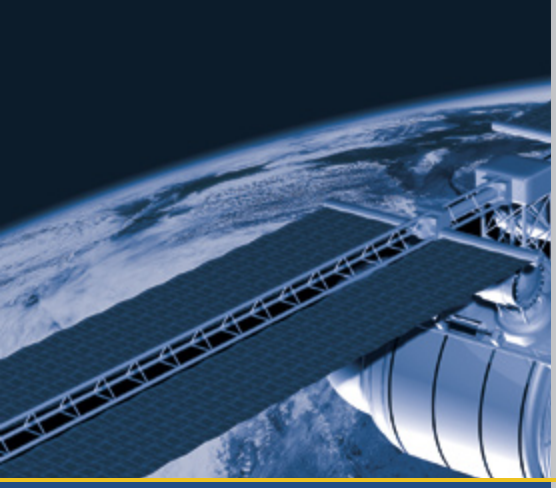

USER GUIDE

Trimble® Acutime™ Gold GPS Smart Antenna

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Trimble®

USER GUIDE

Trimble® Acutime™ Gold GPS Smart Antenna

Version 1.0
Revision B
Part Number 58873-00
February 2012

Trimble

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Release Notice

This is the February 2012 release (Revision B) of the *Trimble Acutime Gold GPS Smart Antenna User Guide*, part number 58873-00.

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For applicable product Limited Warranty information, please consult your local Trimble authorized sales manager.

For applicable product Limited Warranty information, please refer to Legal Notices in the Help for this product, or consult your local Trimble authorized dealer.

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Product Limited Warranty

Subject to the following terms and conditions, Trimble Navigation Limited ("Trimble") warrants that for a period of one (1) year from date of purchase this Trimble product (the "Product") will substantially conform to Trimble's publicly available specifications for the Product and that the hardware and any storage media components of the Product will be substantially free from defects in materials and workmanship.

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– your name, address, and telephone numbers

– proof of purchase

– a description of the nonconforming Product including the model number and serial number

– an explanation of the problem

The customer service representative may need additional information from you depending on the nature of the problem.

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This Product limited warranty shall only apply in the event and to the extent that (a) the Product is properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Trimble's applicable operator's manual and specifications, and; (b) the Product is not modified or misused. This Product limited warranty shall not apply to, and Trimble shall not be responsible for, defects or performance problems resulting from (i) the combination or utilization of the Product with hardware or software products, information, data, systems, interfaces, or devices not made, supplied, or specified by Trimble; (ii) the operation of the Product under any specification other than, or in addition to, Trimble's standard specifications for its products; (iii) the unauthorized installation, modification, or use of the Product; (iv) damage caused by: accident, lightning or other electrical discharge, fresh or salt water immersion or spray (outside of Product specifications); or exposure to environmental conditions for which the Product is not intended; (v) normal wear and tear on consumable parts (e.g., batteries); or (vi) cosmetic damage. Trimble does not warrant or guarantee the results obtained through the use of the Product, or that software components will operate error free.

NOTICE REGARDING PRODUCTS EQUIPPED WITH TECHNOLOGY CAPABLE OF TRACKING SATELLITE SIGNALS FROM SATELLITE BASED AUGMENTATION SYSTEMS (SBAS) (WAAS/EGNOS, AND MSAS), OMNISTAR, GPS, MODERNIZED GPS OR GLONASS SATELLITES, OR FROM IALA BEACON SOURCES: TRIMBLE IS NOT RESPONSIBLE FOR THE OPERATION OR FAILURE OF OPERATION OF ANY SATELLITE BASED POSITIONING SYSTEM OR THE AVAILABILITY OF ANY SATELLITE BASED POSITIONING SIGNALS.

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Official Language

THE OFFICIAL LANGUAGE OF THESE TERMS AND CONDITIONS IS ENGLISH. IN THE EVENT OF A CONFLICT BETWEEN ENGLISH AND OTHER LANGUAGE VERSIONS, THE ENGLISH LANGUAGE SHALL CONTROL.

Notices

Class B Statement – Notice to Users. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communication. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes and modifications not expressly approved by the manufacturer or registrant of this equipment can void your authority to operate this equipment under Federal Communications Commission rules.

Canada

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

Australia and New Zealand

This product conforms with the regulatory requirements of the Australian Communications Authority (ACA) EMC framework, thus satisfying the requirements for C-Tick Marking and sale within Australia and New Zealand.

Notice to Our European Union Customers

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

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

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

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

As of July 1, 2006, the Product is compliant in all material respects with DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) and Amendment 2005/618/EC filed under C(2005) 3143, with exemptions for lead in solder pursuant to Paragraph 7 of the Annex to the RoHS Directive applied. The foregoing is limited to Product placed on the market in the Member States of the European Union on or after 1 July 2006. Trimble has relied on representations made by its suppliers in certifying this Product as RoHS compliant.

Declaration of Conformity

We, Trimble Navigation Limited,

935 Stewart Drive
PO Box 3642
Sunnyvale, CA 94088-3642
United States
+1-408-481-8000

declare under sole responsibility that the product:
Acutime Gold GPS smart antenna
complies with Part 15 of FCC Rules.

Operation is subject to the following two conditions:
(1) this device may not cause harmful interference, and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Safety Information

Warnings and Cautions

An absence of specific alerts does not mean that there are no safety risks involved.

Always follow the instructions that accompany a Warning or Caution. The information they provide is intended to minimize the risk of personal injury and/or damage to the equipment. In particular, observe safety instructions that are presented in the following formats:

WARNING – A Warning alerts you to a likely risk of serious injury to your person and/or damage to the equipment.

CAUTION – A Caution alerts you to a possible risk of damage to the equipment and/or loss of data.

Operation and storage

WARNING – Operating or storing the Acutime Gold smart antenna outside the specified temperature range can damage it. For more information, see the product specifications on the data sheet.

Routing any cable

CAUTION – Be careful not to damage the cable. Take care to avoid sharp bends or kinks in the cable, hot surfaces (for example, exhaust manifolds or stacks), rotating or reciprocating equipment, sharp or abrasive surfaces, door and window jambs, routing near high EMI/EMF (Electro-Magnetic Induction/Field) transformers or equipment, and corrosive fluids or gases.

CAUTION – Be careful not to exceed the manufacturer's specifications for sharp bends and radius turns when routing the Acutime Gold GPS antenna cable.

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CHAPTER

1

Introduction

In this chapter:

- Features of the Acutime Gold GPS smart antenna
- Operation
- Starter kit
- Use and care
- Related information
- Technical assistance
- Your comments

Welcome to the *Trimble Acutime Gold GPS Smart Antenna User Guide*. The user guide describes how to install, set up, and use the Trimble® Acutime™ Gold GPS smart antenna and timing receiver ("Acutime Gold").

The Acutime Gold integrates the latest GPS technology into a rugged, self-contained antenna unit that provides optimal GPS timing performance, in all weather conditions, with continuous operation, long-term reliability, ease of operation, and simple installation.

The Acutime Gold provides an accurate one pulse-per-second (PPS) output to synchronize and time broadband wireless, cellular basestations, Time Difference of Arrival (TDOA) applications ,and many other Supervisory and Data Acquisition (SCADA) applications.

For more information on GPS, go to http://www.trimble.com/gps/index.shtml.

Features of the Acutime Gold GPS smart antenna

Hardware features

The Acutime Gold contains the following in a sealed, waterproof housing:

- An active patch GPS antenna with a proprietary pre-amp design and integrated band-pass filtering providing excellent performance against jamming signals.
- A 12-channel, parallel-tracking GPS receiver, operating on the L1 frequency (1575.42 MHz).
- A connector that supports both the power and data interface connection.
- Two user-configurable RS-422 I/O communication ports.

The Acutime Gold operates with a 5 to 36 VDC power supply with protection against reverse polarity. Internal circuitry reduces the power to operate the receiver at 3.3 VDC.

When power is applied, the Acutime Gold initializes by itself, acquires satellite signals, and begins a self-survey, which culminates in a transition from the Positioning Mode to an Over-determined Clock Mode.

Interface protocols

You can select the protocol for the Acutime Gold. There are two options:

- Trimble Standard Interface Protocol (TSIP) is a binary packet protocol that allows the system designer maximum configuration control over the GPS receiver for optimum performance in timing applications. TSIP supports multiple commands and their associated response packets for use in configuring the Acutime Gold receiver to meet your requirements. See Appendix A Trimble Standard Interface Protocol.
- NMEA 0183 (National Marine Electronics Association) is an industry standard protocol common to marine applications. It provides direct compatibility with other NMEA-capable devices such as chart plotters and radar. The Acutime Gold supports the ZDA NMEA message for GPS timing. You can select other NMEA messages and output rates as required. See Appendix B NMEA 0183.

Standard timing software features

- Automatic self survey
- Over-determined (OD) Clock Mode
- Single-satellite Timing Mode
- Timing Superpackets
- Timing Receiver Autonomous Integrity Monitoring (T-RAIM)
- Position integrity (P-RAIM). When the receiver detects a position difference greater than 1000 meters from its stored position, it will restart the self-survey.
- Cable delay compensation

Operation

When the Acutime Gold is turned on, it runs a self-survey process and then switches into the Over-determined Clock Mode. In this mode, the reference position from the self-survey is retained in memory and the receiver solves only for clock error and clock bias. This mode also provides for T-RAIM, which allows the receiver to remove a satellite that provides incorrect information from the timing solution. If a receiver is moved more than 1000 meters from its surveyed location, a new self-survey ensures position integrity by automatically initiating and correcting the reference location.

The first time that the Acutime Gold is turned on, it searches for satellites from a cold start with no almanac, time, ephemeris, or stored position. The Acutime Gold begins to compute position and time solutions within the first 46 seconds, but it must track satellites continuously for approximately 15 minutes to download a complete almanac and ephemeris. ***Do not interrupt the initialization process.***

The Acutime Gold generates a 1 PPS output, synchronized to GPS or Coordinated Universal Time (UTC) time within 15 ns (one sigma). This level of accuracy is obtained using an Over-determined Clock solution and T-RAIM. The 1 PPS output and data signals conform to the RS-422 standard and support very long cable runs. The Acutime Gold outputs a comprehensive time packet after each 1 PPS on a dedicated serial port, it can accept an external event input, and report time stamps in response to an event signal.

Note – *The delay inherent in the cable from the antenna to the receiver can be overcome by determining the length of the cable and then entering the offset based on information from the cable manufacturer about the specific cable type. See* *Command Packet 0x8E-4A: Set/Request PPS Characteristics, page 89*.

Starter kit

The Acutime Gold Starter Kit contains all the components required for a high-performance, cost-effective reference time source that uses GPS technology to precisely synchronize computers, servers and Internet applications for evaluation and engineering purposes. It is quick and easy to install. To set up the starter kit, see page 17.

Use and care

The Acutime Gold is a high-precision electronic instrument and should be treated with reasonable care.

If a problem arises with the unit, an amber indication appears in the AcuGold_Mon program. Contact Trimble for technical direction and repair. There are no user-serviceable parts inside the Acutime Gold and any modification to the unit by the user voids the warranty.

Related information

An electronic copy of this manual is available in portable document format (PDF). Use Adobe Reader to view the file.

Contact your local sales representative or Trimble Support for more information about the support agreement contracts for software and firmware.

Technical assistance

If you have a problem and cannot find the information you need in the product documentation, contact the Trimble Technical Assistance Center at 800-767-4822 or email timing@trimble.com.

Your comments

Your feedback about the supporting documentation helps us to improve it with each revision. E-mail your comments to ReaderFeedback@trimble.com.

CHAPTER

2

Setting up and Running the Acutime Gold

In this chapter:

- System requirements
- Installing and using the software
- Acutime Gold starter kit
- Setting up the starter kit
- Starter kit components

Trimble recommends that you install the Acutime Gold Monitor (AcuGold_Mon) software ***before*** setting up the Acutime Gold, as this will enable you to monitor the acquisition of satellites once you start up the GPS antenna.

A starter kit is available for testing, evaluation, and engineering purposes. This section describes the components of the starter kit, and how to set it up.

The hardware integration is described in Chapter 3, Hardware integration.

System requirements

Hardware

- For evaluation or engineering purposes:

  The Trimble Acutime Gold GPS smart antenna starter kit, see page 17

- For permanent installation:

  Trimble Acutime Gold GPS smart antenna

  Interface cable with DB-25 connector

  Universal Interface Module

Computer

- An office computer running a version of the Microsoft® Windows® operating system (Windows NT or later)

System software

- Acutime Gold Monitor (AcuGold_Mon). This is used to monitor GPS performance and to assist system integrators in developing a software interface for the GPS module. The software is compatible with the Windows 95, 98, 2000, XP, and Windows Vista™ operating systems. See Acutime Gold Monitor (AcuGold_Mon), page 15.
- Trimble Standard Interface Protocol (TSIP). This consists of command packets and report packets. See Appendix A Trimble Standard Interface Protocol.
- NMEA-0183. See Appendix B NMEA 0183

Installing and using the software

All software programs for the Acutime Gold starter kit are available online from the Trimble website at http://www.trimble.com/timing.shtml. These programs enable you to monitor the Acutime Gold and change its settings.

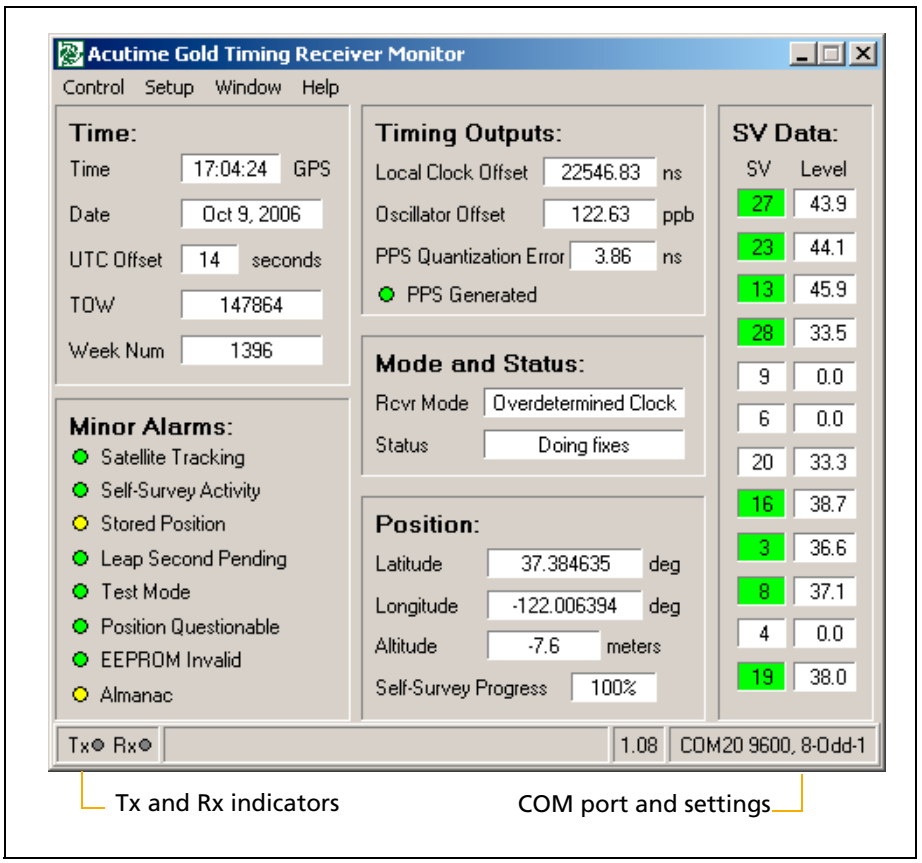
Tip – Install and set up the monitor program before turning on the Acutime Gold—this allows you to watch the timing process, from start up to fully functioning.

