ACUTIME 360

MULTI-GNSS SMART ANTENNA

USER GUIDE

For use with:

- Acutime 360 multi-GNSS smart antenna (P/N 106406-XX)
- Acutime 360 Starter Kit (P/N 106222-XX)

Firmware Version 1.08 and later

Version 1.08
Revision B
June 2022
P/N: 107467-00

Legal Notices

Corporate Office

Protempis, LLC

www.Protempis.com

Email: support@protempis.com

Release Notice

This is the June 2022 release of the Acutime 360 Multi-GNSS Smart Antenna User Guide..

The Australian Consumer Law

Under the Competition and Consumer Act 2010 (Cth) (the “Australian Consumer Law”), certain consumer guarantees, warranties, rights, or remedies cannot be limited, excluded, restricted, or modified (“Non-excludable Condition”). To the extent permitted by law, Protempis’s liability in relation to breach of any such Non-excludable Condition shall be limited as follows:

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dealer rather than from Protempis directly, Protempis may, at its option, forward the software Fix to the Protempis authorized dealer for final distribution to you. Minor Updates, Major Upgrades, new products, or substantially new software releases, as identified by Protempis, are expressly excluded from this update process and limited warranty. Receipt of software Fixes or other enhancements shall not serve to extend the limited warranty period. For purposes of this warranty the following definitions shall apply:

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(2) “Minor Update” occurs when enhancements are made to current features in a software program; and

(3) “Major Upgrade” occurs when significant new features are added to software, or when a new product containing new features replaces the further development of a current product line.

Protempis reserves the right to determine, in its sole discretion, what constitutes a Fix, Minor Update, or Major Upgrade.

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If the Protempis Product fails during the warranty period for reasons covered by this limited warranty, and you notify Protempis of such failure during the warranty period, Protempis will at its option repair OR replace the nonconforming Product with new, equivalent to new, or reconditioned parts or Product, OR refund the Product purchase price paid by you, upon your return of the Product in accordance with Protempis's product return procedures then in effect.

How to Obtain Warranty Service

To obtain warranty service for the Product, please contact your local Protempis authorized dealer. Alternatively, you may contact Protempis to request warranty service by sending an email to support@protempis.com.

Please prepare to provide:

- Contact name, address, and telephone numbers
- proof of purchase DIRECTLY FROM PROTEMPIS
- a description of the nonconforming Product, including the Protempis part number
- a detailed explanation of the problem

The customer service representative may need additional information from you depending on the nature of the problem. Any expenses incurred in the making of a claim under this warranty will be borne by you. Protempis shall not be responsible for any modification or damage to, or loss of any programs, data, or other information stored on any media or any part of any Product serviced by it, or for the consequence of such damage or loss, e.g., business loss in the event of system, program or data failure. It is your responsibility, prior to servicing, to backup data and remove all features, parts, alterations, and attachments not covered by warranty prior to releasing the Product to Protempis. The Product will be returned to you configured as originally purchased.

Warranty Exclusions and Disclaimer

This Product limited warranty shall only apply in the event and to the extent that:

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(b) the Product is not modified or misused.

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(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;

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(vi) cosmetic damage.

Protempis does not warrant or guarantee the results obtained through the use of the Product, or that software components will operate error- free.

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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 digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus as set out in the radio interference regulations of the Canadian Department of Communications, ICES-003.

Le présent appareil numérique n’émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de Classe B prescrites dans le règlement sur le brouillage radioélectrique édicté par le Ministère des Communications du Canada, ICES-003.

Europe

This product has been tested and found to comply with the requirements for a Class B device pursuant to European Council Directive 89/336/EEC on EMC, thereby satisfying the requirements for CE Marking and sale within the European Economic Area (EEA). These requirements are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential or commercial environment.

Notice to Our European Union Customers

For product recycling instructions and more information, please contact customer support.

Recycling in Europe: To recycle Protempis WEEE (Waste Electrical and Electronic Equipment, products that run on electrical power.), contact customer support.

Declaration of Conformity

We, Protempis, LLC,

United States of America

declare under sole responsibility that the product Acutime 360 Multi-GNSS Smart Antenna complies with Part 15B of FCC Rules.

Document History

Version	Date	Author	Changes
V1.08 Rev B	June 2022	CV	Protempis update
V1.08 Rev A	May 2021	FAE	Updates for firmware 1.08

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 it provides is intended to minimize the risk of personal injury and/or damage to property. In particular, observe safety instructions that are presented in the following format:

WARNING – This alert warns of a potential hazard which, if not avoided, could result in severe injury or even death.

CAUTION – This alert warns of a potential hazard or unsafe practice which, if not avoided, could result in injury or property damage or irretrievable data loss.

CAUTION – Electrical hazard – risk of damage to equipment. Make sure all electrostatic energy is dissipated before installing or removing components from the device. An electrostatic discharge (ESD) can cause serious damage to the component once it is outside the chassis.

This system can become extremely hot and cause burns. To reduce the risk of injury from a hot system, allow the surface to cool before touching it.

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

Operation and storage

WARNING – Operating or storing the Acutime 360 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, and corrosive fluids or gases.

Contents

1

Introduction

Welcome to the Protempis Protempis Acutime 360 Multi-GNSS Smart Antenna User Guide. This user guide describes how to install, set up and use the Protempis® Acutime™ 360 multi-GNSS smart antenna and timing receiver.

For more information on Protempis timing and synchronization products go to http://www.Protempis.com/timing/.

For more information on GNSS, go to: http://www.Protempis.com/gps_tutorial/.

