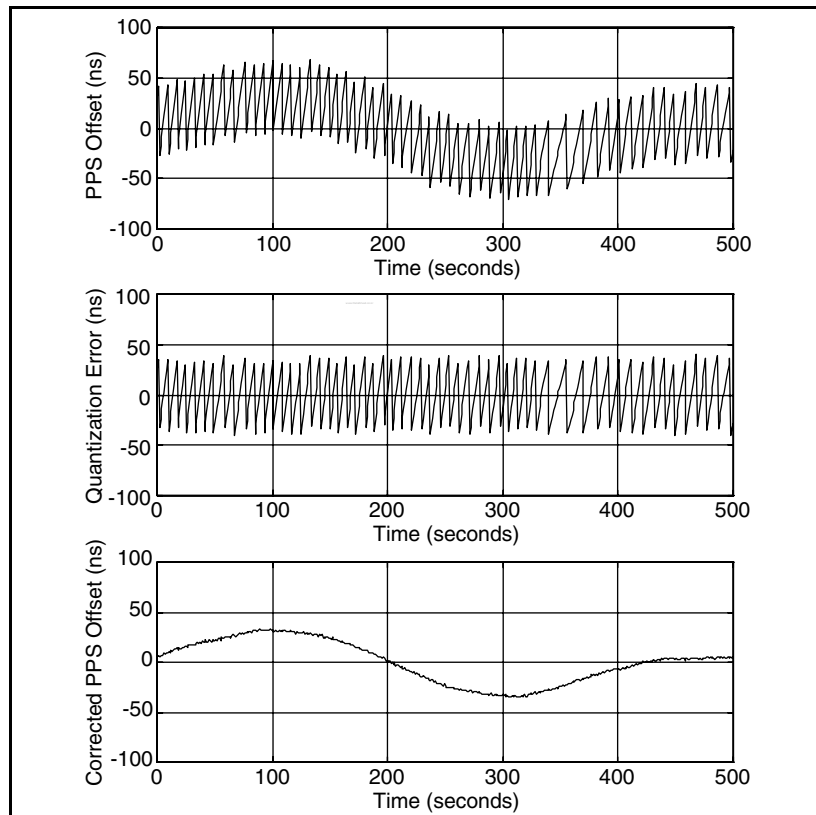
The amount of quantization error present on each PPS output pulse is reported in packet 0x8F-AC. This quantization error information can be used to reduce the effective amount of jitter on the PPS pulse.

Figure 5-2 illustrates the result of removing the quantization error from the PPS output in a user system.

The top plot shows the offset of the PPS output pulse relative to a stable standard such as a Cesium atomic clock. The quantization error is responsible for the jagged appearance of the waveform.

The middle plot shows the quantization error as reported by the Acutime 20000 in packet 0x8F-AC.

The bottom plot is the result of subtracting the quantization error from the PPS offset.



**Figure 5-2 Removing the Quantization Error from the PPS Output**



### **5.2.5 External Event Input**

The Acutime 2000 provides an External Event Input that allows the user to time tag external event pulses. The event capture mechanism is triggered on the low-to-high transition of the external event input. The time tag provides a resolution of 320 nanoseconds and represents the time at which the event pulse occurred at the Acutime 2000 connector input. Therefore, it is offset by the amount of delay in the cable. The time tag information is reported in packet 0x8F-0B (or 8F-AD). This feature is intended for use with relatively infrequent event pulses. A practical limit on event pulse frequency is about 10 Hz. To prevent the Acutime 2000 hardware and firmware from being overrun with event pulse inputs, make sure that an event pulse will not occur until the time tag from the previous event pulse reported in packet 0x8F-0B (or 8F-AD) is received.

### **5.2.6 Cable Delay Compensation**

The PPS output from the Acutime 2000 is calibrated to be aligned with UTC/GPS at the connector. The PPS you receive is delayed by the amount of propagation delay in the cable between the Acutime 2000 and your equipment. You can compensate for this delay by setting the PPS offset field of packet 0x8E-4A. The propagation delay through the cable depends on the cable type used, but in general, the delay is approximately 1.25 nanosecond per foot of cable. Negative PPS offset values cause the PPS output to occur early, which compensates for the propagation delay of the cable.

## 5.3 Serial Data Communication

When the Acutime 2000 has acquired a set of satellites that conforms to the mask and mode settings and has collected a valid ephemeris for each satellite, it automatically commences periodic outputs of GPS data and generates a timing pulse (PPS).

### 5.3.1 Port B

The Acutime 2000 outputs periodic TSIP health, mode, and time messages on Port B. These status messages confirm that the receiver is working. These packets are described in Appendix A, Trimble Standard Interface Protocol.

The factory default port setting is 9600 baud in/out, 8 data bits, odd parity, 1 stop bit. The serial port setting can be changed and stored in serial EEPROM using a TSIP command.

This port can also be configured to transmit timing packets, using packet 8E-A5 to determine which timing packet to output on this port.

### 5.3.2 Port A (Timing)

The Acutime 2000 has a dedicated serial port for outputting comprehensive time packets. Messages are output after the PPS and after external events. The factory default setting is TSIP, 9600, 8-odd-1, output only.

The host system receives both the PPS and the time packet identifying each pulse. Use packet 8E-A5 to determine which timing superpacket to output on this port.

The Acutime 2000 generates a packet in response to the external event input. The event count field in packet 8F-0B (or 8F-AD) increments for each event received. This field resets after a power cycle and rolls over at 65535. The event tag messages are interleaved with the PPS messages. PPS tags are distinguished by a zero (0) in the event count field. The Acutime 2000 accepts external events up to a 10 Hertz rate. Use packet 8E-A5 to configure this port to output the 8F-0B (or 8F-AD) packet in response to external events.

## 5.4 GPS Timing

In many timing applications, such as time/frequency standards, site synchronization systems, wireless voice and data networks, and event measurement systems, GPS receivers are used to steer a local reference oscillator. The steering algorithm combines the short-term stability of the oscillator with the long-term stability of the GPS PPS. An accurate GPS PPS allows the use of cost-effective crystal oscillators, which have poorer stability than expensive, high-quality oscillators, such as atomic cells.

The GPS constellation consists of at least 24 orbiting satellites. Unlike most telecommunications satellites, GPS satellites are not geostationary, so satellites in view are constantly changing. Each GPS satellite contains four highly-stable atomic clocks, which are continuously monitored and corrected by the GPS control segment. Consequently, the GPS constellation can be considered a set of 24 orbiting "clocks" with worldwide 24-hour coverage.

A Trimble GPS receiver uses the signals from these GPS "clocks" to correct its own internal clock, which is not as stable or accurate as the GPS atomic clocks. A GPS receiver like the Acutime 2000 outputs a highly accurate timing pulse (PPS) generated by its internal clock, which is constantly corrected using the GPS clocks. In the case of the Acutime 2000, this timing pulse is synchronized to UTC within 50 nanoseconds (one sigma) after survey is complete.

In addition to serving as highly-accurate stand-alone time sources, GPS receivers are used to synchronize distant clocks in communication or data networks. This is possible because all GPS satellites are corrected to a common master clock. Therefore, the relative clock error is the same, regardless of which satellites are used. For synchronization applications requiring a common clock, GPS is the ideal solution.

GPS time accuracy is affected by the same major source of error that affects position accuracy: Selective Availability (S/A). The position and time errors are related by the speed of light. Therefore, a position error of 100 meters corresponds to a time error of approximately 333 nanoseconds. The GPS receiver's clocking rate and software affect PPS accuracy. The Acutime 2000's 12.5 MHz clocking rate enables a steering resolution of 80 ns ( $\pm 40$  ns). Using software algorithms like an overdetermined clock solution, the Acutime 2000 mitigates the effects of S/A to achieve a PPS accuracy of 50 ns (one sigma) after survey is complete.

### 5.4.1 Timing Operation

The Acutime 2000 automatically outputs a PPS and time tag. With an accurate reference position, the Acutime 2000 automatically switches to an overdetermined clock mode, activates its T-RAIM algorithm and outputs a precise PPS. The overdetermined clock solution mitigates the effects of S/A. Using a simple voting scheme based on pseudo-range residuals, the Acutime 2000's integrity algorithm automatically removes the worst satellite with the highest residual from the solution set if that satellite's residual is above a certain threshold.

The Acutime 2000's default configuration provides optimal timing accuracy. The only item under user or host control that can affect the Acutime 2000's absolute PPS accuracy is the delay introduced by the interface cable. For long cable runs, this delay can be significant (1.25 nanoseconds per foot). TSIP packet 8Ex4A sets the cable delay parameter, which is stored in non-volatile memory. For the best absolute PPS accuracy, adjust the cable delay to match the installed cable length. The cable delay is 1.25 nanoseconds per foot of cable. To compensate for cable delay, use a negative offset to advance the PPS output.

### Timing Pulse Output (PPS)

A pulse-per-second (PPS), 1 microsecond-wide pulse is available on the Acutime 2000's interface connector. The pulse is sent once per second and the leading edge of the pulse is synchronized to UTC or GPS time. The pulse shape is affected by the distributed capacitance of the attached cabling and input circuit. The leading edge is typically less than 20 nanoseconds wide. The pulse's trailing edge should never be used for timing applications. An accurate timing pulse is available only when the Acutime 2000 is operating in the static Overdetermined Clock mode.



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**Note** – GPS time differs from UTC (Universal Coordinated Time) by a small, sub-microsecond offset and an integer-second offset. The small offset is the steering offset between the GPS DoD clock ensemble and the UTC (NIST) clock ensemble. The large offset is the cumulative number of leap seconds since 1 January 1970, which, on 31 December 1998, was increased from 12 to 13 seconds. Historically, the offset increases by one second approximately every 18 months, usually just before midnight on 30 June or 31 December. System designers should note whether the output time is UTC or GPS time.

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**Note** – The event time reported in 8F-0B and 8-AD is corrected for the fractional UTC offset if UTC PPS (default) is selected.

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## 5.5 Using the Acutime 2000 in Mobile Applications

Although it is intended primarily for use in static applications, the Acutime 2000 can also be used in mobile applications. The factory default settings for the Acutime 2000 assume that the antenna is going to be used in a static timing application. To use the Acutime 2000 in mobile applications, you must disable the Acutime's self-survey mechanism and ensure that a stored position does not exist in the nonvolatile EEPROM.

To prepare the Acutime 2000 for mobile applications, complete the following steps.

- Make sure that there is no stored position in the nonvolatile EEPROM by using command packet 8E-45 with data byte 1 set to 6 (accurate position segment.)

This operation clears any stored position from the EEPROM.

- Disable the self-survey mechanism using command packet 8E-A9.

If not disabled, the self-survey mechanism will automatically survey the antenna's position and then set the receiver to operate in a static, time-only mode.

- Set the desired position fix mode using command packet BB.

After these steps are completed, the Acutime 2000 is ready to operate properly in mobile applications. While operating in a mobile application, the Acutime 2000 can continue to output a PPS pulse as well as timing packets.



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**Note** – The accuracy of the PPS output pulse will be degraded by a factor of about 3 when the unit is operated in a mobile application.

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## 5.6 Customizing Acutime 2000 Operations

The Acutime 2000 provides a number of user configurable parameters that allow you to customize the operation of the unit. These parameters are stored in a non-volatile memory chip (EEPROM) to be retained during loss of power and through resets. At reset or power-up, the Acutime 2000 configures itself based on the parameters stored in the EEPROM. You can change the values of these parameters to achieve the desired operations using a variety of TSIP packets. The Acutime 2000 configures itself based on the new parameter immediately, but the new parameter value is not automatically saved to the EEPROM. You must direct the Acutime 2000 to save the parameters to the EEPROM.

Parameters are grouped into sections of the EEPROM called segments. Each segment is identified with a number and contains a group of related parameters. To change the parameter values stored in EEPROM, send packet 0x8E-26 to direct the Acutime 2000 to save the current parameter values in a specified segment in the EEPROM. You can also direct the Acutime 2000 to set the parameter values to their factory default settings with packet 0x8E-45. When a segment is set to its factory defaults, the contents of the EEPROM segment are set and the Acutime 2000 configures itself with the default settings.

In brief, to customize the Acutime 2000 operations for your application:

- Configure the Acutime 2000 using TSIP command packets until the desired operation is achieved.
- Use TSIP packet 0x8E-26 to save the settings in non-volatile memory (EEPROM.)

The new settings will control the Acutime 2000 operations whenever it is reset or power cycled.

Tables 5-2 through 5-12 list the user configurable parameters by segment number. Each table lists the parameter name, its factory default value, and the TSIP packet that sets or reads the parameter value (typically, one TSIP packet sets or reads several related parameters.)



**Table 5-2 Receiver Configuration (segment 2)**

<b>Parameter</b>	<b>Factory default</b>	<b>Set</b>	<b>Request</b>	<b>Report</b>
Operating dimension	4 (Full Position 3D)	BB	BB	BB
DGPS mode	3 (Auto DGPS/GPS)	BB	BB	BB
Dynamics code	1 (Land)	BB	BB	BB
Elevation mask	0.175 radians (10 degrees)	BB	BB	BB
Signal level mask	4.0 AMU	BB	BB	BB
PDOP mask	8.0	BB	BB	BB
PDOP switch	6.0	BB	BB	BB
Foliage mode	0 (never)	BB	BB	BB
DGPS age limit	30 seconds	BB	BB	BB
Have reference altitude flag	FALSE	2A	2A	4A
Reference altitude (meters)	0.0	2A	2A	4A

**Table 5-3 OEM Configuration (segment 3)**

<b>Parameter</b>	<b>Factory Default</b>	<b>Set</b>	<b>Request</b>	<b>Report</b>
Datum index	WGS 84 Ellipsoid	8E-14	8E-15	8F-15
Position	0x12	35	35	35
Velocity	0x02	35	35	35
Time	0x01	35	35	35
Auxiliary	0x02	35	35	35
Super packets output mask (byte 1)	0x32	8E-A5	8E-A5	8F-A5
Super packets output mask (byte 2)	0x21	8E-A5	8E-A5	8F-A5
Auto TSIP output mask	0xFFFFFFFFC0	8E-4D	8E-4D	8F-4D

**Table 5-4 Port A and B Configuration (segment 4)**

Parameter	Factory default	Set	Request	Report
Input baud rate	9600	BC	BC	BC
Output baud rate	9600	BC	BC	BC
Parity	Odd	BC	BC	BC
Data bits	8	BC	BC	BC
Stop bits	1	BC	BC	BC
Input protocol	none	BC	BC	BC
Output protocol	TSIP	BC	BC	BC

**Table 5-5 PPS Configuration (segment 5)**

Parameter	Factory default	Set	Request	Report
PPS enabled switch	Enabled	8E-4A	8E-4A	8E-4A
PPS timebase	UTC	8E-4A	8E-4A	8E-4A
Polarity	TRUE	8E-4A	8E-4A	8E-4A
PPS offset	0.0 Seconds	8E-4A	8E-4A	8E-4A
Bias uncertainty threshold	300.0 Meters	8E-4A	8E-4A	8E-4A
PPS width	10.0e-6 Seconds	8E-4F	8E-4F	8E-4F
PPS driver switch	3 (At least 1 SV)	8E-4E	8E-4E	8E-4E

**Table 5-6 Position Information (segment 6)**

Parameter	Factory default	Set	Request	Report
XYZ coordinates	Such that LLA coordinates are all zeros	31		
Have position flag	FALSE			

**Table 5-7 Self-Survey Configuration (segment 7)**

Parameter	Factory default	Set	Request	Report
Survey enable flag	TRUE	8E-A6	8E-A6	8F-A6
Survey length	2000	8E-A6	8E-A6	8F-A6
Survey save flag	FALSE	8E-A6	8E-A6	8F-A6
Survey operating dimension	Full Position 3D	0xBB	0xBB	0xBB

The survey operating dimension can be set to auto and 2D if segments are saved (8E-26) while a survey is in process. The receiver uses the dimension setting saved for the next survey. If a reference altitude has been entered and the receiver is set to 2D survey, the reference altitude is used. If a reference altitude has not been entered and the receiver is set to 2D survey, an altitude of 0 is used for 2D survey (not recommended).

**Table 5-8 NMEA Configuration (segment 8)**

Parameter	Factory default	Set	Request	Report
NMEA message mask	0x00000020 (ZDA)	7A	7A	7A
NMEA message rate	1	7A	7A	7A
NMEA options	0	7A	7A	7A

**Table 5-9 UTC Information (segment 11)**

Parameter	Factory default	Set	Request	Report
have_utc	FALSE			



# A Trimble Standard Interface Protocol

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The Trimble Standard Interface Protocol (TSIP) provides commands that the system designer can use to configure a GPS receiver for optimum performance in a variety of applications. TSIP enables the system designer to customize the configuration of a GPS module to meet the requirements of a specific application.

TSIP is a simple bidirectional, binary packet protocol used in a wide variety of Trimble GPS receivers. TSIP offers a broad range of command packets and report packets that provide the GPS user with maximum control over the Acutime 2000 receiver.

This appendix provides the information needed to make use of the powerful TSIP features, enhance overall system performance, and reduce the total development time. The reference tables beginning on page A-5 help you determine which packets apply to your application. For those applications requiring customization, see Table A-10 for a detailed description of the key setup parameters. Application guidelines are provided for each TSIP command packet, beginning on page A-9.

## A.1 Interface Scope

The Trimble Standard Interface Protocol (TSIP) is based on the transmission of packets of information between the user equipment (host) and the GPS receiver. Each packet includes an identification code (1 byte, representing 2 hexadecimal digits) that identifies the

meaning and format of the data that follows. Each packet begins and ends with control characters.

### A.1.1 Packet Structure

TSIP packet structure is the same for both commands and reports. The packet format is:

<DLE> <id> <data string bytes> <DLE> <ETX>

<DLE> is the byte 0x10, <ETX> is the byte 0x03, and <id> is a packet identifier byte, which can have any value except for <ETX> and <DLE>. The bytes in the data string can have any value. To prevent confusion with the frame sequences <DLE> <id> and <DLE><ETX>, every <DLE> byte in the data string is preceded by an extra <DLE> byte ('stuffing'). These extra <DLE> bytes must be added ('stuffed') before sending a packet, and removed ('unstuffed') after receiving the packet.



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**Note** – A simple <DLE> <ETX> sequence does not necessarily signify the end of the packet, as these can be bytes in the middle of a data string. The end of a packet is <ETX> preceded by an odd number of <DLE> bytes.

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Multiple-byte numbers (integer, float, and double) follow the ANSI/IEEE Std 754 IEEE Standard for Binary Floating-Point Arithmetic as illustrated below. They are sent most-significant-byte-first. This may involve switching the order of the bytes as they are normally stored in Intel-based machines. Only the fractional part of the mantissa for real numbers, SINGLE and DOUBLE, is reported because the leading bit on the mantissa is always 1. Specifically:

INTEGER is a 16-bit unsigned number sent in two's complement format.

SINGLE (float, or 4 byte REAL) is sent as a series of four bytes; it has a precision of 24 significant bits, approximately 6.5 digits.

DOUBLE (8 byte REAL) is sent as a series of eight bytes (a, b, c, d, e, f, g, h); it has a precision of 52 significant bits, a little better than 15 digits.

The TSIP protocol is the primary protocol used by the Acutime 2000 receiver. This document describes in detail all TSIP packet identification codes, the format of each packet, and all available information that can be output from the Acutime 2000. This manual allows the user to configure the receiver to output information required for a particular application. The receiver transmits some of the information (position and velocity solutions, etc.) automatically when it is available, while other information is transmitted only on request.

## A.2 Physical Interface Characteristics

The Acutime 2000 utilizes high-quality serial I/O components to drive the available serial transmit and receive channels.

The Acutime 2000 is available in RS-232 and RS-422 configurations.

This section is provided to provide the user with a complete understanding of the capabilities of each receiver.

### A.2.1 Nomenclature

Historically, the ports of the Smart Antenna product lines which include Acutis, Acutime and Palisade products, have been described using letters "A" and "B".

The Acutime 2000 ports are referenced by letters "A" and "B", conformant to standards established by the Palisade product line.

**Table A-1 Acutime 2000 Port Translation Table**

Function	Label	Internal
TSIP	Port B	Port 0
Timing	Port A	Port 1

## A.2.2 Protocol Capabilities

The I/O ports of the Acutime 2000 are highly configurable. Port settings are stored in non-volatile memory, and are retained across power outages.

For systems with minimal bandwidth for processing serial data streams, the receivers can be configured as silent devices, which only generate I/O when polled. The Acutime 2000 receiver can be configured to output various automatic report packets and protocols to satisfy demanding real-time update requirements of complex monitoring systems.

### Event Input

The Acutime 2000 features an event input which can capture and report time stamps with the same precision as the PPS signal.

### Primary Port Features (Port B)

The Acutime 2000 features a primary bi-directional port, which is factory configured as for TSIP input and output.

### Secondary Port Features (Port A)

The Acutime 2000 has a bi-directional, programmable secondary port, that is designated as the Timing port. The timing port's protocol input lines are shared with the Event input feature.

The receiver can be configured to accept protocol input or event signals, but not both. Acutime 2000 cannot generate event time tags if port A is configured for RTCM input.

The port can be configured to accept and output data using various protocols as shown in the table below.

**Table A-2 Secondary Port Features**

Port Designator	Input	Default	Output	Default
"Port A"	TSIP, RTCM	none	TSIP, NMEA	TSIP



### A.2.3 Event Input

The Acutime 2000 receiver is capable of time-stamping external events with high-precision. Events are triggered by an input pulse, and can be reported by either or both of two super packets. The output of the event packets can be configured using packet 8E-A5.

The data in both packets allows constructing a unique 4-dimensional coordinate identifying each event.

#### Event Reporting

**Table A-3 Event Packets**

Super Packet	Length	Description
8F-0B	74	Comprehensive time with LLA position
8F-AD	22	Primary UTC time with leap information

The receivers can output the event reports on any available TSIP port.

## A.3 Packets Output at Power-Up

The following table lists the messages output by the receiver at power-up. After completing its self-diagnostics, the receiver automatically outputs a series of packets that indicate the initial operating condition of the receiver. Messages are output in the following order. Upon output of packet 82, the sequence is complete and the receiver is ready to accept commands.

**Table A-4 Packets Output at Power-Up**

Output ID	Description	Notes
46	Receiver health	
4B	Machine code/status	
45	Software version	

**Table A-4 Packets Output at Power-Up**

Output ID	Description	Notes
83	Double precision XYZ position	If single precision is selected, packet 42 is output instead.
84	Double precision LLA position	If single precision is selected, packet 4A is output instead.
82	DGPS position fix mode	

## A.4 Receiver Warm Start

You can warm-start the receiver by sending each of the following commands after the receiver has completed its internal initialization and has output packet 82 (see Table A-4).

**Table A-5 Receiver Warm Start Commands**

Input ID	Description
2B/23	Initial position (LLA/ECEF)
2E	Initial time
38 (type 2)	Almanac (for each SV)
38 (type 3)	Almanac health
38 (type 4)	Ionosphere page
38 (type 5)	UTC correction

## A.5 Default Background Packets (Port B)

The Acutime 2000 automatically outputs a set of packets on Port B that you can monitor for changes in receiver operations, including receiver health, time, almanac pages, and ephemeris updates. These messages are output at the rates indicated in the table below.

**Table A-6 Background Packets**

Output ID	Description	Notes
41	GPS time	If the receiver's GPS clock is set and the receiver is not outputting positions, time is output approximately every 16 seconds. Output approximately every 2.5 minutes if the receiver is doing position fixes.
46	Receiver health	Output approximately every 16 seconds, if the receiver is not doing fixes. Output approximately every 30 seconds if the receiver is doing position fixes. Whenever any bit in the health message changes, receiver health is automatically output.
6D	Mode packet	Output approximately every 30 seconds or when a constellation change occurs.



**Note** – The background packets listed in this table are automatically output. Background packets can be turned off. For more information on this option, see Command Packet 8E-4D.

## A.6 Default Automatic Position and Velocity Reports

The Acutime 2000 automatically outputs position and velocity reports at set intervals. Report intervals are controlled by packet 35.

**Table A-7 Automatic position and Velocity Reports**

Output ID	Description
42	Single precision XYZ position
83	Double-precision XYZ position
4A	Single-precision LLA position
84	Double-precision LLA position
43	Velocity fix (XYZ ECEF)
54	Bias and Bias rate (See Note)
56	Velocity fix (ENU)



**Note** – When the receiver is in the Manual or Overdetermined Clock mode, it outputs packet 54 to provide the computed clock-only solution.

## A.7 Automatic Primary and Supplemental Timing Reports

Timing Packets 8F-AB and 8F-AC are automatically output at 1 Hz. These packets are part of the low-latency packet series AB/AC/AD/OB. See section A.8.

## A.8 Low-Latency Timing Packets

The Acutime 2000 features a sequence of high-priority timing super packets, which are output within a bounded period of time after the PPS. The LLT packets offer an advanced data interface for applications requiring accurate data reports in a time constrained environment.

The first super packet will start transmission no later than 15–25 ms after the PPS transition.

The super packets which meet the LLTP criteria are in the table below. The packets are listed in order of output priority. Output of each packet can be turned on/off by using the mask in packet 8E-A5, but the output order cannot be changed.

The packets may also be requested, please refer to the specific packet documentation for details.

**Table A-8 Low-Latency Timing Packets**

LLTP Packet ID	Description	Request Packet ID
8F-AB	Primary Timing	8E-AB
8F-AC	Supplemental Timing	8E-AC
8F-AD	Primary UTC Time	8E-AD
8F-0B	Comprehensive Time and Position	8E-0B

The receiver will output all other TSIP packets after the transmission of LLT packet sequence is complete.



**Note** – Only the first packet will meet the LLTP specification. All other LLT packets will be output immediately after the first LLT packet completes.