Acutime Gold Monitor (AcuGold_Mon)

CAUTION – Use only the Acutime Gold Monitor with this product. Previous versions may not be compatible.

To install the Acutime Gold Monitor application from the website:

1. Go to http://www.trimble.com/acutime_gold.shtml and then select *Support / Acutime Gold Software Downloads: Installation Files.*
2. Click *Acutime Gold Monitor Program* and then download the AcuGold_Mon.exe file to the computer's hard drive.
3. To run the application, double-click the file . The *Acutime Gold Monitor* screen appears:



4. To specify the communications port and protocol for your office computer, right-click in the bottom right of the *Acutime Gold Monitor* screen and then select the required COM port and settings.
5. Connect the Acutime Gold antenna to the Universal Interface Module using the provided antenna interface cable. Connect the 12-pin connector to the antenna, and the DB-25 connector to the Universal Interface Module.

6. Connect one end of the USB cable to the USB port of the universal interface module.
7. Connect the other end of the cable to the USB port of your computer.
8. Turn on the DC power source or plug in the AC/DC converter and then turn on the power.

   The Tx and Rx in the lower left of the status bar indicate the following:

   – If the Tx blinks, the computer is transmitting commands to the receiver.
   – If the Rx blinks, the computer is receiving reports from the receiver.
9. The Acutime Gold automatically begins its self-survey. When this is complete and the receiver achieves a position fix, the following information appears:

   – position
   – time
   – satellites tracked
   – GPS receiver status

Note – *The receiver sends a health report every few seconds, even if satellites are not being tracked.*

Data fields

If the Acutime Gold Monitor program displays a question mark (?) in a data field, the receiver has not reported a status for this field. If the question mark stays in place, the GPS module may not be communicating with the computer. Check the interface cable connections and verify the serial port selection and settings.

If the communication fails, call the Trimble Technical Assistance Center (TAC) at 1 (800) 767-4822.

TSIP

The Trimble Standard Interface Protocol (TSIP) consists of command packets and report packets, see Appendix A Trimble Standard Interface Protocol.

The TSIP is installed by factory default.

NMEA-0813

To convert to the NMEA protocol, please refer to and use the AcuGold_Mon program for serial port protocol, Input/Output, message type output, and baud rate configuration.

Acutime Gold starter kit

Acutime Gold GPS smart antenna, see page 22.

Universal Interface Module (RS-422 to USB converter), see page 18.

Power converter (24 VDC AC/DC), see page 18

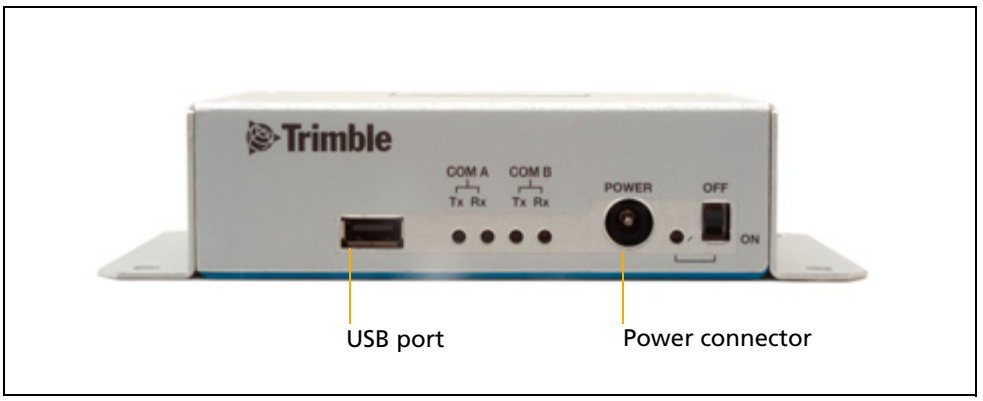
Power pin adapters

100 feet of interface cable with DB-25 connector

USB cable

Universal Interface Module (UIM)

The UIM that is included with the starter kit makes it easy to evaluate and develop software when it is connected to the GPS smart antenna. It has a Type 2 USB interface to the Acutime Gold that is compatible with most computers.



- Network power (5 to 36 VDC) is supplied through the power connector on the front of the module.
- The USB connector and interface cable allows for easy connection to a PC USB port.

Note – *The Acutime Gold is a dual port receiver. The Acutime Gold requires power separate from the USB.*

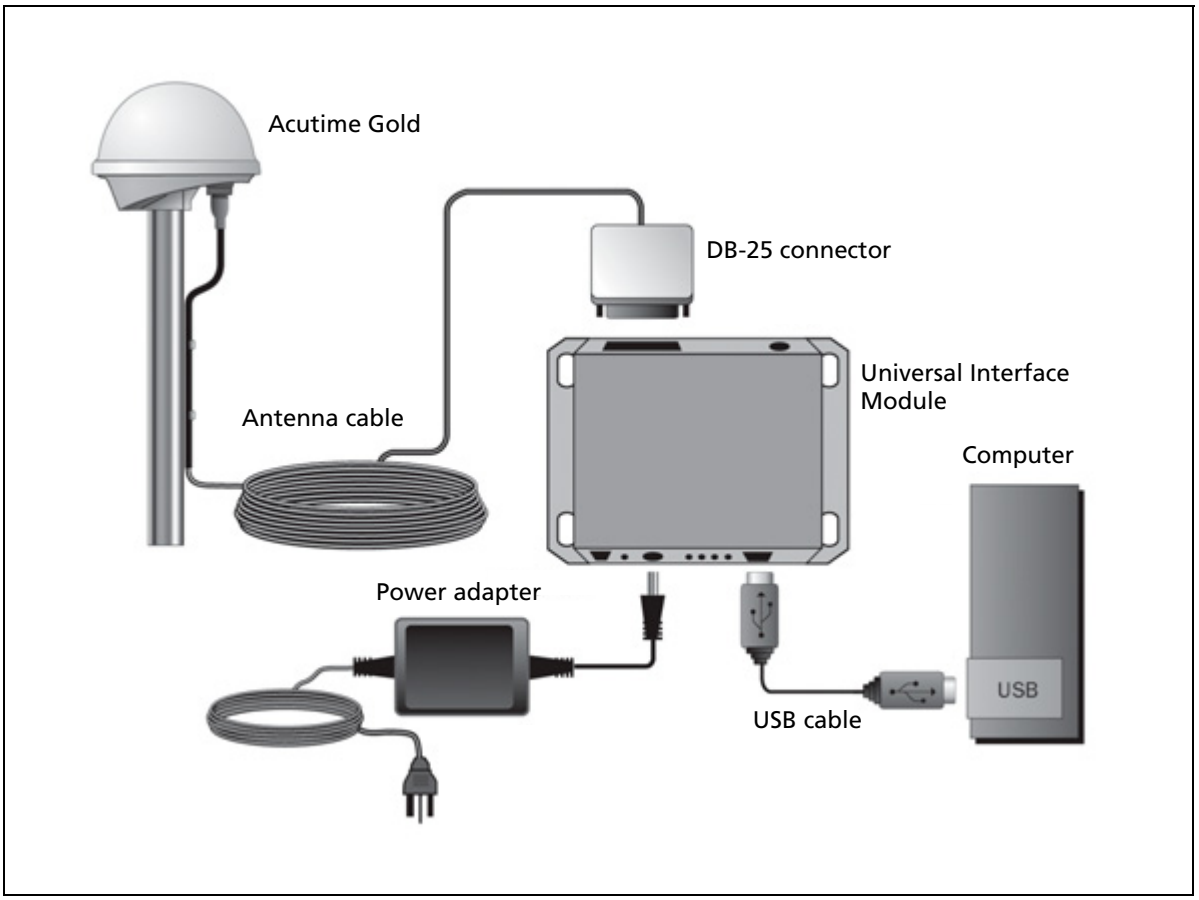
- The motherboard has a switching power supply, which converts the prime voltage input to 24 V that is required to power the receiver over most available cable lengths.
- Connect the output device to the 1 PPS connector on the rear of the unit.

Power converter (AC/DC)

The AC/DC power converter provides an alternative power source for the interface unit and enables you to run the module from network power.

It converts 110 or 220 VAC to a regulated +24 VDC that is compatible with the UIM. The AC/DC power converter output cable is terminated with a standard DC power connector that is compatible with the power connector on the metal enclosure.

Setting up the starter kit



1. Mount the Acutime Gold GPS antenna on a 1" OD marine pipe or 3/4" ID pipe, with 14 threads per inch.
2. Connect the antenna cable to the Acutime Gold GPS smart antenna. Allow for the cable to maintain a "drip-loop" to prevent water intrusion and to allow for flex on the antenna to cable connector.
3. Place the Acutime Gold so that it has the fullest possible view of the sky to ensure that the maximum number of satellites are available.
4. Use the DB-25 connector to connect the antenna cable to the rear of the UIM.

CAUTION – Be careful not to damage the cable. Take care to avoid sharp bends or kinks in the cable, hot surfaces (for example, exhaust manifolds or stacks), rotating or reciprocating equipment, sharp or abrasive surfaces, door and window jambs, routing near high EMI / EMF (Electro-Magnetic Induction / Field) transformers or equipment, and corrosive fluids or gases.

5. When using the TSIP protocol, connect one end of the USB interface cable to the USB port of the interface unit. Connect the other end of the cable to USB port on a computer.

Note – *The receiver supports the TSIP or NMEA protocols. Dual ports support either the input/output of TSIP messages or the output of NMEA messages.*

6. To connect the power connector to the UIM, do one of the following:

   – Use the DC power cable. Connect the terminated end of the power cable to the power connector on the UIM. Connect the red lead to DC positive voltage (+12 to +24 VDC) and the black power lead to DC ground. The yellow wire is not used.

   – Use the AC/DC power converter. Connect the output cable of the converter to the power connector on the UIM. Use the appropriate 3-pin power adapters to connect the converter to mains power (110 or 220 VAC).

7. Switch on the DC power source or turn on the mains power.

To integrate the GPS smart antenna, into your system, see Chapter 3, Hardware integration.

Starter kit components

The Acutime Gold GPS receiver is available as part of the starter kit, or as an individual item. The starter kit includes all the components necessary to quickly test and integrate the receiver.

Product	Part Number
Acutime Gold GPS timing receiver	55238-00
100 ft. Acutime Gold cable	60155 (included with the Starter Kit)
200 ft Acutime Gold cable	60156 (sold separately)
Acutime Gold Universal Interface Module	Available as part of the Starter Kit only.
AC/DC power supply module	Available as part of the Starter Kit only.
Interface cable (USB/USB)	Available as part of the Starter Kit only.

Note – *Part numbers are subject to change. Confirm part numbers with your Trimble representative when placing your order.*

CHAPTER

3

Hardware integration

In this chapter:

- Acutime Gold GPS smart antenna
- Interface cables
- Power requirements

The setup procedures for the Acutime Gold GPS smart antenna are described in Chapter 2, Setting up and Running the Acutime Gold.

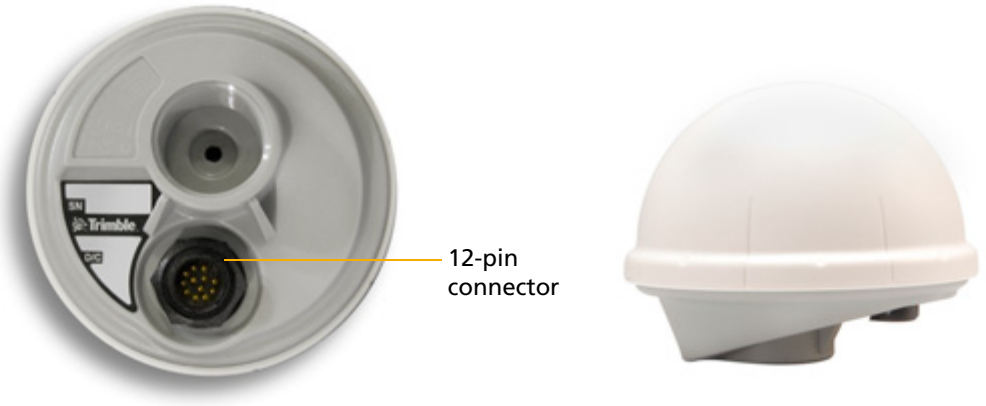
This chapter describes the hardware components, to assist you when you integrate the Acutime Gold into a system.

To integrate the Acutime Gold GPS smart antenna into your system you must:

- Connect to a standard serial interface port on the host system
- Design a circuit to read the electrical 1 PPS
- Develop a software interface

The setup procedures for the Acutime Gold GPS smart antenna starter kit are described on page 19.