Overview

The Acutime 360 antenna integrates the latest multi-GNSS technology into a rugged, self-contained antenna unit that provides optimal GNSS timing performance, in all weather conditions, with continuous operation, long- term reliability, ease of operation, and simple installation.

The Acutime 360 antenna provides an accurate one pulse-per-second (PPS) output to synchronize and time broadband wireless, cellular base stations, Time Difference of Arrival (TDOA) applications, and many other Supervisory and Data Acquisition (SCADA) applications.

Features of the Acutime 360 multi-GNSS smart antenna

Hardware features

The Acutime 360 antenna contains the following in a sealed, weatherproof housing:

- An active patch multi-GNSS antenna with a proprietary pre-amp design and integrated band-pass filtering providing excellent performance against jamming signals.
- A connector that supports both the power and data interface connection.
- Two user-configurable RS-422 I/O communication ports.

The Acutime 360 antenna 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 360 antenna 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 360 antenna. There are two options:

- Protempis Standard Interface Protocol (TSIP) is a binary packet protocol that allows the system designer maximum configuration control over the GNSS receiver for optimum performance in timing applications. TSIP supports multiple commands and their associated response packets for use in configuring the Acutime 360 antenna to meet your requirements. See Appendix A, Protempis 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 360 antenna supports the ZDA NMEA message for GNSS timing. You can select other NMEA messages and output rates as required. See Appendix B, NMEA 0183 Protocol.

Standard timing software features

- Automatic self-survey
- Over-determined (OD) Clock Mode

- Time-keeping from a single satellite (a minimum of two satellites is needed for re-acquiring the time)
- Timing Superpackets
- Timing Receiver Autonomous Integrity Monitoring (T-RAIM)
- Position integrity (P-RAIM). When the receiver detects a position difference greater than 100 meters from its stored position, it will restart the self-survey.
- Cable delay compensation

Operation

When the Acutime 360 antenna 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 100 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 360 antenna is turned on, it searches for satellites from a cold start with no almanac, time, ephemeris, or stored position. The Acutime 360 antenna 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 360 antenna generates a 1 PPS output, synchronized to GPS or Coordinated Universal Time (UTC) or GLONASS 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 360 antenna 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.

Starter kit

The Acutime 360 Starter Kit contains all the components required for a high-performance, cost-effective reference time source that uses GNSS technology to precisely synchronize computers, servers and Internet applications for evaluation and engineering purposes. It is quick and easy to install.

Use and care

TheAcutime 360 antenna is a high-precision electronic instrument and should be treated with reasonable care.

> **CAUTION –** There are no user-serviceable parts inside the Acutime 360 antenna 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 Protempis 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, send an email to the Protempis Technical Assistance Center using the following address: tsgsupport@Protempis.com.

2

Setting up the Acutime 360 antenna

Protempis recommends that you install the Protempis VTS software before setting up the Acutime 360 smart antenna, as this will enable you to monitor the acquisition of satellites once you start up the multi-GNSS 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 Hardware Integration, page 26.

System requirements

Hardware

- For evaluation or engineering purposes:
  - The Protempis Acutime 360 multi-GNSS smart antenna starter kit, see later in this chapter.
- For permanent installation:
  - Protempis Acutime 360 multi-GNSS smart antenna
  - Interface cable with DB-25 connector
  - Universal Interface Module

Computer

An office computer powered by a version of the Microsoft® Windows® operating system (Windows XP or later).

System software

- Protempis VTS software. This is used to monitor the Acutime 360 antenna's performance and to assist system integrators in developing a software interface for the smart antenna. The software is compatible with the Windows operating systems. See Protempis VTS software, page 20.
- Protempis Standard Interface Protocol (TSIP). This consists of command packets and report packets. See Appendix A Protempis Standard Interface Protocol, page 46.
- NMEA-0183. See Appendix B NMEA 0183 Protocol, page 116.

Installing and using the software

All software programs for the Acutime 360 starter kit are available online from the Protempis website at http://www.Protempis.com/Timing/Acutime-360.aspx. These programs enable you to monitor the Acutime 360 antenna and change its settings.

> **TIP –** Install and set up the monitor program before turning on the Acutime 360 antenna—this allows you to watch the timing process, from start up to fully functioning.

Protempis VTS software

> **CAUTION –** Use only the Protempis VTS software with this product. Previous software versions may not be compatible.

To install the Protempis VTS software from the website:

1. Go to http://www.Protempis.com/timing/acutime-360.aspx and then select **Support for TGS** / **Installation Files**.
2. Select and then download Protempis VTS.exe to the computer's hard drive.
3. To run the application, double-click the file. The **Protempis VTS** screen appears.
4. To specify the communications port and protocol for your office computer, right-click in the bottom right of the Protempis VTS screen and then select the required COM port and settings.
5. Connect the Acutime 360 antenna to the Universal Interface Module (UIM) using the provided antenna interface cable. Connect the 12-pin connector to the antenna, and the DB-25 connector to the UIM.
6. Connect one end of the USB cable to the USB port of the UIM.
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 360 antenna 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 Protempis VTS software 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 Acutime 360 antenna 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 Protempis Technical Assistance Center (TAC) at 1 (800) 767-4822.

TSIP

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

The TSIP is installed by factory default.

NMEA-0813

To convert to the NMEA protocol, refer to and use the Protempis VTS software for serial port protocol, Input/Output, message type output, and baud rate configuration.

Acutime 360 starter kit

Acutime 360 Multi-GNSS Smart Antenna

Universal Interface Module (RS-422 to USB converter)

Power converter (AC to 24 VDC)

Power pin adapters

USB cable

100 feet of interface cable with DB-25 connector

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 Acutime 360 antenna. It has a Type 2 USB interface to the Acutime 360 antenna 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 360 requires power separate from the USB.