## A.9 Event Packets

Event packets 8F-0B and 8F-AD are output in response to the event input as configured by packet 8E-A5

## A.10 Satellite Data Packets

The following packets request data transmitted by the GPS satellites and satellite tracking information.

**Table A-9 Satellite Data Packets**

Input ID	Description	Output ID
20	Request almanac	40
27	Request signal levels	47
28	Request GPS system message	48
29	Request almanac health page	49
2F	Request UTC parameters	4F
38	Request/load satellite system data	58
39	Set/request satellite disable or ignore health	59
3A	Request last raw measurement	5A
3B	Request satellite ephemeris status	5B
3C	Request tracking status	5C

## A.11 Customizing Receiver Operations

The following packets let you customize the receiver output for your application.

**Table A-10 Customizing Receiver Operations**

Input ID	Description	Output ID
23	Set Initial position (XYZ Cartesian ECEF)	
24	Request receiver position fix mode	6D
26	Request receiver health	46 and 4B
27	Request satellite signal levels	47
2A	Set Altitude for 2-D mode	4A
2B	Set Initial position (LLA)	
2E	Set GPS time	4E
35	Set input/output options	55
7A	Set/request NMEA interval and message mask	7B
BB	Set/request receiver configuration	BB
BC	Set/request port configuration	BC
8E-14	Set/request datum value	8F-14
8E-4A	Set/request PPS characteristics	8F-4A
8E-A5	Set/request packet broadcast mask	8F-A5
8E-A6	Issue self-survey command	8F-A6

Note 1: Output is determined by packet 35 settings (see Table A-3).

The following packets let you customize receiver operations.

**Table A-11 Advanced Packets**

<b>Input ID</b>	<b>Description</b>	<b>Output ID</b>
1E	Clear memory, reset	(Note 1)
25	Soft reset and self test	(Note 1)
2D	Request Oscillator offset	4D
39	Satellite disable or ignore health	59 (Note 2)
BB	Set receiver configuration parameters	BB
8E-4A	Set PPS characteristics	8F-4A
8E-4E	Set PPS output option	8F-4E
8E-4F	Set PPS Width (Acutime 2000 only)	8F-4F
8E-20	Set Fixed Point Superpacket Output	8F-20

Note 1: Output is determined by packet 35 settings. For packets 1E and 25, see Table A-4 to determine which packets are output at power-up.

Note 2: Not all modes of packet 39 cause a reply (see the description for packet 39, page A-34).



## A.12 Command Packets Sent to the Receiver

Table A-12 summarizes the command packets sent to the receiver. It includes a short description of each packet and the associated output packet. In some cases, the response packets depend on user-selected options. These selections are described beginning on page A-18.

**Table A-12 Command Packets Sent to the Receiver**

Input	Packet Description	Output ID
1D	Oscillator Offset	
1E	Reset receiver	(Note 1)
1F	Software version	45
20	Almanac	40
21	Current GPS time	41
22	Fix Mode select	(Note 2)
23	Initial position (XYZ Cartesian ECEF)	
24	Receiver position fix mode	6D
25	Soft reset and self-test	(Note 1)
26	Receiver health	46, 4B
27	Signal levels	47
28	GPS system message	48
29	Almanac health page	49
2A	Altitude for 2-D mode	4A
2B	Initial position (LLA)	
2C	Operating parameters	4C
2D	Oscillator offset	4D
2E	Set GPS time	4E
2F	UTC parameters	4F
31	Accurate initial position (XYZ Cartesian ECEF)	
32	Accurate initial position (LLA)	
34	Satellite # for 1-SV mode	
35	I/O options	55
37	Status and values of last position and velocity	57 (Note 4)
38	Load satellite system data	58

**Table A-12 Command Packets Sent to the Receiver (Continued)**

<b>Input</b>	<b>Packet Description</b>	<b>Output ID</b>
39	Satellite enable/disable and health heed/ignore	59 (Note 3)
3A	Last raw measurement	5A
3B	Satellite ephemeris status	5B
3C	Tracking status	5C
3D	Timing port configuration	3D
3F-11	Request EEPROM segment status	5F-11
7A	Set/request NMEA interval and message mask	7B
BB	Set receiver configuration	BB
BC	Set port configuration	BC
8E-0B	8F-0B output configuration	8F-A5/8F-0B
8E-14	Set new datum	8F-14
8E-15	Current datum values	8F-15
8E-20	Last fix (fixed point)	8F-20
8E-26	Write receiver configuration EEPROM	8F-26
8E-41	Manufacturing parameters	8F-41
8E-42	Production parameters	8F-42
8E-45	Revert segments to default settings	8F-45
8E-4A	Set/request PPS characteristics	8F-4A
8E-4B	Survey limit	8F-4B
8E-4D	Packet Output Mask	8F-4D
8E-4E	Set PPS output option	8F-4E
8E-4F	Set PPS Width (Acutime 2000 only)	8F-4F
8E-A5	Set or request packet broadcast mask	8F-A5
8E-A6	Issue self-survey command	8F-A6
8E-AB	Set/request primary timing packet	8F-AB
8E-AC	Set/request supplemental timing packet	8F-AC
8E-AD	8F-AD output configuration	8F-A5/8F-AD

Note 1: Output is determined by packet 35 settings. See Table to determine which messages are output at power-up.

Note 2: Entering 1SV mode initiates automatic output of packet 54.

Note 3: Not all packet 39 operations have a response. See packet 39 description.

Note 4: Output is determined by packet 35 settings.

## A.13 Report Packets Sent by the GPS Receiver to the User

Table A-13 summarizes the packets output by the receiver. It includes the output packet ID, a short description of each packet, and the associated input packet. In some cases, the response packets depend on user-selected options. These selections are covered in the packet descriptions beginning on page A-18.

**Table A-13 Report Packets Sent by GPS Receiver to User**

Output ID	Packet Description	Input
3D	Timing port configuration	3D
40	Almanac data for one satellite	20
41	GPS time	21
42	Single-precision XYZ ECEF position	37
43	Velocity fix (XYZ ECEF)	37
45	Software version information	1F
46	Health of receiver	26
47	Signal level for all satellites	27
48	GPS system message	28
49	Almanac health for all satellites	29
4A	Single-precision LLA position	37
4B	Machine code/status	26
4C	Report operating parameters	2C
4D	Oscillator offset	2D
4E	Response to set GPS time	2E
4F	UTC parameters	2F
54	One-satellite bias and bias rate	22

**Table A-13 Report Packets Sent by GPS Receiver to User (Continued)**

<b>Output ID</b>	<b>Packet Description</b>	<b>Input</b>
55	I/O options	35
56	Velocity fix (ENU)	37
57	Information about last computed fix	37
58	GPS system data/acknowledge	38
59	Satellite enable/disable and health heed/ignore	39
5A	Raw measurement data	3A
5B	Satellite ephemeris status	3B
5C	Satellite tracking status	3C
5F-11	Request EEPROM segment status	3F-11
6D	All-in-view satellite selection	24
7B	NMEA interval and message mask	7A
83	Double-precision XYZ position	37
84	Double-precision LLA position	37
BB	Receiver configuration	BB
BC	Port configuration	BC
8F-0B	Comprehensive time	Auto/Event
8F-14	Current datum values	8E-14
8F-20	Last fix with extra information (fixed point)	8E-20
8F-26	Response to save EEPROM segments	8E-26
8F-41	Manufacturing parameters	8E-41
8F-42	Production parameters	8E-42
8F-45	Response to revert segments to default	8E-45
8F-4A	PPS characteristics	8E-4A
8F-4B	Survey limit	8E-4B
8F-4D	Automatic packet output mask	8E-4D
8F-4E	PPS output option	8E-4E
8F-4F	Set PPS width	8E-4F
8F-A5	Packet broadcast mask	8E-A5
8F-A6	Response to self-survey command	8E-A6

**Table A-13 Report Packets Sent by GPS Receiver to User (Continued)**

<b>Output ID</b>	<b>Packet Description</b>	<b>Input</b>
8F-AB	Primary timing packet	8E-AB
8F-AC	Supplemental timing packet	8E-AC
8F-AD	UTC event time	Event/Auto

## A.14 Packet Descriptions

Command packets are sent from an external device, such as a computer or terminal, to the receiver when requesting report packets, setting receiver parameters, or performing receiver command operations such as resetting the receiver. Many command packets have a corresponding report packet, which is sent to the external device in response to the command packet. Some commands perform discrete operations and have no matching report packet.

### 0x1D Command Packet 1D Oscillator Offset

This packet commands the GPS receiver to set or clear the oscillator offset in battery backed memory. This is normally used for servicing the unit.

**Table A-14 Command Packet 1D - Clear Oscillator Offset**

Byte	Item	Type	Value	Response
0	Operation	BYTE	"C," 43 hex	Clear the oscillator offset

To set the oscillator offset, four data bytes are sent: the oscillator offset in Hertz relative to L1 as a SINGLE real value. The oscillator offset is automatically updated when the receiver is doing fixes.

**Table A-15 Command Packet 1D - Set Oscillator Offset**

Byte	Item	Type	Value	Response
0-3	Offset	SINGLE	Offset in Hertz	Set the oscillator offset




---

**Note** – Use of this packet is for diagnostic purposes only and is not recommended for the user.

---

## 0x1E

### Command Packet 1E Initiate Cold or Factory Reset

This command packet tells the receiver to perform either a cold reset or a factory reset. A cold reset clears all navigation data (for example, almanac, and ephemeris) stored in RAM and is equivalent to a power cycle. A factory reset also restores the factory defaults for all configuration and navigation parameters stored in non-volatile memory. This packet can affect separately the configuration parameters and navigation parameters. It contains one data byte equal to one of the following ASCII letters: 'K', 'F', 'C', 'N', or 'R'.

**Table A-16 Command Packet 1E**

Byte	Item	Type	Value	Response
0	Rest	BYTE	'K' (0x4B) 'F' (0x46) 'C' (0x43)  'N' (0x4E)  'R' (0x52)	Cold reset Factory reset Compatibility re-start for the Palisade firmware version v7.02  Clear navigation data in EEPROM and cold reset  Set configuration parameters in EEPROM to factory defaults and cold reset



**Caution** – The factory reset commands 0x1E-‘F’ and 0x1E-‘R’ will delete the stored position and cause a self-survey to restart. All almanac, ephemeris, current position, mode, and communication port setup information stored in RAM is lost by the execution of these commands.

## 0x1F

### Command Packet 1F Software Versions Request

This packet requests information about the version of software running in the Navigation and Signal Processors. This packet contains no data bytes. The GPS receiver returns packet 45.

**0x20****Command Packet 20  
Almanac Request**

This packet requests almanac data for one satellite from the GPS receiver. This packet contains one data byte specifying the satellite PRN number. The GPS receiver returns packet 40 hex.

**0x21****Command Packet 21  
Current Time Request**

This packet requests current GPS time. This packet contains no data. The GPS receiver returns packet 41 hex.

**0x23****Command Packet 23  
Initial Position (XYZ Cartesian ECEF) Command**

This packet provides the GPS receiver with an approximate initial position in XYZ coordinates. This packet is useful if the user has moved more than about 1,000 miles since the previous fix.



---

**Note** – The GPS receiver can initialize itself without any data from the user; this packet merely reduces the time required for initialization.

---

This packet is ignored if the receiver is already calculating positions.

The origin is the earth's center. The X-axis points toward the intersection of the equator and the Greenwich meridian, the Y-axis points toward the intersection of the equator and the 90° meridian, and the Z-axis points toward the North Pole. The cold-start default LLA (not XYZ) position is 0, 0, 0.



The data format is shown in the table below.

**Table A-17 Command Packet 23**

Byte	Item	Type	Units
0-3	X	SINGLE	meters
4-7	Y	SINGLE	meters
8-11	Z	SINGLE	meters

## 0x24

### Command Packet 24 GPS Receiver Position Fix Mode Request

This packet requests the current position fix mode of the GPS receiver. This packet contains no data. The GPS receiver returns packet 6D.

## 0x25

### Command Packet 25 Initiate Soft Reset / Self Test Command

This packet commands the GPS receiver to perform a software reset. The GPS receiver performs a self-test as part of the reset operation. This packet contains no data. Following completion of the reset, the receiver outputs the startup messages (see Table A-1). The receiver retains the time, survey position, port configuration, and almanac contents during this operation.




---

**Note** – The GPS receiver sends packet 45 only on power-up and reset (or on request). If packet 45 appears unrequested, either the GPS receiver power was cycled or the GPS receiver was reset.

---

## 0x26

### Command Packet 26 Health Request

This packet requests health and status information from the GPS receiver. This packet contains no data. The GPS receiver returns packets 46 and 4B.

## **0x27**      **Command Packet 27** **Signal Levels Request**

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. The GPS receiver returns packet 47.

## **0x28**      **Command Packet 28** **GPS System Message Request**

This packet requests the GPS system ASCII message sent with the navigation data by each satellite. This packet contains no data. The GPS receiver returns packet 48.

## **0x29**      **Command Packet 29** **Almanac Health Page Request**

This packet requests the health page from the almanac. This packet contains no data. The GPS receiver returns packet 49.

## **0x2A**      **Command Packet 2A** **Altitude for 2-D Mode Command**

This packet provides the altitude to be used for 2-dimensional navigation mode. This packet contains one SINGLE number (4 bytes) specifying the altitude in meters, using the WGS-84 model of the earth or MSL geoid altitude, depending on I/O options (set by packet 35). The GPS receiver returns packet 4A. It is recommended that the user upload the reference altitude before the receiver starts doing position fixes.

If an altitude is not provided, the receiver will use the altitude of the previous 3-D fix (altitude-hold mode). Sending packet 2A with one data byte equal to 0xFF will cancel altitude-set mode and return the reference altitude to 0. The altitude setting is stored in non-volatile memory. Packet 0x8E-26 can be used to write receiver configuration to EEPROM.

To use the fixed altitude survey mode, the receiver must be configured to Manual 2-D navigation mode using packet BB. The reference altitude will be used in 2-D survey from both warm and cold starts.



---

**Note** – If the receiver altitude is set above 18,000 m, the receiver will be forced to reset each time it acquires satellites. This is implemented to conform with the COCOM industry standard.

---

## 0x2B

### Command Packet 2B Initial Position (Latitude, Longitude, Altitude) Command

This packet provides the GPS receiver with an approximate initial position in latitude and longitude coordinates (WGS-84). This packet is useful if the user has moved more than about 1,000 miles since the previous fix.



---

**Note** – The GPS receiver can initialize itself without any data from the user; this packet merely reduces the time required for initialization.

---

This packet is ignored if the receiver is already calculating positions. The cold-start default LLA position is 0, 0, 0.

The data format is shown below.

**Table A-18 Command Packet 2B**

Byte	Item	Type	Units
0-3	Latitude	SINGLE	radians, north
4-7	Longitude	SINGLE	radians, east
8-11	Altitude	SINGLE	meters

The GPS receiver returns packet 4B.

## 0x2D

### Command Packet 2D Oscillator Offset Request

This packet requests the calculated offset of the GPS receiver master oscillator. This packet contains no data. The GPS receiver returns packet 4D hex. This packet is used mainly for service.

## 0x2E

### Command Packet 2E GPS Time Command

This packet provides the approximate GPS time of week and the week number to the GPS receiver. The GPS receiver returns packet 4E. The

data format is shown below. The GPS week number reference is Week # 0 starting January 6, 1980. The seconds count begins at the midnight which begins each Sunday morning.

**Table A-19 Command Packet 2E**

Byte	Item	Type	Units
0-3	GPS time of week	SINGLE	seconds
4-5	GPS week number	INTEGER	weeks

This packet is ignored if the receiver has already calculated the time from tracking a GPS satellite.

## 0x2F

### Command Packet 2F UTC Parameters Request

This packet requests the current UTC-GPS time offset (leap seconds). The packet has no data. The receiver returns packet 4F.

## 0x31

### Command Packet 31 Accurate Initial Position (XYZ Cartesian ECEF) Command

This packet is identical in content to packet 23. This packet provides an initial position to the GPS receiver in XYZ coordinates. However, the GPS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the GPS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters. TRAIM flags come on if this position is not accurate enough.

Inputting accurate position sets the self-survey completion state to 100%. The uploaded position is not stored in EEPROM unless it is stored with command packet 8E-26. The input position is reported by packet 8F-AC.

## 0x32

### **Command Packet 32 Accurate Initial Position (Latitude, Longitude, Altitude) Command**

This packet is identical in content to packet 2B. This packet provides the GPS receiver with an initial position in latitude, longitude, and altitude coordinates. However, the GPS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the GPS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters. TRAIM flags come on if this position is not accurate enough.

Inputting accurate position sets the self-survey completion state to 100%. The uploaded position is not stored in EEPROM unless it is stored with command packet 8E-26. The input position is reported by packet 8F-AC.

## 0x34

### **Command Packet 34 Satellite Number For One-Satellite Mode Command**

This packet allows the user to control the choice of the satellite to be used for the 1D Timing mode. This packet contains one byte. If the byte value is 0, the GPS receiver automatically chooses the usable satellite with the highest elevation above the horizon. This automatic selection of the highest satellite is the default action, and the GPS receiver does this unless it receives this packet. If the byte value is from 1 to 32, the packet specifies the PRN number of the satellite to be used. A subsequent value of 0 will return the receiver to automatic 1-SV mode.

## 0x35

### Command Packet 35 I/O Option Flags Command

This packet requests the current I/O option states and optionally allows the I/O option states to be set as desired.

To request the option states without changing them, the user sends the packet with no data bytes included. To change any option states, the user includes 4 data bytes with the values indicated below in the packet. The I/O options, their default states, and the byte values for all possible states are shown below. These option states are held in non-volatile memory. The GPS receiver returns packet 55. Use packet 8E-26 to save settings to EEPROM.

These abbreviations apply:

- ALT - Altitude
- ECEF - Earth-centered, Earth-fixed
- XYZ - Cartesian coordinates
- LLA - Latitude, Longitude, Altitude
- HAE - Height Above Ellipsoid
- WGS-84 - Earth model (ellipsoid)
- MSL geoid - Earth Mean Sea Level mode
- UTC - Universal Coordinated Time

**Table A-20 Command Packet 35**

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packets
0	Position	0 (LSB)	0	XYZ ECEF Output 0: Off, 1: On	42 or 83
		1	1	LLA Output 0: Off, 1: On	4A or 84
		2	0	LLA ALT Output 0: HAE (current datum) 1: MSL geoid	4A or 84
		3	0	ALT input 0: HAE (current datum) 1: MSL geoid	2A
		4	1	Precision-of-position output 0: Single-precision packet 42 and/or 4A. 1: Double-precision packet 83 and/or 84	
		5	0	8F-20 Output 0: Off 1: On	
		6-7	0	Unused	
1	Velocity	0	0	XYZ ECEF Output 0: Off, 1: On	43
		1	1	ENU output 0: Off, 1: On	56
		2-7	0	Unused	
2	Timing	0	1	Time type 0: GPS time, 1: UTC	
		1	0	Fix computation time 0: ASAP 1: Next integer sec	
		2	0	Fix output time 0: When computed 1: Only on request	37



**Table A-20 Command Packet 35 (Continued)**

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packets
2	Timing	3	0	Synchronized measurements 0: Off 1: On	N/A
		4	0	Minimize Projection 0: Off, 1: On	N/A
		5-7	0	Unused	
3	Auxiliary	0	0	Raw measurements 0: Off, 1: On	5A
		1	1	Doppler smoothed codephase 0: Raw, 1: Smoothed	5A
		2-7		Unused	

Packet 35 is used to control the format and timing of the position and velocity output.

### Bytes 0-1

Bytes 0 and 1 control the message output format.

### Byte 2

Byte 2 contains the five time parameters described below:

- Time Type - This bit defines whether the time tags associated with a position fix are in GPS time or UTC time. The default is UTC time.
- Fix Computation Time - This bit controls the time and frequency of position fixes. The default is ASAP.

Alternatively, in the integer second mode, the most recent measurements are projected to next integer second, and the solution is then valid at this time. The benefit of this mode is the standard fix time and a 1 Hz output rate. The drawbacks are that some measurement projection is performed and that the fix may be slightly older than with the default option. This mode also conforms to the output rate of NMEA.

- **Output Time** - This bit defines whether fixes are automatically output when computed or only sent in response to a packet 37 request. The default is automatic output.
- **Synchronized Measurements** - This bit controls whether all satellite range measurements are required to have the same time tag. The default is OFF. Slightly older measurements are tolerated (on the order of 3-5 seconds) to provide solutions when obscurations make it impossible to obtain exactly concurrent measurements from each satellite.

When this bit is ON, all measurements are required to have the same time tag. This mode is used only when the user application requires all satellite measurements to be identical to the position time tag. If a satellite that is in the selected set for the solution is lost, then no fix will be made until a new selection is made.

The synchronized measurement mode combined with the minimized projection timing mode (see next paragraph) allows absolutely no measurement projection. However, obscurations may reduce the fix density when there are limited satellites. Use this mode cautiously.

- **Minimized Projection** - This bit controls the time of the position fix relative to the time of the satellite range measurements. The default mode is OFF. In this mode, the time of solution is the time at which the GPS position fix is computed. Thus, all measurements are projected by an interval which is roughly the amount of time it takes to compute the solution. This approach minimizes the latency between the time tag of the computed solution and the solution output. The drawback is that the measurement projection (which is only about 100 ms) may induce some error during high accelerations.

Alternatively, when minimized projection is ON, the time of the solution is the time of the most recent measurements. Thus, if all measurements are taken at exactly the same time, there is no measurement projection. If a selected satellite's measurement time lags the most recent measurement, then it is projected to this time. The difference is that the fix will have more latency than a fix provided with the above timing option. This is the best choice for users performing non real-time error analysis, or non real-time DGPS solution-space corrections. This is also the preferable mode for users integrating GPS with other sensors, where communication lags are the dominant latencies, and thus the time lag between the applicability and availability of the fix is small.

### **Byte 3**

Byte 3, the auxiliary byte, controls the output of additional fix data. It contains two control bits:

- Bit 0 controls the output of raw measurements (Packet 5A).
- Bit 1 controls whether the raw measurements output in packet 5A are doppler smoothed.

## 0x37

### Command Packet 37 Last Position and Velocity Request

This packet requests information regarding the last position fix. The GPS receiver returns packet 57 and the appropriate position packet 42 or 4A, or 83 or 84, and the appropriate velocity packet 43 or 56, based on the I/O options in effect. In timing mode, the GPS receiver returns packets 57 and 54.

## 0x38

### Command Packet 38 Download and Upload Satellite System Data

This packet requests current satellite data (almanac, ephemeris, etc.) or permits loading initialization data from an external source (for example, by extracting initialization data from an operating GPS receiver via a data logger or computer and then using that data to initialize a second GPS receiver unit). The GPS receiver returns packet 58.



---

**Note** – The GPS receiver can initialize itself without any data from the user; it just requires more time.

---

To request data without loading data, use only bytes 0 through 2.  
To load data, use all bytes.



---

**Caution** – Proper structure of satellite data is critical to receiver operation. Requesting data is not hazardous; loading data improperly is hazardous. Use this packet only with extreme caution. The data should not be modified in any way. It should only be retrieved and stored for later reload.

---

**Table A-21 Command Packet 38**

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	1 2	Request data from receiver Load data into receiver
1	Type of data	BYTE	1 2 3 4 5 6	Not used Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN#	BYTE	0 1-32	Data that is not satellite-ID specific Satellite PRN number
3	length (n)	BYTE		Number of bytes of data to be loaded
4 to n+3	data		n Bytes	

**0x39****Command Packet 39  
Satellite Attribute Database Command**

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) that satisfy all mask values for use in the position solution. This packet allows you to override the internal logic and force the receiver to either unconditionally disable a particular satellite or to ignore a bad health flag. The GPS receiver returns packet 59 for operation modes 3 and 6 only.

**Table A-22 Command Packet 39**

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	1	Enable for selection (default)
			2	Disable for selection
			3	Request enable or disable status of all 32 satellites
			4	Heed health on satellite (default)
			5	Ignore health on satellite
			6	Request heed or ignore health on all 32 satellites
1	Satellite #	BYTE	0	All 32 satellites
			1-32	Any one satellite PRN number

At power-on and after a reset the default values are set for all satellites.



**Caution** – Ignoring health can cause the GPS receiver software to fail, as an unhealthy satellite may contain defective data. Use extreme caution in ignoring satellite health.

## 0x3A Command Packet 3A Last Raw Measurement Request

This packet requests the most recent raw measurement data for one specified satellite. The GPS receiver returns packet 5A if data is available.

**Table A-23 Command Packet 3A**

Byte	Item	Type	Value	Meaning
1	Satellite #	BYTE	0	All satellites in the current tracking set
			1-32	Desired satellite

## 0x3B Command Packet 3B Satellite Ephemeris Status Request

This packet requests the current status of satellite ephemeris data. The GPS receiver returns packet 5B if data is available.

**Table A-24 Command Packet 3B**

Byte	Item	Type	Value	Meaning
1	Satellite #	BYTE	0	All satellites for which ephemeris data is available
			1-32	Desired satellite

**0x3C****Command Packet 3C  
Satellite Tracking Status Request**

This packet requests the current satellite tracking status. The GPS receiver returns packet 5C if data is available.

**Table A-25 Command Packet 3C**

Byte	Item	Type	Value	Meaning
1	Satellite #	BYTE	0 1-32	All satellites in the current tracking set Desired satellite



## 0x3D Command Packet 3D Timing Port Configuration Command

This packet is superseded by 0xBC.

## 0x3F-11 Command Packet 3F-11 EEPROM Segment Commands

This command packet requests the status of the EEPROM segments and clears the EEPROM status minor alarm bit (Bit 10) in the supplemental timing packet 8F-AC. The GPS receiver replies with report packet 5F-11.