Acutime Gold GPS smart antenna



Performance specifications

General	L1 frequency, CA/code (SPS), continuous tracking receiver, static Over-determined Clock Mode
Update rate	1 Hz
Event update rate	5 Hz / second (maximum)
Accuracy horizontal position	<6 meters (50%) <9 meters (90%)
Accuracy altitude position	<11 meters (50%) <18 meters (90%)
Velocity	0.06 m/sec
Time to first fix	No stored position: <46 s (50%), <50 s (90%) Stationary with stored position (for example, recovery after a power outage): <14 s (50%), <18 s (90%)
Reaquisition after 60 second signal loss	<2 s (90%)
Dynamics	Velocity: 500 m/s maximum Accelaration: 4 g (39.2 m/sec^2) Jerk: 20 m/s^3
PPS output	Physical interface: RS-422 Width: 10 microseconds (default); user programmable from 10 microseconds to 500 milliseconds On-time edge: Rising edge on time (default); user programmable rising or falling Resolution: 80 nanoseconds (quantization error reported throught TSIP) Accuracy: UTC 15 nanoseconds (static), UTC 90 nanoseconds (dynamic, TDOP ≤ 3)

External event capture	Interface: RS-422 Resolution: 488 nanoseconds
Minimum pulse width	10 microseconds, rising edge-on-edge
Reporting mechanism	TSIP packet

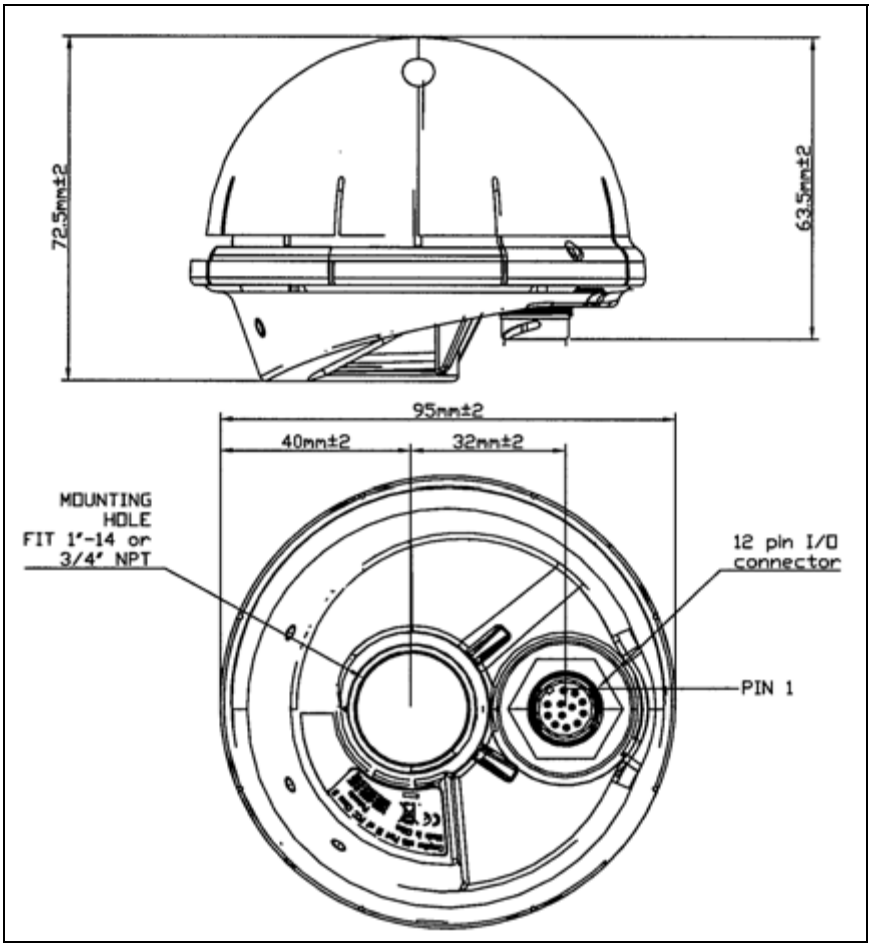
Environmental specifications

Operating temperature	-40 °C to +85 °C (-40 °F to 185 °F)
Storage temperature	-55 °C to +105 °C (-67 °F to 221 °F)
Vibration	0.008 g^2/Hz 5 Hz to 20 Hz 0.05 g^2/Hz 20 Hz to 100 Hz -3 dB/octave 100 Hz to 900 Hz
Operating humidity	95% RH, non-condensing at 60 °C (140 °F)
EMC	CE, FCC Class B
Ingress protection	IP x 7

Physical characteristics

Power consumption	50 mA @ 12 Volts 0.6 W (typical), < 1 W maximum
Dimensions	95 mm (depth) x 72.5 mm (height) (3.74" x 2.85")
Weight	154 g (5.4 oz)
Mounting	1” - 14” straight thread or 3/4” pipe thread

The following diagram shows the module dimensions of the Acutime Gold:



Interface cables

The Acutime interface cable is twisted-pair technology, 22 American Wire Gauge (AWG), 6 pair/12 conductors, shielded, and protected with a PVC-U/V outer sheath.

Acutime Gold interface cables are available in the following standard lengths:

- 15 m (50 feet)
- 30 m (100 feet)
- 60 m (200 feet)
- 120 m (400 feet)

For custom-length cables of up to 550 m (1800 feet), contact Trimble.

All cables are terminated on the antenna end.

For a list of part numbers, see http://www.trimble.com/tmg_acutimegold_htb.shtml.

Power requirements

The Acutime Gold GPS receiver is designed for static timing applications and requires a nominal +12 to +24 VDC input (a range of +5 to +36 VDC is possible). You can apply power to the Universal Interface Monitor using one of two options: the DC power cable, or the AC/DC power converter (see page 18).

Tip – Some voltage drop will occur over the cable run. If feed voltage is limited to +5 VDC, the cable length is limited to 30 feet. When the cable is 100 feet or longer, the feed voltage must be at least +12 VDC. Trimble recommends +24 VDC for most runs.

The red wire (Acutime Gold pin 1) and the black wire (Acutime Gold pin 9) on the interface cable support power and ground connections, respectively. The Acutime Gold features a linear power supply, which supports +5 to +36 VDC. The Acutime Gold is protected against reverse polarity and brief over voltage conditions, however, extended over-voltage conditions may cause permanent damage.

Power consumption of the Acutime Gold is less than 70 mA at 12 VDC.

Serial port interfaces

The pin-out descriptions and color codes for the standard unterminated cables and DB-25 interface cable are as follows:

Acutime Gold connector	Wire color	Function	DB-25 interface	Protocol
Pin 1	Red	DC Power	Pin 1	+5 to +36 VDC
Pin 2	Violet	Port B: Receive -	Pin 25	TSIP RS-422
Pin 3	Orange	Port B: Receive +	Pin 13	TSIP RS-422
Pin 4	Brown	Port B: Transmit -	Pin 11	TSIP RS-422
Pin 5	Yellow	Port B: Transmit +	Pin 23	TSIP RS-422
Pin 6	White	Port A: Receive -	Pin 24	Event Input
Pin 7	Gray	Port A: Receive +	Pin 12	Event Input
Pin 8	Green	Port A: Transmit -	Pin 10	NMEA / TSIP RS-422
Pin 9	Black	DC Ground	Pin 7	Ground
Pin 10	Blue	Port A: Transmit +	Pin 22	NMEA / TSIP RS-422
Pin 11	Orange w/ white stripe	1 PPS Transmit +	Pin 21	RS-422
Pin 12	Black w/ white stripe	1PPS Transmit -	Pin 9	RS-422

Pulse-Per-Second (PPS)

The Acutime Gold provides a 1.0 microsecond wide, RS-422, Pulse-Per-Second (PPS) on antenna connector pins 11 and 12. The pulse is sent once per second and the leading edge of the pulse is synchronized to either UTC or GPS time.

The pulse shape is affected by the distributed capacitance of the attached cabling and input circuit. The pulse's trailing edge should not be used for timing applications. An accurate timing pulse is available only when the Acutime Gold is operating in the static Over-determined Clock Mode with a timing accuracy of <15 nanoseconds (one sigma) to UTC or GPS time .

The PPS output can be programmed to provide an even-second output using TSIP packet 0x8F-4E.

Timing pulse connections

The Acutime Gold outputs a timing pulse for timing and synchronization applications. The timing pulse is generated using an RS-422 line driver circuit (connector 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 upon the distributed capacitance of the interface cable.

Serial ports

The Acutime Gold has two RS-422 communication ports. The functions of these ports (B and A) are described below.

Port B

Port B is the primary serial port for the Acutime Gold. Using this port, you can:

- Send commands and receive command responses.
- Query for and receive satellite data (for example, ephemeris, tracking information, and signal levels).
- Receive timing packets that are synchronized with the PPS output.
- Enable TSIP timing packets 0x8F-AB and 0x8F-AC (which output automatically after the self-survey has been completed) or 0x8F-AD using command packet 0x8E-A5. When enabled, these packets are sent within 30 milliseconds after the PPS pulse.
- Configure Port B to transmit NMEA packets. When enabled these packets are ***not*** guaranteed to be sent within 30 milliseconds after the PPS output.

The Acutime Gold automatically sends a range of satellite data packets on Port B. You may not need these data packets—to disable them, use command packet 0x8E-A5. This ensures that only the timing packets are sent. You can also choose to receive the timing packets on Port A , and use Port B to only send commands and receive satellite data.

Port A

Port A serves as a dedicated transmit port for timing packets and is also used by default to receive external event inputs.

The user can select NMEA output on port A, with TSIP in / TSIP out on port B.

Serial port connections

Trimble recommends that you:

- Use port B to:
  - Configure the Acutime Gold as necessary
  - Query for specific satellite data as needed
  - Disable the automatic output packets, using command packet 0x8E-A5.
  - Transmit the desired timing packet
- Use Port A to:
  - Receive line to time-tag external events or input data
  - Output NMEA message
- If you have two serial ports, use
  - ***Port B*** to configure the Acutime Gold and query for specific satellite data as needed.
  - ***Port A*** to transmit the desired timing packet and use it as a receive line to time-tag external events or input data.

Event input

The Acutime Gold accepts an external event input in the shape of an RS-422 pulse. The external event pulse input is supported on Port A (pins 6 and 7). The Acutime Gold transmits a TSIP time packet (0x8F-0B or 0x8F-AD) 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 488 nanoseconds of its arrival at the Acutime Gold interface connector.

CHAPTER

4

System Operation

In this chapter:

- Start-up
- Timing receiver performance
- Communicating with the receiver
- Automatic operation
- PPS quantization error
- Serial data communication
- GPS timing
- Using Acutime Gold in mobile applications
- Cutomizing operations

The Acutime Gold receives the amplified GPS satellite signals through the antenna feed line connector and passes them to the RF down-converter. A highly stable crystal reference oscillator is used by the down-converter to produce the signals used by the digital signal processor (DSP). The DSP tracks the GPS satellite signals and extracts the carrier code information as well as the navigation data at 50 bits per second.

Operation of the tracking channels is controlled by the navigation processor. The software tracking channels track the highest twelve satellites above the horizon. The navigation processor then uses the optimum satellite combination to compute a position. The navigation processor also manages the ephemeris and almanac data for all of the satellites, and performs the data I/O.

Start-up

On startup the receiver automatically runs a self-survey process and then provides an over-determined timing solution.

The first time that the Acutime Gold is turned on, it begins searching for satellites from a cold start with no almanac, time, ephemeris, or stored position. The receiver starts computing position and time solutions within the first 46 seconds, but the receiver must continuously track satellites for approximately 15 minutes to download a complete almanac and ephemeris. ***Do not interrupt the initialization process.***

During the satellite acquisition phase, the Acutime Gold outputs periodic TSIP messages on Port B. These status messages confirms that the receiver is working.

Note – *the Acutime Gold 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.*

Timing receiver performance

The receiver and patch antenna contained in the Acutime Gold are in a single board format. The board has been adapted for timing applications where reliability, performance, and ease of integretation are required.

The receiver features Trimble's improved signal processing code, a high-gain RF section, and RS-422 line drivers to deliver a differentially driven 1 PPS output for timing and synchronization applications.

Timing applications are assumed to be static. The specialized timing software used within the Acutime Gold configures the unit into an automatic self-survey mode at start up. The receiver will average position fixes for a specified time (one per second) and at the end of this period, this reference location is used to solve for time. The receiver goes into an Over-determined Clock Mode and no longer solves for position but only for clock error and clock bias using all of the available satellites. This procedure will provide an accuracy of less than 15 ns (one sigma) to GPS or UTC time for the 1 PPS output.

To change the default port parameters and NMEA settings, issue the appropriate TSIP command and then store the settings in the receiver's non-volatile (flash) memory. The settings are retained when mains power is removed, without the need for battery back up. The factory default setting for Port B, the primary I/O port, is bi-directional TSIP at 9600 baud, 8 data bits, odd parity, and 1 stop bit.

Note – *When customizing port assignments or characteristics, confirm that your changes do not affect your ability to communicate with the receiver.*

Communicating with the receiver

Communication with the receiver is through an RS-422 compatible serial port. The port characteristics can be modified to accommodate your application requirements. Port parameters are stored in flash memory, which does not require back-up power. The default port characteristics are:

Parameter	Factory default
Input baud rate	9600
Output baud rate	9600
Parity	Odd
Data bits	8
Stop bits	1
Input protocol	TSIP input
Output protocol	TSIP output

Note – *The Acutime Gold also supports the NMEA message protocol.*

Port B configuration

The factory default protocol on Port B is TSIP in and out at 9600-odd-8-1.

The serial port can be changed and stored in flash memory. The receiver protocol can be re-configured using TSIP command packet 0xBC, Timing Receiver, AcuGold_Mon, or a user-written serial interface program.

C-source code examples for TSIP commands are also provided in Appendix A Trimble Standard Interface Protocol. When used as software design templates, this source code can significantly speed up code development.

The protocol settings and options are stored in Random Access Memory (RAM). They can be saved into the flash memory using command packet 0x8E-26.

Port A configuration

Port A is a dedicated port for outputting comprehensive timing packets. Messages are output after the PPS and after external events. The factory default setting is TSIP, output only, at 9600-8-odd-1.

The host system receives both the PPS and the time packet identifying each pulse. Use packet 0x8E-A5 to determine which Timing Superpacket to output on this port.

Note – *The Acutime Gold generates a packet in response to the external event input. The event count field in packet 0x8F-0B (or 0x8F-AD) increments for each event received. This field resets after a power cycle and rolls over at 65535. The event age messages are interleaved with the PPS messages. The PPS tags are distinguished by a zero (0) in the event count field. The Acutime Gold accepts external events up to a 5 Hz rate. Use packet 0x8E-A5 to configure this port to output the 0x8F-0B (or 0x8F-AD) packet in response to external events.*

Automatic operation

When the Acutime Gold has acquired and locked onto a set of satellites that meet the mask criteria listed below, and has obtained a valid ephemeris for each satellite, it performs a self-survey. After a number of fixes (user-determinable; the default is 2000) lasting about 34 minutes, the self-survey is complete. At that time, the Acutime Gold automatically switches to a time-only mode and periodic outputs of navigation data cease.

Satellite masks

The Acutime Gold continuously tracks and uses up to twelve satellites in an Over-Determined clock solution. The satellites must pass the mask criteria to be included in the solution.

The following table lists the default satellite masks used by the Acutime Gold:

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

These masks serve as the screening criteria for satellites, are used in fix computations, and ensure that the solutions meet a minimum level of accuracy. The satellite masks can be adjusted by using the TSIP protocol. See Appendix A Trimble Standard Interface Protocol.