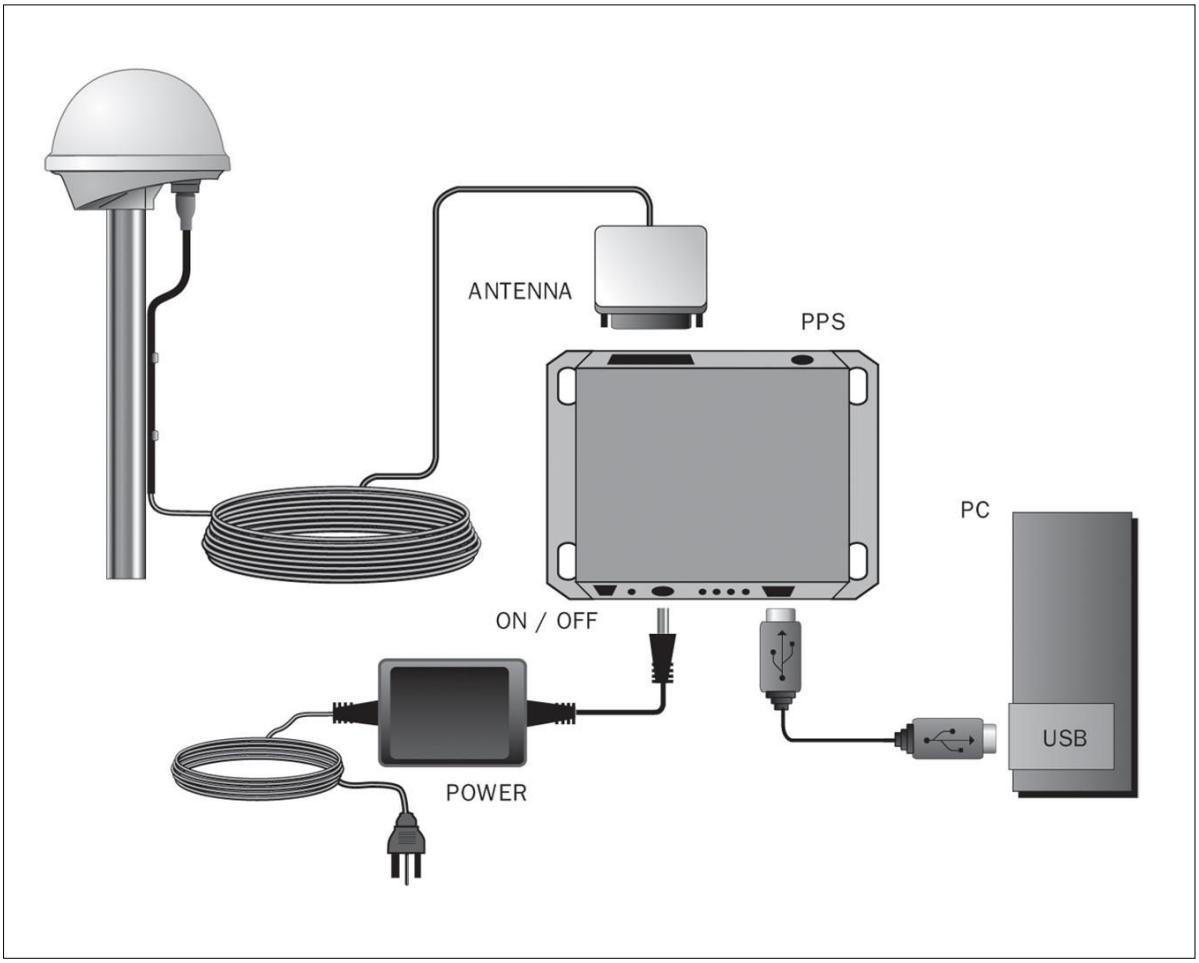
- The motherboard has a switching power supply, which converts the prime voltage input to the 24 V that is required to power the receiver over most available cable lengths.
- Connect the output device to the 1 PPS connector on the rear of the unit.

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 360 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 360 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 360 antenna so that it has the fullest possible view of the sky to ensure that the maximum number of satellites is 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 the USB port on a computer.

> **NOTE -** The antenna 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 VDC 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 VAC or 220 VAC).
7. Switch on the DC power source or turn on the mains power.

To integrate the multi-GNSS smart antenna, into your system, see Hardware Integration, page 26.

Starter kit components

The Acutime 360 antenna 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 360 multi-GNSS timing module (Default: GPS & GLO)	106406-00
100’ Acutime 360 cable	60155 (included in Starter kit)

Product	Part Number
Acutime 360 Universal Interface Module	Available with SK only
AC/DC power supply module	Available with SK only
Interface cable (USB/USB)	Available with SK only

NOTE – Part numbers are subject to change. Confirm part numbers with your Protempis representative when placing your order.

3

Hardware Integration

The setup procedures for the Acutime 360 multi-GNSS Smart antenna are described in Setting up the Acutime 360 antenna.

This chapter describes the hardware components, to assist you when you integrate the Acutime 360 antenna into a system.

To integrate the Acutime 360 multi-GNSS 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 1PPS
- Develop a software interface

The setup procedures for the Acutime 360 multi-GNSS Smart antenna starter kit are described in Setting up the Acutime 360 antenna.