**Table A-26 Command Packet 3F-11**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0x11	EEPROM segment status

## 0x40 Report Packet 40 Almanac Data Page Report

This packet provides almanac data for a single satellite. The GPS receiver sends this packet on request (packet 20 hex) and optionally, when the data is received from a satellite. The data format is shown below.

**Table A-27 Report Packet 40**

Byte	Item	Type	Units
0	satellite	BYTE	(identification number)
1-4	T_zc	SINGLE	seconds
5-6	week number	INTEGER	weeks
7-10	eccentricity	SINGLE	(dimensionless)
11-14	T_oa	SINGLE	seconds
15-18	i_o	SINGLE	radians
19-22	OMEGA_dot	SINGLE	radians/second
23-26	square_root_A	SINGLE	(meters) <sup>1/2</sup>

**Table A-27 Report Packet 40 (Continued)**

Byte	Item	Type	Units
27-30	OMEGA_0	SINGLE	radians
31-34	omega	SINGLE	radians
35-38	M_0	SINGLE	radians

T<sub>zc</sub> is normally positive. If no almanac data is available for this satellite, then T<sub>zc</sub> is negative. T<sub>zc</sub> and the week number in this packet refer to the Z-count time and week number at the time the almanac was received. The remaining items are described in the ICD-GPS-200.

## 0x41

### Report Packet 41 GPS Time Report

This packet provides the current GPS time of week and the week number. The GPS receiver sends this packet in response to packet 21 and during an update cycle. Update cycles occur approximately every 15 seconds when not doing fixes and occur approximately every 150 seconds when doing fixes. The data format is shown below.

**Table A-28 Report Packet 41**

Byte	Item	Type	Units
0-3	GPS time of week	SINGLE	seconds
4-5	GPS week number	INTEGER	weeks
6-9	GPS/UTC offset	SINGLE	seconds



**Note** – GPS time differs from UTC by a variable integral number of seconds.  $UTC = (GPS\ time) - (GPS/UTC\ offset)$ .




---

**Caution** – GPS week numbers run from 0 to 1023 and then cycles back to week #0. Week #0 began January 6, 1980. Another week #0 began August 22, 1999. The receiver automatically adds 1024 to the GPS week number after August 21, 1999, and reports the cumulative week number.

---

The seconds count begins with "0" each Sunday morning at midnight GPS time. A negative indicated time-of-week indicates that time is not yet known; in that case, the packet is sent only on request. The following table shows the relationship between the information in packet 41, and the packet 46 status code.

**Table A-29 Relationship Between Packet 41 and Packet 46**

Approximate Time Accuracy	Time Source	Sign (TOW)	Packet 0x46 Status Code
None	No time at all	–	0x01
Unknown	Approximate time from real-time clock or packet 2E	+	0x01
20 to 50 msec + clock drift	Time from satellite	+	not 0x01
Full accuracy	Time from GPS solution	+	0x00




---

**Note** – Before using the GPS time, verify that the packet 46 status code is 0x00 ("Doing position fixes"). This ensures the most accurate GPS time.

---

**0x42****Report Packet 42  
Single-Precision Position Fix, XYZ ECEF Report**

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O "position" option is set to "XYZ ECEF" and the I/O "precision-of-position output" (Packet 35) is set to single-precision, and the packet is masked for output by packet 8E-4D, then the GPS receiver sends this packet each time a fix is computed. The data format is shown below.

**Table A-30 Report Packet 42**

Byte	Item	Type	Units
0-3	X	SINGLE	meters
4-7	Y	SINGLE	meters
8-11	Z	SINGLE	meters
12-15	time-of-fix	SINGLE	seconds

The time-of-fix is in GPS time or UTC as selected by the I/O "timing" option. At start-up, this packet or packet 83 is also sent with a negative time-of-fix to report the current known position. Packet 83 provides a double-precision version of this information.

**0x43****Report Packet 43  
Velocity Fix, XYZ ECEF Report**

This packet provides current GPS velocity fix in XYZ ECEF coordinates. If the I/O "velocity" option (Packet 35) is set to "XYZ ECEF ", and the packet is masked for output by packet 8E-4D, then the GPS receiver sends this packet each time a fix is computed. The data format is shown below.

**Table A-31 Report Packet 43**

Byte	Item	Type	Units
0-3	X velocity	SINGLE	meters/second
4-7	Y velocity	SINGLE	meters/second
8-11	Z velocity	SINGLE	meters/second
12-15	bias rate	SINGLE	meters/second
16-19	time-of-fix	SINGLE	seconds

The time-of-fix is in GPS time or UTC as selected by the I/O "timing" option.

**0x45****Report Packet 45  
Software Version Information Report**

This packet provides information about the version of software in the Navigation and Signal Processors. The GPS receiver sends this packet after power-on and in response to packet 1F.

**Table A-32 Report Packet 45**

Byte	Item	Type
0	Major version number	BYTE
1	Minor version number	BYTE
2	Month	BYTE
3	Day	BYTE
4	Year number minus 1900	BYTE
5	Major revision number	BYTE
6	Minor revision number	BYTE
7	Month	BYTE
8	Day	BYTE
9	Year number minus 1900	BYTE

The first five bytes refer to the Navigation Processor and the second five bytes refer to the Signal Processor.

**0x46****Report Packet 46  
Health of Receiver Report**

This packet provides information about the satellite tracking status and the operational health of the receiver. The receiver sends this packet after power-on or software-initiated resets, in response to packet 26, during an update cycle, when a new satellite selection is attempted, and when the receiver detects a change in its health. Packet 4B is always sent with this packet. The data format is given in the following table.

**Table A-33 Report Packet 46**

Byte	Item	Type	Value	Meaning
0	Status code	Byte	00 hex 01 hex 03 hex 08 hex 09 hex 0A hex 0B hex 0C hex	Doing position fixes Do not have GPS time yet PDOP is too high No usable satellites Only 1 usable satellite Only 2 usable satellites Only 3 usable satellites The chosen satellite is unusable
1	Error codes	Byte		See Table A-34

The error codes in Byte 1 of packet 46 are encoded into individual bits within the byte. The bit positions and their meanings are shown in Table A-34.

**Table A-34 Report Packet 46**

<b>Error Code Bit Position</b>	<b>Meaning if bit value = 1</b>
0 (LSB)	(Unused)
1	Signal Processor error (Note 1)
2	Alignment error, channel or chip 1 (Note 1)
3	Alignment error, channel or chip 2 (Note 1)
4	Antenna feed line fault (Open or Short)
5	Excessive reference frequency error (Note 2)
6	(Unused)
7 (MSB)	(Unused)

Note 1: After this error is detected, the bit remains set until the receiver is reset.

Note 2: This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance. (Packet 2D requests the oscillator offset and packet 4D returns the oscillator offset to the user.)



## 0x47

### Report Packet 47 Signal Levels for all Satellites Report

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (that is, above the elevation mask and healthy according to the almanac). The receiver sends this packet only in response to packet 27. Table A-35 shows the data format.

**Table A-35 Report Packet 47**

Byte	Item	Type
0	Count	BYTE
1	Satellite number 1	BYTE
2-5	Signal level 1	SINGLE
6	Satellite number 2	BYTE
7-10	Signal level 2	SINGLE
(etc.)	(etc.)	(etc.)

Up to 8 satellite number/signal level pairs may be sent, indicated by the count field. Signal level is normally positive. If it is zero then that satellite has not yet been acquired. If it is negative then that satellite is not currently in lock. The absolute value of signal level field is the last known signal level of that satellite.

The signal level provided in this packet is a linear measure of the signal strength after correlation or de-spreading.

## 0x48

### Report Packet 48 GPS System Message Report

This packet provides the 22-byte ASCII message carried in the GPS satellite navigation message. The receiver sends this packet in response to packet 28 and when this data is received from a satellite.

The message is effectively a bulletin board from the Air Force to GPS users. The format is free-form ASCII. The message may be blank.

**0x49****Report Packet 49  
Almanac Health Page Report**

This packet provides health information on all 32 satellites. Packet data consists of 32 bytes each containing the 6-bit health from almanac page 25. The first byte is for satellite #1, and so on. The receiver sends this packet in response to packet 29 and when this data is received from a satellite.

**Table A-36 Report Packet 49**

Byte	Item
0	health of satellite #1
1	health of satellite #2
---	---
---	---
---	---
31	health of satellite #32

In each data byte of this packet, a value "0" indicates that the satellite is healthy; all other values indicate that the satellite is unhealthy.

**0x4A****Report Packet 4A  
Reference Altitude or Single-Precision LLA Position  
Fix Report**

The Reference Altitude variation of the packet is returned in response to command packet 2A when setting or requesting reference altitude.

**Table A-37 Report Packet 4A – Report Reference  
Altitude**

Byte	Item	Type	Units
0-3	Altitude	SINGLE	Meters above WGS-84 or MSL
4-7	Reserved	SINGLE	Reserved
8	Reserved	BYTE	Reserved

The Single-Precision LLA Position Fix variation of the packet provides current GPS position fix in LLA (latitude, longitude, and altitude) coordinates. If the I/O "position" option is set to "LLA" and the I/O "precision-of-position output" is set to single-precision, and the packet is masked with packet 8E-4D, then the receiver sends this packet each time a fix is computed. The data format is shown below.

**Table A-38 Report Packet 4A – Report Single-Precision LLA Position**

Byte	Item	Type	Units
0-3	Latitude	SINGLE	Radians; + for north, - for south
4-7	Longitude	SINGLE	Radians; + for east, - for west
8-11	Altitude	SINGLE	Meters
12-15	Clock Bias	SINGLE	Meters
6-19	Time-of-Fix	SINGLE	Seconds

The LLA conversion is done according to the datum selected using packet 8E-14. The default is WGS-84. Altitude is referred to the WGS-84 ellipsoid or the MSL Geoid, depending on which I/O "LLA altitude" option is selected. The time-of-fix is in GPS time or UTC, depending on which I/O "timing" option is selected.

This packet also is sent at start-up with a negative time-of-fix to report the current stored position. Packet 84 provides a double-precision version of this information.



**Caution** – When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant  $\pi$ (Pi). The value of the constant Pi as specified in ICD-GPS-200 is 3.1415926535898.

The MSL option is only valid with the WGS-84 datum. When using other datums, only the HAE option is valid.

**0x4B****Report Packet 4B  
Machine/Code ID and Additional Status Report**

The receiver transmits this packet in response to packets 25 and 26 and following a change in state. This packet identifies the receiver and may present error messages. Packet 46 is always sent with this packet. The machine ID can be used by equipment communicating with the receiver to determine the type of receiver to which the equipment is connected. Then the interpretation and use of packets can be adjusted accordingly.

**Table A-39 Report Packet 4B**

Byte	Item	Type/ Value	Status/Meaning
0	Machine ID	BYTE	0x61 =Acutime 2000
1	Status 1	BYTE	The Status 1 codes are encoded into individual bits within the byte
2	Status 2	BYTE	Super packets are supported.

The status codes are encoded into individual bits within the bytes. The bit positions and their meanings are shown below.

**Table A-40 Byte 1 Bit Encoding – Status 1**

Status 1 Bit Position	Meaning if bit value = 1
0 (LSB)	(Not Used)
1	(Not Used)
2	(Not Used)
3	The Almanac stored in the receiver is not complete and current
4-7	Not used

**0x4C****Report Packet 4C  
Operating Parameters Report**

This packet provides several operating parameter values of the receiver. The receiver sends this packet in response to packet 2C. The data string is four SINGLE values. The dynamics code indicates the expected vehicle dynamics and is used to assist the initial solution. The elevation angle mask determines the lowest angle at which the receiver tries to track a satellite. The signal level mask sets the required signal level for a satellite to be used for position fixes.

The PDOP mask sets the maximum PDOP with which position fixes are calculated. The PDOP switch sets the threshold for automatic 3-D/2-D mode. If 4 or more satellites are available and the resulting PDOP is not greater than the PDOP mask value, then 3-dimensional fixes are calculated. This information is stored in non-volatile memory.

**Table A-41 Report Packet 4C**

Byte	Item	Type, Units	Default	Value, Velocity
0	Dynamics code	BYTE	Land	(0) value left unchanged (1) land, <120 knots (2) sea, <50 knots (3) air, <800 knots (4) static, stationary
1-4	Elevation angle mask	SINGLE, radians	0.1745 (or 10°)	
5-8	Signal level mask	SINGLE/---	4.0	
9-12	PDOP mask	SINGLE/---	8.0	
13-16	PDOP switch (3-D or 2-D)	SINGLE/---	6.0	

## 0x4D

### Report Packet 4D Oscillator Offset

This packet provides the current value of the receiver master oscillator offset in Hertz at carrier. This packet contains one SINGLE number (4 Bytes). The receiver sends this packet in response to packet 2D.

## 0x4E

### Report Packet 4E GPS Time Set Acknowledgment

Indicates whether the receiver accepted the time given in a Set GPS Time packet. The receiver sends this packet in response to packet 2E. This packet contains one byte.

**Table A-42 Report Packet 4E**

Value	Meaning
ASCII "Y"	The receiver accepts the time entered via packet 2E. The receiver has not yet received the time from a satellite.
ASCII "N"	The receiver does not accept the time entered via packet 2E. The receiver has received the time from a satellite and uses that time. The receiver disregards the time in packet 2E.

**0x4F****Report Packet 4F  
UTC Parameters Report**

This packet is sent in response to command packet 2F and contains 26 bytes. It reports the UTC information broadcast by the GPS system. For details on the meanings of the following parameters, consult ICD-200, Sections 20.3.3.5.2.4, 20.3.3.5.1.8, and Table 20-IX. On the simplest level, to get UTC time from GPS time, subtract  $\Delta T_{LS}$  seconds. The other information contained in this packet indicates when the next leap second is scheduled to occur.

**Table A-43 Report UTC Parameters**

Byte	Value	Type
0-7	A0	DOUBLE
8-11	A1	SINGLE
12-13	$\Delta T_{LS}$	INTEGER
14-17	$T_{OT}$	SINGLE
18-19	$WN_T$	INTEGER
20-21	$WN_{LSF}$ —	INTEGER
22-23	DN	INTEGER
24-25	$\Delta T_{LSF}$	INTEGER

## 0x54

### Report Packet 54 Bias and Bias Rate Report

The receiver sends this packet to provide the computed clock-only solution when the receiver is in the manual or automatic Overdetermined Clock mode or Time Only (1-SV) mode.

**Table A-44 Report Packet 54**

Byte	Item	Type	Units
0-3	Bias	SINGLE	meters
4-7	Bias rate	SINGLE	meters/second
8-11	Time of fix	SINGLE	seconds

The bias is the offset of the receiver internal time clock from GPS time. Bias is expressed as meters of apparent range from the satellites. It is used to correct the one PPS output. Bias rate is the frequency error of the receiver internal oscillator. It is expressed as apparent range rate. Time-of-fix is in GPS or UTC time as selected by the I/O "timing" option in packet 0x35.



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**Caution** – For accurate interpretation of the propagation delay, the precise constant for the speed of light must be used. The ICD-200 value for the speed of light is 299,792,458 meters per second.

---

## 0x55

### Report Packet 55 I/O Option Flags Report

This packet provides current I/O options in response to packet 35 request. The data format is the same as for packet 35. See packet 35 for details.



**0x56****Report Packet 56****Velocity Fix, East-North-Up (ENU) Report**

If single precision East-North-Up (ENU) coordinates have been selected for the I/O "velocity" option (Packet 35), the receiver sends this packet under the following conditions: (1) each time that a fix is computed if masked for output by packet 8E-4D; (2) in response to packet 37 (last known fix). The data format is shown in Table A-45.

**Table A-45 0x56 – Velocity Fix, East-North-Up (ENU) Report**

Byte	Item	Type	Units
0-3	East Velocity	SINGLE	m/s; + for east, - for west
4-7	North Velocity	SINGLE	m/s; + for north, - for south
8-11	Up Velocity	SINGLE	m/s; + for up, - for down
12-15	Clock Bias Rate	SINGLE	m/s
16-19	Time-of-fix	SINGLE	seconds

The time-of-fix is in GPS or UTC time as selected by the I/O "timing" option.

**0x57****Report Packet 57  
Information About Last Computed Fix Report**

This packet provides information concerning the time and origin of the previous position fix. The receiver sends this packet, among others, in response to packet 37.

The data format is shown below.

**Table A-46 Report Packet 57**

Byte	Item	Type/Units	Value
0	Source of information	BYTE/- - -	0/none 1/regular fix
1	Tracking mode	BYTE/- - -	0/Auto 1/Time Only 1-SV 2/2D Clock Hold 3/2D 4/3D 5/Overdetermined Clock 6/DGPS Reference
2-5	Time of last fix	SINGLE/seconds, GPS time	
6-7	Week of last fix	INTEGER/weeks, GPS time	

**0x58****Report Packet 58  
Satellite System Data/Acknowledge from Receiver**

This packet provides GPS data (almanac, ephemeris, etc.). The receiver sends this packet under the following conditions: (1) on request; (2) in response to packet 38 (acknowledges the loading of data). The data format is shown below.

**Table A-47 Report Packet 58**

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	1	Acknowledge
			2	Data Out
1	Type of data	BYTE	1	not used
			2	Almanac
			3	Health page, T_oa, WN_oa
			4	Ionosphere
			5	UTC
			6	Ephemeris
2	Sat PRN #	BYTE	0	Data that is not satellite ID-specific
			1 to 32	Satellite PRN number
3	length (n)	BYTE		Number of bytes of data to follow
4 to n+3	data	n BYTES		

The binary almanac, health page, and UTC data streams are similar to reports 40, 49, and 4F respectively, and those reports are preferred. To get ionosphere or ephemeris, this report must be used.

**Table A-48 Report Packet 58 – ALMANAC Data Report**

Byte	Item	Type	Meaning
4	t_oa_raw	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.2)
5	SV_HEALTH	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.2)
6-9	e	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
10-13	t_oa	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
14-17	i_o	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
18-21	OMEGADOT	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
22-25	sqrt_A	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
26-29	OMEGA_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
30-33	omega	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
34-37	M_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
38-41	a_f0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
42-45	a_f1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
46-49	Axis	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
50-53	n	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
54-57	OMEGA_n	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
58-61	ODOT_n	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
62-65	t_zc	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
66-67	weeknum	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.2)
68-69	wn_oa	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.2)

Note: All angles are in radians.

**Table A-49 Report Packet 58 – ALMANAC HEALTH Data Report**

Byte	Item	Type	Meaning
4	week # for health	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.3)
5-36	SV_health	32 BYTES	(cf. ICD-200, Sec 20.3.3.5.1.3)
37	t_oa for health	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.3)
38	current t_oa	BYTE	units = seconds/2048
39-40	current week #	INTEGER	

**Table A-50 Report Packet 58 – IONOSPHERE Data Report**

Byte	Item	Type	Meaning
4-11	---	---	compact storage of the following info
12-15	alpha_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
16-19	alpha_1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
20-23	alpha_2	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
24-27	alpha_3	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
28-31	beta_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
32-35	beta_1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
36-39	beta_2	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
40-43	beta_3	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)

**Table A-51 Report Packet 58 – UTC Data Report**

Byte	Item	Type	Meaning
4-16	---	---	compact storage of the following info
17-24	A_0	DOUBLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
25-28	A_1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
29-30	delta_t_LS	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.8)
31-34	t_ot	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
35-36	WN t	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.8)
37-38	WN_LSF	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.8)
39-40	DN	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.8)
41-42	delta_t_LSF	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.8)

**Table A-52 Report Packet 58 – EPHEMERIS Data Report**

Byte	Item	Type	Meaning
4	sv_number	BYTE	SV PRN number
5-8	t_ephem	SINGLE	time of collection
9-10	weeknum	INTEGER	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
11	codeL2	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
12	L2Pdata	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
13	SVacc_raw	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
14	SV_health	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
15-16	IODC	INTEGER	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
17-20	T_GD	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
21-24	t_oc	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
25-28	a_f2	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
29-32	a_f1	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
33-36	a_f0	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)
37-40	SVacc	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-1)

**Table A-52 Report Packet 58 – EPHEMERIS Data Report (Continued)**

Byte	Item	Type	Meaning
41	IODE	BYTE	(cf. ICD-200, Sec 20.3.3.4)
42	fit_interval	BYTE	(cf. ICD-200, Sec 20.3.3.4)
43-46	C_rs	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
47-50	delta_n	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
51-58	M_0	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
59-62	C_uc	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
63-70	e	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
71-74	C_us	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
75-82	sqrt_A	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
83-86	t_oe	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
87-90	C_ic	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
91-98	OMEGA_0	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
99-102	C_is	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
103-110	i_o	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
111-114	C_rc	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
115-122	omega	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
123-126	OMEGADOT	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
127-130	IDOT	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
131-138	Axis	DOUBLE	= (sqrt_A) <sup>2</sup>
139-146	n	DOUBLE	derived from delta_n
147-154	r1me2	DOUBLE	= sqrt(1.0-e <sup>2</sup> )
155-162	OMEGA_n	DOUBLE	derived from OMEGA_0, OMEGADOT
163-170	ODOT_n	DOUBLE	derived from OMEGADOT

Note: All angles are in radians.

**0x59****Report Packet 59  
Satellite Attributes Database Report**

This packet is returned in response to packet 39 if operation mode 3 or 6 is used with packet 39.

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) which satisfy all mask values, for use in the position solution.

Packet 59 indicates whether each satellite is allowed or not allowed to be selected for use in the position solution, or whether each satellite's health is to be heeded or ignored. The data format is shown below.



**Note** – When viewing the satellite disabled list, the satellites are not numbered but are in numerical order. The disabled satellites are signified by a 1 and enabled satellites are signified by a 0.

**Table A-53 Report Packet 59**

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	3	The remaining bytes tell whether receiver is allowed to select each satellite.
			6	The remaining bytes tell whether the receiver heeds or ignores each satellite's health as a criterion for selection.
1 to 32	Satellite #	32 BYTES (1 byte per satellite)	0	Enable satellite selection or heed satellite's health. Default value.
			1	Disable satellite selection or ignore satellite's health.



# 0x5A

## Report Packet 5A Raw Measurement Data Report

This packet provides raw GPS measurement data. If the I/O auxiliary option for "raw data" has been selected (packet 35), and it is masked for output by packet 8E-4D, the receiver outputs a packet 5A for each satellite being tracked, once per second. The receiver also sends this packet in response to packet 3A. The data format is shown below.

**Table A-54 Report Packet 5A**

Byte	Item	Type	Units
0	Satellite PRN number	BYTE	
1-4	reserved	SINGLE	
5-8	Signal level	SINGLE	
9-12	Code phase	SINGLE	1/16th chip
13-16	Doppler	SINGLE	Hertz
17-24	Time of Measurement	DOUBLE	seconds




---

**Note** – Report Packet 5A provides the raw satellite signal measurement information used in computing a fix.

---

The *satellite PRN* (Byte 0) number is a unique identification for each of the 32 GPS satellites.

### Signal level

The *Signal Level* (Byte 5) is a linear approximation of C/N0 which is stated in antenna amplitude measurement units (AMUs), a Trimble devised unit.

---

**Note** –  $SNR_{(\pm 3)} = 20\log((\text{signal counts}/\text{noise counts}) * (\text{BW}/2))$  where:  
signal counts = 64 \* AMU; noise counts = 90, and BW = 1000Hz.

---

The C/N0 is affected by five basic parameters:

- signal strength from the GPS satellite
- receiver/antenna gain
- pre-amplifier noise figure
- receiver noise bandwidth
- accumulator sample rate and statistics

The approximation is very accurate from 0 to 25 AMUs.

### Codephase

The *codephase* (Byte 9) value is the average delay over the sample interval of the received C/A code and is measured with respect to the receiver's millisecond timing reference. Thus, it includes all receiver, satellite, and propagation biases and errors. It is expressed in 1/16th of a C/A code chip.

### Doppler

The *Doppler* (Byte 13) value is apparent carrier frequency offset averaged over the sample interval. It is measured with respect to the nominal GPS L1 frequency of 1575.42 MHz, referenced to the receiver's internal oscillator. Thus, it includes all receiver and satellite clock frequency errors. It is expressed in Hertz at the L1 carrier.

### Time of measurement

The *time of measurement* (Byte 17) is the center of the sample interval adjusted by adding the receiver-supplied codephase (modulo mS) to a user-determined integer number of mS between user and satellite.

The receiver codephase resolution is 1/16th of a C/A code chip. This corresponds to:

$$\begin{aligned}
 1/16 \times \text{C/A code chip} &= 977.517\text{ns}/16 \approx 61.0948 \text{ ns} \\
 &\approx \\
 &\approx 61.0948 \times \text{speed of light, m/s} \\
 &\approx 18.3158 \text{ meters}
 \end{aligned}$$

The integer millisecond portion of the pseudo-range must then be derived by utilizing the approximate user and satellite positions. Rough user position (within a few hundred kilometers) must be known; the satellite position can be found in its almanac/ephemeris data.

Each mS integer corresponds to:

$$\begin{aligned}
 \text{C/A code epoch} \times \text{speed of light} &= 1 \text{ ms} \times \text{speed of light m/s} \\
 &= \\
 &\approx 300 \text{ km (approximate)} \\
 &\approx 299.792458 \text{ km (precise)}
 \end{aligned}$$

The satellite time-of-transmission for a measurement can be reconstructed using the code phase, the time of measurement, and the user-determined integer number of milliseconds.

**0x5B****Report Packet 5B  
Satellite Ephemeris Status Report**

This packet is sent in response to packet 3B and optionally, when a new ephemeris (based on IODE) is received. It contains information on the status of the ephemeris in the receiver for a given satellite. The structure of packet 5B is shown in the table below.