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 further through the ionospheric and tropospheric layers and undergo distortion due to these atmospheric conditions.

SNR mask

Although the Acutime Gold can track signals with an SNR 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. Set the SNR mask to 4 or higher to minimize the impact of multi-reflected signals.

PDOP mask

Position Dilution of Precision (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 lower position accuracy. For most applications, a PDOP mask of 8 offers a satisfactory trade-off between accuracy and GPS coverage.

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

Tracking modes

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

- Self-survey mode, page 33 (position fix mode)
- Over-determined Clock Mode, page 34

After establishing a reference position in self-survey mode, the Acutime Gold automatically switches to Over-determined Clock Mode.

Self-survey mode

On startup, the Acutime Gold performs a self-survey by averaging 2000 position fixes (default). The number of position fixes until the survey is complete can be configured using the 8E-4B or 8E-A9 command. If fewer than four conforming satellites are visible, the Acutime Gold suspends data output.

The fix modes are:

- 3-D manual. This is the default mode during the self-survey. Also select this mode if you require a high-accuracy fix mode, where altitude is always calculated along with the latitude, longitude, and time. A position fix requires four satellites with a PDOP below the PDOP mask and PDOP switch. 3-D mode can be restrictive when the receiver is obscured or when the geometry is poor due to an incomplete constellation.
- 2-D manual. Select this mode if a 2-D solution is required, or if the exact altitude is known. 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.

To set the required position fix mode, use packet 0xBB.

Note – *Altitude and the fix mode are stored in flash memory.*

Over-determined Clock Mode

Over-determined Clock Mode is used only in stationary timing applications and is the default mode. When the Acutime Gold self-surveys its static reference position, it automatically switches to Over-determined 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 Gold does not navigate or update positions and velocities, but maintains the PPS output, solving only for clock error (bias) and error rate (bias rate).

PPS output options

The PPS (Pulse Per Second) output is the primary timing output generated by the Acutime Gold and is provided through an RS-422 differential driver. Although an RS-422 differential receiver provides the best noise immunity, you can use only one side of the differential signal for single-ended applications.

To program the characteristics of the PPS, use the following TSIP packets:

- To set an accuracy criterion for the generation of the PPS signal, based on the number of usable satellites, use packet 0x8E-4E.

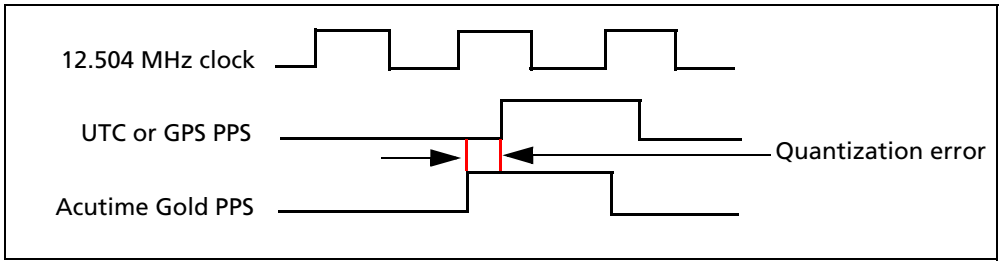
  The accuracy of the PPS output depends to some degree on the number of satellites used in the solution that determine the placement of the PPS output. In some systems it is preferable to have the PPS generated only when it meets the highest levels of accuracy and to leave it off if these accuracy levels are not met.

- To set the width of the PPS from 10 µs to 500 ms, use packet 0x8E-4F.

PPS quantization error

The Acutime Gold 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 Gold 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. Since both clock edges are used, the quantization error on the PPS output is between ±20ns.

The quantization error is illustrated below:



- The top waveform represents the 12.504 MHz clock—the Acutime Gold output must be placed on one of the edges of this clock.
- The middle waveform represents the UTC/GPS on-time mark as determined by the receiver's electronics.
- The bottom waveform represents the Acutime Gold PPS output which is output on the clock edge closest to the actual UTC/GPS on-time mark

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.

Serial data communication

The Acutime Gold outputs TSIP Superpackets (see page 41) or NMEA messages.

On start-up, the Acutime Gold outputs TSIP packets 0x8F-AB, 0x8F-AC, and PPS. To enable or disable timing packets and automatic output packets, use packet 0x8E-A5.

The factory default port setting is 9600-odd-8-1 (in/out). To change the serial port setting and store it in flash memory, use the appropriate TSIP command. The port can also be configured to transmit timing packets, using packet 0x8E-A5.

For more information on the ports, see Serial ports, page 26.

GPS timing

For many timing applications, such as time/frequency standards, site synchronization systems, and wireless voice and data networks, the Acutime Gold can be 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 less stability than expensive, high-quality oscillators, such as Oven Controlled Crystal Oscillators (OCXO).

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 the GPS satellites to correct its internal clock, which is not as stable or accurate as the GPS atomic clocks. The Acutime Gold outputs a highly accurate timing pulse (PPS) generated by its internal clock, which is constantly corrected using the GPS clocks. This timing pulse is synchronized to GPS/UTC time within 15 ns (one sigma) after the survey is complete.

In addition to serving as highly-accurate stand-alone time sources, GPS timing 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.

An accurate reference position is critical. A position error of 100 meters corresponds to a time error of approximately 333 ns.

The GPS receiver's clocking rate and software affect PPS accuracy. The Acutime Gold has a clocking rate of 12.504 MHz, which enables a steering resolution of 40 ns (±20 ns). Using both the rising edge and falling edge of the pulse enables a steering resolution of ±20 ns. Using software algorithms such as an Over-determined Clock solution, the Acutime Gold mitigates the effects of clock error to achieve a PPS accuracy within 15 ns (one sigma) to GPS/UTC after survey is complete.

Timing operation

The Acutime Gold automatically outputs a PPS and time tag. With an accurate reference position, the receiver automatically switches to an Over-determined Clock Mode, activates its T-RAIM algorithm and then outputs a precise PPS. Using a simple voting scheme based on pseudo-range residuals, the Acutime Gold 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 Gold's default configuration provides optimal timing accuracy. The only item under user or host control that can affect the receiver's absolute PPS accuracy is the delay introduced by the antenna cable. For long cable runs, this delay can be significant, up to 1.25 ns per 30 cm (1 foot) of cable. TSIP packet 0x8Ex4A sets the cable delay parameter, which is stored in flash memory. For the best absolute PPS accuracy, adjust the cable delay to match the installed cable length (check with your cable manufacturer for the delay for a specific cable type). To compensate for the cable delay, use a negative offset to advance the PPS output.

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*

2005, was increased from 13 to 14 seconds. The offset increases by one second, as needed, usually just before midnight on 30 June or 31 December. System designers should note whether the output time is UTC or GPS time.

Using Acutime Gold in mobile applications

Although the Acutime Gold is intended primarily for use in static applications, it can also be used in mobile applications. As the factory default settings for the Acutime Gold assume that the antenna is going to be used in a static timing application, you you must disable the receiver's self-survey mechanism and ensure that a stored position does not exist in the flash memory before using it in a mobile application.

To prepare the Acutime Gold receiver for mobile applications, do the following:

To ...	use command packet ...
confirm that there is no stored position in the flash memory / delete the stored position (if one exists)	0x8E-A6
disable the self-survey mechanism	0x8E-A9
Note – *If this is not done, 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	0xBB
enable the automatic output packets such as position and velocity (optional)	0x8E-A5
save the new configuration to flash storage	0x8E-26
retain the settings during power cycles and resets	0x8E-26

The Acutime Gold receiver is now ready to operate in mobile applications—the receiver can continue to output a PPS pulse as well as timing packets.

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

Cutomizing operations

The Acutime Gold has a number of configurable parameters that allow you to customize the operation of the unit. These parameters are stored in a flash memory chip and are retained during loss of power and after resets.

When the receiver is reset, or on startup, it configures itself based on the parameters stored in the flash memory. When you change a parameter, the Acutime Gold reconfigures itself immediately, but you must direct the receiver to save the new parameter values to the flash memory.

To change the parameters, use the following TSIP packets:

- To change the parameter values stored in flash memory, use command packet 0x8E-26 to save the current parameter values.

- To save a position that was not automatically saved during the self-survey or a position that was entered manually, or to delete the stored position, use command packet 0x8E-A6.
- To direct the receiver to set the parameter values to their factory default settings (and to erase the stored position), use packet 0x1E.

Configuration parameters

The following tables list the user configurable parameters. 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).

Receiver configuration

Parameter	Factory default
Operating dimension	4 (Full Position 3D)
Dynamics code	1 (Land)
Elevation mask	0.175 radians (10°)
Signal level mask	4.0 AMU
PDOP mask	8.0
PDOP switch	6.0
Foliage mode	0 (never)
Have reference altitude flag	FALSE
Reference altitude (meters)	0.0

OEM configuration

Parameter	Factory default
Datum index	WGS 84 Ellipsoid
Position	0x12
Velocity	0x02
Time	0x01
Auxiliary	0x02
Superpackets output mask (byte 1)	0x32
Superpackets output mask (byte 2)	0x21
Auto TSIP output mask	0xFFFFFFFC0

Port A and B configuration

Parameter	Factory default
Input baud rate	9600
Output baud rate	9600
Parity	Odd
Data bits	8
Stop bits	1
Input protocol	TSIP
Output protocol	TSIP

PPS configuration

Parameter	Factory default
PPS enabled switch	Enabled
PPS timebase	UTC
Polarity	TRUE
PPS offset	0.0 seconds
Bias uncertainty threshold	300.0 meters
PPS width	10.0e-6 seconds
PPS driver switch	3 (at least 1 SV)

Position information

Parameter	Factory default
XYZ coordinates	Such that LLA coordinates are all zeros
Have position flag	FALSE

Self-survey configuration

Parameter	Factory default
Survey enable flag	TRUE
Survey length	2000
Survey save flag	FALSE
Survey operating dimension	Full Position 3D

NMEA 0183 protocol and data output options

The National Marine Electronics Association (NMEA) protocol is an industry standard data protocol, which was developed for the marine industry. Trimble has chosen to adhere stringently to the NMEA 0183 data specification as published by the NMEA. The Acutime Gold GPS smart antenna also adheres to the NMEA 0183, Version 3.0 specification.

NMEA data is output in standard ASCII sentence formats. Message identifiers signify what data is contained in each sentence. Commas within the NMEA sentence separate data fields. In the Acutime Gold GPS receiver, NMEA is an output-only protocol.

The receiver is shipped from the factory with the TSIP protocol configured on Port A and B. Port A can be reconfigured for NMEA output through Port B using TSIP command packet 0xBC, in conjunction with Acu_Gold Mon, or a user-written serial-interface program.

The NMEA output messages selection and message output rate can be set using TSIP command packet 0x7A. The default setting is to output the ZDA message at a 1-second interval, when the receiver output protocol is configured to NMEA, using packet 0xBC.

To use NMEA permanently, use TSIP command 0x8E-26 to store the protocol configuration (0xBC) and NMEA message output setting (0x7A) in the flash memory.

The industry standard port characteristics for NMEA are:

- Baud rate: 4800
- Data bits: 8
- Parity: None
- Stop bits:1
- No flow control

Any standard serial communications program, such as Windows HyperTerminal or PROCOMM, can be used to view the NMEA output messages.

TSIP is a binary protocol; it outputs raw binary serial data that cannot be read when using the Windows HyperTerminal or PROCOMM applications.

CAUTION – When you use the TSIP protocol to change port assignments or settings, confirm that your changes do not affect the ability to communicate with the receiver. For example, that you have not inadvertently selected PC COM port settings that do not match the receiver settings, or changed the output protocol to TSIP if you are not using the AcuGold_Mon program.

APPENDIX

A

Trimble Standard Interface Protocol

In this appendix:

- Introduction
- Physical interface characteristics
- Packets output at startup
- Receiver warm-start
- Default background packets (Port B)
- Default automatic position and velocity reports
- Automatic primary and supplemental timing reports
- Customizing receiver operations
- Packet descriptions
- Custom OEM packets
- TSIP Superpackets
- Datums
- Sample TSIP routines

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, and 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 Gold receiver.

This appendix describes how to use the powerful TSIP features, enhance overall system performance, and reduce the total development time. The reference tables beginning on page 44 help you determine which packets apply to your application. For those applications requiring customization, see Customizing receiver operations, page 47 for a detailed description of the key setup parameters. Application guidelines are provided for each TSIP command packet.

Introduction

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.

Packet structure

TSIP packet structure is the same for both commands and reports.The packet format is **<DLE> <id> <data string bytes> <DLE> <ETX>**

Where:

- **<DLE>** is the byte 0x10
- **<ETX>** is the byte 0x03
- **<id>** is a packet identifier byte, which can have any value other than **<ETX>** or **<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”). Extra **<DLE>** bytes must be added before sending a packet, and removed (“unstuffed”) after receiving the packet. Notice that 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.

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 Gold 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 Gold. This manual allows you to configure the receiver to output information required for a

particular application. The receiver transmits some of the information (such as position and velocity solutions) automatically when it is available, while other information is transmitted only on request.

Physical interface characteristics

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

The Acutime Gold is available in an RS-422 configuration.

This section explains the capabilities of each receiver.

Nomenclature

As with previous GPS smart antennas by Trimble, including the Acutis™, Acutime, and Palisade™ products, the Acutime Gold ports are referenced as "A" and "B", and conform to standards established by the Palisade product line.

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

Protocol capabilities

The I/O ports of the Acutime Gold are highly configurable. Port settings are stored in flash memory, and are retained after power failures.

For systems with minimal bandwidth for processing serial data streams, the receivers can be configured as silent devices, which generate I/O only when polled. The Acutime Gold 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 Gold 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 Gold features a primary bi-directional port, which is factory configured for TSIP input and output.

Secondary port features – port A

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

Port designator	Input	Default	Output	Default
Port A	TSIP	TSIP	TSIP NMEA	TSIP

Event input

The Acutime Gold receiver can time-stamp external events with high-precision. Events are triggered by an input pulse, and can be reported by either or both of two Superpackets. The output of the event packets can be configured using packet 0x8E-A5.

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

Event reporting

Superpacket	Length	Description
0x8F-0B	74	Comprehensive time with LLA position
0x8F-AD	22	Primary UTC time with leap information

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

Packets output at startup

The following messages are output by the receiver at startup. After completing its self-survey, 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 0x84, the sequence is complete and the receiver is ready to accept commands.