Acutime 360 multi-GNSS smart antenna

Bottom view

Side view

Performance specifications

Parameter	Description
General	GPS, GLONASS, BeiDou frequencies, continuous tracking receiver, static Over-determined Clock Mode
Update rate	1Hz
Event Update rate	5Hz / Second (max)
Accuracy horizontal position	<6 meters (50%) <9 meters (90%)
Accuracy altitude position	<7 meters (50%) <10 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%)
Reacquisition after 60s signal loss	<2 s (90%)
Dynamics	Velocity: 500 m/s maximum Acceleration: 4 g (39.2 m/sec2) Jerk: 20 m/s3
PPS output	Physical interface: RS-422 Width: 10 milliseconds (default); user programmable from 1 millisecond to 500 milliseconds On-time edge: Rising edge on time (default); user programmable rising or falling resolution :<32 nanoseconds Accuracy: UTC 15 nanoseconds (static), UTC 90 nanoseconds (dynamic, TDOP ≤ 3)
External event capture	Interface: RS-422 Resolution: <500ns
Minimum pulse width	10 milliseconds, rising edge-on-edge
Reporting mechanism	TSIP packet

Environmental specifications

Parameter	Condition	
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 g2/Hz 0.05 g2/Hz -3 dB/octave	5 Hz to 20 Hz 20 Hz to 100 Hz 100 Hz to 900 Hz

Parameter	Condition
Operating humidity	95% RH, non-condensing at 60° C (140° F) EMC
EMC	CE, FCC Class B
Ingress protection	IP 67

Physical characteristics

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

Interface cables

The Acutime 360 smart antenna's 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.

The 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 Protempis.

All cables are terminated on the antenna end.

For a list of part numbers, see http://www.Protempis.com/timing/acutime-360.aspx.

Power requirements

The Acutime 360 multi-GNSS receiver is designed for static timing applications and requires a nominal +12 VDC to +24 VDC input (a range of +5 VDC 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.

> **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. Protempis recommends +24 VDC for most runs.

The red wire (Acutime 360 pin 1) and the black wire (Acutime 360 pin 9) on the interface cable support power and ground connections, respectively. The Acutime 360 smart antenna features a linear power supply, which supports +5 to +36 VDC. The antenna is protected against reverse polarity and brief over voltage conditions, however, extended over-voltage conditions may cause permanent damage.

Power consumption of the Acutime 360 smart antenna is less than 80 mA at 12 VDC.

Serial port interfaces

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

Accutime 360 Connector Pin #	Wire Color	Function	DB-25 Interface Pin#	Protocol
1	Red	DC Power	1	+5 VDC to +36 VDC
2	Violet	Port B: Receive -	25	TSIP RS-422
3	Orange	Port B: Receive +	13	TSIP RS-422
4	Brown	Port B: Transmit -	11	TSIP RS-422
5	Yellow	Port B: Transmit +	23	TSIP RS-422
6	White	Port A: Receive -	24	Event Input
7	Gray	Port A: Receive +	12	Event Input
8	Green	Port A: Transmit -	10	NMEA / TSIP RS-422
9	Black	DC Ground	7	Ground
10	Blue	Port A: Transmit +	22	NMEA / TSIP RS-422
11	Orange w/white stripe	1 PPS Transmit +	21	RS-422
12	Black w/white stripe	1PPS Transmit -	9	RS-422

Pulse-Per-Second (PPS)

The Acutime 360 smart antenna provides a 10 ms 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 UTC, GPS, or GNSS 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 360 smart antenna is operating in the static.

Over-determined Clock Mode with a timing accuracy of <15 nanoseconds (one sigma) to UTC, GPS, or GNSS time.

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

Timing pulse connections

The Acutime 360 smart antenna 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 360 smart antenna 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 360 smart antenna. 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.
- Configure Port B to transmit NMEA packets.

The Acutime 360 smart antenna 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.

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

Event input

The Acutime 360 smart antenna 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 360 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 500 ns of its arrival at the Acutime 360 interface connector.

NOTE – The event capture feature is design for low frequency events of 1 PPS or longer.

NOTE – When the event input on Port A is enabled the serial receive function on Port A is disabled.

4

System Operation

Startup

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

The first time that the Acutime 360 smart antenna 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 360 antenna outputs periodic TSIP messages on Port B. These status messages confirm that the receiver is working.

> **NOTE -** The Acutime 360 smart antenna 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 360 smart antenna are in a single board format. The board has been adapted for timing applications where reliability, performance, and ease of integration are required.

The receiver features Protempis'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 360 smart antenna 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, UTC, or GNSS 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 backup. The factory default setting for Port B, the primary I/O port, is bi-directional TSIP at 115,200 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	115,200
Output baud rate	115,200
Parity	Odd
Data bits	8
Stop bits	1
Input protocol	TSIP input
Output protocol	TSIP output

NOTE - The Acutime 360 smart antenna also supports the NMEA message protocol.

Port B configuration

The factory default protocol on Port B is TSIP in and out at 115,200-odd-8-1.

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

C-source code examples for TSIP commands are also provided in Appendix A Protempis 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 115,200-8-odd-1.

> **NOTE -** When the event input on Port A is enabled the serial receive function on Port A is disabled.

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.

> The information reported in the 0x8F-0B message relates to only the GPS constellation. This packet is only valid for GPS satellites.

Automatic operation

When the Acutime 360 antenna has acquired and locked onto a set of satellites that pass the mask criteria listed below, and has obtained a valid ephemeris for each tracked satellite, it performs a self-survey. After a number of valid position fixes, the self-survey is complete. At that time, the Acutime 360 antenna automatically switches to a time-only mode (overdetermined clock mode).