**Table A-55 Report Packet 5B**

Byte	Item	Type	Units
0	Satellite PRN number	BYTE	
1-4	Time of Collection	SINGLE	seconds
5	Health	BYTE	
6	IODE	BYTE	
7-10	toe	SINGLE	seconds
11	Fit Interval Flag	BYTE	
12-15	SV Accuracy (URA)	SINGLE	meters

SV PRN Number is from 1 to 32 representing the satellite PRN number. Time of Collection is the GPS time when this ephemeris data was collected from the satellite. Health is the 6-bit ephemeris health. IODE, toe, and Fit Interval Flag are as described in ICD-GPS-200. SV Accuracy (URA) is converted to meters from the 4-bit code as described in ICD-GPS-200.

**0x5C****Report Packet 5C  
Satellite Tracking Status Report**

This packet provides tracking status data for a specified satellite. Some of the information is very implementation-dependent and is provided mainly for diagnostic purposes. The receiver sends this packet in response to packet 3C hex. The data format is shown below.

**Table A-56 Report Packet 5C**

Byte/Item	Type/Units	Value/Meaning
Byte 0 / Satellite PRN number	BYTE/ number 1-32	
Byte 1 / Channel and slot code	BYTE	
		Bit position within Byte 1: bits 7(MSB)-3 (channel number beginning with 0) (MSB) 0 0 0 0 channel 1: used by all receivers 0 0 0 1 channel 2: 8-channel receivers 0 0 1 0 channel 3: 8-channel receivers 0 0 1 1 channel 4: 8-channel receivers 0 0 1 0 0 channel 5: 8-channel receivers 0 0 1 0 1 channel 6: 8-channel receivers 0 0 1 1 0 channel 7: 8-channel receivers 0 0 1 1 1 channel 8: 8-channel receivers
Byte 2 / Acquisition flag	BYTE	0 never acquired 1 acquired 2 re-opened search
Byte 3 / Ephemeris flag	BYTE	0 flag not set ≠ (0 or 33) good ephemeris for this satellite ( <4 hours old, good health)
Byte 4-7 / Signal level	SINGLE	same as in packet 47 hex
Byte 8-11 / GPS time of last measurement	SINGLE/ seconds	<0 no measurements have been taken ≥0 center of the last measurement taken from this satellite

**Table A-56 Report Packet 5C (Continued)**

<b>Byte/Item</b>	<b>Type/Units</b>	<b>Value/Meaning</b>
Byte 12-15 / Elevation	SINGLE/ radians	Approximate elevation of this satellite above the horizon. Updated about every 15 seconds. Used for searching and computing measurement correction factors.
Byte 16-19 / Azimuth	SINGLE/ radians	Approximate azimuth from true north to this satellite. Updated about every 15 seconds. Used for computing measurement correction factors.
Byte 20 / old measurement flag	BYTE	N/A
Byte 21 / Integer msec flag	BYTE	N/A
Byte 22 / bad data flag	BYTE	N/A
Byte 23 / Data collection flag	BYTE	N/A

## 0x5F-11

### Report Packet 5F-11 EEPROM Segment Status Reports

This report packet is sent in response to command packet 3F-11. It contains all the segments in the EEPROM. The Segment Status is bitwise encoded with the status of each segment and is cleared to 0 after it is read. A zero in the bit field indicates that the segment contents are valid. A one in the bit field indicates that the segment contents were corrupt and had to be reverted to their factory default values. The Manufacturing and Production parameters (Bits 0, 1) do not have factory default values.

**Table A-57 Report Packet 5F-11 – EEPROM Segment Status Report**

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	BYTE	0x11	
1-2	0	Segment Status	Bit field U16	—	Manufacturing parameters (8F-41)
	1				Production parameters (8F-42)
	2				Receiver configuration
	3				Packet I/O control
	4				Serial port configuration
	5				Timing output configuration
	6				Accurate position
	7				Self-survey configuration
	8				NMEA configuration
	9-10				(Not Used)
	11				UTC information
	12-15				(Not used)

**0x60****Command Packet 0x60  
Type 1 Differential GPS Corrections**

This packet provides the receiver with differential corrections from RTCM SC-104 record types 1 and 9, in the TSIP format. There is no response to this packet. If bit 6 is set, the corrections are as in RTCM Type 9 records. The format for this packet is shown in Table A-58.

**Table A-58 Report Packet 0x60 Data Formats**

Byte	Bit	Item	Type	Range	Units
0 - 1		Modified z-count	U16	0-5999	.6 SEC
2		Station health	U8	--	
3	0 - 5	Number of SVs in packet	Bits	0-31	0 - 5
3	6	Type 9 flag	Bit	0 1	type 1 type 9
3	7	Version 2 flag	Bit	1	must be set



The next 5 bytes are repeated as a group for each satellite. The SV PRN and scale factor contains the SV PRN in the lower 5 bits, and the scale factor in the upper 3 bits. Range corrections are scaled by 0.02 meters times 2 raised to the scale factor power. Range-rate corrections are scaled by 0.002 meters per second times 2 raised to the scale factor power. The format is shown in Table A-59.

**Table A-59 Report Packet 0x60 Data Formats for Health and Power**

Byte	Bit	Item	Type	Value	Definition
4+ (N*5)	0-4	SV PRN		0-31	"0" Is SV 32
4+ (N*5)	5-7	Scale factor		0 4 7	Low Scale factor (.02m, .002 m/s) High Scale factor (.32m, .032 m/s) Correction not usable
5+ (N*5)		Range correction	U16		RTCM-104
7+ (N*5)		Range-rate correction	U8		RTCM-104
8+ (N*5)		IODE	U8		

## 0x61 Command Packet 0x61 Set Differential GPS Corrections

This TSIP packet provides the delta differential corrections from RTCM-104 record type 2. There is no response to this packet. Scale factors are version 1 unless the version 2 flag is set. The format for this packet is shown in Table A-60.

**Table A-60 Command Packet 0x61 Data Formats**

Byte	Bit	Item	Type	Value	Definition
0 - 1		Modified Z-count	U16	0-5999	.6 SEC
2	0-6	Number of SVs		0-31	
2	7	Version 2 flag	Bit	1	must be set
The next 3 bytes are repeated as a group for each satellite:					
3+(N*2)	0-4	SV PRN		0-31	"0" Is SV 32
3+(N*2)	5-7	Scale factor		0 4 7	Low Scale factor (.02m, .002 m/s) High Scale factor (.32m, .032 m/s) Correction not usable
4+(N*2)		Range correction	U16		RTCM-104

The units and scale factors are as defined by Packet 0x60. Delta range correction rates are not entered.

**0x6D****Report Packet 6D  
All-In-View Satellite Selection Report**

This packet provides a list of satellites used for position fixes by the GPS receiver. The packet also provides the PDOP, HDOP, and VDOP of that set and provides the current mode (automatic or manual, 3-D or 2-D). This packet has variable length equal to 16+nsvs (minimum 4), where "nsvs" is the number of satellites used in the solution.

The GPS receiver sends this packet in response to packet 24 or whenever a new satellite selection is attempted. The GPS receiver attempts a new selection every 30 seconds and whenever satellite availability and tracking status change. The data format is shown below.

**Table A-61 Report Packet 6D**

Byte	Item	Type	Units		
			Bit	Value	Meaning
0	Mode	BYTE	0-2	0	Auto
				1	Time Only (1-SV)
				2	2D Clock Hold
				3	2D
				4	3D
				5	Overdetermined Clock
				6	DGPS Reference
			3	0	Auto
				1	Manual
4-7	--	nsvs			
1-4	PDOP	SINGLE	PDOP		
5-8	HDOP	SINGLE	HDOP		
9-12	VDOP	SINGLE	VDOP		
13-16	TDOP	SINGLE	TDOP		
(16+nsvs)	SV PRN	BYTE			

**0x7A****Command Packet 7A  
Set or Request NMEA Interval and Message Mask**

The NMEA mask determines whether or not a given NMEA message will be output. If the bit for a message is set, the message will be sent every “interval” seconds. To determine the NMEA interval and message mask, use the values shown in Table A-62. While fixes are being generated, the output order is: ZDA, GGA, GLL, VTG, GSA, GSV, RMC.

**Table A-62 Command Packet 7A**

Byte	Bit	Item	Type	Value	Definition
0		Subcode	U8	0	
1		Interval	U8	1-255	Fix interval in seconds
2		Reserved	U8	0	
3		Reserved	U8	0	
4	0	RMC	Bit	0 1	Off On
4	1-7	Reserved	Bit	0	
5	0	GGA	Bit	0 1	Off On
5	1	GLL	Bit	0 1	Off On
5	2	VTG	Bit	0 1	Off On
5	3	GSV	Bit	0 1	Off On
5	4	GSA	Bit	0 1	Off On
5	5	ZDA	Bit	0 1	Off On
5	6-7	Reserved	Bit	0	

## 0x7B

### Report Packet 7B NMEA Message Output

This packet is sent in response to command packet 7A and has the same data format as packet 7A.

## 0x83

### Report Packet 83 Double-precision XYZ Position Fix And Bias Information

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O "position" option is set to "XYZ ECEF", the I/O double-precision option is selected (packet 35), and the packet is masked for output in packet 8E-4D, the receiver sends this packet each time a fix is computed. The data format is shown below.

**Table A-63 Report Packet 83**

Byte	Item	Type	Units
0-7	X	DOUBLE	meters
8-15	Y	DOUBLE	meters
16-23	Z	DOUBLE	meters
24-31	clock bias	DOUBLE	meters
32-35	time of fix	SINGLE	seconds

The time-of-fix is in GPS time or UTC, as selected by the I/O "timing" option in packet 0x35. At start-up, if the I/O double-precision option is selected, this packet is also sent with a negative time-of-fix to report the current stored position.

Packet 42 provides a single-precision version of this information.

## 0x84

### Report Packet 84 Double-precision LLA Position Fix and Bias Information

This packet provides current GPS position fix in LLA coordinates. If the I/O "position" option is set to "LLA", the double-precision option

is selected (packet 35), and the packet is masked for output in packet 8E-4D, the receiver sends this packet each time a fix is computed. The data format is shown in the table below.

**Table A-64 Report Packet 84**

Byte	Item	Type	Units
0-7	latitude	DOUBLE	radians; + for north, – for south
8-15	longitude	DOUBLE	radians; + for east, – for west
16-23	altitude	DOUBLE	meters
24-31	clock bias	DOUBLE	meters
32-35	time of fix	SINGLE	seconds

The time-of-fix is in GPS time or UTC, as selected by the I/O "timing" option packet 35. At start-up, this packet is also sent with a negative time-of-fix to report the current stored position.

Packet 4A provides a single-precision version of this information.




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**Caution** – When converting from radians to degrees, using an insufficiently precise approximation for the constant  $\pi$  (Pi) introduces significant and readily visible errors. The value of  $\pi$  as specified in ICD-GPS-200 is 3.1415926535898.

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**0xBB****Command Packet BB  
Set Primary Receiver Configuration**

TSIP command packet BB contains the primary receiver configuration parameters.

The Acutime 2000 stores 3 independent sets of configuration parameters. These are designated as the "Mobile", "Survey" and "Timing" configurations.

The active configuration is determined by the survey state:

**Table A-65 Survey State Configurations**

<b>Survey State</b>	<b>Active Configuration</b>
Survey Disabled	Mobile
Survey Active	Survey
Survey Complete	Timing

When the survey state changes, the receiver automatically switches to the new configuration. Only the active configuration can be programmed.

To program configurations, switch the active configuration by changing to the appropriate survey state using packets 8E-A6 and 8E-A9, update the configuration (BB), and save settings (8E-26).

There are restrictions to the dynamics code and operating dimension settings, which take effect when survey is enabled, ensuring that the receiver performs a valid survey and enters a timing mode afterwards.

The following table shows valid settings for each configuration.

**Table A-66 Vaild GPS Configuration Settings**

Survey State	Active Configuration	Dynamics Code	Operating Dimension
Survey Disabled	Mobile	any	any
Survey Active	Survey	Land/Sea/Air	2D or 3D or Auto
Survey Complete	Timing	Stationary	1SV or Over-determined

Send packet BB with subcode 0 as the only data byte, to query for the primary receiver configuration. The receiver will respond with report packet BB. The table below lists the individual fields within the BB packet. When sending this packet, enter 0xFF or -1.0 to leave any parameter unchanged.

### Dynamics Code

The default is LAND mode, where the receiver assumes a moderate dynamic environment. In this case, the satellite search and re-acquisition routines are optimized for vehicle-type environments. In SEA mode, the search and re-acquisition routines assume a low acceleration environment and the receiver reverts to the user-entered altitude in 2-D auto. In AIR mode, the search and re-acquisition routines are optimized for high acceleration conditions.

### Elevation Mask

This is the minimum elevation angle for satellites to be used in a solution output by the receiver. Satellites near the horizon are typically more difficult to track due to signal attenuation, and are also generally less accurate due to higher variability in the ionospheric and tropospheric corruption of the signal. When there are no obstructions, the receiver can generally track a satellite down to near the horizon. However, when this mask is set too low, the receiver may experience frequent constellation switching due to low elevation satellites being obscured.



Frequent constellation switching is undesirable because position jumps may be experienced when Selective Availability is present and DGPS is not available to remove these effects. The benefit of a low elevation mask is that more satellites are available for use in a solution and a better PDOP may be yielded. The current default mask is set to 0.1745 radians ( $10^\circ$ ) and provides a reasonable trade-off between the benefits and drawbacks.

### Signal Level Mask

This mask defines the minimum signal strength for a satellite used in a solution. There is some internal hysteresis on this threshold, which allows brief excursions below the threshold if lock is maintained and the signal was previously above the mask. This mask should be lowered only with caution since it is also used to minimize the effects of jammers and reflected signals on the receiver. Users who require high accuracy can use a slightly higher mask of 6.0-8.0, since weaker measurements may be noisier and are often caused by reflected signals, which provide erroneous ranges.

Make sure that the elevation and SNR masks are not set too low. The satellite geometry is sometimes improved considerably by selecting low-elevation satellites. These satellites are, however, subject to significant signal degradation by the greater ionospheric and tropospheric attenuation that occurs. They are also subject to more obscuration by the passing scenery when the receiver is in a moving vehicle. The code phase data from those satellites is more difficult to decode and therefore has more noise.



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**Note** – A level of hysteresis in the signal level mask is allowed in the core operating software. The hysteresis allows the receiver to continue using satellite signals which fall slightly below the mask and prevents the receiver from incorporating a new signal until the signal level slightly exceeds the mask. This feature minimizes constellation changes caused by temporary fluctuations in signal levels.

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### PDOP Mask and Switch

The PDOP mask is the maximum PDOP limit for which any 2-D or 3-D position solution will be made. The PDOP switch is the level at which the receiver stops attempting a 3-D solution, and tries for a 2-D solution when in automatic 2-D/3-D mode. The switch level has no effect on either manual mode. Raising the PDOP mask generally increases the fix density during obscuration, but the fixes with the higher PDOP are less accurate (especially with Selective Availability present). Lowering the mask improves the average accuracy at the risk of lowering the fix density.



**Note** – The receiver may require an initial position fix before switching to some modes.

**Table A-67 Command Packet BB**

Byte #	Item	Type	Value	Meaning	Default
0	Subcode	BYTE	0	Primary receiver configuration block	
1	Operating Dimension	BYTE	0 1 3 4 5 6 7	Automatic Time only (1-SV) Horizontal (2D) Full position (3D) DGPS reference 2D clock hold Overdetermined clock	Full Position
2	DGPS Mode	BYTE	0 1 3	DGPS off DGPS only DGPS auto	DGPS Auto
3	Dynamics Code	BYTE	1 2 3 4	Land, <120 knots Sea, <50 knots Air, <800 knots Static	Land

**Table A-67 Command Packet BB (Continued)**

Byte #	Item	Type	Value	Meaning	Default
4	Solution Mode	BYTE	1	Overdetermined fix	Over-determined fix
5-8	Elevation Mask	SINGLE	$0-\pi/2$	Lowest satellite elevation for fixes	0.1745 (10 deg.)
9-12	AMU Mask	SINGLE		Minimum signal level for fixes	4.0
13-16	PDOP Mask	SINGLE		Maximum PDOP for fixes	8
17-20	PDOP Switch	SINGLE		Selects 2D/3D mode	6
21	DGPS Age	BYTE		Maximum time to use a DGPS correction (seconds)	30 seconds
22	Foliage Mode	BYTE	0	Never	Never
23	Reserved	BYTE	N/A	N/A	
24	Reserved	BYTE	N/A	N/A	
25	Measurement Rate	BYTE	0	1 Hertz	1 Hz
26	Position Fix Rate	BYTE	0	1 Hertz	1 Hz
27-42	Reserved	BYTE	-1	Reserved for future use	

## 0xBB Report Packet BB Report Receiver Configuration

TSIP report packet BB is used to report the receiver configuration options. For information about the data formats, see command packet BB.

## 0xBC Command Packet BC Set Port Configuration Parameters

TSIP command packet BC is used to set the communication parameters on Port A and Port B. The table below lists the individual fields within the BC packet.

Flow control is not supported. Please refer to section A.2 "Physical Interface Characteristics" for details on the capabilities of each port on the Acutime 2000.

**Table A-68 Command Packet BC**

Byte #	Item	Type	Value	Meaning	Default
0	Port Number	BYTE	0 1 0xFF	Port B Port A current port	
1	Input Baud Rate	BYTE	0 1 2 3 4 5 6 7 8 9	None 110 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud	9600
2	Output Baud Rate	BYTE	As above	As above	9600
3	# Data Bits	BYTE	2 3	7 bits 8 bits	8 bits

**Table A-68 Command Packet BC (Continued)**

Byte #	Item	Type	Value	Meaning	Default
4	Parity	BYTE	0 1 2	None Odd Even	Odd
5	# Stop Bits	BYTE	0 2	1 bit 2 bits	1 bit
6	reserved	BYTE	0	None	
7	Input Protocols	BYTE	0 2 8	None TSIP (Port B only) RTCM (Port A only)	TSIP (Port B) None (Port A)
8	Output Protocols	BYTE	0 2 4	None TSIP NMEA	TSIP
9	Reserved	BYTE	0	None	

## 0xBC

### Report Packet BC Request Port Configuration Parameters

TSIP packet BC is used to request the communication parameters on Port B. To query a port's configuration parameters, send packet BC with only Byte 0. Table A-68, above, lists the individual fields within the BC report packet.

## **A.15 Custom OEM Packets**

Several packets have been added to the core TSIP protocol to provide additional capability for OEM receivers. In OEM packets 8E and their 8F responses, the first data byte is a subcode that indicates the superpacket type. For example, in packet 8E-14, 14 is the subcode that indicates the superpacket type. Therefore, the ID code for OEM packets is 2 bytes long, followed by the data.

## **A.16 TSIP Superpackets**

Superpackets describes packets that reduce the I/O traffic with the receiver and facilitate interpretation to a modem or data acquisition device with limited programming facilities.

## **0x8E-0B**

### **Command Packet 8E-0B Request or Configure Super Packet Output**

The 8E-0B packet is identical in function to the 8E-AD packet. If the 8E-0B byte sequence is sent with no data, the receiver will return an 8F-0B packet on Port B. The time reported by the 8F-0B packet on Port B is always the beginning of the current second.

## 0x8E-14

### Command Packet 8E-14 Set or Request Datum

To request the current datum, send this packet with no data. The receiver will return packet 8F-14.

This packet allows the user to change the default datum from WGS-84 to one of 180 selected datums or to a user-entered custom datum. The datum is a set of 5 parameters which describe an ellipsoid to convert the GPS receiver's internal coordinate system of XYZ ECEF into Latitude, Longitude and Altitude (LLA). This will affect all calculations of LLA in packets 4A and 84 and 8F-AC and 8F-0B. The receiver responds with packet 8F-14.

The user may want to change the datum to match coordinates with some other system (usually a map). Most maps are marked with the datum used and in the US the most popular datum for maps is NAD-27. The user may also want to use a datum that is more optimized for the local shape of the earth in that area. However, these optimized datums are truly "local" and will provide very different results when used outside of the area for which they were intended. WGS-84 is an excellent general ellipsoid valid around the world.

To change to one of the internally held datums the packet must contain exactly 2 bytes representing the integer value of the index of the datum desired. For a list of the datums and their indexes, see Table A-99.

**Table A-69 Command Packet 8E-14**

Byte #	Type	Value
0	Superpacket ID	0x14
1-2	INTEGER	Datum index



Alternatively, the unit will accept a 40 byte input packet containing 5 double-precision floating point values representing the ellipse. The first 3 are DX, DY, and DZ, which represent an offset in meters from the ECEF origin for the ellipse. The fourth parameter is the semi-major axis of the ellipse (called the a-axis) and is also in meters. The fifth parameter is the eccentricity of the ellipse and is dimensionless.




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**Caution** – The GPS receiver does not perform an integrity check on the datum values. If unusual inputs are used, the output will be equally unusual.

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**Table A-70 Command Packet 8E-14**

Byte #	Type	Value	Units
0	Superpacket ID	0x14	
1-8	DOUBLE	DX	meters
9-16	DOUBLE	DY	meters
17-24	DOUBLE	DZ	meters
25-32	DOUBLE	A-axis	meters
33-40	DOUBLE	Eccentricity Squared	None

## 0x8E-20

### Command Packet 8E-20 Request Last Fix with Extra Information

This packet requests packet 8F-20 or marks it for automatic output. If only the first byte (20) is sent, an 8F-20 report containing the last available fix will be sent immediately. If two bytes are sent, the packet is marked/unmarked for auto report according to the value of the second byte.

**Table A-71 Command Packet 8E-20**

Byte #	Item	Type	Value
0	Sub-packet ID	BYTE	0x20
1	Mark for Auto-report	BYTE	0 = do not auto-report 1 = auto-report



**Note** – Auto-report requires that superpacket output is enabled. Refer to command packet 35. This packet must also be enabled with packet 8E-4D.

## 0x8E-26

### Command Packet 8E-26 Write Receiver Configuration to EEPROM

This command packet causes the current configuration settings to be written to the EEPROM. It also generates a report packet 8F-26. This packet contains only a single byte: the subpacket ID.

## 0x8E-41

### Command Packet 8E-41 Manufacturing Operating Parameters

This packet is used to request the manufacturing parameters stored in nonvolatile memory. The packet contains only a single byte, the subpacket ID. The receiver returns packet 8F-41.

## 0x8E-42

### Command Packet 8E-42 Production Parameters

This packet is used to request the production parameters stored in nonvolatile memory. This packet contains only a single byte, the subpacket ID. The receiver returns packet 8F-42.

## 0x8E-45

### Command Packet 8E-45 Revert Segments to Default Settings

This command packet reverts the parameters stored in a specific EEPROM segment (or all segments) to their factory default settings and reconfigures the Acutime 2000 using those settings. The receiver returns packet 8F-45.

**Table A-72 Command Packet 0x8E-45**

Byte	Item	Type	Value	Segment Description
0	Subcode	BYTE	0x45	
1	Segment number	BYTE	2 3 4 5 6 7 8 11 0xFD 0xFF	Receiver configuration Packet I/O control Serial port configuration Timing output configuration Accurate position Self-survey configuration NMEA configuration UTC information Segments 2 through 8 All segments

## 0x8E-4A

### Command Packet 8E-4A Set/Request PPS Characteristics

Using this packet, you can query and control the receiver's PPS characteristics. The receiver responds to a query or control command with packet 8F-4A. The packet contains 16 bytes in the following order:

**Table A-73 Command Packet 8E-4A**

Byte #	Item	Type	Meaning
0	Sub-packet ID	BYTE	Always 0x4A
1	PPS Driver Switch	BYTE	0 = off 1 = on (default)
2	Time Base	BYTE	0: GPS 1: UTC (default)
3	PPS Polarity	BYTE	0: positive (default) 1: negative
4-11	PPS Offset or Cable Delay	DOUBLE	seconds (default = 0.0)
12-15	Bias Uncertainty Threshold	SINGLE	meters (default = 300)

To request 8F-4A, send a two-byte 8E-4A packet without any parameters. To update parameters, send the entire 16-byte message.

The default setting for byte 3 is positive. Bytes 4 to 11 define the PPS cable delay offset. The default offset is 0, which corresponds to a 100-foot (30-meter) cable. These bytes allow the application to adjust the cable delay offset for longer or shorter cable lengths. Use a cable delay of  $\pm 1.25$  ns/foot to adjust PPS offset for cable lengths different than 100 feet. For a longer cable, a negative value should be used to advance the PPS. The receiver estimates the bias uncertainty as part of a PPS validity monitor. If the bias uncertainty exceeds the threshold, then the receiver disables the PPS output. The default bias uncertainty threshold is 300 meters, but this parameter may be programmed by the application. The receiver limits the threshold to  $3 \times 10^8$  meters. Each time the application adjusts the packet 8E-4A settings, the new settings are stored in nonvolatile memory.

## 0x8E-4D

### Command Packet 8E-4D Automatic Packet Output Mask

Automatic output of packets on Port B can be throttled using this command packet. The current mask can be requested by sending this packet with no data bytes except the subcode byte. The receiver returns packet 8F-4D.

The automatic packet output mask can be set by sending this packet with 4 data bytes. This mask only disables automatic packet output. Packets generated in response to TSIP set or query commands will always be output by the receiver.

**Table A-74 Command Packet 8E-4D**

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0x4D
1-4	Auto-output mask	LONG	32-bit packet enable bitmap

The bits are numbered in descending order of receipt, starting with bit 31 as the MSB of Byte 1, down to bit 0 as the LSB of Byte 4. A "0" in the bit position disables automatic output of the associated packets; a "1" in the bit position makes the associated packets available for automatic output. Table A-75 describes the packets affected by each bit.