Output ID	Description	Notes
0x46	Receiver health	
0x4B	Machine code/status	
0x45	Software version	
0x83	Double precision XYZ position	If single precision is selected, packet 0x42 is output instead.
0x84	Double precision LLA position	If single precision is selected, packet 0x4A is output instead.

Receiver warm-start

Once the Acutime Gold has completed its internal initialization and has output packet 0x84 (see Packets output at startup, page 44), you can send the following commands to restart it:

Input ID	Description
0x2B/23	Initial position (LLA/ECEF)
0x2E	Initial time
0x38 (type 2)	Almanac (for each SV)
0x38 (type 3)	Almanac health
0x38 (type 4)	Ionosphere page
0x38 (type 5)	UTC correction

Default background packets (Port B)

The Acutime Gold 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.

Output ID	Description	Notes
0x41	GPS time	Output approximately every 1.6 minutes if the receiver's GPS clock is set and the receiver is not outputting positions. Output approximately every 2.5 minutes if the receiver is doing position fixes.
0x46	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.
0x6D	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. See also* *Command Packet 0x8E-4D: Automatic Packet Output Mask, page 90*.

Default automatic position and velocity reports

The Acutime Gold automatically outputs position and velocity reports at set intervals. Report intervals are controlled by packet 0x35.

Output ID	Description
0x42	Single precision XYZ position
0x83	Double-precision XYZ position
0x4A	Single-precision LLA position
0x84	Double-precision LLA position
0x43	Velocity fix (XYZ ECEF)
0x54	Bias and Bias rate[1]
0x56	Velocity fix (ENU)

[1]When the receiver is in the Manual or Over-determined Clock Mode, it outputs packet 0x54 to provide the computed clock-only solution.

Automatic primary and supplemental timing reports

Timing Packets 0x8F-AB and 0x8F-AC are automatically output at 1 Hz when enabled by packet 0x8E-A5. These packets are part of the low-latency packet series 0x8F-AB/AC/AD/OB.

Low-latency timing packets

The Acutime Gold features a sequence of high-priority Timing Superpackets, which are output within a bounded period of time after the PPS.

The Superpackets that meet the LLTP criteria are shown below. Output of each packet can be turned on/off by using the mask in packet 0x8E-A5, but the output order cannot be changed.

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

LLTP packet ID	Description	Request packet ID
0x8F-AB	Primary Timing	0x8E-AB
0x8F-AC	Supplemental Timing	0x8E-AC
0x8F-AD	Primary UTC Time	0x8E-AD
0x8F-0B	Comprehensive Time and Position	0x8E-0B

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

Event packets

Event packets 0x8F-0B and 0x8F-AD are output in response to the event input as configured by packet 0x8E-A5

Satellite data packets

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

Input ID	Description	Output ID
0x20	Request almanac	0x40
0x27	Request signal levels	0x47
0x28	Request GPS system message	0x48
0x29	Request almanac health page	0x49
0x2F	Request UTC parameters	0x4F
0x38	Request/load satellite system data	0x58
0x39	Set/request satellite disable or ignore health	0x59
0x3A	Request last raw measurement	0x5A
0x3B	Request satellite ephemeris status	0x5B
0x3C	Request tracking status	0x5C

Customizing receiver operations

Customizing receiver output for the application

Input ID	Description	Output ID
0x23	Set Initial position (XYZ Cartesian ECEF)	
0x24	Request receiver position fix mode	0x6D
0x26	Request receiver health	0x46 and 0x4B
0x27	Request satellite signal levels	0x47
0x2A	Set Altitude for 2-D mode	0x4A
0x2B	Set Initial position (LLA)	
0x2E	Set GPS time	0x4E
0x35	Set input/output options	0x55
0x7A	Set/request NMEA interval and message mask	0x7B
0xBB	Set/request receiver configuration	0xBB
0xBC	Set/request port configuration	0xBC
0x8E-14	Set/request datum value	0x8F-14
0x8E-4A	Set/request PPS characteristics	0x8F-4A
0x8E-A5	Set/request packet broadcast mask	0x8F-A5
0x8E-A6	Issue self-survey command	0x8F-A6

Note – *Output is determined by packet* 0x*35 settings (see Command Packet 0x35: I/O Option Flags Command, page 58).*

Customizing receiver operations

Input ID	Description	Output ID
0x1E	Clear memory, reset	[1]
0x25	Soft reset and self test	[1]
0x2D	Request Oscillator offset	0x4D
0x39	Satellite disable or ignore health	0x59[2]
0xBB	Set receiver configuration parameters	0xBB
0x8E-4A	Set PPS characteristics	0x8F-4A
0x8E-4E	Set PPS output option	0x8F-4E
0x8E-4F	Set PPS Width (Acutime Gold only)	0x8F-4F
0x8E-20	Set Fixed Point Superpacket Output	0x8F-20

[1]Output is determined by packet 35 settings. For packets 0x1E and 0x25, see Packets output at startup, page 44 to determine which packets are output at power-up.

[2]Not all modes of packet 0x39 cause a reply (see the description for packet 0x39, page 63).

Command packets sent to the receiver

Command packets sent to the receiver are summarized below, including 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 51.

Input	Packet description	Output ID
0x1C-01	Software version information	0x1C-81
0x1C-03	Hardware version information	0x1C-83
0x1D	Oscillator Offset	
0x1E	Reset receiver	[1]
0x1F	Software version	0x45
0x20	Almanac	0x40
0x21	Current GPS time	0x41
0x22	Fix Mode select	[2]
0x23	Initial position (XYZ Cartesian ECEF)	
0x24	Receiver position fix mode	0x6D
0x25	Soft reset and self-test	[1]
0x26	Receiver health	0x46, 0x4B
0x27	Signal levels	0x47
0x28	GPS system message	0x48
0x29	Almanac health page	0x49
0x2A	Altitude for 2-D mode	0x4A
0x2B	Initial position (LLA)	

Input	Packet description	Output ID
0x2C	Operating parameters	0x4C
0x2D	Oscillator offset	0x4D
0x2E	Set GPS time	0x4E
0x2F	UTC parameters	0x4F
0x31	Accurate initial position (XYZ Cartesian ECEF)	
0x32	Accurate initial position (LLA)	
0x34	Satellite # for 1-SV mode	
0x35	I/O options	0x55
0x37	Status and values of last position and velocity	0x57 [3]
0x38	Load satellite system data	0x58
0x39	Satellite enable/disable and health heed/ignore	0x59 [4]
0x3A	Last raw measurement	0x5A
0x3B	Satellite ephemeris status	0x5B
0x3C	Tracking status	0x5C
0x3D	Timing port configuration	0x3D
0x3F-11	Request EEPROM segment status	0x5F-11
0x7A	Set/request NMEA interval and message mask	0x7B
0xBB	Set receiver configuration	0xBB
0xBC	Set port configuration	0xBC
0x8E-0B	0x8F-0B output configuration	0x8F-A5 / 0x8F-0B
0x8E-14	Set new datum	0x8F-14
0x8E-15	Current datum values	0x8F-15
0x8E-20	Last fix (fixed point)	0x8F-20
0x8E-26	Write receiver configuration EEPROM	0x8F-26
0x8E-41	Manufacturing parameters	0x8F-41
0x8E-42	Production parameters	0x8F-42
0x8E-45	Revert segments to default settings	0x8F-45
0x8E-4A	Set/request PPS characteristics	0x8F-4A
0x8E-4B	Survey limit	0x8F-4B
0x8E-4D	Packet Output Mask	0x8F-4D
0x8E-4E	Set PPS output option	0x8F-4E
0x8E-4F	Set PPS Width (Acutime Gold only)	0x8F-4F
0x8E-A5	Set or request packet broadcast mask	0x8F-A5
0x8E-A6	Issue self-survey command	0x8F-A6
0x8E-AB	Set/request primary timing packet	0x8F-AB
0x8E-AC	Set/request supplemental timing packet	0x8F-AC
0x8E-AD	0x8F-AD output configuration	0x8F-A5 / 0x8F-AD

[1]Output is determined by packet 0x35 settings. See Packets output at startup, page 44 to determine which messages are output at power-up.

[2]Entering 1SV mode initiates automatic output of packet 0x54.

[3]Output is determined by packet 0x35 settings.

[4]Not all packet 0x39 operations have a response. See packet 0x39 description.

Report packets sent by the GPS receiver to the receiver

Packets output by the receiver are summarized below, including 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 51.

Output ID	Packet Description	Input
0x1C-81	Software version information	0x1C-81
0x1C-83	Hardware version information	0x1C-03
0x3D	Timing port configuration	0x3D
0x40	Almanac data for one satellite	0x20
0x41	GPS time	0x21
0x42	Single-precision XYZ ECEF position	0x37
0x43	Velocity fix (XYZ ECEF)	0x37
0x45	Software version information	0x1F
0x46	Health of receiver	0x26
0x47	Signal level for all satellites	0x27
0x48	GPS system message	0x28
0x49	Almanac health for all satellites	0x29
0x4A	Single-precision LLA position	0x37
0x4B	Machine code/status	0x26
0x4C	Report operating parameters	0x2C
0x4D	Oscillator offset	0x2D
0x4E	Response to set GPS time	0x2E
0x4F	UTC parameters	0x2F
0x54	One-satellite bias and bias rate	0x22
0x55	I/O options	0x35
0x56	Velocity fix (ENU)	0x37
0x57	Information about last computed fix	0x37
0x58	GPS system data/acknowledge	0x38
0x59	Satellite enable/disable and health heed/ignore	0x39
0x5A	Raw measurement data	0x3A
0x5B	Satellite ephemeris status	0x3B
0x5C	Satellite tracking status	0x3C
0x5F-11	Request EEPROM segment status	0x3F-11
0x6D	All-in-view satellite selection	0x24
0x7B	NMEA interval and message mask	0x7A
0x83	Double-precision XYZ position	0x37
0x84	Double-precision LLA position	0x37
0xBB	Receiver configuration	0xBB
0xBC	Port configuration	0xBC
0x8F-0B	Comprehensive time	Auto/Event
0x8F-14	Current datum values	0x8E-14

Output ID	Packet Description	Input
0x8F-20	Last fix with extra information (fixed point)	0x8E-20
0x8F-26	Response to save EEPROM segments	0x8E-26
0x8F-41	Manufacturing parameters	0x8E-41
0x8F-42	Production parameters	0x8E-42
0x8F-45	Response to revert segments to default	0x8E-45
0x8F-4A	PPS characteristics	0x8E-4A
0x8F-4B	Survey limit	0x8E-4B
0x8F-4D	Automatic packet output mask	0x8E-4D
0x8F-4E	PPS output option	0x8E-4E
0x8F-4F	Set PPS width	0x8E-4F
0x8F-A5	Packet broadcast mask	0x8E-A5
0x8F-A6	Response to self-survey command	0x8E-A6
0x8F-AB	Primary timing packet	0x8E-AB
0x8F-AC	Supplemental timing packet	0x8E-AC
0x8F-AD	UTC event time	Event/Auto

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.

Command Packet 0x1C-01 / Report Packet 0x1C-81: Software Version Information

The command packet 0x1C may be used to obtain software version information. The packet format is defined as follows:

Command Packet 0x1C-01

Byte	Item	Type	Value	Response
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x01	Sub-code 0x01 for software component version information request

Report Packet 0x1C-81

Byte	Item	Type	Value	Response
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x81	Sub-code 0x81 for software component version information request
2	Reserved	U8	Any	Reserved
3	Major Version	U8	Any	Firmware major version
4	Minor version	U8	Any	Firmware minor version
5	Build number	U8	Any	Firmware build number
6	Month	U8	1-12	Firmware build month
7	Day	U8	1-31	Fimrware build day
8 . . 9	Year	U16	Any	Firmware build year
10	Length of first module name	U8	Any	The length of the product name (L_1)
11 . . . (10 +L_1)	Product name	U8	String	Product name in ASCII

Command Packet 0x1C-03 / Report Packet 0x1C-83: Hardware Version Information

The command packet 0x1C may be used to obtain hardware version information. The report packet is of variable length, depending on the length of the hardware ID. The packet format is defined as follows:

Command Packet 0x1C-03

Byte	Item	Type	Value	Response
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x03	Sub-code 0x03 for hardware component version information request

Report Packet 0x1C-83.

Byte	Item	Type	Value	Response
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x83	Sub-code 0x83 for hardware component version information report
2-5	Serial number	U32	Any	Board serial number
6	Build day	U8	1-31	Day board was built
7	Build month	U8	1-12	Month board was built
8, 9	Build year	U16	Any	Year board was built
10	Build hour	U8	0-23	Hour board was built
11, 12	Hardware Code	U16	Any	Hardware Code associated with Hardware ID
13	Length of Hardware ID	U8	Any	The length of the Hardware ID (L)
14 (13+L)	Hardware ID	U8	String	Hardware ID string in ASCII (Acutime Gold GPS Timing Receiver)

Command Packet 0x1E: 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 flash 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'.

Byte	Item	Type	Value	Response
0	Rest	BYTE	'K' (0x4B)	Cold reset
			'F' (0x46)	Factory reset
			'C' (0x43)	Compatibility re-start for the Palisade firmware version 7.02
			'N' (0x4E)	Clear navigation data in EEPROM and cold reset
			'R' (0x52)	Set configuration parameters in EEPROM to factory defaults and cold reset

CAUTION – The factory reset commands 0x1E-'F' and 0x1E-'R' delete the stored position and restart the self-survey. All almanac, ephemeris, current position, mode, and communication port setup information stored in RAM is lost by executing these commands.

Command Packet 0x1F: 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 0x45.

Command Packet 0x20: 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 0x40 hex.

Command Packet 0x21: Current Time Request

This packet requests current GPS time. This packet contains no data. The GPS receiver returns packet 0x41 hex.

Command Packet 0x23: 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 you have moved more than about 1000 meters since the previous fix.

Note – *The GPS receiver can initialize 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.

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

Command Packet 0x24: 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 0x6D.

Command Packet 0x25: Initiate Soft Reset / Self Test Command

This packet commands the GPS receiver to perform a soft reset. The GPS receiver performs a self-survey as part of the reset operation. This packet contains no data. Following the reset is completed, the receiver outputs the startup messages (see Packets output at startup, page 44). The receiver retains the time, survey position, port configuration, and almanac contents during this operation.

Note – *The GPS receiver sends packet* 0x*45 only on power-up and reset (or on request). If packet* 0x*45 appears unrequested, either the GPS receiver power was cycled or the GPS receiver was reset.*

Command Packet 0x26: Health Request

This packet requests health and status information from the GPS receiver. This packet contains no data. The GPS receiver returns packets 0x46 and 0x4B.

Command Packet 0x27: Signal Levels Request

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. The GPS receiver returns packet 0x47.

Command Packet 0x28: 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 0x48.