Satellite masks

The Acutime 360 smart antenna continuously tracks and uses up to 32 satellites in an overdetermined 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 360 antenna. These masks serve as the screening criteria for satellites used in fix computations and ensure that solutions meet a minimum level of accuracy. The satellite masks can be adjusted using the TSIP protocol described in Appendix A, Protempis Standard Interface Protocol.

Mask	Default Setting	Description
Elevation	5°	Satellite elevation above horizon
C/N0 [dBHz]	30	Signal strength (carrier-to-noise power ratio)

Mask	Default Setting	Description
PDOP	6	Position Dilution of Precision (PDOP), used for self-survey only

Mask	Default Setting	Description
Elevation	10°	Satellite elevation above horizon
AMU	4	Signal strength
PDOP	8	Position Dilution of Precision (PDOP), used for self-survey only

Elevation mask

Generally, signals from low-elevation satellites are of poorer quality than signals from higher elevation satellites. These signals travel farther through the ionospheric and tropospheric layers and undergo distortion due to these atmospheric conditions. For example, an elevation mask of 10° excludes very low satellites from position fix computations and reduces the likelihood of potential errors induced by using those signals.

SNR mask

Low SNR values can result from low-elevation satellites, partially obscured signals (for example, dense foliage), or multi-reflected signals (multipath).

Multi-reflected signals, also known as multipath, can degrade the position and timing 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.

If the Acutime 360 antenna has a clear view of the sky (outdoor antenna placement), an SNR mask of 35 is recommended for optimal results. However, for indoor use or operation with an obscured view of the sky, the mask must be low enough to allow valid weak signals to be used. For indoor operation, an SNR mask of 4 AMU is recommended.

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.

Operating modes

The Acutime 360 smart antenna operates in one of the following main modes:

- Self-survey mode (position fix operating mode)
- Overdetermined clock mode

After establishing a reference position in self-survey mode, the Acutime 360 antenna automatically switches to overdetermined (OD) clock mode.

Self-survey mode

At power-on, the Acutime 360 smart antenna performs a self-survey by averaging position fixes, default of 2,000 fixes will be averaged.

The number of position fixes until survey completion is configurable using the 8E-A9 command.

The default mode during self-survey is 3D Automatic, where the receiver must obtain a three-dimensional (3D) position solution. The very first fix in 3D Automatic mode must include at least five satellites. After a successful first fix, only four satellites are required. If fewer than the required number of satellites are visible, the Acutime 360 antenna suspends the self-survey. 3D mode may not be achieved when the receiver is subjected to frequent obscuration or when the geometry is poor due to an incomplete constellation.

Overdetermined clock mode

Overdetermined clock mode is used only in stationary timing applications. This is the default mode for the Acutime 360 antenna once a surveyed (or user input) position is determined. After the receiver self-surveys its static reference position, it stores the surveyed reference position, automatically and switches to overdetermined clock mode and determines the clock solution. The timing solution is qualified by T-RAIM (Time Receiver Autonomous Integrity Monitoring) algorithm, which automatically detects and rejects faulty satellites from the solution.

Using the default anti-jamming setting, a minimum of two satellites is required for an initial PPS fix in overdetermined clock mode. Once PPS alignment has been determined only a single satellite is required to maintain that time. If all satellites are lost, then a minimum of two satellites is again required to re-establish PPS alignment.

In this mode, the Acutime 360 antenna does not navigate or update positions and velocities, but maintains the PPS output, solving only for the receiver clock error (bias) and error rate (bias rate). If the anti- jamming setting is disabled, only one satellite is required for a valid timing fix. To set Anti Jamming, see Command packet 0xBB: Set Receiver Configuration, page 86.

PPS output options

The PPS (Pulse Per Second) output is the primary timing output generated by the Acutime 360 smart antenna 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 pulse-per-second output depends to some degree on the number of satellites used in the solution. 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 ms to 500 ms, use packet 0x8E-4F.

Serial data communication

The Acutime 360 smart antenna outputs TSIP superpackets or NMEA messages.

On start-up, the Acutime 360 antenna 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 115,200-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.

GNSS timing

For many timing applications, such as time & frequency standards, site synchronization systems, and wireless voice and data networks, the Acutime 360 antenna smart antenna 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 GNSS PPS. An accurate GNSS 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 GNSS system consists of several GPS, GLONASS, BeiDou, Galileo and other regional constellation orbiting satellites. Unlike most telecommunications satellites, GNSS satellites are not geostationary[1], so satellites in view are constantly changing. Each GNSS 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.

> **NOTE -** There are geo-stationary satellites for GNSS augmentation and regional coverage.

A Protempis multi-GNSS 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 360 antenna outputs a highly accurate timing pulse (PPS) generated by its internal clock, which is constantly corrected using the GPS or GNSS clocks. This timing pulse is synchronized to GPS/UTC/GLONASS time within 15 ns (one sigma) after the survey is complete.

> **NOTE -** GLONASS time is supported when the unit is operating in GLONASS only mode.

In addition to serving as highly-accurate stand-alone time sources, GNSS timing modules are used to synchronize distant clocks in communication or data networks. This is possible because all GNSS 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, GNSS 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 GNSS receiver's clocking rate and software affect PPS accuracy. The Acutime 360 smart antenna has a clocking rate of 26 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 360 antenna mitigates the effects of clock error to achieve a PPS accuracy within 15 ns (one sigma) to GPS//UTC after the survey is complete.

GNSS constellation configuration

The Acutime 360 smart antenna can be configured to use either just one GNSS system, such as GPS, GLONASS, BeiDou, Galileo or QZSS, or a combination of these systems. The receiver can use any combination of GNSS systems, except where GLONASS and BeiDou

are enabled simultaneously. The receiver will automatically clear the BeiDou option when both constellations (BeiDou and GLONASS) are enabled.