**Table A-75 Command Packet 8E-4D - Packets Affected By Bits**

Bit #	Output Packets	Default A2K	When Output	Meaning
0 (LSB)	40	0	After Decode	Almanac data collected from satellite.
1	58, 5B	0	After Decode	Ephemeris data collected from satellite.
2	4F	0	After Decode	UTC data collected from satellite.
3	58	0	After Decode	Ionospheric data collected from satellite.
4	48	0	After Decode	GPS Message.
5	49	0	After Decode	Almanac health page collected from satellite.
6	Reserved	1		Reserved
7	Reserved	1		Reserved
8	41	1	New Fix	Partial and full fix complete and packet output timer has expired.
9	Reserved	1		Reserved
10	Reserved	1		Reserved
11 (Note 1)	6D, 46, 4B, 82	1	Constellation Change, New Fix	New satellite selection

**Table A-75 Command Packet 8E-4D - Packets Affected By Bits**

Bit #	Output Packets	Default A2K	When Output	Meaning
12-29	Reserved	1		Reserved
30	42, 43, 4A, 54, 56, 83, 84, 8F-20,	1	New Fix Update	Kinetic and Timing information. Output must be enabled using I/O options.
31	5A	1	New Fix	Raw Measurement Data Output must be enabled using I/O options.

Note 1: A 1 in the bit mask turns on the associated packets and a 0 turns off the output of the associated packets.

## 0x8E-4E

### Command Packet 8E-4E Set PPS Output Option

This command packet sets the PPS driver switch to one of the values listed in Table A-76. The receiver returns packet 8F-4E. The current driver switch value can be requested by sending this packet with no data bytes except the subcode byte.

Driver switch values 3 and 4 only make sense in Overdetermined Timing mode. In any position fix mode the effective choices are always on or during fixes, which you get if you set the driver switch to 3 or 4.

**Table A-76 Command Packet 0x8E-4E**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0x4E	
1	PPS driver switch	BYTE	2 3 4	PPS is always output PPS is output when at least one satellite is tracking PPS is output when at least three satellites are tracking

## 0x8E-4F

### Command Packet 8E-4F for Acutime 2000 only Set PPS Width

This command packet sets the PPS width to a value in the range of 10 microseconds to 500 milliseconds. The receiver returns packet 8F-4F. The current PPS width can be requested by sending this packet with no data bytes except the subcode byte.

**Table A-77 Command Packet 0x8E-4F**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0x4F	
1-8	PPS width	DOUBLE		Seconds



## 0x8E-A5

### **Command Packet 8E-A5 Set or Request Packet Broadcast Mask**

Use command packet 8E-A5 to set the packet broadcast masks or to request the current mask settings. The receiver replies to requests with response packet 8F-A5. The broadcast mask is bitwise encoded to allow the user to turn on and off the automatic output (broadcast) of certain packets. For those broadcast packets that have multiple formats, the receiver will broadcast only one of the formats. If more than one of the formats is masked on for broadcast, then the format with the greatest precision of content will be sent and the rest will not. The coding for each bit in the mask follows:

- 0: Turn off automatic output (broadcast) of this packet
- 1: Turn on automatic output (broadcast) of this packet

**Table A-78 Command Packet 8E-A5**

Byte	Bit	Item	Type	Default	Description
0		Subcode	U8	0xA5	Subcode
1-2	0	0x8F-20	Bit field	1	Enable 0x8F-20 output on Port
	1			0	Reserved
	2			0	Reserved
	3			0	Reserved
	4			0	Reserved
	5			1	Enable auto TSIP outputs
	6	0x8F-AB		0	0x8F-AB, Primary timing info on all TSIP output ports
	7	0x8F-AC		0	0x8F-AC, Supplemental timing info on all TSIP output ports
	8	0x8F-0B		0	Synchronous 0x8F-0B (1 Hertz) on Port A
	9	0x8F-0B		1	Event output of 0x8F-0B on Port A
	10	0x8F-0B		0	Event output of 0x8F-0B on Port B
	11	0x8F-0B		0	Synchronous 0x8F-0B on Port B
	12	0x8F-AD		1	Synchronous 0x8F-AD (1 Hertz) on Port A
	13	0x8F-AD		1	Event output of 0x8F-AD on Port A
	14	0x8F-AD		0	Event output of 0x8F-AD on Port B
	15	0x8F-AD	0	Synchronous 0x8F-AD on Port B	
3-4	0-15		Bit field		Reserved (always 0)

## 0x8E-A6

### Command Packet 8E-A6 Issue Self-Survey Command

This command packet starts a self-survey. The receiver responds with report packet 8F-A6. This command has no effect when survey is disabled.

**Table A-79 Command Packet 8E-A6**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0xA6	
1	Self-survey command	BYTE	0	Restart self-survey

## 0x8E-A9

### Command Packet 8E-A9 Set Self-Survey Parameters

Use command packet 8E-A9 to set the self-survey parameters or to request the current settings. The receiver replies with response packet 8F-A9.

#### Data Fields:

Self-Survey Enable: Use this field to enabled or disabled the self-survey mechanism.

0: Disable the self-survey mechanism

1: Enable the self-survey mechanism

Position Save Flag: Use this field to tell the self-survey mechanism to automatically save (or to not save) the self-surveyed position at the end of the self-survey procedure.

0: Do not automatically save the surveyed position when the self-survey is complete

1: Automatically save the surveyed position when the self-survey is complete.

Self-Survey Length: Use this field to specify the number of position fixes that are to be averaged together to form the self-surveyed position used for clock-only fixes.

Limits: 1 to ( $2^{31} - 1$ ) fixes.



**Note** – After disabling the self-survey, the survey in progress can be stopped by issuing a restart self-survey command (0x8E-A6).

**Table A-80 Command Packet 8E-A9 Data Format <<segment 7>>**

Byte	Item	Type	Value	Description
0	Subcode	U8	0xA9	
1	Self-Survey Enable	U8	0	Disabled
			1	Enabled (factory default)
2	Position Save Flag	U8	0	Don't save position (factory default)
			1	Save self-surveyed position
3-6	Self-Survey Length	U32	see above	Number of fixes (factory default = 2000)
7-10	Reserved	U32	0	0

## 0x8E-AB

### Command Packet 8E-AB Request Primary Timing Packet

This command packet may be used to request the primary timing packet 8F-AB. To receive report packet 8F-AB once per second use command 8E-A5 to enable the automatic output.

The Request Type item determines how the receiver will reply to this command.

- Request Type 0: The most current primary timing values will be sent in report packet 8F-AB immediately.
- Request Type 1: The response is not sent immediately. Instead report packet 8F-AB is sent within 20ms after the next PPS output. This is the same time that the packet would be automatically sent if enabled.
- Request Type 2: Same as type 1 except that both report packets 8F-AB and 0x8F-AC are sent after the next PPS output.

**Table A-81 Command Packet 8E-AB**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0xAB	
1	Request type	BYTE	0 1 2	Send 0x8F-AB immediately Send 0x8F-AB on-time next second Send 0x8F-AB and 0x8F-AC on-time next second

## 0x8E-AC

### Command Packet 8E-AC Request Supplemental Timing Packet

This command packet can be used to request the supplemental timing packet 8F-AC. To receive report packet 8F-AC once per second use command 8E-A5 to enable the automatic output.

The Request Type item determines how the receiver will reply to this command.

- Request Type 0: The most current supplemental timing values will be sent in report packet 8F-AC immediately.
- Request Type 1: The response is not sent immediately. Instead report packet 8F-AC is sent within 300ms after the next PPS output. This is the same time that the packet would be automatically sent if enabled.
- Request Type 2: Same as type 1 except that both report packets 8F-AB and 8F-AC are sent after the next PPS output.

**Table A-82 Command Packet 8E-AC**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0xAC	
1	Request type	BYTE	0 1 2	Send 0x8F-AC immediately Send 0x8F-AC on-time next second Send 0x8F-AB and 0x8F-AC on-time next second

## 0x8E-AD

### Command Packet 8E-AD (Request 8F-AD) Request or Configure Super Packet Output

If the 8E-AD byte sequence is sent with no data, the receiver will generate an 8F-AD packet on port B. The time reported by the 8F-AD packet on port B is always the beginning of the current second.

Output of the 8F-AD Primary UTC timing packet on Port A is configured by sending a 3 byte message 8E-AD n, where n ranges from 0 to 3, as defined below. The receiver returns the 8F-A5 Super Packet Output Mask.

**Table A-83 Command Packet 8E-AD**

Byte #	Item	Type	Value	Default	Meaning
0	Subcode	Byte	AD	Required	Super-packet ID
1	Flag	Byte	0 1 2 3	3	Disable packet output on port A Output packet on port A only at PPS Output packet on port A only at event input Output at both event input and PPS

## 0x8F-0B

### Report Packet 8F-0B Comprehensive Time

The output of the packet is synchronized with the PPS, and may also be generated in response to external events. Report packet 8F-0B provides easy identification of each timing pulse and contains all the information required for most timing and synchronization applications. Output of this packet can be disabled and configured using the 8E-A5 packet on Port B. If output of the 8F-AD packet is also enabled, the 8F-0B packet will always be output after the 8F-AD packet. The packet contains 74 bytes in the following order:

**Table A-84 Report Packet 8F-0B**

Byte #	Item	Type	Meaning
0	Subpacket ID	BYTE	Subcode 0x0B
1-2	Event Count	INTEGER	External event counter. Zero for PPS.
3-10	UTC/GPS TOW	DOUBLE	UTC/GPS time of week (seconds)
11	Date	BYTE	Date of event or PPS
12	Month	BYTE	Month of event or PPS
13-14	Year	INTEGER	Year of event or PPS
15	Receiver Mode	BYTE	Receiver operating dimensions 0 Horizontal (2D) 1 Full position (3D) (Survey) 2 Single satellite (0D) 3 Automatic (2D/3D) 4 DGPS reference 4 Clock hold (2D) 6 Overdetermined clock (default)
16-17	UTC Offset	INTEGER	UTC offset value (seconds)
18-25	Oscillator Bias	DOUBLE	Oscillator bias (meters)
26-33	Oscillator Drift Rate	DOUBLE	Oscillator drift (meters/second)
34-37	Oscillator Bias Uncertainty	SINGLE	Oscillator bias uncertainty (meters)



**Table A-84 Report Packet 8F-0B (Continued)**

Byte #	Item	Type	Meaning
38-41	Oscillator Drift Uncertainty	SINGLE	Oscillator bias rate uncertainty (meters/second)
42-49	Latitude	DOUBLE	Latitude in radians
50-57	Longitude	DOUBLE	Longitude in radians
58-65	Altitude	DOUBLE	Altitude according to current datum, meters
66-73	Satellite ID	8 BYTES	Identification numbers of tracking and usable satellites

Bytes 66 through 73 identify the tracking and usable satellites. A tracked satellite is distinguished from a usable satellite by a negative sign (–) appended to its PRN number.

In this superpacket, time is referenced to UTC to correspond to the default PPS timebase. To configure the receiver to output time relative to GPS, the PPS must be characterized accordingly. Command packet 8E-4A enables the PPS to be re-defined at run-time and stores the new settings in nonvolatile memory.




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**Note** – Leap seconds can not be predicted in advance using only the 8F-0B packet. A leap second can be identified by observing that the date does not increment after 86400 seconds have elapsed in the current day. The date rollover is delayed for the duration of the leap second, and the day/month/year count reported does not increment to the next day until the beginning of the second following the leap event. Decoding of the 8F-AD packet provides complete leap status information.

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The UTC offset is incremented at the beginning of the first second following the leap second.

## 0x8F-14

### Report Packet 8F-14 Current Datum Values

This packet contains 43 data bytes with the values for the datum currently in use and is sent in response to packet 8E-14. If a built-in datum is being used, both the datum index and the five double-precision values for that index are returned. If the receiver is operating on a custom user-entered datum, the datum index is set to -1 and the five values are displayed. These five values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA.

**Table A-85 Report Packet 8F-14**

Byte #	Type	Value	Units
0	Super packet ID	14	
1-2	INTEGER	Datum index (-1 for custom)	
3-10	DOUBLE	DX	meters
11-18	DOUBLE	DY	meters
19-26	DOUBLE	DZ	meters
27-34	DOUBLE	A-axis	meters
35-42	DOUBLE	Eccentricity squared	none




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**Note** – A complete list of datums is provided at the end of this appendix.

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## 0x8F-20

### Report Packet 8F-20

#### Last Fix with Extra Information (binary fixed point)

This packet provides information concerning the time and origin of the previous position fix. This is the last-calculated fix; it could be quite old. The receiver sends this packet in response to Packet 8E-20; it also can replace automatic reporting of position and velocity packets. Automatic output of 8F-20 must also be enabled by setting bit 5 of byte 0 in command packet 0x35 and bit 0 of bytes 1-2 in command packet 0x8E-A5.

The data format is shown in the table below.

**Table A-86 Report Packet 8F-20**

Byte #	Item/Type	Meaning
0	Subpacket ID / BYTE	ID for this subpacket (always 0x20)
1	Key Byte/BYTE	Reserved for Trimble DGPS postprocessing
2-3	east velocity / INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
4-5	north velocity / INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
6-7	up velocity /INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
8-11	Time of Week / UNSIGNED LONG	GPS Time in milliseconds
12-15	Latitude / LONG INTEGER	Latitude, units = $2^{-31}$ semicircle, according to current datum. Range = $-2^{30}$ to $2^{32}$
16-19	Longitude / UNSIGNED LONG	Longitude east of meridian, units = $2^{-31}$ semicircle, according to current datum. Range = 0 to $2^{32}$
20-23	Altitude / LONG INTEGER	Altitude above ellipsoid, mm, according current datum.
24	Velocity Scaling	When bit 0 is set to 1, velocities in Bytes 2-7 have been scaled by 4.

**Table A-86 Report Packet 8F-20 (Continued)**

Byte #	Item/Type	Meaning
25	Reserved	0
26	Datum	Datum index + 1
27	Fix Type / BYTE	Type of fix. This is a set of flags. 0 (LSB) 0: Fix was available 1: No fix available 1 0: Fix is autonomous 1: Fix was corrected with RTCM 2 0: 3D fix 1: 2D fix 3 0: 2D fix used last-circulated altitude 1: 2D fix used entered altitude 4 0: Unfiltered 1: Position or altitude filter on 5-7 unused (always 0)
28	Num SVs/BYTE	Number of satellites used for fix. Will be zero if no fix was available.
29	UTC Offset / BYTE	Number of leap seconds between UTC time and GPS time.
30-31	Week/INTEGER	GPS time of fix (weeks)
32-47	Fix SVs	Repeated groups of 2 bytes, one for each satellite. The bytes are 0 if group N/A. The following table describes the contents of each group.
48-55	Iono Param / 8 BYTES	The broadcast ionospheric parameters.

**Table A-87 Report Packet 8F-20**

Bytes 32-47	Item/Type	Meaning
0	PRNX/BYTE	Satellite number and IODC - IODE. PRN = the lower six bits of PRNX. IODC = (PRNX/64)× 256 + IODE
1	IODE/BYTE	

## 0x8F-26

### Report Packet 0x8F-26

### Response to Save EEPROM Segments

This report packet is output after the command packet 8E-26 has been executed.

**Table A-88 Report Packet 0x8F-26**

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0x26	
1-4	Reserved	ULONG	0x00	

## 0x8F-41

### Report Packet 8F-41 Manufacturing Parameters

This packet provides information on the manufacturing parameters stored in nonvolatile memory in response to command packet 8E-41.

**Table A-89 Report Packet 8F-41**

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0x41
1-2	Board serial number prefix	INTEGER	
3-6	Board serial number	ULONG	
7	Year of build	BYTE	
8	Month of build	BYTE	
9	Day of build	BYTE	
10	Hour of build	BYTE	
11-14	Oscillator offset	SINGLE	
15-16	Test code identification number	INTEGER	

## 0x8F-42

### Report Packet 8F-42 Production Parameters

This packet provides information on the production parameters stored in nonvolatile memory in response to command packet 8E-42.

**Table A-90 Report Packet 8F-42**

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0x42
1	Production options prefix	BYTE	
2	Production number extension	BYTE	
3-4	Case serial number prefix	INTEGER	
5-8	Case serial number	ULONG	
9-12	Production number	ULONG	
13-14	Reserved	INTEGER	
15-16	Machine identification number	INTEGER	
17-18	Reserved	INTEGER	

## 0x8F-45

### Report Packet 8F-45

This report packet is output after the command packet 8E-45 has been executed. See the corresponding command packet for information about the data formats.

## 0x8F-4A

### Report Packet 8F-4A PPS Characteristics

This packet reports the receiver's PPS characteristics. This packet is sent in response to a query or control command with packet 8E-4A. The packet contains 16 bytes in the following order:

**Table A-91 Report Packet 8F-4A**

Byte #	Item	Type	Units
0	Subpacket ID	BYTE	Always 0x4A
1	PPS Driver Switch	BYTE	0: Off 1: On
2	Time Base	BYTE	0: GPS 1: UTC (default)
3	PPS Polarity	BYTE	0: Positive (default) 1: Negative
4-11	PPS Offset or Cable Delay	DOUBLE	seconds
12-15	Bias Uncertainty Threshold	SINGLE	meters



## 0x8F-4D

### Report Packet 8F-4D

### Automatic Packet Output Mask

This packet provides information on the automatic packets that may be output by the receiver. Sent in response to 8E-4D query or set.

**Table A-92 Report Packet 8F-4D**

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0x4D
1-4	Bit Mask	ULONG	Bits in the mask enable output packets

A "0" in the bit position means that automatic output of the associated packets is disabled; a "1" in the bit positions means that the associated packets can be automatically output. The following table describes the meaning and packets output by each set bit.

**Table A-93 Report Packet 8F-4D**

Bit #	Output Packets	When Output	Meaning
0(LSB)	40 Alm	After Decode	Almanac data collected from satellite
1	58, 5B	After Decode	Ephemeris data collected from satellite.
2	4F	After Decode	UTC data collected from satellite
3	58	After Decode	Ionospheric data collected from satellite
4	48	After Decode	GPS Message.
5	49	After Decode	Almanac health page collected from satellite.
6			Reserved
7			Reserved
8	41	New Fix	Partial and full fix complete and packet output timer has expired.

**Table A-93 Report Packet 8F-4D (Continued)**

Bit #	Output Packets	When Output	Meaning
9			Reserved
10			Reserved
11	6D, 82	Constellation Change	New satellite selection
12			Reserved
13-29			Reserved
30	4A, 8F-20, 42, 43, 54, 56, 82, 83, 84	New Fix Update	Dynamic and Timing information. Output must be enabled with I/O options.
31 (Note 1)	5A	New Fix	Output must be enabled with I/O options.

Note 1: A 1 in the bit mask indicates that output for the associated packets is ON; a 0 indicates that the output is turned OFF.

## 0x8F-4E

### Report Packet 0x8F-4E

This report packet is output after the command packet 8E-4E has been executed. See the corresponding command packet for information about the data formats.

## 0x8F-A5

### Report Packet 8F-A5

This report packet is output after the command packet 8E-A5 has been executed and is identical in structure to packet 8E-A5. See the corresponding command packet for information about the data formats.

## 0x8F-A6

### Report Packet 8F-A6

This report packet is output after the command packet 8E-A6 has been executed and is identical in structure to packet 8E-A6. See the corresponding command packet for information about the data formats.

## 0x8F-A9

### Report Packet 0x8F-A9

This report packet is output after the command packet 8E-A9 has been executed and is identical in structure to packet 8E-A9. See the corresponding command packet for information about the data formats.

## 0x8F-AB

### Report Packet 8F-AB

This automatic report packet provides time information once per second if enabled with command packet 8E-A5. GPS week number, GPS time-of-week (TOW), UTC integer offset, time flags, date and time-of-day (TOD) information is provided. This packet can be requested with packet 8E-AB. This packet will begin transmission within 30 ms after the PPS pulse to which it refers.

#### Data Fields:

**Time of Week:** This field represents the number of seconds since Sunday at 00:00:00 GPS time for the current GPS week. Time of week is often abbreviated as TOW.

**Week Number:** This field represents the current GPS week number. GPS week number 0 started on January 6, 1980. Unfortunately, the GPS system has allotted only 10-bits of information to carry the GPS week number and therefore it rolls-over to 0 in just 1024 weeks (19.6 years), and there is no mechanism built into GPS to tell the user to which 1024 week epoch the week number refers. The first week

number roll-over occurred as August 21, 1999 (GPS) transitioned to August 22, 1999 (GPS). The receiver adjusts for this week rollover by adding 1024 to any week number reported by GPS that is less than week number 1023, which began on December 14, 1997. With this technique, the receiver will provide an accurate translation of GPS week number and TOW to time and date until July 30, 2017.

**UTC Offset:** This field represents the current integer leap second offset between GPS and UTC according to the relationship:  $\text{Time (UTC)} = \text{Time (GPS)} - \text{UTC Offset}$ . The UTC offset information is reported to receiver by the GPS system and can take up to 12.5 minutes to obtain. Before the receiver has received UTC information from the GPS system, it is only capable of representing time in the GPS time scale, and the UTC offset will be shown as 0.

**Timing Flags:** This field is bitwise encoded to provide information about the timing outputs. Unused bits should be ignored.

**Bit 0:** When 0, the date and time fields broadcast in packet 0x8F-AB are in the GPS time scale. When 1, these fields are in the UTC time scale and are adjusted for leap seconds.

**Bit 2:** When 0, time has been set from GPS. When 1, time has not yet been set from GPS.

**Bit 3:** When 0, UTC offset information has been received. When 1, UTC offset information is not yet known.

**Time of Day:** The time of day is sent in hours-minutes-seconds format and varies from 00:00:00 to 23:59:59, except when time is in UTC and a leap second insertion occurs. In this case the time will transition from 23:59:59 to 23:59:60 to 00:00:00.

**Date:** The date is sent in day-month-year format.

**Table A-94 Report Packet 0x8F-AB**

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	BYTE		0xAB
1-4		Time of week	ULONG		GPS seconds of week
5-6		Week Number	UIINTEGER		GPS Week Number (see above)
7-8		UTC Offset	INTEGER		UTC Offset (seconds)
9	0 1 2 3	Timing Flag	Bit Field	0 1 0 1 0 1 0 1	GPS time UTC time Reserved Reserved Time is set Time is not set Have UTC info No UTC info
10		Seconds	BYTE	0-59	(60 for UTC leap second event)
11		Minutes	BYTE	0-59	Minutes of Hour
12		Hours	BYTE	0-23	Hour of Day
13		Day of Month	BYTE	1-31	Day of Month
14		Month	BYTE	1-12	Month of Year
15-16		Year	UIINTEGER		Four digits of Year (e.g. 1999)

## 0x8F-AC

### Report Packet 8F-AC

This report packet provides supplemental timing information once per second if enabled with command packet 8E-A5. Information regarding position, unit status and health, and the operational state of the unit is provided. This packet can be requested with command packet 8E-AC. When enabled, this packet is transmitted once per second shortly after report packet 8F-AB.

The position sent in report packet 8F-AC depends on the Receiver Operating Mode and on self-survey activity. When a self-survey is in progress, the position sent is the running average of all of the position fixes collected so far. When the self-survey ends or whenever the receiver is using a time-only operating mode, then the position sent is the position the receiver is using to perform time-only fixes. When the self-survey is disabled or otherwise inactive and the receiver is using a position fix operating mode, then the position sent is the position fix computed on the last second.

### Data Fields:

**Receiver Mode:** This field shows the fix mode that the GPS receiver is currently configured for. See packet 0xBB for a description of all available receiver modes.

**Self-Survey Progress:** When a self-survey procedure is in progress, this field shows the progress of the survey as a percentage of fixes collected so far. The self-survey will be complete when the self-survey progress reaches 100 percent.

**Minor Alarms:** This field is bitwise encoded with several minor alarm indicators. A minor alarm indicates a condition that the user should be alerted to, but does not indicate an immediate (or necessarily any) impairment of functionality. For each bit, a value of 0 means that the condition is not indicated. Bits not described below should be ignored.

- Bit 3      When 1, indicates that no satellites are yet usable. In order for a satellite to be usable, it must be tracked long enough to obtain ephemeris and health data.
- Bit 5      When 1, indicates that a self-survey procedure is in progress.
- Bit 6      When 1, indicates that there is no accurate position stored in EEPROM.
- Bit 7      When 1, indicates that the GPS has alerted the GPS receiver that a leap second transition is pending.
- Bit 8      When 1, indicates that the GPS receiver is operating in one of its test modes.
- Bit 9      When 1, indicates that the accuracy of the position being used for a time-only fix is questionable. While operating in the Overdetermined Clock mode (which is most of the time) with at least 2 satellites available, the receiver can detect position inaccuracies as small as 1/2 to 1 mile. If this bit is set, it is likely that the receiver is using a stored position but has been moved to a new site. The stored position should be cleared (packet 0x8E-45) and a new position should be established either by user input (packet 0x31 or 0x32) or by self-survey (packet 0x8E-A6).
- Bit 10     When 1, indicates that one or more EEPROM segments were found to be corrupt at reset and had to be set to their factory default settings. Use packet 0x3F-11 to retrieve details about which segments were corrupt and to clear this bit. The GPS receiver will send packet 0x5F-11 with the segment status. Only bits 2-12 of the segment status are used to set this alarm bit.
- Bit 11     When 1, indicates that the almanac is not current or complete.

**GPS Decoding Status:** This field indicates the decoding status of the GPS receiver.

**Local Clock Offset:** This field carries the offset of the local clock relative to UTC or GPS as reported by the GPS receiver in nanoseconds. Positive values indicate that the receiver's local clock is late relative to GPS or UTC. Also known as bias.

**Oscillator Offset:** This field carries the frequency offset of the local clock relative to UTC or GPS as reported by the GPS receiver in ppb (parts-per-billion). Positive values indicate that the receiver's local clock is running slow relative to GPS or UTC. Also known as bias rate.

**Latitude:** This field carries the latitude of the position being shown. The units are in radians and vary from  $-\pi/2$  to  $+\pi/2$ . Negative values represent southern latitudes. Positive values represent northern latitudes.