Command Packet 0x29: Almanac Health Page Request

This packet requests the health page from the almanac. This packet contains no data. The GPS receiver returns packet 0x49.

Command Packet 0x2A: 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 0x35). The GPS receiver returns packet 0x4A. Trimble recommends that you upload the reference altitude before the receiver starts doing position fixes.

If an altitude is not provided, the receiver uses the altitude of the previous 3-D fix (altitude-hold mode). Sending packet 0x2A with one data byte equal to 0xFF cancels altitude-set mode and returns the reference altitude to 0. The altitude setting is stored in flash memory. You can use packet 0x8E-26 to write receiver configurations to EEPROM.

To use the fixed altitude survey mode, the receiver must be configured to Manual 2-D navigation mode using packet 0xBB. The reference altitude is used in 2-D surveys from both warm and cold starts.

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

Command Packet 0x2B: 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 you have 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 as follows:

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

Command Packet 0x2D: 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 0x4D hex. This packet is used mainly for service.

Command Packet 0x2E: 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 0x4E. The data format is shown below. The GPS week number reference is Week # 0, starting 22 August 1999. The seconds count begins at the midnight that begins each Sunday morning.

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 by tracking a GPS satellite.

Command Packet 0x2F: UTC Parameters Request

This packet requests the current UTC-GPS time offset (leap seconds). The packet has no data. The receiver returns packet 0x4F.

Command Packet 0x31: Accurate Initial Position (XYZ Cartesian ECEF) Command

This packet is identical in content to packet 0x23; it 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. T-RAIM flags come on if this position is not accurate enough.

Entering an 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 0x8E-26. The input position is reported by packet 0x8F-AC.

Command Packet 0x32: Accurate Initial Position (Latitude, Longitude, Altitude) Command

This packet is identical in content to packet 0x2B; it 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 to aid satellite acquisition in systems where another source of position is available and in time transfer (one-satellite mode) applications. For aiding acquisition, 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. T-RAIM flags come on if this position is not accurate enough.

Entering an 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 0x8E-26. The input position is reported by packet 0x8F-AC.

Command Packet 0x34: Satellite Number For One-Satellite Mode Command

This packet enables you to choose the satellite to use 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 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 returns the receiver to automatic 1-SV mode.

Command Packet 0x35: I/O Option Flags Command

Packet 0x35 controls the format and timing of the position and velocity output; it enables you to request and set the I/O option states.

- To request the option states without changing them, send the packet with no data bytes included.
- To change any option states, include 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 in Table A.1 Command Packet 0x35. These option states are held in flash memory. The GPS receiver returns packet 0x55. Use packet 0x8E-26 to save settings to EEPROM.

The following 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.1 Command Packet 0x35

Byte	Parameter	Bit	Value	Option	Associated packets
0	Position	0 (LSB)	0	XYZ ECEF Output 0: Off, 1: On	0x42 or 0x83
		1	1	LLA Output 0: Off, 1: On	0x4A or 0x84
		2	0	LLA ALT Output 0: HAE (current datum) 1: MSL geoid	0x4A or 0x84
		3	0	ALT input 0: HAE (current datum) 1: MSL geoid	0x2A
		4	1	Precision-of-position output 0: Single-precision packet 42 and/or 4A. 1: Double-precision packet 0x83 and/or 0x84	
		5	0	8F-20 Output 0: Off 1: On	
		6-7	0	Unused	
1	Velocity	0	0	XYZ ECEF Output 0: Off, 1: On	0x43
		1	1	ENU output 0: Off, 1: On	0x56
		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	0x37
		3	0	Synchronized measurements 0: Off 1: On	N/A
		4	0	Minimize Projection 0: Off, 1: On	N/A
		5-7	0	Unused	

Table A.1 Command Packet 0x35 (Continued)

Byte	Parameter	Bit	Value	Option	Associated packets
3	Auxiliary	0	0	Raw measurements 0: Off, 1: On	0x5A
		1	1	Doppler smoothed codephase 0: Raw, 1: Smoothed	0x5A
		2		Unused	
		3	0	0: Output AMU 1: Output dB/Hz	0x5A, 0x5C, 0x47
		4-7	Unused		

- Bytes 0 and 1 control the message output format.
- Byte 2 contains the following time parameters:
  - *Time Type* 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* 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* defines whether fixes are automatically output when computed or sent only in response to a packet 0x37 request. The default is automatic output.
  - *Synchronized Measurements* controls whether or not 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* 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 performing non real-time error. This is also the preferable mode for 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 (auxiliary byte) controls the output of additional fix data. It contains the following control bits:
  - Bit 0 controls the output of raw measurements (packet 0x5A).
  - Bit 1 controls whether the raw measurements output in packet 0x5A are doppler smoothed.
  - Bit 3 controls the output of the signal units.

Command Packet 0x37: Last Position and Velocity Request

This packet requests information regarding the last position fix. The GPS receiver returns packet 0x57, and the appropriate position packet 0x42 or 0x4A, or 0x83 or 0x84, and the appropriate velocity packet 0x43 or 0x56, based on the I/O options in effect. In timing mode, the GPS receiver returns packets 0x57 and 0x54.

Command Packet 0x38: Download and Upload Satellite System Data

This packet requests current satellite data (for example, almanac and ephemeris) or permits loading initialization data from an external source (for example, by extracting initialization data from an operating GPS receiver through a data logger or computer and then using that data to initialize a second GPS receiver). The GPS receiver returns packet 0x58.

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 – Correct structure of satellite data is critical to receiver operation. Requesting data is not hazardous. However, incorrectly loading data is hazardous. Use this packet only with extreme caution. Do not modify the data in any way; only retrieve and store it to be reloaded later.

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	

Command Packet 0x39: 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 0x59 for operation modes 3 and 6 only.

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 – Improperly 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.

Command Packet 0x3A: Last Raw Measurement Request

This packet requests the most recent raw measurement data for one specific satellite. The GPS receiver returns packet 0x5A, if data is available.

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

Command Packet 0x3B: Satellite Ephemeris Status Request

This packet requests the current status of satellite ephemeris data. The GPS receiver returns packet 0x5B, if data is available.

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

Command Packet 0x3C: Satellite Tracking Status Request

This packet requests the current satellite tracking status. The GPS receiver returns packet 0x5C, if data is available.

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

Command Packet 0x3D: Timing Port Configuration Command

This packet is superseded by 0xBC.

Command Packet 0x3F-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 0x8F-AC. The GPS receiver replies with report packet 0x5F-11.

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

Report Packet 0x40: Almanac Data Page Report

This packet provides almanac data for a single satellite. The GPS receiver sends this packet on request (packet 0x20 hex) and optionally, when the data is received from a satellite.

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	$(\text{meters})^{1/2}$
27-30	OMEGA_0	SINGLE	radians
31-34	omega	SINGLE	radians
35-38	M_0	SINGLE	radians

T_zc is normally positive, however, if no almanac data is available for this satellite, then T_zc is negative. T_zc 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.

Report Packet 0x41: 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 0x21 and during an update cycle, which occurs approximately every 16 seconds when not doing fixes and approximately every 150 seconds when doing fixes.

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).*

GPS week numbers run from 0 to 1023 and then cycle back to week 0. Week 0 began on 6 January 1980. Another week 0 began on 22 August 1999. The receiver automatically adds 1024 to the GPS week number after 21 August 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 relationship between the information in packet 0x41, and the packet 0x46 status code is shown below:

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 0x2E	+	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 0x46 status code is 0x00 ("Doing position fixes"). This ensures the most accurate GPS time.*

Report Packet 0x42: 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 0x8E-4D, then the GPS receiver sends this packet each time a fix is computed.

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 0x83 is also sent with a negative time-of-fix to report the current known position. Packet 0x83 provides a double-precision version of this information.

Report Packet 0x43: Velocity Fix, XYZ ECEF Report

This packet provides a 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 0x8E-4D, then the GPS receiver sends this packet each time a fix is computed.

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.

Report Packet 0x45: 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 0x1F.

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

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

Report Packet 0x46: 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 0x26, during an update cycle, when a new satellite selection is attempted, and when the receiver detects a change in its health. Packet 0x4B is always sent with this packet. The data format is shown below:

Byte	Item	Type	Value	Meaning
0	Status code	Byte	00 hex	Doing position fixes
			01 hex	Do not have GPS time yet
			03 hex	PDOP is too high
			08 hex	No usable satellites
			09 hex	Only 1 usable satellite
			0A hex	Only 2 usable satellites
			0B hex	Only 3 usable satellites
			0C hex	The chosen satellite is unusable
1	Error codes	Byte		See Report Packet 0x46: Health of Receiver Report, page 67

The error codes in Byte 1 of packet 0x46 are encoded into individual bits within the byte. The bit positions and their meanings are shown below:

Error code bit position	Meaning if bit value = 1
0 (LSB)	(Unused)
1	Signal Processor error[1]
2	Alignment error, channel or chip 1[1]
3	Alignment error, channel or chip 2[1]
4	Antenna feed line fault (open or short)
5	Excessive reference frequency error[2]
6	(Unused)
7 (MSB)	(Unused)

[1]After this error is detected, the bit remains set until the receiver is reset.

[2] This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance. (Packet 0x2D requests the oscillator offset and packet 0x4D returns the oscillator offset to the user.)

Report Packet 0x47: Signal Levels for all Satellites Report

This packet provides received signal levels for all satellites currently being tracked or on which tracking is attempted (above the elevation mask and healthy according to the almanac). The receiver sends this packet only in response to packet 0x27.

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 eight 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 the 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.

Report Packet 0x48: 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 0x28 and when this data is received from a satellite.

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

Report Packet 0x49: Almanac Health Page Report

This packet provides health information on all 32 satellites. Packet data consists of 32 bytes, each of which contains 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 0x29 and when this data is received from a satellite.

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.

Report Packet 0x4A: Reference Altitude or Single-Precision LLA Position Fix Report

The Reference Altitude variation of the packet is returned in response to command packet 0x2A when setting or requesting 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 0x8E-4D, then the receiver sends this packet each time a fix is computed.

Byte	Item	Type	Units
0-3	Latitude	SINGLE	Radians + for north, - for south
4-7	Longitude	SINGLE	Radian + 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 0x8E-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 0x84 provides a double-precision version of this information.

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

Report Packet 0x4B: Machine/Code ID and Additional Status Report

The receiver transmits this packet in response to packets 0x25 and 0x26 and following a change in state. This packet identifies the receiver and may present error messages. Packet 0x46 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.

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

The status codes are encoded into individual bits within the bytes:

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

Report Packet 0x4C: Operating Parameters Report

This packet provides several operating parameter values of the receiver. The receiver sends this packet in response to packet 0x2C. The data string is four SINGLE values. The dynamics code indicates the expected vehicle dynamics and assists 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 flash memory.

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°)	

Byte	Item	Type, Units	Default	Value, Velocity
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	

Report Packet 0x4D: 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 0x2D.

Report Packet 0x4E: GPS Time Set Acknowledgment

Indicates whether or not the receiver accepted the time given in a Set GPS Time packet. The receiver sends this packet in response to packet 0x2E. This packet contains one byte.

Value	Meaning
ASCII "Y"	The receiver accepts the time entered through packet 0x2E. The receiver has not yet received the time from a satellite.
ASCII "N"	The receiver does not accept the time entered via packet 0x2E. The receiver has received the time from a satellite and uses that time. The receiver disregards the time in packet 0x2E.

Report Packet 0x4F: UTC Parameters Report

This packet is sent in response to command packet 0x2F 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 ΔT_{LS} seconds. The other information contained in this packet indicates when the next leap second is scheduled to occur.

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

Report Packet 0x54: 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 Over-determined Clock Mode or Time Only (1-SV) Mode.

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, and corrects the 1 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.

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.

Report Packet 0x55: I/O Option Flags Report

This packet provides current I/O options in response to packet 0x35 request. The data format is the same as for packet 35., see page 58.

Report Packet 0x56: 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 0x35), the receiver sends this packet under the following conditions:

- each time that a fix is computed if masked for output by packet 0x8E-4D
- in response to packet 0x37 (last known fix)

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.

Report Packet 0x57: 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 0x37.

Byte	Item	Type/Units	Value	Meaning
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	Over-determined Clock
2-5	Time of last fix	SINGLE/seconds, GPS time		
6-7	Week of last fix	INTEGER/weeks, GPS time		

Report Packet 0x58: Satellite System Data/Acknowledge from Receiver

This packet provides GPS data (for example, almanac or ephemeris). The receiver sends this packet under the following conditions:

- on request
- in response to packet 0x38 (acknowledges the loading of data)

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, use the following data reports:

Report Packet 0x58 – ALMANAC Data Report

Note – All angles are in radians.

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)

Report Packet 0x58 – 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	

Report Packet 0x58 – 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)

Byte	Item	Type	Meaning
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)

Report Packet 0x58 – 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)

Report Packet 0x58 – EPHEMERIS Data Report

Note – *All angles are in radians.*

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-I)
11	codeL2	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
12	L2Pdata	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
13	SVacc_raw	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
14	SV_health	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
15-16	IODC	INTEGER	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
17-20	T_GD	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
21-24	t_oc	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
25-28	a_f2	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
29-32	a_f1	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
33-36	a_f0	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
37-40	SVacc	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
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)

Byte	Item	Type	Meaning
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	= $(sqrt_A)^2$
139-146	n	DOUBLE	derived from delta_n
147-154	r1me2	DOUBLE	= $sqrt(1.0-e^2)$
155-162	OMEGA_n	DOUBLE	derived from OMEGA_0, OMEGADOT
163-170	ODOT_n	DOUBLE	derived from OMEGADOT

Report Packet 0x59: Satellite Attributes Database Report

This packet is returned in response to packet 0x39 if operation mode 3 or 6 is used with packet 0x39.

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.

Packet 0x59 indicates whether or not each satellite is allowed to be selected for use in the position solution, and whether each satellite's health is to be heeded or ignored.

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.*

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)		(Depends on byte 0 value.)
			0	Enable satellite selection or heed satellite's health. Default value.
			1	Disable satellite selection or ignore satellite's health.

Report Packet 0x5A: Raw Measurement Data Report

This packet provides raw GPS measurement data. If the I/O auxiliary option for "raw data" has been selected (packet 0x35), and it is masked for output by packet 0x8E-4D, the receiver outputs a packet 0x5A for each satellite being tracked, once per second. The receiver also sends this packet in response to packet 0x3A.

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

Note – *Report Packet 0x5A 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.

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

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 receiver and satellite.