The table below shows the possible constellation options you can select.

GPS	Galileo	GLONASS	BeiDou	QZSS
√				
	√			
		√		
			√	
√	√			
√		√		
√			√	
√	√			√
√		√		√
√			√	√
√				√

If a single constellation is chosen, then the PPS and Time alignment is automatically set to the same constellation.

NOTE - QZSS can not be enabled by itself but it can be enabled any combinations with GPS as QZSS uses the same frequency band with GPS.

Timing operation

The Acutime 360 smart antenna automatically outputs a PPS and time tag. With an accurate reference position, the receiver automatically switches to an overdetermined clock mode, activates its T-RAIM algorithm and outputs precise PPS. Using a simple voting scheme based on pseudo-range residuals, the Acutime 360 antenna's integrity algorithm automatically removes the worst satellite with the highest residual from the solution set if that satellite's residual is above a certain threshold.

In addition to T-RAIM, the smart antenna implements position integrity checking on startup, in case the receiver has been moved to a new location. When the receiver power-ups with a surveyed (or user input) position in memory, it compares fixes computed from the GNSS satellites to the surveyed position. If it finds that the surveyed position is off by more than 100 meters horizontally or vertically in the first 60 consecutive GNSS fixes, it deletes the surveyed position from memory (including non-volatile storage), and restarts the self-survey, provided the self-survey is enabled, and the "position save flag" is set to 1 using the 0x8E-A9 command (see page 96).

The default configuration of the smart antenna 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 (1.8 ns per foot). TSIP packet 8Ex4A sets the cable delay parameter, which is stored in non-volatile memory. For the best absolute PPS accuracy, adjust the cable delay to match the installed cable length (check with your cable manufacturer for the delay for a specific cable type). Generally, the cable delay is about 1.8 nanoseconds per foot of cable. 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 1980, which, on 1 January 2017 was increased from 17 to 18 seconds. Historically, the offset increases by one second approximately every 18 to 24 months, usually just before midnight on 30 June or 31 December. System designers should note whether the output time is UTC or GPS time.

Anti-jamming

GNSS jamming is generally caused by intentional or unintentional generation of a signal that interferes at or very near the transmitted frequency of the GNSS satellite signals. This signal causes some background noise of the received signal and a decrease in the received signal-to- noise ratio (C/N0), causing poor tracking and data decoding. This is mitigated in the receivers by the use of filtering to attempt to greatly reduce the jamming signal so that it does not adversely affect the signal. Jamming can be very difficult to protect against because, if the signal is too strong, the front-end RF section of the receiver will be completely overwhelmed and filtering is ineffective.

The Acutime 360 antenna protects against anti-jamming with hardware filtering and software algorithms.

About hardware filtering

- During the design process of the GNSS receiver great care is taken to avoid the component parts like oscillators and microprocessors producing signals that can jam the RF signal path. This can occur by either transmission over the air or conducted along the copper PCB traces.
- Protempis takes into account component choice using low-noise, high-spec parts.
- Component layout
- PCB trace layout
- Grounding techniques

About the software algorithms

- TRAIM (Time-Receiver Autonomous Integrity Monitoring) is used in OD mode using stringent thresholds to improve anti-jamming detection and mitigation.

- TRAIM discards inconsistent information that would degrade the combined overdetermined solution.
- Tracked multiple satellite integrity checks.
- Doppler measurements are examined for consistency with each other. Satellites with Doppler measurements that are far away from the median Doppler measurement are not used to improve anti-jamming detection and mitigation.
- Pseudorange measurements are examined for consistency with each other. Satellites with pseudorange measurements that are far away from the median pseudorange measurement are removed, or their effect reduced in the fix.
- Filter for SV noise and pseudorange offsets. Protempis measures from the median pseudorange value instead of the last value.

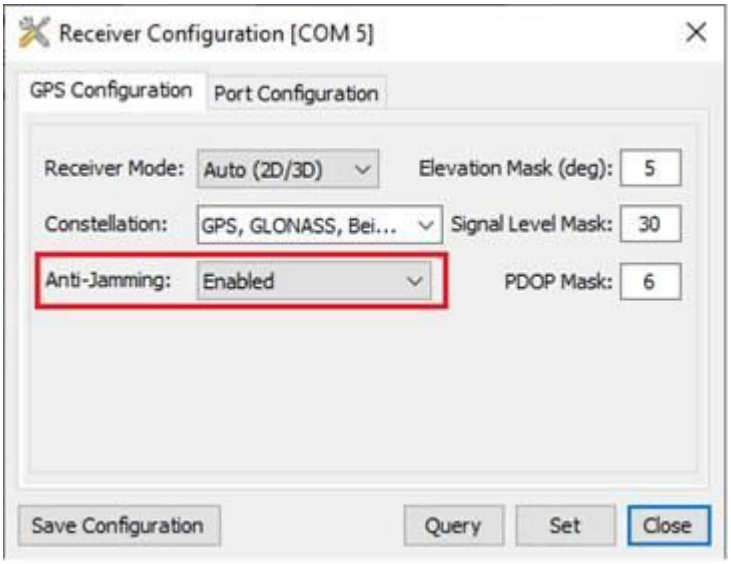
The Acutime 360 antenna has anti-jamming enabled as a default configuration; .

Below is the minimum number of satellites required to be tracked for each startup condition.