**Longitude:** This field carries the longitude of the position being shown. The units are in radians and vary from  $-\pi$  to  $+\pi$ . Negative values represent western longitudes. Positive values represent eastern longitudes.

**Altitude:** This field carries the altitude of the position being shown. The units are in meters according to the current datum.

**PPS Quantization Error:** This field identifies the PPS quantization error in nanoseconds.

**PPS Output Status:** This field identifies the status of the PPS output.



The table below identifies the fields associated with packet 8F-AC.

**Table A-95 Report Packet 8F-AC**

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	BYTE	0xAC	
1		Receiver Mode	BYTE	0 1 3 4 5 6 7	Automatic (2D/3D) Single Satellite (Time) Horizontal (2D) Full Position (3D) DGPS Reference Clock Hold (2D) Overdetermined Clock
2		Reserved			
3		Self-Survey Progress	BYTE	0-100	Percent completed
4-9		Reserved			
10-11		Minor Alarms	UIINTEGER	Bit field	Bit 1: Antenna Open Bit 2: Antenna Shorted Bit 3: Not tracking satellites Bit 5: Survey-in progress Bit 6: No stored position Bit 7: Leap second pending Bit 8: In test mode Bit 10: EEPROM segments status Bit 11: Almanac status
12		GPS Decoding Status	BYTE	0 1 3 8 9 0x0A 0x0B 0x0C 0x10	Doing fixes Do not have GPS time PDOP is too high No usable satellites Only 1 usable satellite Only 2 usable satellites Only 3 usable satellites The chosen satellite is unusable TRAIM rejected the fix
13-15		Reserved			

**Table A-95 Report Packet 8F-AC (Continued)**

Byte	Bit	Item	Type	Value	Meaning
16-19		Bias	SINGLE		Estimate of UTC/GPS offset (ns) of local clock
20-23		Bias Rate	SINGLE		Estimate of UTC/GPS offset (ppb) of local clock
24-35		Reserved			
36-43		Latitude	DOUBLE		Radians
44-51		Longitude	DOUBLE		Radians
52-59		Altitude	DOUBLE		Meters
60-63		PPS Quantization Error	Single		PPS quantization error (ns)
64		PPS output status	U8		0: PPS Not Generated 1: PPS Was Generated
65-67		Reserved			

## 0x8F-AD

### Report Packet 8F-AD Primary UTC Time

The output of the 8F-AD packet is synchronized with the PPS, and may also be generated in response to external events. This packet provides accurate time and date information for time stamping and time transfer. The leap flag provides complete UTC event information, allowing implementation of sophisticated distributed systems intended to operate synchronously with UTC time. This packet is always output first in a possible sequence of up to 4 synchronous packets. Output of this packet can be disabled and configured using the 8E-AD packet .

**Table A-96 Report Packet 8F-AD**

Byte #	Item	Type	Meaning
0	Subpacket ID	BYTE	Subcode 0xAD
1-2	Event Count	INTEGER	External event counter. Zero for PPS.
3-10	Fractional Second	DOUBLE	Time elapsed in current second (seconds)
11	Hour	BYTE	UTC Hour
12	Minute	BYTE	UTC Minute
13	Second	BYTE	Second (0-59; 60 = leap)
14	Day	BYTE	Date (1-31)
15	Month	BYTE	Month (1-12)
16-17	Year	INTEGER	Year (4 digit)
18	Receiver Status	BYTE	Tracking Status (see definition below)
19	UTC Flags	BYTE	Leap Second Flags (see definition below)
20	Reserved	BYTE	Contains 0xFF
21	Reserved	BYTE	Contains 0xFF

The tracking status flag allows precise monitoring of receiver tracking status and allows a host system to determine whether the time output by the receiver is valid. After self-survey has completed, the receiver only needs to track one satellite to maintain precise synchronization with UTC.

**Table A-97 Tracking Status Flag Definitions**

<b>Flag Value</b>	<b>Status</b>	<b>Meaning</b>
0	DOING_FIXES	Receiver is navigating.
1	GOOD_1SV	Receiver is timing using one satellite
2	APPX_1SV	Approximate time
3	NEED_TIME	Start-up
4	NEED_INITIALIZATION	Start-up
5	PDOP_HIGH	Dilution of Precision too High
6	BAD_1SV	Satellite is unusable
7	0SVs	No satellites usable
8	1SV	Only 1 satellite usable
9	2SVs	Only 2 satellites usable
10	3SVs	Only 3 satellites usable
11	NO_INTEGRITY	Invalid solution
12	DCORR_GEN	Differential corrections
13	OVERDET_CLK	Overdetermined fixes

### Leap Second Flag

Leap seconds are inserted into the UTC timescale to counter the effect of gradual slowing of the earth's rotation due to friction. The 8F-AD packet provides extensive UTC leap second information to the user application.

The *Leap Scheduled* bit is set by the receiver, when the leap second has been scheduled by the GPS control segment. The Control segment may schedule the leap second several weeks before the leap second takes place.

The *Leap Pending* bit indicates that the leap second will be inserted at the end of the current day.

The *GPS Leap Warning* bit is set while GPS is operating in the leap exception mode specified in ICD-200.

The *Leap in Progress* bit is set to 1 at the beginning of the leap second, and cleared at the beginning of the second following the leap event. The date rollover is delayed by one second on the day the leap second is inserted. The date will not increment until the beginning of the first second following the leap second.

**Table A-98 Leap Second Flag Definitions**

Bit #	Name	Meaning if set to 1
0	UTC Flag	UTC Time is available
1-3	Reserved	N/A
4	Leap Scheduled	GPS Almanac's leap second date is not in the past.
5	Leap Pending	24-hour warning. Cleared before leap second.
6	GPS Leap Warning	Set +/- 6 hours before/after leap event.
7	Leap in Progress	Leap second is now being inserted.

## A.17 Datums

The table on the following pages lists datums.

**Table A-99 Datums**

Index	DX	DY	DZ	A-axis	Eccentricity	Description
0	0	0	0	6378137.000	0.00669437999014	/*WGS-84*/
1	-128	481	664	637797.155	0.00667437311265	/*Tokyo from old J6 values*/
2	-8	160	176	6378206.400	0.0067865799761	/*NAD-27*/
3	-9	151	185	6378206.400	0.00676865799761	/*Alaska/Canada*/
4	-87	-98	-121	6378388.000	0.00672267002233	/*European*/
5	-133	-48	148	6378160.000	0.00669454185459	/*Australian*/
6	0	0	4	6378135.000	0.00669431777827	/*WGS-72*/
7	0	0	0	6378137.000	0.00669438002290	/*NAD-83*/
8	0	0	0	6378137.000	0.00669437999014	/*NAD-02*/
9	0	0	0	6378137.000	0.00669437999014	/*Mexican*/
10	0	0	0	6378137.000	0.00669437999014	/*Hawaiian*/
11	0	0	0	6378137.000	0.00669437999014	/*Astronomic*/
12	0	0	0	6378137.000	0.00669437999014	/*U S Navy*/
13	-87	-98	-121	6378388.000	0.00672267002233	/*European*/
14	-134	-48	149	6378160.000	0.00669454185459	/*Australian 1984*/
15	-166	-15	204	6378249.145	0.00680351128285	/*Adindan-Mean*/
16	-165	-11	206	6378249.145	0.00680351128285	/*Adindan-Ethiopia*/
17	-123	-20	220	6378249.145	0.00680351128285	/*Adindan-Mali*/
18	-128	-18	224	6378249.145	0.00680351128285	/*Adindan-Senegal*/
19	-161	-14	205	6378249.145	0.00680351128285	/*Adindan-Sudan*/
20	-43	-163	45	6378245.000	0.00669342162297	/*Afgooye-Somalia*/
21	-150	-250	-1	6378388.000	0.00672267002233	/*Ain El Abd-Bahrain*/
22	-491	-22	435	6378160.000	0.00669454185459	/*Anna 1 Astr 1965*/
23	-143	-90	-294	6378249.145	0.00680351128285	/*Arc 1950-Mean*/
24	-138	-105	-289	6378249.145	0.00680351128285	/*Arc 1950-Botswana*/

**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
25	-125	-108	-295	6378249.145	0.00680351128285	<i>/*Arc 1950-Lesotho*/</i>
26	-161	-73	-317	6378249.145	0.00680351128285	<i>/*Arc 1950-Malawi*/</i>
27	-134	-105	-295	6378249.145	0.00680351128285	<i>/*Arc 1950-Swaziland*/</i>
28	-169	-19	-278	6378249.145	0.00680351128285	<i>/*Arc 1950-Zaire*/</i>
29	-147	-74	-283	6378249.145	0.00680351128285	<i>/*Arc 1950-Zambia*/</i>
30	-142	-96	-293	6378249.145	0.00680351128285	<i>/*Arc 1950-Zimbabwe*/</i>
31	-160	-6	-302	6378249.145	0.00680351128285	<i>/*Arc 1960-Mean*/</i>
32	-160	-6	-302	6378249.145	0.00680351128285	<i>/*Arc 1960-Kenya*/</i>
33	-160	-6	-302	6378249.145	0.00680351128285	<i>/*Arc 1960-Tanzania*/</i>
34	-205	107	53	6378388.000	0.00672267002233	<i>/*Ascension Isl 1958*/</i>
35	145	75	272	6378388.000	0.00672267002233	<i>/*Astro Beacon E 1945*/</i>
36	114	-116	-333	6378388.000	0.00672267002233	<i>/*Astro B4 Sorol Atoll*/</i>
37	-320	550	-494	6378388.000	0.00672267002233	<i>/*Astro Dos 71/4*/</i>
38	124	-234	-25	6378388.000	0.00672267002233	<i>/*Astro Station 1952*/</i>
39	-133	-48	148	6378160.000	0.00669454185459	<i>/*Australian Geo 1966*/</i>
40	-127	-769	472	6378388.000	0.00672267002233	<i>/*Bellevue (IGN)*/</i>
41	-73	213	296	6378206.400	0.00676865799761	<i>/*Bermuda 1957*/</i>
42	307	304	-318	6378388.000	0.00672267002233	<i>/*Bogota Observatory*/</i>
43	-148	136	90	6378388.000	0.00672267002233	<i>/*Compo Inchauspe*/</i>
44	298	-304	-375	6378388.000	0.00672267002233	<i>/*Canton Island 1966*/</i>
45	-136	-108	-292	6378249.145	0.00680351128285	<i>/*Cape*/</i>

**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
46	-2	151	181	6378206.400	0.00676865799761	<i>/*Cape Canaveral mean*/</i>
47	-263	6	431	6378249.145	0.00680351128285	<i>/*Carthage*/</i>
48	175	-38	113	6378388.000	0.00672267002233	<i>/*Chatham 1971*/</i>
49	-134	229	-29	6378388.000	0.00672267002233	<i>/*Chua Astro*/</i>
50	-206	172	-6	6378388.000	0.00672267002233	<i>/*Corrego Alegre*/</i>
51	-377	681	-50	6377397.155	0.00667437223180	<i>/*Djakarta (Batavia)*/</i>
52	230	-199	-752	6378388.000	0.00672267002233	<i>/*DOS 1968*/</i>
53	211	147	111	6378388.000	0.00672267002233	<i>/*Easter Island 1967*/</i>
54	-87	-98	-121	6378388.000	0.00672267002233	<i>/*Euro 1950-Mean*/</i>
55	-104	-101	-140	6378388.000	0.00672267002233	<i>/*Euro 1950-Cyprus*/</i>
56	-130	-117	-151	6378388.000	0.00672267002233	<i>/*Euro 1950-Egypt*/</i>
57	-86	-96	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Eng/ Scot*/</i>
58	-86	-96	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Eng/Ire*/</i>
59	-84	-95	-130	6378388.000	0.00672267002233	<i>/*Euro 1950-Greece*/</i>
60	-117	-132	-164	6378388.000	0.00672267002233	<i>/*Euro 1950-Iran*/</i>
61	-97	-103	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Sardinia*/</i>
62	-97	-88	-135	6378388.000	0.00672267002233	<i>/*Euro 1950-Sicily*/</i>
63	-87	-95	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Norway*/</i>
64	-87	-107	-120	6378388.000	0.00672267002233	<i>/*Euro 1950-Port/ Spain*/</i>
65	-86	-98	-119	6378388.000	0.00672267002233	<i>/*European 1979*/</i>
66	-133	-321	50	6378388.000	0.00672267002233	<i>/*Gandajika Base*/</i>
67	84	-22	209	6378388.000	0.00672267002233	<i>/*Geodetic Datum 1949*/</i>
68	-100	-248	259	6378206.400	0.00676865799761	<i>/*Guam 1963*/</i>
69	252	-209	-751	6378388.000	0.00672267002233	<i>/*GUX 1 Astro*/</i>



**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
70	-73	46	-86	6378388.000	0.00672267002233	/*Hjorsey 1955*/
71	-156	-271	-189	6378388.000	0.00672267002233	/*Hong Kong 1963*/
72	209	818	290	6377276.345	0.00663784663020	/*Indian-Thai/Viet*/
73	295	736	257	6377301.243	0.00663784663020	/*Indian-India/Nepal*/
74	506	-122	611	6377340.189	0.00667053999999	/*Ireland 1965*/
75	208	-435	-229	6378388.000	0.00672267002233	/*ISTS O73 Astro 1969
76	89	-79	-202	6378388.000	0.00672267002233	/*Johnston Island 1961*/
77	-97	787	86	6377276.345	0.00663784663020	/*Kandawala*/
78	145	-187	103	6378388.000	0.00672267002233	/*Kerguelen Island*/
79	-11	851	5	6377304.063	0.00663784663020	/*Kertau 1948*/
80	94	-948	-1262	6378388.000	0.00672267002233	/*La Reunion*/
81	42	124	147	6378206.400	0.00676865799761	/*L.C. 5 Astro*/
82	-90	40	88	6378249.145	0.00680351128285	/*Liberia 1964*/
83	-133	-77	-51	6378206.400	0.00676865799761	/*Luzon-Phillippines*/
84	-133	-79	-72	6378206.400	0.00676865799761	/*Luzon-Mindanao*/
85	41	-220	-134	6378249.145	0.00680351128285	/*Mahe 1971*/
86	-289	-124	60	6378388.000	0.00672267002233	/*Marco Astro*/
87	639	405	60	6377397.155	0.00667437223180	/*Massawa*/
88	31	146	47	6378249.145	0.00680351128285	/*Merchich*/
89	912	-58	1227	6378388.000	0.00672267002233	/*Midway Astro 1961*/
90	-92	-93	122	6378249.145	0.00680351128285	/*Minna*/
91	-247	-148	369	6378249.145	0.00680351128285	/*Nahrwan-Masirah*/
92	-249	-156	381	6378249.145	0.00680351128285	/*Nahrwan-UAE*/
93	-243	-192	477	6378249.145	0.00680351128285	/*Nahrwan-Saudia*/
94	616	97	-251	6377483.865	0.00667437223180	/*Namibia*/
95	-10	375	165	6378388.000	0.00672267002233	/*Naparima*/
96	-8	159	175	6378206.400	0.00676865799761	/*NAD 27-Western US*/

**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
97	-9	161	179	6378206.400	0.00676865799761	/*NAD 27-Eastern US*/
98	-5	135	172	6378206.400	0.00676865799761	/*NAD 27-Alaska*/
99	-4	154	178	6378206.400	0.00676865799761	/*NAD 27-Bahamas*/
100	1	140	165	6378206.400	0.00676865799761	/*NAD 27-San Salvador*/
101	-10	158	187	6378206.400	0.00676865799761	/*NAD 27-Canada*/
102	-7	162	188	6378206.400	0.00676865799761	/*NAD 27-Alberta/BC*/
103	-22	160	190	6378206.400	0.00676865799761	/*NAD 27-East Canada*/
104	-9	157	184	6378206.400	0.00676865799761	/*NAD 27-Manitoba/Ont*/
105	4	159	188	6378206.400	0.00676865799761	/*NAD 27-NW Ter/Sask*/
106	-7	139	181	6378206.400	0.00676865799761	/*NAD 27-Yukon*/
107	0	125	201	6378206.400	0.00676865799761	/*NAD 27-Canal Zone*/
108	-3	143	183	6378206.400	0.00676865799761	/*NAD 27-Caribbean*/
109	0	125	194	6378206.400	0.00676865799761	/*NAD 27-Central Amer*/
110	-9	152	178	6378206.400	0.00676865799761	/*NAD 27-Cuba*/
111	11	114	195	6378206.400	0.00676865799761	/*NAD 27-Greenland*/
112	-12	130	190	6378206.400	0.00676865799761	/*NAD 27-Mexico*/
113	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Alaska*/
114	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Canada*/
115	0	0	0	6378137.0	0.00669438002290	/*NAD 83-CONUS*/
116	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Mex/Cent Am*/
117	-425	-169	81	6378388.0	0.00672267002233	/*Observatorio 1966*/

**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
118	-130	110	-13	6378200.0	0.00669342162297	/*Old Egyptian 1907*/
119	61	-285	-181	6378206.400	0.00676865799761	/*Old Hawaiian-mean*/
120	89	-279	-183	6378206.400	0.00676865799761	/*Old Hawaiian-Hawaii*/
121	45	-290	-172	6378206.400	0.00676865799761	/*Old Hawaiian*/
122	65	-290	-190	6378206.400	0.00676865799761	/*Old Hawaiian*/
123	58	-283	-182	6378206.400	0.00676865799761	/*Old Hawaiian*/
124	-346	-1	224	6378249.15	0.00680351128285	/*Oman*/
125	375	-111	431	6377563.4	0.00667053999999	/*Ord Sur Brit '36-Mean*/
126	375	-111	431	6377563.4	0.00667053999999	/*OSB-England*/
127	375	-111	431	6377563.4	0.00667053999999	/*OSB-Isle of Man*/
128	375	-111	431	6377563.4	0.00667053999999	/*OSB-Scotland/Shetland*/
129	375	-111	431	6377563.4	0.00667053999999	/*OSB-Wales*/
130	-307	-92	127	6378388.0	0.00672267002233	/*Pico De Las Nieves*/
131	-185	165	42	6378388.0	0.00672267002233	/*Pitcairn Astro 1967*/
132	16	196	93	6378388.0	0.00672267002233	/*Prov So Chilean1963*/
133	-288	175	-376	6378388.0	0.00672267002233	/*Prov S. American 1956-Mean*/
134	-270	188	-388	6378388.0	0.00672267002233	/*Prov S. American 1956-Bolivia*/
135	-270	183	-390	6378388.0	0.00672267002233	/*Prov S. American 1956-N Chile*/
136	-305	243	-442	6378388.0	0.00672267002233	/*Prov S. American 1956-S Chile*/
137	-282	169	-371	6378388.0	0.00672267002233	/*Prov S. American 1956-Colom*/

**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
138	-278	171	-367	6378388.0	0.00672267002233	<i>/*Prov S. American 1956-Ecuador*/</i>
139	-298	159	-369	6378388.0	0.00672267002233	<i>/*Prov S. American 1956-Guyana*/</i>
140	-279	175	-379	6378388.0	0.00672267002233	<i>/*Prov S. American 1956-Peru*/</i>
141	-295	173	-371	6378388.0	0.00672267002233	<i>/*Prov S. American 1956-Venez*/</i>
142	11	72	-101	6378206.4	0.00676865799761	<i>/*Puerto Rico*/</i>
143	-128	-283	22	6378388.0	0.00672267002233	<i>/*Quatar National*/</i>
144	164	138	-189	6378388.0	0.00672267002233	<i>/*Qornoq*/</i>
145	-225	-65	9	6378388.0	0.00672267002233	<i>/*Rome 1940*/</i>
146	-203	141	53	6378388.0	0.00672267002233	<i>/*Santa Braz*/</i>
147	170	42	84	6378388.0	0.00672267002233	<i>/*Santo (DOS)*/</i>
148	-355	21	72	6378388.0	0.00672267002233	<i>/*Sapper Hill 1943*/</i>
149	-57	1	-41	6378160.0	0.00669454185459	<i>/*S. American 1969-Mean*/</i>
150	-62	-1	-37	6378160.0	0.00669454185459	<i>/*S. American 1969-Argentina*/</i>
151	-61	2	-48	6378160.0	0.00669454185459	<i>/*S. American 1969-Bolivia*/</i>
152	-60	-2	-41	6378160.0	0.00669454185459	<i>/*S. American 1969-Brazil*/</i>
153	-75	-1	-44	6378160.0	0.00669454185459	<i>/*S. American 1969-Chile*/</i>
154	-44	6	-36	6378160.0	0.00669454185459	<i>/*S. American 1969-Colombia*/</i>
155	-48	3	-44	6378160.0	0.00669454185459	<i>/*S. American 1969-Ecuador*/</i>
156	-53	3	-47	6378160.0	0.00669454185459	<i>/*S. American 1969-Guyana*/</i>
157	-61	2	-33	6378160.0	0.00669454185459	<i>/*S. American 1969-Paraguay*/</i>

**Table A-99 Datums (Continued)**

<b>Index</b>	<b>DX</b>	<b>DY</b>	<b>DZ</b>	<b>A-axis</b>	<b>Eccentricity</b>	<b>Description</b>
158	-58	0	-44	6378160.0	0.00669454185459	/*S. American 1969-Peru*/
159	-45	12	-33	6378160.0	0.00669454185459	/*S. American 1969-Trin/Tob*/
160	-45	8	-33	6378160.0	0.00669454185459	/*S. American 1969-Venezuela*/
161	7	-10	-26	6378155.0	0.00669342162297	/*South Asia*/
162	-499	-249	314	6378388.0	0.00672267002233	/*Southeast Base*/
163	-104	167	-38	6378388.0	0.00672267002233	/*Southwest Base*/
164	-689	691	-46	6377276.345	0.00663784663020	/*Timbalai 1948*/
165	-148	507	685	6377397.16	0.00667437223180	/*Tokyo-Mean*/
166	-146	507	687	6377397.16	0.00667437223180	/*Tokyo-Korea*/
167	-158	507	676	6377397.16	0.00667437223180	/*Tokyo-Okinawa*/
168	-632	438	-609	6378388.0	0.00672267002233	/*Tristan Astro 1968*/
169	51	391	-36	6378249.15	0.00680351128285	/*Viti Levu 1916*/
170	102	52	-38	6378270.0	0.00672267002233	/*Wake-Eniwetok*/
171	-265	120	-358	6378388.0	0.00672267002233	/*Zanderij*/
172	-384	664	-48	6377397.16	0.00667437223180	/*Bukit Rimpah*/
173	-104	-129	239	6378388.0	0.00672267002233	/*Camp Area Astro*/
174	-403	684	41	6377397.16	0.00667437223180	/*Gunung Segara*/
175	-333	-222	114	6378388.0	0.00672267002233	/*Herat North*/
176	-637	-549	-203	6378388.0	0.00672267002233	/*Hu-Tzu-Shan*/
177	-189	-242	-9	6378388.0	0.00672267002233	/*Tananarive Observ. 1925*/
178	-155	171	37	6378388.0	0.00672267002233	/*Yacare*/
179	-146.43	507.89	681.46	6377397.155	0.00667437223180	/*Tokyo GSI coords*/

## A.18 Sample TSIP Routines

The following sections give sample routines that use command packet 0x1F and report packet 0x45 for getting software version information from the Acutime 2000 via COM1. Source code for a working TSIP monitor program is available at [www.trimble.com/support/files](http://www.trimble.com/support/files).

### Sending out TSIP command packet 0x1F

In general, all TSIP packets use the structure TSIPPKT:

```
#define MAX_RPTBUF 256

typedef struct {
    short
        cnt;                /* size of buf */
    unsigned char
        status,             /* TSIP packet format and parse status */
        code,               /* TSIP id code */
        buf[MAX_RPTBUF];   /* command or report string */
} TSIPPKT;
```

Communication with the Acutime 2000 is accomplished through command routines and report routines. Each command routine use *send\_cmd()* which supplies the DLE stuffing to the command string and sends the command to the serial port using the primitive function *sendb()*.