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

1/16 × C/A code chip ≈	977.517ns/16 ≈ 61.0948 ns
≈	61.0948 × speed of light, m/s
≈	18.3158 meters

The integer millisecond portion of the pseudo-range must then be derived by utilizing the approximate receiver and satellite positions. Rough receiver 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:

C/A code epoch × speed of light =	1 ms × speed of light m/s
≈	300 km (approximate)
≈	299.792458 km (precise)

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.

Report Packet 0x5B: Satellite Ephemeris Status Report

This packet is sent in response to packet 0x3B 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.

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

The satellite PRN number is in the range 1–32. 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.

Report Packet 0x5C: 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 0x3C hex.

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 0 channel 1: used by all receivers 0 0 0 0 1 channel 2: 12-channel receivers 0 0 0 1 0 channel 3: 12-channel receivers 0 0 0 1 1 channel 4: 12-channel receivers 0 0 1 0 0 channel 5: 12-channel receivers 0 0 1 0 1 channel 6: 12-channel receivers 0 0 1 1 0 channel 7: 12-channel receivers 0 0 1 1 1 channel 8: 12-channel receivers 0 1 0 0 0 channel 9: 12-channel receivers 0 1 0 0 1 channel 10: 12-channel receivers 0 1 0 1 0 channel 11: 12-channel receivers 0 1 0 1 1 channel 12: 12-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 0x47 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
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

Report Packet 0x5F-11: EEPROM Segment Status Reports

This report packet is sent in response to command packet 0x3F-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 0 in the bit field indicates that the segment contents are valid. A 1 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.

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	BYTE	0x11	
1-2	0	Segment	Bit field		Manufacturing parameters (0x8F-41)
	1	Status	U16		Production parameters (0x8F-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)

Report Packet 0x6D: 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 0x24 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.

Byte	Item	Type	Bit	Value	Meaning
0	Mode	BYTE	0-2	0	Auto
				1	Time Only (1-SV)
				2	2D Clock Hold
				3	2D
				4	3D
				5	Over-determined Clock
			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			

Command Packet 0x7A: 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 below. While fixes are being generated, the output order is: ZDA, GGA, GLL, VTG, GSA, GSV, RMC.

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
	1-7	Reserved	Bit	0	
5	0	GGA	Bit	0 1	Off On
	1	GLL	Bit	0 1	Off On
	2	VTG	Bit	0 1	Off On
	3	GSV	Bit	0 1	Off On
	4	GSA	Bit	0 1	Off On
	5	ZDA	Bit	0 1	Off On
	6-7	Reserved	Bit	0	

Report Packet 0x7B: NMEA Message Output

This packet is sent in response to command packet 0x7A. It has the same data format as packet 0x7A.

Report Packet 0x83: Double-precision XYZ Position Fix And Bias Information

This packet provides a 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 0x35), and the packet is masked for output in packet 0x8E-4D, the receiver sends this packet each time a fix is computed.

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 0x0x35. 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 0x42 provides a single-precision version of this information.

Report Packet 0x84: 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 0x35), and the packet is masked for output in packet 0x8E-4D, the receiver sends this packet each time a fix is computed.

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 0x35. At start-up, this packet is also sent with a negative time-of-fix to report the current stored position.

Packet 0x4A provides a single-precision version of this information.

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

Command Packet 0xBB: Set Primary Receiver Configuration

TSIP command packet 0xBB contains the primary receiver configuration parameters.

The Acutime Gold stores three independent sets of configuration parameters. These are designated as the "Mobile", "Survey" and "Timing" configurations. The active configuration is determined by the survey state:

Survey state	Active configuration
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 0x8E-A6 and 0x8E-A9, update the configuration (0xBB) and then save settings (0x8E-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.

Valid settings for each configuration are as follows:

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

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) 2D clock hold Over-determined Clock	Full Position
2	Not enabled	BYTE	0 1 3	Not enabled	
3	Dynamics Code	BYTE	1 2 3 4	Land, <120 knots Sea, <50 knots Air, <800 knots Static	Land
4	Solution Mode	BYTE	1	Over-determined fix	Over-determined fix
5-8	Elevation Mask	SINGLE	0-π/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	Not enabled	BYTE		Not enabled	30 seconds
22	Foliage Mode	BYTE	0	Never	Never
23	Reserved	BYTE	N/A	N/A	
24	Reserved	BYTE	N/A	N/A	

Byte	Item	Type	Value	Meaning	Default
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	

The following terms are relevant to GPS receiver settings:

- *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* 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.

  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°) and provides a reasonable trade-off between the benefits and drawbacks.
- *Signal Level 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 signal level 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.

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.*

- *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.*

Report Packet 0xBB: Report Receiver Configuration

TSIP report packet 0xBB is used to report the receiver configuration options. For information about the data formats, see command packet 0xBB.

Command Packet 0xBC: Set Port Configuration Parameters

TSIP command packet 0xBC is used to set the communication parameters on Port A and Port B. The individual fields within the 0xBC packet are shown below.

Flow control is not supported. For details on the capabilities of each port on the Acutime Gold, see Physical interface characteristics, page 43.

Byte	Item	Type	Value	Meaning	Default
0	Port Number	BYTE	0 1 0xFF	Port B Port A current port	
1	Input Baud Rate	BYTE	6 7 8 9 10 11	4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud	9600
2	Output Baud Rate	BYTE	As above	As above	9600
3	# Data Bits	BYTE	2 3	7 bits 8 bits	8 bits
4	Parity	BYTE	0 1 2	None Odd Even	Odd
5	# Stop Bits	BYTE	0 2	1 bit 2 bits	1 bit

Byte	Item	Type	Value	Meaning	Default
6	reserved	BYTE	0	None	
7	Input Protocols	BYTE	0 2	None TSIP (Port B only)	TSIP (Port B) TSIP (Port A)
8	Output Protocols	BYTE	0 2 4	None TSIP NMEA	TSIP
9	Reserved	BYTE	0	None	

Report Packet 0xBC : Request Port Configuration Parameters

TSIP packet 0xBC is used to request the communication parameters on Port B. To query a port's configuration parameters, send packet 0xBC with only Byte 0. For details of the individual fields within the 0xBC report packet, see Command Packet 0xBC: Set Port Configuration Parameters, page 85.

Custom OEM packets

Several packets have been added to the core TSIP protocol to provide additional capability for OEM receivers. In OEM packets 0x8E and their 0x8F responses, the first data byte is a subcode that indicates the Superpacket type. For example, in packet 0x8E-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.

TSIP Superpackets

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

Command Packet 0x8E-0B: Request or Configure Superpacket Output

The 0x8E-0B packet is identical in function to the 0x8E-AD packet. If the 0x8E-0B byte sequence is sent with no data, the receiver will return a 0x8F-0B packet on Port B. The time reported by the 0x8F-0B packet on Port B is always the beginning of the current second.

Command Packet 0x8E-14: Set or Request Datum

To request the current datum, send this packet with no data. The receiver will return packet 0x8F-14.

This packet allows you 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 that 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 0x4A and 0x84, and 0x8F-AC and 0x8F-0B. The receiver responds with packet 0x8F-14.

You 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. You 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 Datums, page 107.

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 three 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.

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.

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

Command Packet 0x8E-20: Request Last Fix with Extra Information

This packet requests packet 0x8F-20 or marks it for automatic output. If only the first byte (20) is sent, an 0x8F-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.

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. See* *Command Packet 0x35: I/O Option Flags Command, page 58**. This packet must also be enabled with packet 0x8E-4D.*

Command Packet 0x8E-26: Write Receiver Configuration to EEPROM

This command packet causes the current configuration settings to be written to the EEPROM and initiates a soft reset. This packet contains only a single byte: the subpacket ID.

Command Packet 0x8E-41: Manufacturing Operating Parameters

This packet is used to request the manufacturing parameters stored in flash memory. The packet contains only a single byte—the subpacket ID. The receiver returns packet 0x8F-41.

Command Packet 0x8E-42: Production Parameters

This packet is used to request the production parameters stored in flash memory. This packet contains only a single byte—the subpacket ID. The receiver returns packet 0x8F-42.

Command Packet 0x8E-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 Gold using those settings. The receiver returns packet 0x8F-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

Command Packet 0x8E-4A: Set/Request PPS Characteristics

Thus packet is used to query and control the receiver's PPS characteristics. The receiver responds to a query or control command with packet 0x8F-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 0x8F-4A, send a two-byte 0x8E-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 1-foot cable delay offset. The default offset is 0, which corresponds to a cable. These bytes allow the application to adjust the cable delay offset for longer or shorter cable lengths. Use a cable delay of ± 1.25 ns/foot to adjust PPS offset for cable lengths other than 1 foot. For a longer cable, use a negative value to advance the PPS. The receiver estimates the bias uncertainty as part of a PPS validity monitor. If the bias uncertainty exceeds the threshold, 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 $3x10^8$ meters. Each time the application adjusts the packet 0x8E-4A settings, the new settings are stored in nonvolatile memory.

Command Packet 0x8E-4D: Automatic Packet Output Mask

This packet is used to disable automatic output of packets on Port B.

- To request the current mask, send this packet with no data bytes except the subcode byte. The receiver returns packet 0x8F-4D.
- To set the automatic packet output mask , send 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.

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 most significant byte (MSB) of byte 1, down to bit 0 as the least significant byte (LSB) of byte 4.

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

The packets affected by each bit are as follows:

Bit	Output packets	Default A2K	When output	Meaning
0 (LSB)	0x40	0	After Decode	Almanac data collected from satellite.
1	0x58, 0x5B	0	After Decode	Ephemeris data collected from satellite.
2	0x4F	0	After Decode	UTC data collected from satellite.
3	0x58	0	After Decode	Ionospheric data collected from satellite.
4	0x48	0	After Decode	GPS Message.
5	0x49	0	After Decode	Almanac health page collected from satellite.
6	Reserved	1		Reserved
7	Reserved	1		Reserved
8	0x41	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
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.

Command Packet 0x8E-4E: Set PPS Output Option

This command packet sets the PPS driver switch to one of the values show below. The receiver returns packet 0x8F-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 are relevant only in Over-determined 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. The Acutime Gold can also be configured to generate an even second pulse in place of the PPS pulse by setting the value as shown below: .

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0x4E	
1	PPS driver switch	BYTE	2	PPS is always output.
			3	PPS is output when at least one satellite is tracking.
			4	PPS is output when at least three satellites are tracking
			130	PPS is always output. PPS is generated every even second.
			131	PPS is output when at least one satellite is tracking. PPS is generated every even second.
			132	PPS is output when at least three satellites are tracking. PPS is generated every second.

Command Packet 0x8E-4F for Acutime Gold 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 0x8F-4F. The current PPS width can be requested by sending this packet with no data bytes except the subcode byte.

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

Command Packet 0x8E-A5: Set or Request Packet Broadcast Mask

Use this command packet to set the packet broadcast masks or to request the current mask settings. The receiver replies to requests with response packet 0x8F-A5. The broadcast mask is bitwise encoded to allow you to turn on and then turn 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 is as follows:

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

Byte	Bit	Item	Type	Default	
0		Subcode	U8	0xA5	
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 TSIP output ports
	7	0x8F-AC		0	0x8F-AC, Supplemental timing info on 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			Bit field		

Command Packet 0x8E-A6: Issue Self-Survey Command

This command packet starts a self-survey. The receiver responds with report packet 0x8F-A6. This command has no effect when self-survey is disabled.

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

Command Packet 0x8E-A9: Set Self-Survey Parameters

This command packet sets the self-survey parameters or requests the current settings. The receiver replies with response packet 0x8F-A9. The table shows the 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

Byte	Item	Type	Value	Description
3-6	Self-Survey Length	U32	see above	Number of fixes (factory default = 2000)
7-10	Reserved	U32	0	0

The data fields are as follows:

- *Self-Survey Enable* enables or disables the self-survey mechanism:

  0: Disable the self-survey mechanism

  1: Enable the self-survey mechanism

- *Position Save Flag* tells 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* specifies 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 you disable the self-survey, you can issue a restart self-survey command (0x8E-A6) to stop the the survey in progress.*

Command Packet 0x8E-AB: Request Primary Timing Packet

This command packet can be used to request the primary timing packet 0x8F-AB. To receive report packet 0x8F-AB once per second, use command 0x8E-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 immediately in report packet 0x8F-AB.
- Request Type 1: The response is not sent immediately. Instead, report packet 0x8F-AB is sent within 20 ms 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 report packets 0x8F-AB and 0x8F-AC are sent after the next PPS output.

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

Command Packet 0x8E-AC: Request Supplemental Timing Packet

This command packet can be used to request the supplemental timing packet 0x8F-AC. To receive report packet 0x8F-AC once per second, use command 0x8E-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 immediately in report packet 0x8F-AC.
- Request Type 1: The response is not sent immediately. Instead, report packet 0x8F-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 report packets 0x8F-AB and 0x8F-AC are sent after the next PPS output.

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

Command Packet 0x8E-AD (Request 0x8F-AD): Request or Configure Superpacket Output

If the 0x8E-AD byte sequence is sent with no data, the receiver generates an 0x8F-AD packet on port B. The time reported by the 0x8F-AD packet on port B is always the beginning of the current second.

Output of the 0x8F-AD Primary UTC timing packet on Port A is configured by sending a 3-byte message 0x8E-AD *n*, where n ranges from 0 to 3, as defined below. The receiver returns the 0x8F-A5 Superpacket Output Mask.

Byte	Item	Type	Value	Default	Meaning
0	Subcode	Byte	AD	Required	Superpacket 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

Report Packet 0x8F-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 0x8F-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 0x8E-A5 packet on Port B. If output of the 0x8F-AD packet is also enabled, the 0x8F-0B packet will always be output after the 0x8F-AD packet.

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 N/A 5 Clock hold (2D) 6 Over-determined Clock Mode (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)
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 0x8E-4A enables the PPS to be re-defined at run-time and stores the new settings in flash memory.

Note – *Leap seconds can not be predicted in advance using only the 0x8F-0B packet. A leap second can be identified by observing that the date does not increment once 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 0x8F-AD packet provides complete leap status information.*

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

Report Packet 0x8F-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 0x8E-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.

Byte	Type	Value	Units
0	Superpacket 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

Note – *For a complete list of datums, see* *Datums, page 107**.*

Report Packet 0x8F-20: Last Fix with Extra Information (binary fixed point)

This packet provides information about 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 0x8E-20; it also can replace automatic reporting of position and velocity packets. Automatic output of 0x8F-20 must also be enabled by setting bit 5 of byte 0 in command packet 0x0x35 and bit 0 of bytes 1-2 in command packet 0x8E-A5..

Byte	Item	Type	Meaning
0	Subpacket ID	BYTE	ID for this subpacket (always 0x20)
1	Key Byte	BYTE	N/A
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.