Condition	Anti-jamming enabled?	Minimum number of satellite tracking
Position NOT validated before (self-surveying)	YES	≥ 5 SVs
Position validated before	YES	≥ 4 SVs
First timing fix after all SVs drop	YES	≥ 2 SVs
Timing fix	YES	≥ 1 SVs

If the Acutime 360 antenna drops all the satellites (SV count is 0) after position validated, it needs ≥ 2 satellites to re-establish a time relationship for the first timing fix again and If it drops to ≥ 1, it will continue working indefinitely before it discards all satellites with enabling anti-Jamming.

To enable or disable anti-jamming, refer to Command packet 0xBB: Set Receiver Configuration, page 86. It also can be set in the VTS tool as shown:



Customizing operations

The Acutime 360 smart antennaRES/ICM 720 provides a number of user configurable parameters to customize the operation of the unit. These parameters can be stored in non-volatile storage (NVS) to be retained during loss of power and through resets with TSIP command 0x91-02 (see page 85). At reset or power-up, the receiver configures itself based on the parameters stored in the flash memory. You can change the value of these parameters to achieve the desired operations using a variety of TSIP packets. The smart antenna configures itself based on the new parameter immediately, but the new parameter value is not automatically saved to flash. You must use the Save command to retain the parameters changed values in flash.

Send packet 0x91-02 to direct the smart antenna to save the current parameter values to the flash. To save or delete the stored position, use command packet 0x8E-A6 (see page 95). You can also direct the receiver to set the parameter values to their factory default settings (and to erase the stored position) with packet 0x1E.

In brief, to customize the smart antenna operations for your application:

- Configure the receiver using TSIP command packets until the desired operation is achieved.
- Use TSIP packet 0x91-02 to save the settings in nonvolatile storage (flash). Check for the TSIP packet 0x91-02 response to verify the settings were saved successfully.
- If the position was not automatically saved during the self-survey or if it was manually entered, the position can be saved to flash memory using TSIP packet 8E-A6.

The new settings will control receiver operations whenever it is reset or power cycled.

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).

Parameter	Factory default
Operating dimension	4 (Full Position 3D)
Dynamic 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
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	115,200 bps
Output baud rate	115,200 bps
Parity	Odd
Data bits	8 bits
Stop bits	1 bit
Input protocol	TSIP input
Output protocol	TSIP output

PPS configuration

Parameter	Factory default
PPS enabled switch	Enabled
PPS timebase	UTC
Polarity	True
PPS offset	0.0 seconds
PPS width	$10e^{-3}$ seconds
PPS driver switch	3 (at least 1SV)

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. Protempis has chosen to adhere stringently to the NMEA 0183 data specification as published by the NMEA. The Acutime 360 multi-GNSS 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 360 GNSS 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 the Protempis VTS software, 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: 115.2 kbps
- 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 Protempis VTS software.

A

Protempis Standard Interface Protocol

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

TSIP is a simple bi-directional, binary packet protocol used in a wide variety of Protempis GNSS receivers. TSIP offers a broad range of command packets and report packets that provide the GNSS user with maximum control over the Acutime 360 receiver.

This appendix describes how to use the powerful TSIP features, enhance overall system performance, and reduce the total development time. The reference tables help you determine which packets apply to your application. For those applications requiring customization, see Customizing receiver operations, page 52, for a detailed description of the key setup parameters. Application guidelines are provided for each TSIP command packet.

Introduction to TSIP

TSIP is a powerful and compact interface protocol which has been designed to allow the system developer a great deal of flexibility in interfacing to a Protempis product. Many TSIP data packets are common to all products which use TSIP. An example would be a single precision position output packet. Other packets may be unique to a product. Custom packets are only used in the products for which they have been created.

Interface scope

The Acutime 360 GNSS smart antenna has one configurable serial I/O communication port, which is a bi-directional control and data port utilizing a Protempis Standard Interface Protocol (TSIP). The data I/O port characteristics and other options are user programmable and stored in non-volatile memory (Flash memory).

The TSIP protocol is based on the transmission of packets of information between the user equipment 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.

TSIP packet structure

The basic structure of a TSIP packet is the same for both command and report packets.

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

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

Multiple-byte numbers (integer, float, and double) follow the ANSI / IEEE Std. 754 IEEE Standard for binary Floating-Point Arithmetic. They are sent most-significant byte first. ***You must switch the byte order on Intel-based machines***.

The data types used in the Acutime 360 smart antenna TSIP are as follows:

Data Type	Description
UINT8	An 8- bit unsigned number (0 to 255)
SINT8	An 8-bit signed number (-128 to 127)
UINT16	A 16-bit unsigned number (0 to 65,535)
SINT16	A 16-bit signed number (-32,768 to 32,767)
UINT32	A 32-bit unsigned number (0 to 4,294,967,295)
SINT32	A 32-bit signed number (-2,147,483,648 to 2,147,483,647 Single - Float (4 bytes) (3.4x10-38 to 1.7x1038) (24 bit precision) Double - Float (8 bytes) (1.7x10-308 to 3.4x10308) (53 bit precision)

NOTE - Default settings are 115,200-8-odd-1

Physical interface characteristics

The basic structure of a TSIP packet is the same for both command and report packets.

The Acutime 360 smart antenna uses high-quality serial I/O components to drive the available serial transmit and receive channels.

The Acutime 360 antenna is available in an RS-422 configuration. This section explains the capabilities of each receiver.

Nomenclature

As with previous Multi-GNSS Smart antennas by Protempis, including the Acutis™, Acutime, and Palisade™ products, the Acutime 360 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 360 smart antenna 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 360 receiver

can be configured to output various automatic report packets and protocols to satisfy demanding real-time update requirements of complex monitoring systems.