All TSIP packet formats take the form  $\langle DLE \rangle \langle ID \rangle \langle Data\ String\ Bytes \rangle \langle DLE \rangle \langle ETX \rangle$ , where  $\langle DLE \rangle$  and  $\langle ETX \rangle$  are reserved frame characters with values 0x10 and 0x03, respectively, and  $\langle ID \rangle$  is the packet identifier. The following routines perform DLE stuffing on a command packet and send it to the Acutime 2000.

```
#define DLE  0x10
#define ETX  0x03

#define PORT 1

/* Send a byte to Port 1 */
short sendb(unsigned char db)
{
    /* put_char outputs a character to the serial port; it
     * returns 0 for success and 1 for failure.
     */
    return(put_char(PORT, db));
}

/* Format a command for sending to a TSIP receiver */
void send_cmd(TSIPPKT *cmd)
{
    short i;

    sendb(DLE);
    sendb(cmd->code);
    for (i = 0; i < cmd->cnt; i++) {
        if (cmd->buf[i] == DLE)
            sendb(DLE);

        sendb(cmd->buf[i]);
    }

    sendb(DLE);
    sendb(ETX);
}

```

To issue command packet 0x41 to request software version from the Acutime 2000 use the following routine.

```

/* Request software version */
void cmd_0x1F(void)
{
    TSIPPKT cmd;

    cmd.cnt = 0;
    cmd.code = 0x1F;
    send_cmd(&cmd);
}

```

### Handling incoming TSIP packet 0x45

Report routines handle incoming receiver packets. They call the routine *end\_of\_rptpkt()* which accumulates from the serial buffer, unstuffs these bytes, and checks whether the end-of-packet sequence <DLE><EXT> has been received.

```

#define FALSE          0
#define TRUE           !FALSE
#define INCOMPLETE    0
#define HAVE_DLE      1
#define COMPLETE      2
#define MAXEND_RPTBUF 256

/* Read bytes until serial buffer is empty or a complete report has
 * been received; end of report is signified by DLE ETX.
 */
short end_of_rptpkt(TSIPPKT *rpt)
{
    short this_byte;

    for (;;) {
        this_byte = getb();
        if (this_byte == -1) {
            return(FALSE);
        }

        if (rpt->status == HAVE_DLE) {
            switch (this_byte) {
                case DLE: /* DLE-stuffed, so it's a data byte */
                    break;

```



```

        case ETX: /* End of message. */
            rpt->status = COMPLETE;
            return(TRUE);
        default: /* If previous message has ended, this is new ID
            code. */
            reset_rptbuf(rpt); /* if not, this is an error. */
            rpt->code = this_byte;
            return(FALSE);
    }
}
else if (this_byte == DLE) {
    /* DLE byte without previous DLE stuffing..must be stuffing.
*/
    rpt->status = HAVE_DLE;
    continue;
}

/* normal byte; add to report */
rpt->status = INCOMPLETE;
rpt->buf[rpt->cnt] = this_byte;
rpt->cnt++;
if (rpt->cnt > MAX_RPTBUF) {
    reset_rptbuf (rpt);
    return(FALSE);
}
}
}

/* Prepare for receipt of new report */
void reset_rptbuf (TSIPPKT *rpt)
{
    rpt->cnt = 0;
    rpt->code = ETX;
    rpt->status = INCOMPLETE;
}

```



# B Timing Receiver Monitor

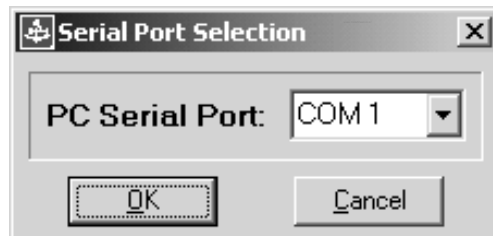
---

The Timing Receiver Monitor program disk is included with the Acutime 2000 Synchronization Kit. The latest version of the program is also available on the Trimble website:

- [www.trimble.com/products/acutime2000](http://www.trimble.com/products/acutime2000)

## B.1 Start-Up

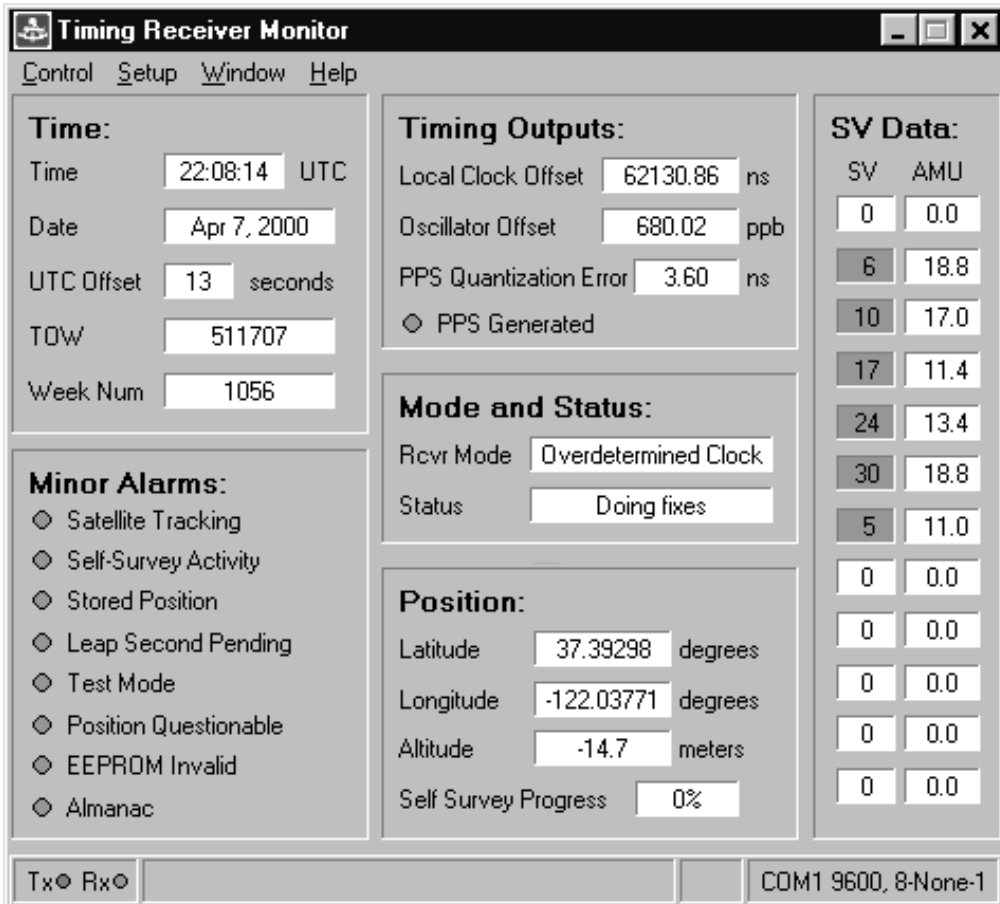
The *Serial Port Selection* screen shown below appears at the start of the program:



This screen lets you choose which PC serial port the ACE UTC is connected to. If the desired port is not available in the selection box, you can start the program using the parameter `-c*`, with \* being the number of the serial port you want to select.

## B.2 Main screen

The main screen for the Timing Receiver Monitor is shown below:



The main screen displays time, position, SV selection and data, receiver status, and timing outputs. The status bar displays Tx and Rx activity, program hints, firmware version number, and serial port settings. The menu provides other options for sending data to and requesting data from the receiver.

For additional program information and help, see the Help menu.

## C NMEA 0183

---

NMEA 0183 is an interface protocol created by the National Marine Electronics Association. The latest release of NMEA 0183 is Version 2.1 (October 15, 1995). This protocol was originally established to allow marine navigation equipment to share information. NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. Since it is a well established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics.

For those applications requiring output only from the GPS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The Acutime 2000 GPS smart antenna is available with firmware that supports a subset of the NMEA 0183 messages: GGA and VTG. For a nominal fee, Trimble can offer custom firmware with a different selection of messages to meet your application requirements.

This appendix provides a brief overview of the NMEA protocol and describes both the standard and optional messages offered by the ACE UTC.

For a complete copy of the NMEA 0183 standard, contact:

NMEA National Office  
PO Box 3435  
New Bern, NC 28564-3435  
U.S.A.  
Telephone: +1-919-638-2626  
Fax: +1-919-638-4885

## C.1 The NMEA 0183 Communication Interface

NMEA 0183 allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners). The table below lists the characteristics of the NMEA 0183 data transmissions.

**Table C-1 NMEA 0183 Characteristics**

Signal Characteristic	NMEA Standard
Baud Rate	4800
Data Bits	8
Parity	None (Disabled)
Stop Bits	1

## C.2 NMEA 0183 Message Format

The NMEA 0183 protocol covers a broad array of navigation data. This broad array of information is separated into discrete messages, which convey a specific set of information. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to a GPS receiver like the ACE UTC. The NMEA message structure is described below.

$\$IDMSG, D1, D2, D3, D4, \dots, Dn * CS [CR] [LF]$

- “\$”            The “\$” signifies the start of a message.
- ID            The talker identification is a two-letter mnemonic that describes the source of the navigation information. The GP identification signifies a GPS source.
- MSG          The message identification is a three-letter mnemonic that describes the message content and the number and order of the data fields.
- “,”            Commas serve as delimiters for the data fields.

Dn	Each message contains multiple data fields (Dn), which are delimited by commas.
“*”	The asterisk serves as a checksum delimiter.
CS	The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR][LF]	The carriage return [CR] and line feed [LF] combination terminate the message.

NMEA 0183 messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the “\$” and the [CR][LF]. The data field block, including delimiters, is limited to 74 characters or less.

### C.3 NMEA 0183 Message Options

The Acutime 2000 can output any or all of the messages listed in Table C-2. When NMEA is chosen, its default configuration (as shipped from the factory) outputs two messages: GGA and VTG. These messages are output at a one-second interval with the “GP” talker ID and checksums.




---

**Note** – The user can configure a custom mix of the messages listed in Table C-2. See Port A (Timing), page 5-11, and TSIP command packets 0xBC, 0x7A, and 0x8E 0x26 in Appendix A, Trimble Standard Interface Protocol, for details on configuring NMEA output.

---




---

**Warning** – If too many messages are specified for output, you may need to increase the unit’s baud rate.

---

**Table C-2 Acutime 2000 NMEA Messages**

Setting	Message	Description
Default	GGA	GPS fix data (NMEA Version 2.1)
	GLL	Geographic position - Latitude/ Longitude
	GSA	GPS DOP and active satellites
	GSV	GPS satellites in view
	RMC	Recommended minimum specific GPS/ Transit data
Default	VTG	Track made good and ground speed
	ZDA	Time & Date



## C.4 NMEA 0183 Message Formats

The format for each message is described in more detail in the following sections.

### C.4.1 GGA – GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

```
$GP GGA,hhmmss,l111.l11,a,nnnnn.nnn,b,t,uu,v.v,w.w,
M,x.x,M,y.y,zzzz*hh <CR><LF>
```

**Table C-3 GGA – GPS Fix Data Message Parameters**

Field	Description
1	UTC of Position
2,3	Latitude, N (North) or S (South)
4,5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters, M = Meters
11, 12	Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level.
13	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update
14	Differential Reference Station ID (0000 to 1023)
hh	Checksum

### C.4.2 GLL – Geographic Position – Latitude/Longitude

The GLL message contains the latitude and longitude of the present vessel position, the time of the position fix and the status.

```
$GP GLL,1111.111,a,yyyyy.yyy,a,hhmmss.s,
A*hh<CR><LF>
```

**Table C-4 GLL – Geographic Position – Latitude / Longitude Message Parameters**

Field #	Description
1,2	Latitude, N (North) or S (South)
3,4	Longitude, E (East) or W (West)
5	UTC of position
6	Status: A = Valid, V= Invalid
hh	Checksum

### C.4.3 GSA – GPS DOP and Active Satellites

The GSA messages indicates the GPS receiver's operating mode and lists the satellites used for navigation and the DOP values of the position solution.

```
$GP GSA, a, x, xx, xx, xx, xx, xx, xx, xx, xx, xx, xx, xx,
xx, xx, x.x, x.x, x.x*hh<CR><LF>
```

**Table C-5 GSA – GPS DOP and Active Satellites  
Message Parameters**

Field #	Description
1	Mode: M = Manual, A = Automatic. In manual mode, the receiver is forced to operate in either 2D or 3D mode. In automatic mode, the receiver is allowed to switch between 2D and 3D modes subject to the PDOP and satellite masks.
2	Current Mode: 1 = fix not available, 2 = 2D, 3 = 3D
3 to 14	PRN numbers of the satellites used in the position solution. When less than 12 satellites are used, the unused fields are null
15	Position dilution of precision (PDOP)
16	Horizontal dilution of precision (HDOP)
17	Vertical dilution of precision (VDOP)
hh	Checksum

#### C.4.4 GSV – GPS Satellites in View

The GSV message identifies the GPS satellites in view, including their PRN number, elevation, azimuth and SNR value. Each message contains data for four satellites. Second and third messages are sent when more than four satellites are in view. Fields #1 and #2 indicate the total number of messages being sent and the number of each message respectively.

```
$GP GSV, x, x, xx, xx, xx, xxx, xx, xx, xx, xxx, xx, xx, xx,
xxx, xx, xx, xx, xxx, xx*hh<CR><LF>
```

**Table C-6 GSV – GPS Satellites in View Message Parameters**

Field #	Description
1	Total number of GSV messages
2	Message number: 1 to 3
3	Total number of satellites in view
4	Satellite PRN number
5	Satellite elevation in degrees (90° Maximum)
6	Satellite azimuth in degrees true (000 to 359)
7	Satellite SNR (C/No), null when not tracking
8,9,10,11	PRN, elevation, azimuth and SNR for second satellite
12,13,14,15	PRN, elevation, azimuth and SNR for third satellite
16,17,18,19	PRN, elevation, azimuth and SNR for fourth satellite
hh	Checksum

### C.4.5 RMC – Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the GPS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed two seconds. All data fields must be provided unless the data is temporarily unavailable. Null fields may be used when data is temporarily unavailable.

```
$GP RMC,hhmmss.s,A,llll.lll,a,yyyy.yyy,a,x.x,x.x,xxxxxx,x.x,a*hh<CR><LF>
```

**Table C-7 RMC – Recommended Minimum Specific GPS / Transit Data Message Parameters**

Field #	Description
1	UTC of Position Fix.
2	Status: A = Valid, V = navigation receiver warning
3,4	Latitude, N (North) or S (South).
5,6	Longitude, E (East) or W (West).
7	Speed over the ground (SOG) in knots
8	Track made good in degrees true.
9	Date: dd/mm/yy
10,11	Magnetic variation in degrees, E = East / W= West
hh	Checksum (Mandatory for RMC)

### C.4.6 VTG – Track Made Good and Ground Speed

The VTG message conveys the actual track made good (COG) and the speed relative to the ground (SOG).

```
$GP VTG, x.x, T, x.x, M, x.x, N, x.x, K*hh<CR><LF>
```

**Table C-8 VTG – Track Made Good and Ground Speed Message Parameters**

Field #	Description
1	Track made good in degrees true.
2	Track made good in degrees magnetic.
3,4	Speed over the ground (SOG) in knots.
5,6	Speed over the ground (SOG) in kilometer per hour.
hh	Checksum

### C.4.7 ZDA – Time & Date

The ZDA message contains UTC, the day, the month, the year and the local time zone.

```
$GP ZDA, hhmmss.ss, xx, xx, xxxx, , *hh<CR><LF>
```

**Table C-9 ZDA – Time & Date Message Parameters**

Field #	Description
1	UTC
2	Day (01 to 31)
3	Month (01 to 12)
4	Year
5	unused
6	unused
hh	Checksum




---

**Note** – Fields #5 and #6 are null fields in the ACE UTC output. A GPS receiver cannot independently identify the local time zone offsets.

---




---

**Caution** – If UTC offset is not available, time output will be in GPS time.

---




---

**Note** – GPS time can be used as a time tag for the 1 PPS. The ZDA message comes out 100–500 msec after the PPS.

---





# D Specifications and Drawings

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This appendix contains the specifications for the Acutime 2000 GPS smart antenna and a diagram of the Acutime 2000 Interface Cable.



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**Note** – The interface cable specifications provided in this appendix are for the 100-foot (30-meter) versions of the cables. Longer versions of these cables are available. The specifications for the longer cables are identical to that of the 100-foot version.

---

## D.1 Acutime 2000 GPS Smart Antenna Specifications

The following tables list the specifications for the Acutime 2000 GPS Smart Antenna.

**Table D-1 Physical Specifications**

<b>Dimensions:</b>	6.12" D, 5.0" H (155.5mm x 127.0mm)
<b>Weight:</b>	12.8 oz. (363 g)
<b>Connector:</b>	12-pin round, waterproof
<b>Mounting:</b>	1"-14 straight thread
<b>Dimensions:</b>	Height: 5.0" (127 mm) Width: 6.12" (155.5 mm)

**Table D-2 Environmental Specifications**

<b>Operating temp:</b>	-40 to +85° C	
<b>Storage temp:</b>	-55 to +105° C	
<b>Vibration:</b>	0.008 g <sup>2</sup> /Hz	5 Hz to 20 Hz
	0.05 g <sup>2</sup> /Hz	20 Hz to 100 Hz
	-3dB/octave	100 Hz to 900 Hz
<b>Operating Humidity:</b>	95% RH, non-condensing @ 60° C	
<b>EMC:</b>	CE, FCC Class B	

**Table D-3 Performance Specifications**

<b>General:</b>	L1 frequency, C/A code (SPS), continuous tracking receiver. Available in 8-channel	
<b>Update Rate:</b>	1Hz	
<b>Accuracy:</b>	<b>Dynamic SPS (with S/A)</b>	<b>Dynamic DGPS</b>
<b>Position</b>	40m CEP	1.5m CEP
<b>Velocity</b>	0.25 m/s CEP	0.05 m/s CEP
<b>Time to First Fix (no stored position):</b>	8-channel typical cold start: < 120 seconds	
<b>Time to First PPS (stationary with stored position, e.g., recovery after power outage):</b>	<60 seconds	
<b>Re-acquisition after 60-second signal loss:</b>	<2 seconds (90%)	
<b>Dynamics:</b>		
<b>Velocity:</b>	500 m/sec. maximum	

**Table D-3 Performance Specifications (Continued)**

<b>Acceleration:</b>	4g (39.2 m/sec. <sup>2</sup> )
<b>Jerk:</b>	20 m/sec. <sup>3</sup>
<b>PPS output</b>	
<b>Physical Interface:</b>	RS-422
<b>Width:</b>	10 microseconds (default). User-programmable from 10 microseconds to 500 milliseconds.
<b>On-Time Edge:</b>	Rising edge on-time (default). User-programmable rising or falling.
<b>Resolution:</b>	80 nanoseconds (quantization error reported through TSIP)
<b>Accuracy (one sigma):</b>	UTC 50 nanoseconds (static) UTC 150 nanoseconds (dynamic, TDOP≤3)
<b>External Event Capture</b>	
<b>Interface:</b>	RS-422/485 or RS-232
<b>Resolution:</b>	320 nanoseconds
<b>Minimum Pulse Width:</b>	1 microsecond, rising edge on-time
<b>Reporting Mechanism:</b>	TSIP Packet

**Table D-4 Electrical Specifications**

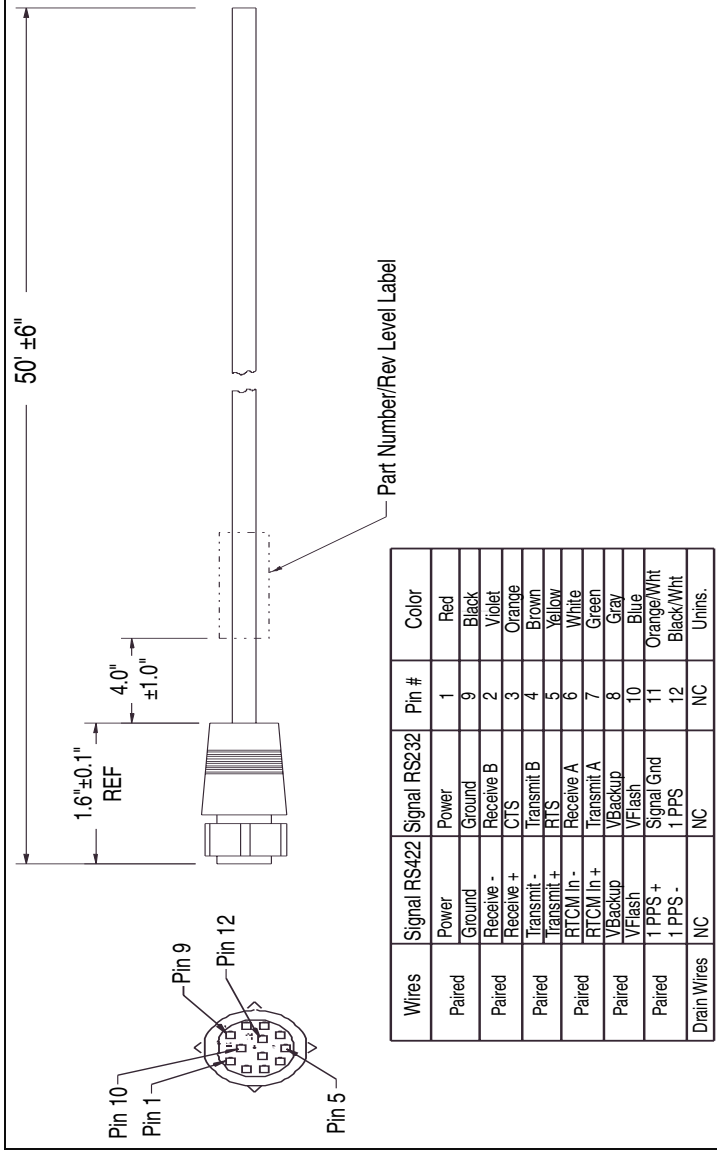
<b>Prime Power:</b>	+8 Vdc to +36 Vdc, reverse polarity protection
<b>Power Consumption:</b>	110mA @ 12 volts, 1.3 watts (typical), <1.5 watts max

**Table D-5 Serial Protocols**

<b>Port</b>	<b>Interface</b>	<b>Protocols</b>	<b>Defaults</b>
TxB (primary)	RS-422/485 or RS-232	TSIP, NMEA	TSIP @ 9600, 8-odd-1
RxB (primary)	RS-422/485 or RS-232	TSIP	TSIP @ 9600, 8-odd-1
TxA (secondary)	RS-422/485 or RS-232	TSIP	TSIP @ 9600, 8-odd-1
RxA (secondary)	RS-422/485 or RS-232	Event/RTCM	Event Input
All ports support baud rates of 300-38,400; 8 data bits; even, odd, no parity			
NMEA messages (default):	ZDA		
Available messages:	GGA, GLL, VTG, GSV, GSA, ZDA, RMC		

## **D.2 Acutime 2000 Standard Interface Cable Diagram**

Figure D-1 provides a technical drawing of the Acutime 2000 standard interface cable.



Wires	Signal RS422	Signal RS232	Pin #	Color
Paired	Power	Power	1	Red
	Ground	Ground	9	Black
Paired	Receive -	Receive B	2	Violet
	Receive +	CTS	3	Orange
Paired	Transmit -	Transmit B	4	Brown
	Transmit +	RTS	5	Yellow
Paired	RTCM In -	Receive A	6	White
	RTCM In +	Transmit A	7	Green
Paired	VBackup	VBackup	8	Gray
	VFlash	VFlash	10	Blue
Paired	1 PPS +	Signal Gnd	11	Orange/Wht
	1 PPS -	1 PPS -	12	Black/Wht
Drain Wires	NC	NC	NC	Unins.

**Figure D-1 Acutime 2000 Standard Interface Cable**

# E Theory of Operation

---

This chapter describes the smart antenna's satellite acquisition and tracking processes, performance characteristics and system architecture. This discussion assumes you are familiar with basic GPS theory.

The smart antenna's satellite acquisition and tracking algorithms can achieve a position solution without any initialization. The receiver tracks up to eight satellites and automatically selects the best combination of satellites to compute position, velocity and time. As satellites move out of view, the smart antenna automatically acquires new satellites and includes them in the solution set as required.

Before proceeding to the detailed discussion of the satellite acquisition and tracking process, please review the GPS satellite message description on the next page.

## E.1 GPS Satellite Message

Every GPS satellite transmits the Coarse/Acquisition (C/A) code and satellite data modulated onto the L1 carrier frequency (1575.42 MHz). The C/A code is a unique pseudo-random sequence for each satellite. The satellite data transmitted by each satellite includes a satellite almanac for the entire GPS system, its own satellite ephemeris, and its own clock correction.

The satellite data is transmitted in 30-second frames. Each frame contains the clock correction and ephemeris for that specific satellite, and two pages of the 50-page GPS system almanac. The time required to transmit the complete system almanac is 12.5 minutes; the time to transmit the satellite ephemeris is 30 seconds.

The system almanac contains information about each of the satellites in the constellation, ionospheric data, and special system messages. The ephemeris contains detailed orbital information for a specific satellite. The GPS system almanac changes infrequently and is typically valid for weeks. Ephemeris data changes hourly, but is valid for up to four hours. The GPS control segment updates the system almanac weekly and the ephemeris hourly through three ground-based control stations. During normal operation, the smart antenna updates the ephemeris stored in its memory at 30-minute intervals.

The performance of a GPS receiver at power-on is determined largely by the availability and accuracy of the satellite ephemeris data and the availability of a GPS system almanac.



## E.2 Satellite Acquisition and Time to First Fix

This section describes satellite acquisition times for different start conditions.

### E.2.1 Cold Start

The term *cold start* describes the performance of a GPS receiver at power-on when no navigation data is available. *Cold* signifies that the receiver does not have a current almanac, satellite ephemeris, initial position, or time. The cold start search algorithm applies to a smart antenna that is powered on without the memory backup circuit connected to a source of DC power. Since the Acutime 2000 has no provision for external backup power, it always operates from a cold start. This is the condition of the GPS module as received from the factory.

In a cold start condition, the receiver automatically selects a set of satellites and dedicates an individual tracking channel to search the Doppler frequency for each satellite in the set. If none of the selected satellites are acquired after a pre-determined period of time (time-out), the receiver selects a new search set of satellites and repeats the process until the first satellite is acquired. As satellites are acquired, the receiver automatically collects ephemeris and almanac data. The smart antenna uses the information gained from acquiring a specific satellite to eliminate other satellites (those below the horizon) from the search set. This strategy speeds the acquisition of additional satellites required to achieve the first position fix.

The cold start search sets are established to ensure that at least three satellites are acquired within the first two time-out periods. As soon as four satellites are acquired, the receiver computes an initial position fix. The Acutime 2000 typically achieves a cold start in under two minutes.

A complete system almanac is not required to achieve a first position fix. The almanac is used in subsequent *warm starts*, and to aid in acquiring GPS satellites that come into view.

## **E.2.2 Warm Start**

In a warm start condition, the receiver has a current almanac, an initial position (within 3,000 km) and current time (within five minutes) stored in memory. Although the smart antenna does not have an onboard battery for preserving memory, it can be initialized using the TSIP protocol. To force a warm start, the almanac, time, and initial position must be uploaded to the receiver.

During a warm start, the smart antenna identifies the satellites that are expected to be in view, given the system almanac, the initial position and the time. The receiver calculates the elevation and expected Doppler shift for each satellite in this expected set and directs the eight tracking channels in a parallel search for these satellites. If the internal oscillator error is known, the smart antenna compensates for the offset to optimize the search. If the offset is not known, the search algorithms are set wide enough to allow for oscillator tolerance, aging, and temperature errors.