Byte	Item	Type	Meaning
24	Velocity scaling		When bit 0 is set to 1, velocities in bytes 2-7 have been scaled by 4.
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: N/A 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	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.
32-47	0: PRNX 1: IODE	BYTE BYTE	Satellite number and IODC - IODE. PRN = the lower six bits of PRNX. IODC = (PRNX/64)×256 + IODE

Report Packet 0x8F-26: Response to Save EEPROM Segments

This report packet is output after the command packet 0x8E-26 has been executed.

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

Report Packet 0x8F-41: Manufacturing Parameters

This packet provides information about the manufacturing parameters stored in flash memory in response to command packet 0x8E-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	

Report Packet 0x8F-42: Production Parameters

This packet provides information on the production parameters stored in nonvolatile memory in response to command packet 0x8E-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	

Report Packet 0x8F-45

This report packet is output after the command packet 0x8E-45 has been executed. For information about the data formats, see Command Packet 0x8E-45: Revert Segments to Default Settings, page 89

Report Packet 0x8F-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 0x8E-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

Report Packet 0x8F-4D: Automatic Packet Output Mask

This packet provides information on the automatic packets that may be output by the receiver. This packet is sent in response to 0x8E-4D query, or is set.

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 meaning and packets output by each set bit is as follows:.

Bit	Output packets	When output	Meaning
0(LSB)	0x40 Alm	After Decode	Almanac data collected from satellite
1	0x58, 0x5B	After Decode	Ephemeris data collected from satellite.
2	0x4F	After Decode	UTC data collected from satellite
3	0x58	After Decode	Ionospheric data collected from satellite
4	0x48	After Decode	GPS Message.
5	0x49	After Decode	Almanac health page collected from satellite.
6			Reserved
7			Reserved
8	0x41	New Fix	Partial and full fix complete and packet output timer has expired.
9			Reserved
10			Reserved

Bit	Output packets	When output	Meaning
11	0x6D	Constellation Change	New satellite selection
12			Reserved
13-29			Reserved
30	0x4A, 0x8F-20, 0x42, 0x43, 0x54, 0x56, 0x83, 0x84	New Fix Update	Dynamic and Timing information. Output must be enabled with I/O options.
31[1]	0x5A	New Fix	Output must be enabled with I/O options.

[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

Report Packet 0x8F-4E

This report packet is output after the command packet 0x8E-4E has been executed. See Command Packet 0x8E-4E: Set PPS Output Option, page 91.

Report Packet 0x8F-A5

This report packet is output after the command packet 0x8E-A5 has been executed and is identical in structure to packet 0x8E-A5. See Command Packet 0x8E-A5: Set or Request Packet Broadcast Mask, page 91.

Report Packet 0x8F-A6

This report packet is output after the command packet 0x8E-A6 has been executed and is identical in structure to packet 0x8E-A6. See Command Packet 0x8E-A6: Issue Self-Survey Command, page 92.

Report Packet 0x8F-A9

This report packet is output after the command packet 0x8E-A9 has been executed and is identical in structure to packet 0x8E-A9. See Command Packet 0x8E-A9: Set Self-Survey Parameters, page 92.

Report Packet 0x8F-AB

This automatic report packet provides time information once per second if enabled with command packet 0x8E-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 0x8E-AB. This packet will begin transmission within 30 ms after the PPS pulse to which it refers.

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	BYTE		0xAB
1-4		Time of week	ULONG		GPS seconds of week
5-6		Week Number	UINTEGER		GPS Week Number (see above)
7-8		UTC Offset	INTEGER		UTC Offset (seconds)
9	0	Timing Flag	Bit field	0	GPS time
				1	UTC time
	1			0	Reserved
				1	Reserved
	2			0	Time is set
				1	Time is not set
	3			0	Have UTC info
				1	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	UINTEGER		Four digits of Year (e.g. 1999)

The data fields are as follows:

- *Time of Week* 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* represents the current GPS week number. GPS week number 0 started on 6 January 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). 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 21 August 1999 (GPS) transitioned to 22 August 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 14 December 1997. With this technique, the receiver will provide an accurate translation of GPS week number and TOW to time and date until 30 July 2017.

- *UTC Offset* represents the current integer leap second offset between GPS and UTC according to the relationship: Time (UTC) = Time (GPS) - 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* are 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* 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* is sent in day-month-year format.

Report Packet 0x8F-AC

This report packet provides supplemental timing information once per second if enabled with command packet 0x8E-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 0x8E-AC. When enabled, this packet is transmitted once per second shortly after report packet 0x8F-AB.

The position sent in report packet 0x8F-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.

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0xAC	
1	Receiver mode	BYTE	1	Automatic (2D/3D)
			2	Single Satellite (Time)
			3	Horizontal (2D)
			4	Full Position (3D)
			5	N/A
			6	Clock Hold (2D)
			7	Over-determined Clock Mode

Byte	Item	Type	Value	Meaning
2	Reserved			
3	Self-survey Progress	BYTE	0-100	Percent completed
4-9	Reserved			
10-11	Minor Alarms	UNINTEGER	Bit field	1: Antenna Open 2: Antenna Shorted 3: Not tracking satellites 5: Survey-in progress 6: No stored position 7: Leap second pending 8: In test mode 10: EEPROM segments status 11: Almanac status
12	GPS Decoding Status	BYTE	0	Doing fixes
			1	Do not have GPS time
			3	PDOP is too high
			8	No usable satellites
			9	Only 1 usable satellite
			0x0A	Only 2 usable satellites
			0x0B	Only 3 usable satellites
			0x0C	The chosen satellite is unusable
			0x10	T-RAIM rejected the fix
13-15	Reserved			
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	Altigude	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			

The data fields are as follows:

- *Receiver Mode* 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* 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* 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. 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 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 a test mode.
Bit 9	When 1, indicates that the accuracy of the position being used for a time-only fix is questionable. While operating in the Over-determined 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 where 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* indicates the decoding status of the GPS receiver.
- *Local Clock Offset* 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* 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* 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* 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* carries the altitude of the position being shown. The units are in meters according to the current datum.
- *PPS Quantization Error* identifies the PPS quantization error in nanoseconds.
- *PPS Output Status* identifies the status of the PPS output.

Report Packet 0x8F-AD: Primary UTC Time

The output of the 0x8F-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 four synchronous packets. Output of this packet can be disabled and configured using the 0x8E-AD packet.

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

Tracking Status flag

This 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. The definitions are as follows:.

Flag Value	Status	Meaning
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_INITALIZATION	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

Flag Value	Status	Meaning
12	DCORR_GEN	Differential corrections
13	OVERDET_CLK	Over-determined 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 0x8F-AD packet provides extensive UTC leap second information to the user application. The definitions are as follows:

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.

- 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

Datums

The following datums are currently available:

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*/
25	-125	-108	-295	6378249.145	0.00680351128285	/*Arc 1950-Lesotho*/
26	-161	-73	-317	6378249.145	0.00680351128285	/*Arc 1950-Malawi*/
27	-134	-105	-295	6378249.145	0.00680351128285	/*Arc 1950-Swaziland*/
28	-169	-19	-278	6378249.145	0.00680351128285	/*Arc 1950-Zaire*/
29	-147	-74	-283	6378249.145	0.00680351128285	/*Arc 1950-Zambia*/
30	-142	-96	-293	6378249.145	0.00680351128285	/*Arc 1950-Zimbabwe*/
31	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Mean*/
32	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Kenya*/
33	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Tanzania*/
34	-205	107	53	6378388.000	0.00672267002233	/*Ascension Isl 1958*/
35	145	75	272	6378388.000	0.00672267002233	/*Astro Beacon E 1945*/
36	114	-116	-333	6378388.000	0.00672267002233	/*Astro B4 Sorol Atoll*/
37	-320	550	-494	6378388.000	0.00672267002233	/*Astro Dos 71/4*/

Index	DX	DY	DZ	A-axis	Eccentricity	Description
38	124	-234	-25	6378388.000	0.00672267002233	/*Astro Station 1952*/
39	-133	-48	148	6378160.000	0.00669454185459	/*Australian Geo 1966*/
40	-127	-769	472	6378388.000	0.00672267002233	/*Bellevue (IGN)*/
41	-73	213	296	6378206.400	0.00676865799761	/*Bermuda 1957*/
42	307	304	-318	6378388.000	0.00672267002233	/*Bogota Observatory*/
43	-148	136	90	6378388.000	0.00672267002233	/*Compo Inchauspe*/
44	298	-304	-375	6378388.000	0.00672267002233	/*Canton Island 1966*/
45	-136	-108	-292	6378249.145	0.00680351128285	/*Cape*/
46	-2	151	181	6378206.400	0.00676865799761	/*Cape Canaveral mean*/
47	-263	6	431	6378249.145	0.00680351128285	/*Carthage*/
48	175	-38	113	6378388.000	0.00672267002233	/*Chatham 1971*/
49	-134	229	-29	6378388.000	0.00672267002233	/*Chua Astro*/
50	-206	172	-6	6378388.000	0.00672267002233	/*Corrego Alegre*/
51	-377	681	-50	6377397.155	0.00667437223180	/*Djakarta (Batavia)*/
52	230	-199	-752	6378388.000	0.00672267002233	/*DOS 1968*/
53	211	147	111	6378388.000	0.00672267002233	/*Easter Island 1967*/
54	-87	-98	-121	6378388.000	0.00672267002233	/*Euro 1950-Mean*/
55	-104	-101	-140	6378388.000	0.00672267002233	/*Euro 1950-Cyprus*/
56	-130	-117	-151	6378388.000	0.00672267002233	/*Euro 1950-Egypt*/
57	-86	-96	-120	6378388.000	0.00672267002233	/*Euro 1950-Eng/Scot*/
58	-86	-96	-120	6378388.000	0.00672267002233	/*Euro 1950-Eng/Ire*/
59	-84	-95	-130	6378388.000	0.00672267002233	/*Euro 1950-Greece*/
60	-117	-132	-164	6378388.000	0.00672267002233	/*Euro 1950-Iran*/
61	-97	-103	-120	6378388.000	0.00672267002233	/*Euro 1950-Sardinia*/
62	-97	-88	-135	6378388.000	0.00672267002233	/*Euro 1950-Sicily*/
63	-87	-95	-120	6378388.000	0.00672267002233	/*Euro 1950-Norway*/
64	-87	-107	-120	6378388.000	0.00672267002233	/*Euro 1950-Port/Spain*/
65	-86	-98	-119	6378388.000	0.00672267002233	/*European 1979*/
66	-133	-321	50	6378388.000	0.00672267002233	/*Gandajika Base*/
67	84	-22	209	6378388.000	0.00672267002233	/*Geodetic Datum 1949*/
68	-100	-248	259	6378206.400	0.00676865799761	/*Guam 1963*/
69	252	-209	-751	6378388.000	0.00672267002233	/*GUX 1 Astro*/
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*/

Index	DX	DY	DZ	A-axis	Eccentricity	Description
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*/
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*/
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*/

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

Index	DX	DY	DZ	A-axis	Eccentricity	Description
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*/

Sample TSIP routines

The following sample routines use command packet 0x0x1F and report packet 0×45 to retrieve software version information from the Acutime Gold through COM1. Source code for a working TSIP monitor program is available at 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 Gold 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 <*DLE*><*ID*><*Data String Bytes*><*DLE*><*ETX*>, where <*DLE*> and <*ETX*> are reserved frame characters with values 0x10 and 0x03, respectively, and <*ID*> is the packet identifier. The following routines perform DLE stuffing on a command packet and send it to the Acutime Gold.

```
#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 Gold 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;
}
```

APPENDIX

B

NMEA 0183

In this appendix:

- Communication interface
- Message structure
- Message options
- Message formats

NMEA 0183 is an interface protocol created by the National Marine Electronics Association, that was originally established to allow marine navigation equipment to share information. The latest release is version 2.1, 15 October 1995.

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, a NMEA 0183 software application code already exists. The Acutime Gold 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 Acutime Gold.

For a complete copy of the NMEA 0183 standard, contact the National Marine Electronics Association at www.nmea.org.

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 characteristics of the NMEA 0183 data transmissions are as follows:

Signal characteristic	NMEA standard
Baud rate	4800
Data bits	8
Parity	None (disabled)
Stop bits	1

Message structure

The NMEA 0183 protocol covers a broad array of navigation data. This 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 applies to a GPS receiver like the Acutime Gold. The NMEA message structure is:

$IDMSG,D1,D2,D3,D4,.....,Dn*CS[CR][LF]

Where ...	signifies ....
"$"	The start of a message.
ID (2-letter mnemonic)	The source of the navigation information. ***Note –*** *GP signifies a GPS source.*
MSG (3-letter mnemonic)	The message content and the number and order of the data fields.
","	Delimiters for the data fields.
Dn	Data field block. Each message contains multiple data fields (Dn), which are delimited by commas.
"*"	Checksum delimiter.
CS (2 ASCII characters)	Checksum field. This contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR][LF]	This combination terminates 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.

Message options

The Acutime Gold can output any or all of the messages below. When you select NMEA, 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 – *You can configure a custom mix of the messages listed below. See Port A configuration, page 31, and TSIP command packets 0xBC, 0x7A, and 0x8E 0x26 in Appendix A Trimble Standard Interface Protocol for details on configuring NMEA output.*

CAUTION – If too many messages are specified for output, you may need to increase the unit's baud rate.

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

Message formats

GGA – GPS Fix Data

The GGA message includes time, position and fix related data for the GPS receiver.

$GPGGA,hhmmss,llll.lll,a,nnnnn.nnn,b,t,uu,v.v,w.w,
M,x.x,M,y.y,zzzz*hh <CR><LF>

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
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters (M)
11, 12	Geoidal Separation in Meters (M). 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

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,llll.lll,a,yyyyy.yyy,a,hhmmss.s, A*hh<CR><LF>

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

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,x.x,x.x,x.x*hh<CR><LF>

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

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>

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

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,yyyyy.yyy,a,x.x,x.x,
xxxxxx,x.x,a*hh<CR><LF>

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)

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>

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

ZDA – Time & Date

The ZDA message contains UTC, the day, the month, the year and the local time zone.

$GP ZDA,hhmmss.s,xx,xx,xxxx,,*hh<CR><LF>

Field	Description
1	UTC
2	Day (01 to 31)
3	Month (01 to 12)
4	Year
5	unused
6	unused
hh	Checksum

Notes –
Fields #5 and #6 are null fields in the ACE UTC output. A GPS receiver cannot independently identify the local time zone offsets.
GPS time can be used as a time tag for the 1 PPS. The ZDA message comes out 100–500 msec after the PPS.
If UTC offset is not available, time output will be in GPS time.

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