If the receiver has an almanac and an initial position, but does not have the current time, it executes a cold start search until the first satellite is acquired. Once this first satellite is acquired, the receiver can obtain an approximate time and will convert to warm start mode to acquire additional satellites. Although the time to first fix is slightly longer in this case, it is significantly shorter than a complete cold start.

The warm start time to first fix is usually less than 50 seconds (40 seconds is typical).

### **E.2.3 "Garage Search" Strategy**

During a warm start search, the smart antenna knows which satellites to search for, based on the system almanac, the initial position and the current time. In some cases, the receiver may not be able to acquire the expected satellite signals (for example, if the Acutime 2000 is in a jamming environment). Trimble's patented *garage search* strategy, also known as a split search, is designed for such situations.

If the receiver does not acquire the expected set of satellites within five minutes of a warm start, one of the channels is directed in a cold start search. This strategy minimizes the time to first fix in cases where the stored almanac, position and time are invalid. If the cold start search proves effective and the garage search fails, the stored information is flushed from memory.

### **E.2.4 Hot Start**

A hot start strategy applies when the almanac, position, time and ephemeris in memory are valid. The hot start search strategy is similar to a warm start, but since the ephemeris data in memory is considered current and valid, the acquisition time is typically less than 30 seconds. This may occur if the GPS signals are temporarily obscured or jammed.

## **E.3 Position Accuracy**

GPS position accuracy is degraded by atmospheric distortion, satellite and receiver clock errors, and Selective Availability (S/A). Effective models for atmospheric distortion of satellite signals have been developed to minimize the impact of tropospheric and ionospheric effects. The impact of satellite clock errors is minimized by incorporating the clock corrections transmitted by each satellite used in the position solution. S/A is the most significant contributor to position error and cannot be effectively counteracted except with differential GPS.

### **E.3.1 Selective Availability (S/A)**

The U.S. Department of Defense, through a program called Selective Availability, intentionally degrades GPS accuracy for civilian users. The S/A program creates position errors by modifying the apparent position of each satellite and introducing random dither into each satellite's clock.

In extreme cases, all sources of error (natural, PDOP, and S/A) can combine to produce large position errors. The DOD's definition of accuracy under S/A is 100 meters 2 dRMS (horizontal two-dimensional, 95 percent of the time).

## **E.4 Coordinate Systems**

This section lists the coordinate system formats supported by the TSIP and NMEA 0183 protocols.

### **E.4.1 TSIP**

In the default TSIP configuration, position is output in a Latitude-Longitude-Altitude (LLA) format based on a default datum, WGS-84. The LLA format can be easily converted by the host system to other coordinate systems using the appropriate translation algorithm. By sending the appropriate TSIP command, the smart antenna's position output can be changed to a Cartesian (XYZ) coordinate format. The datum used for LLA transformations can also be changed using the TSIP 8E packet. The smart antenna offers a selection of 179 datums, which are listed in Appendix A, Trimble Standard Interface Protocol.

The TSIP velocity output format is also three-dimensional. The default format is X-Y-Z with the option of an East-North-Up (ENU) coordinate format. Time tags on fix messages default to UTC (Universal Coordinated Time), but can be switched to GPS time by sending the appropriate TSIP command.

### **E.4.2 NMEA 0183**

The NMEA 0183 protocol supports only LLA format and UTC time. If a custom datum is required, it can be set through TSIP using command 0x8E-15.

## E.5 Performance Characteristics

This section lists performance information for the Acutime 2000.

### E.5.1 Update Rate

The Acutime 2000 updates position at one-second intervals during self-survey. The surveyed position is frozen after the survey completes.

### E.5.2 Dynamic Limits

The dynamic operating limits for the various receiver designs are listed below. These operating limits assume that the smart antenna is correctly installed and that the overall system is designed to operate under the same dynamic conditions.

**Table E-1 Dynamic Upper Bound**

Dynamic	Operating Limits
Velocity	500 m/s
Acceleration	4 g (39.2 m/s <sup>2</sup> )
Jerk	20 m/s <sup>3</sup>

### E.5.3 Re-Acquisition

When a satellite signal is momentarily interrupted during normal operation, the receiver continues to search for the lost signal at the satellite's last known Doppler frequency. If the lost signal is not re-acquired within 15 seconds, the receiver initiates a broader frequency search. The smart antenna uses the last known information about the dynamics of the receiver and the satellite to establish the center frequency and range for the search. Every 15 seconds, until the lost signal is re-acquired, a new center frequency and search range is computed. Each frequency range is searched in 500 Hz increments. The duration of the code search at a given frequency is approximately one second and switches automatically.

If ephemeris or almanac data is available for the lost satellite, then the satellite's velocity is factored into the center frequency calculation. The diminished accuracy of an older almanac is accounted for in the width of the search range. If neither the ephemeris nor almanac is available, then the Doppler frequency at last lock is searched for two minutes. If the satellite has not been re-acquired after two minutes, then the maximum expected Doppler frequency, based on satellite dynamics, is searched.

If the current position is not accurately known, the search width is increased. If the smart antenna is computing velocity or velocity aiding is provided, then the receiver's motion is also factored into the Doppler frequency. If velocity information is not available, then the dynamics code is used to determine the maximum expected Doppler frequency.

The re-acquisition time for momentary signal blockages is typically under two seconds.

## E.6 System Architecture

The standard Acutime 2000 incorporates a proprietary DSP (Digital Signal Processor), which operates at the L1 frequency (1575.42 MHz) and processes the Coarse/Acquisition (C/A) code portion of the GPS signal. The RF and digital signal processing components of the GPS module are custom ASICs designed by Trimble. In addition to the signal processing functions, these ASICs also contain support circuitry for the microprocessor. The microprocessor performs the navigation computations in addition to controlling the DSP channels and managing the I/O operations.

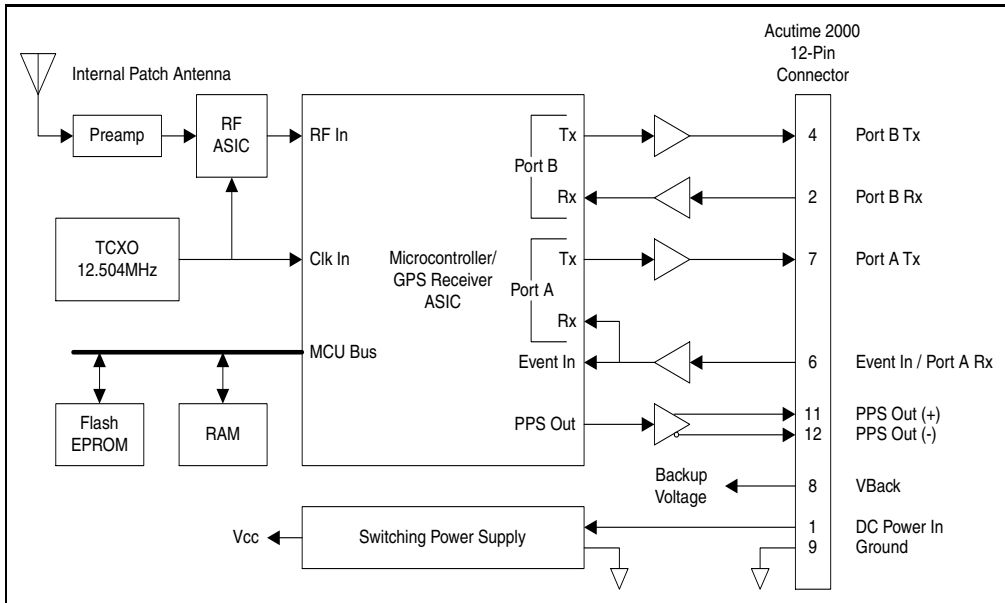
GPS satellite signals are collected by the antenna, filtered and amplified by the antenna's pre-amp and then fed to the RF down converter. A highly stable, crystal reference oscillator, operating at 12.504 MHz, supports the down converter in producing the correct signals for the digital signal processor. The signal processing stage tracks the GPS satellite signals and extracts the carrier code information, as well as the navigation data at 50 bits per second.

In addition to supporting the down conversion process, the crystal oscillator also serves as the reference clock for the navigation processor. This microprocessor controls the operation of the signal processing channels by allocating the channels during satellite acquisition and tracking. In the overdetermined mode of operation, the smart antenna automatically tracks the highest eight (or twelve) satellites above the horizon and selects the optimal set of satellites for the position solution.

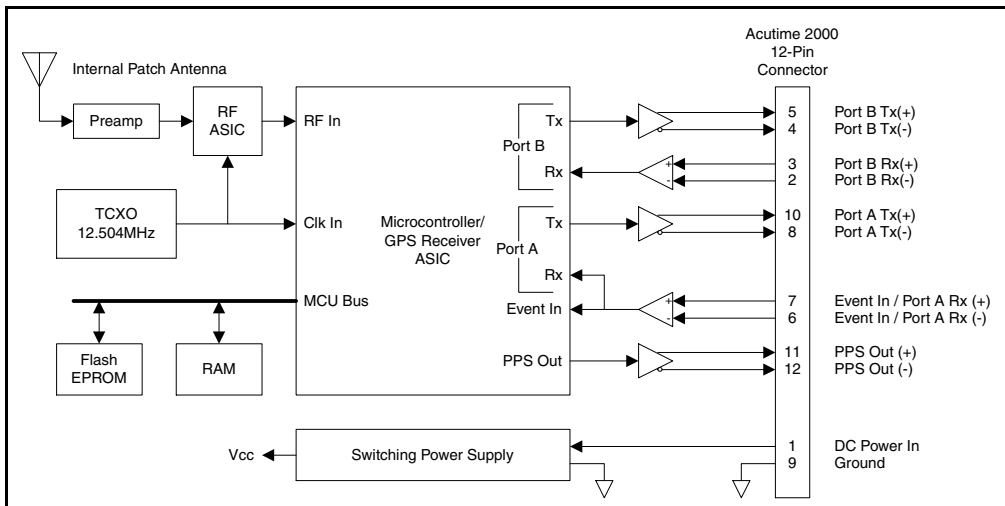
In addition to controlling the DSP stage, the navigation processor also collects the ephemeris and almanac data for all of the satellites and manages the Universal Asynchronous Receiver/Transmitter (UART or DUART) interface. The UART supports full-duplex serial communication with the smart antenna.

The RS-232 and RS-422 versions of the Acutime 2000 block diagram for the GPS smart antenna are illustrated in Figure E-1 and Figure E-2.





**Figure E-1 Acutime 2000 Block Diagram (RS-232 Version)**



**Figure E-2 Acutime 2000 Block Diagram (RS-422 Version)**



# Glossary

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This section defines technical terms and abbreviations used in this manual. It includes terms from the field of GPS technology.

- 2-D** Two Dimensional. A 2-D position is defined as latitude and longitude. Altitude is assumed to be fixed.
- 2-D GPS mode** A procedure of determining a 2-D position using signals received from the best (or only) three available GPS satellites. Altitude is assumed to be known and constant. A 2-D position solution will only be determined if signals from three or more satellites are available.
- 3-D** Three Dimensional. A 3-D position is defined as latitude, longitude, and altitude.
- 3-D GPS mode** A procedure of determining a 3-D position using signals received from the best (or only) four available GPS satellites. A 3-D position solution will only be determined if signals from four or more satellites are available.
- almanac** A reduced-precision subset of the ephemeris parameters. Used by the receiver to compute the elevation angle, azimuth angle, and estimated Doppler of the satellites. Each satellite broadcasts the almanac for all the satellites in the system.

<b>ASCII</b>	American Standard Code for Information Interchange. A standard set of 128 characters, symbols and control codes used for computer communications. ASCII characters require 7 bits of data to send, but are often sent 8 bits at a time with the extra bit being a zero.
<b>auto GPS mode</b>	A procedure of automatically determining either a 2-D or 3-D position using signals received from GPS satellites. The solution automatically transitions between 2-D and 3-D depending on the number of satellites available, the PDOP of the available satellites, and the defined PDOP switch value. (See PDOP and PDOP constellation switch).
<b>azimuth angle</b>	The angle of the line-of-site vector, projected on the horizontal plane, measured clockwise from true North.
<b>bandwidth</b>	The range of frequencies occupied by a signal. Also, the information carrying capability of a communication channel or line.
<b>baud</b>	A measure of the speed of data transmission. Baud and bit rate are the same for direct equipment interconnections (for example, through RS-232). Baud and bit rate are not the same for modulated data links, whether wire or radio.
<b>bit</b>	Binary digit. The smallest unit of information into which digital data can be subdivided and which a computer can hold. Each bit has only two values (e.g., on/off, one/zero, true/false).
<b>bit rate</b>	The rate at which bits are transmitted over a communication path. Normally expressed in bits per second (bps).
<b>byte</b>	A set of contiguous bits that make up a discrete item of information. A byte usually consists of a series of 8 bits, and represents one character.

<b>C/A code</b>	The Coarse/Acquisition code. This is the civilian code made available by the Department of Defense. It is subject to selective availability (SA). Users can reduce the effects of SA by using differential GPS.
<b>carrier</b>	The radio signal on which information is carried. The carrier can be sensed to determine the presence of a signal.
<b>channel</b>	Either a single frequency or a pair of radio frequencies used as a communication path.
<b>chip</b>	The length of time to transmit either a zero or a one in a binary pulse code.
<b>chip rate</b>	Number of chips per second (e.g., C/A code = 1.023 MHz).
<b>configuration</b>	A set of conditions or parameters that define the structure of an item. In regards to Placer, a configuration defines the GPS processing and characteristics of the RS-232 interface ports. The term configuration can also define the hardware components that comprise a subsystem or system.
<b>data bits</b>	The bits in a byte of data which carry the actual information.
<b>datum</b>	A mathematical model of the earth. Many local datums model the earth for a small region: for example, Tokyo datum, Alaska, NAD-27 (North America). Others, such as WGS-84, model the whole earth.
<b>DCE</b>	Data Communications Equipment. The equipment that provides the functions required to establish, maintain, and terminate a communication connection. Any equipment that connects to DTE using an RS-232 or CCITT V.24 standard interface.

<b>default setting</b>	A preset or initial value that is assumed to be the preferred or appropriate selection for most situations. The Placer GPS sensor is shipped with factory default configuration settings; the settings were determined by Trimble.
<b>differential relative positioning</b>	Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Static differential GPS involves determining baseline vectors between pairs of receivers. Also see <i>differential GPS</i> .
<b>dilution of precision</b>	<p>A description of the purely geometrical contribution to the uncertainty in a position fix, given by the expression <math>DOP = \sqrt{\text{TRACE}(A^{-1}A)}</math> where <math>A^{-1}A</math> is the design matrix for the instantaneous position solution (dependent on satellite-receiver geometry). The DOP factor depends on the parameters of the position-fix solution. Standard terms for the GPS application are:</p> <p>GDOP – Geometric (three position coordinates plus clock offset in the solution) – PDOP – Position (three coordinates) HDOP – Horizontal (two horizontal coordinates) VDOP – Vertical (height only) TDOP – Time (clock offset only) RDOP – Relative (normalized to 60 seconds)</p>
<b>DOP</b>	See <i>dilution of precision</i> .
<b>Doppler shift</b>	The apparent change in frequency of a received signal due to the rate of change of the range between the transmitter and receiver.
<b>earth-centered earth-fixed (ECEF)</b>	Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The vectors rotate with the earth. Z is the direction of the spin axis.

<b>elevation angle</b>	The angle between the line of sight vector and the horizontal plane.
<b>elevation mask angle</b>	A measure of the minimum elevation angle, above the horizon, above which a GPS satellite must be located before the signals from the satellite will be used to compute a GPS location solution. Satellites below the elevation angle are considered unusable. The elevation mask angle is used to prevent the GPS receiver from computing position solutions using satellites which are likely to be obscured by buildings or mountains.
<b>ellipsoid</b>	In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid; these are usually given as the length of the semi-major axis, $a$ , and the flattening, $f = (a - b)/a$ , where $b$ is the length of the semi-minor axis.
<b>ephemeris</b>	A set of parameters that describe the satellite orbit very accurately. It is used by the receiver to compute the position of the satellite. This information is broadcast by the satellites.
<b>epoch</b>	Measurement interval or data frequency, as in making observations every 15 seconds. Loading data using 30-second epochs means loading every other measurement.
<b>firmware</b>	A set of software computer/processor instructions that are permanently or semi-permanently resident in read-only memory.

<b>frequency</b>	<p>The number of vibrations per second of an audio or radio signal. Measured in hertz (Hz), kilohertz (kHz), or megahertz (MHz).</p> <p>GPS frequencies are: L1 = 1575.42 MHz L2 = 1227.60 MHz</p>
<b>GDOP</b>	<p>Geometric Dilution of Precision. GDOP describes how much an uncertainty in pseudo-range and time affects the uncertainty in a position solution. GDOP depends on where the satellites are relative to the GPS receiver and on GPS clock offsets.</p>
<b>geodetic datum</b>	<p>A mathematical model designed to best fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude, and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point. The GPS uses WGS-84.</p>
<b>geoid</b>	<p>The actual physical shape of the earth which is hard to describe mathematically because of the local surface irregularities and sea-land variations. In geodetic terms it is the particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is everywhere perpendicular to the force of gravity.</p>
<b>GPD</b>	<p>GPS with differential corrections applied.</p>



<b>GPS</b>	<p>Global Positioning System. A satellite-based navigation system operated and maintained by the U.S. Department of Defense and consisting of a constellation of 24 satellites providing worldwide, 24-hour, three-dimensional (3-D) GPS coverage. These satellites transmit signals used (by GPS receivers) to determine precise location (position, velocity, and time) solutions. GPS signals are available in all weather conditions. This system also includes 5 monitor ground stations, 1 master control ground station, and 3 upload ground stations.</p> <p>GPS is emerging as the technology of choice in many timing applications, including site and network synchronization.</p>
<b>GPS antenna</b>	<p>An antenna designed to receive GPS radio navigation signals.</p>
<b>GPS processor</b>	<p>An electronic device that interprets the GPS radio navigation signals (received by a GPS antenna) and determines a location solution. The GPS processor may also be able to apply (and determine) differential GPS corrections.</p>
<b>GPS receiver</b>	<p>The combination of a GPS antenna and a GPS processor.</p>
<b>GPS time</b>	<p>The length of the second is fixed and is determined by primary atomic frequency standards. Leap-seconds are not used, as they are in UTC. Therefore, GPS time and UTC differ by a variable whole number of seconds.</p>
<b>HDOP</b>	<p>Horizontal Dilution of Precision.</p>
<b>host system</b>	<p>The device or instrument connected to the Acutime 2000 smart antenna. The host system can be a PC, network equipment, or timing system, depending on the application.</p>

<b>HOW</b>	Hand-over word. The word in the GPS message that contains time synchronization information for the transfer from C/A to P-code.
<b>interface cable</b>	The interface cable allows data to flow between the Acutime 2000 and the communication equipment.
<b>interference</b>	Refers to the unwanted occurrences on communication channels that are a result of natural or man-made noises and signals, not properly a part of the signals being transmitted or received.
<b>integrated Doppler</b>	A measurement of Doppler shift frequency or phase over time.
<b>IODE</b>	Issue Of Data, Ephemeris. Part of the navigation data. It is the issue number of the ephemeris information. A new ephemeris is available usually on the hour. Especially important for Differential GPS operation that the IODE change is tracked at both the reference station and mobile stations.
<b>jamming</b>	Interference (in either transmitting or receiving signals) caused by other radio signals at exactly or approximately the same frequency.
<b>masks</b>	See <i>satellite masks</i> .
<b>maximum PDOP</b>	A measure of the maximum Position Dilution of Precision (PDOP) that is acceptable in order for the GPS processor to determine a location solution (see PDOP).
<b>NAVSTAR</b>	The name given to the GPS satellites, built by Rockwell International, which is an acronym formed from NAVigation System with Time And Ranging.

<b>NMEA</b>	National Marine Electronics Association. An association that defines marine electronic interface standards for the purpose of serving the public interest.
<b>NMEA 0183 message</b>	NMEA 0183 is a standard for interfacing marine electronics navigational devices. The standard specifies the message format used to communicate with marine devices/components.
<b>packet</b>	An "envelope" for data, which contains addresses and error checking information as well as the data itself.
<b>parity</b>	A scheme for detecting certain errors in data transmission. Parity defines the condition (i.e., even or odd) of the number of items in a set (e.g., bits in a byte).
<b>PDOP</b>	Position Dilution of Precision. PDOP is a unitless figure of merit that describes how an uncertainty in pseudo-range affects position solutions.
<b>PDOP constellation switch</b>	A value, based on PDOP, that defines when the GPS receiver/processor should switch between 2-D and 3-D GPS modes. The PDOP constellation switch is only active when the GPS mode of operation is set to Auto.
<b>PRN</b>	Pseudo-random noise. Each GPS satellite generates its own distinctive PRN code, which is modulated onto each carrier. The PRN code serves as identification of the satellite, as a timing signal, and as a subcarrier for the navigation data.
<b>protocol</b>	A formal set of rules that describe a method of communication. The protocol governs the format and control of inputs and outputs.

<b>pseudo-range</b>	A measure of the range from the GPS antenna to a GPS satellite. Pseudo-range is obtained by multiplying the speed of light by the apparent transit time of the signal from the GPS satellite. Pseudo-range differs from actual range because the satellite and user clocks are offset from GPS time and because of propagation delays and other errors.
<b>RAM</b>	Random-Access Memory.
<b>random-access memory</b>	Memory in which information can be referred to in an arbitrary or random order. The contents of RAM are lost when the System Unit is turned off.
<b>range</b>	A term used to refer to the distance radio signals can travel before they must be received or repeated due to loss of signal strength, the curvature of the earth and the noise introduced because of moisture in the air surrounding the earth's surface.
<b>range rate</b>	The rate of change of range between the satellite and receiver. The range to a satellite changes due to satellite and observer motions. Range rate is determined by measuring the Doppler shift of the satellite beacon carrier.
<b>read-only memory</b>	Memory whose contents can be read, but not changed. Information is placed into ROM only once. The contents of ROM are not erased when the system unit's power is turned off.
<b>relative positioning</b>	The process of determining the vector distance between two points and the coordinates of one spot relative to another. This technique yields GPS positions with greater precision than a single point positioning mode can.
<b>rise/set time</b>	The period during which a satellite is visible (i.e., has an elevation angle that is above the elevation mask). A satellite is said to "rise" when its elevation angle exceeds the mask and "set" when the elevation drops below the mask.

<b>ROM</b>	Read-Only Memory.
<b>RTCM</b>	Radio Technical Commission for Maritime Services. Commission that recommends standards for differential GPS services. <i>RTCM Recommended Standards For Differential GPS Service</i> , prepared by RTCM Special Committee No. 104 (RTCM SC-104), defines a communication protocol for sending GPS differential corrections from a differential reference station to remote GPS receivers.
<b>satellite masks</b>	As satellites approach the horizon, their signals can become weak and distorted, preventing the receiver from gathering accurate data. Satellite masks enable you to establish criteria for using satellite data in a position solution. There are three types of satellite masks: Elevation, SNR, and PDOP.
<b>SA</b>	Selective Availability. This is the name of the policy and the implementation scheme by which unauthorized users of GPS will have their accuracy limited to 100 meters 2D RMS horizontal and 156 meters 2D RMS vertical.
<b>SEP</b>	Spherical Error Probability. The radius of a sphere such that 50% of the position estimates will fall within the surface of the sphere.
<b>serial communication</b>	A system of sending bits of data on a single channel one after the other, rather than simultaneously.
<b>serial port</b>	A port in which each bit of information is brought in/out on a single channel. Serial ports are designed for devices that receive data one bit at a time.
<b>signal-to-noise level</b>	GPS signals with SNRs that do not meet the mask criteria are considered unusable.

<b>signal-to-noise ratio</b>	A measure of the relative power levels of a communication signal and noise on a data line. SNR is expressed in decibels (dB).
<b>SNR</b>	Signal-to-Noise Ratio.
<b>spread spectrum</b>	The received GPS signal is a wide bandwidth, low-power signal (-160 dBW). This property results from modulating the L-band signal with a PRN code in order to spread the signal energy over a bandwidth which is much greater than the signal information bandwidth. This is done to provide the ability to receive all satellites unambiguously and to provide some resistance to noise and multi-path.
<b>SPS</b>	Standard Positioning Service. Refers to the GPS as available to the authorized user.
<b>start bit</b>	In asynchronous transmission, the start bit is appended to the beginning of a character so that the bit sync and character sync can occur at the receiver equipment.
<b>stop bit</b>	In asynchronous transmission, the stop bit is appended to the end of each character. It sets the receiving hardware to a condition where it looks for the start bit of a new character.
<b>SV</b>	Space Vehicle (GPS satellite).
<b>synchronous communication</b>	A method of sending digital data in which the bits come at fixed, rather than random, times and are synchronized to a clock.
<b>TSIP</b>	Trimble Standard Interface Protocol. A binary/hex packet bi-directional protocol, also known as the TANS protocol. Used by a large number of Trimble sensors. TSIP is the subset of TANS which is recognized by all Trimble sensors except the 4000 series. The TSIP protocol is defined in full in Appendix A.

- URA** Satellite user range accuracy. The URA is sent by the satellite and is computed by the GPS operators. It is a statistical indicator of the contribution of the apparent clock and ephemeris prediction accuracies to the ranging accuracies obtainable with a specific satellite based on historical data.
- UTC** Universal Coordinated Time. Uniform atomic time system/standard that is maintained by the US Naval Observatory. UTC defines the local solar mean time at the Greenwich Meridian.
- UTC offset** The difference between local time and UTC (Example: UTC - EST = 5 hours).





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## Reader Comment Form

**Acutime 2000 Synchronization Kit User Guide**  
**P/N: 45005-00-ENG**

**May 2002**  
**Revision C**

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