Primary port features - port B

The Acutime 360 smart antenna features a primary bi-directional port, which is factory configured for TSIP input and output.

Secondary port features - port A

The Acutime 360 antenna has a bi-directional, programmable secondary port that is designated as the Timing port.

Event Input

The Acutime 360 antenna features an event input, which can capture and report time stamps with the same precision as the PPS signal.

Superpacket	Lenght	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
0x84	Double precision LLA position	If single precision is selected, packet 0x4A is output

Receiver warm-start

Once the Acutime 360 smart antenna has completed its internal initialization and has output packet 0x84 (see Packets output at startup), you can send the following commands to restart

it.

Output ID	Description
0x2B/23	Initial position (LLA/ECEF)
0x38 (type 2)	GPS almanac (for each SV)
0x38 (type 3)	GPS almanac health
0x38 (type 4)	Ionosphere page
0x38 (type 5)	UTC correction
0x38 (type 6)	GPS ephemeris
0x38 (type 7)	GLONASS almanac
0x38 (type 8)	GLONASS ephemeris

Default background packets (Port B)

Output ID	Description	Notes
0x41	GPS time	Output approximately every 1.6 minutes if the receiver's GNSS 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 every second, 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.
0x6C	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 91.

NOTE - The packet 0x4B is always sent with report packet 0x46.

Default automatic position and velocity reports

The Acutime 360 smart antenna 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 360 smart antenna 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; refer to the specific packet documentation for details.

LLT Packet ID	Description	Request packet ID
0x8F-AB	Primary Timing	0x8E-AB
0x8F-AC	Supplemental Timing	0x8E-AC
0x8E-AD	Primary UTC	0x8E-AD
0x8F-0B	Comprehensive Time & Position	0x8E-0B

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

Satellite data packets

Input ID	Description	Output ID
0x20	Request almanac	0x40

Input ID	Description	Output ID
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	0x5D

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	0x6C
0x26	Request receiver health	0x46 and 0x4B
0x27	Request satellite signal levels	0x47
0x2B	Set Initial position (LLA)	
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-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 0x35 settings (see Command packet 0x35: Set or Request I/O Options, page 63).

Customizing receiver operation

Input ID	Description	Output ID
0x1E	Clear memory reset	[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 360 antenna only)	0x8F-4F
0x8E-20	Set Fixed Point Superpacket output	0x8F-20

[1]Output is determined by packet 35 settings. For packets 0x1E see Packets output at startup 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).

Command Packets: User to Acutime 360 antenna

The table below summarizes the packets that can be input by the user. The table includes the input packet ID, a short description of each packet, and the associated output packet.

Input ID	Description	Output ID
0x1C-01	Firmware version	0x1C-81
0x1C-03	Hardware component information	0x1C-83
0x1E	Initiate cold reset or factory reset	[1]
0x1F	Software version	0x45
0x21	Current GPS time	0x41
0x23	Set initial position (XYZ Cartesian ECEF)	
0x24	Request GPS satellite selection	0x6C
0x26	Receiver health	0x46, 0x4B
0x27	Request signal levels	0x47
0x2B	Set approximate initial position (LLA)	
0x2F	UTC parameters	0x4F
0x30	Set UTC Date and Time for future roll over date	
0x31	Accurate initial position (XYZ Cartesian ECEF)	0x31

Input ID	Description	Output ID
0x32	Set accurate initial position (LLA)	0x32
0x35	Set/Request I/O options	0x55
0x37	status and values of last position and velocity	0x57[2]
0x38	Load or request satellite system data	0x58
0x39	Satellite enable/disable and health heed/ignore	0x59[3]
0x3A	Request last raw measurement	0x5A
0x3B	Satellite ephemeris status	0x5B
0x3C	Request current satellite tracking status	0x5D
0x7A	NMEA Set/Request	0x7B
0xBB	Set receiver configuration	0xBB
0xBC	Set port configuration	0xBC
0x8E-02	Request UTC information	0x8F-02
0x8E-0B	Request or configure superpacket output	0x8F-0B/0x8F-A5
0x8E-20	Last fix (fixed point)	0x8F-20
0x8E-26	Save configuration	
0x8E-41	Request manufacturing parameters	0x8F-41
0x8E-42	Request production parameters	0x8F-42
0x8E-4A	Set PPS characteristics	0x8F-4A
0x8E-4D	Packet Output Mask	0x8F-4D
0x8E-4E	PPS output option	0x8F-4E
0x8E-4F	Set PPS width	0x8F-4F
0x8E-A2	UTC/GPS timing	0x8F-A2
0x8E-A5	Packet broadcast mask	0x8F-A5
0x8E-A6	Self-survey commands	0x8F-A6
0x8E-A9	Self-survey parameters	0x8F-A9
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 49 to determine which messages are output at power-up.

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

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

Report Packets: Acutime 360 to user

The table below summarizes the packets output by the Acutime 360 smart antenna. The table includes the output packet ID, a short description of each packet, and the associated input packet. In some cases, the response packets depend on user-selected options.

0x13	Unparsable packet	error
0x1C-81	Firmware version	0x1C-01
0x1C-83	Hardware component information	0x1C-03
0x31	Accurate initial position (XYZ Cartesian ECEF)	0x31
0x32	Set accurate initial position (LLA)	0x32
0x41	GPS time	0x21
0x42	Single precision XYZ ECEF position fix	0x35
0x43	Velocity fix (XYZ ECEF)	0x37, auto
0x45	Software version	0x1E, 0x1F, power up
0x46	Health of receiver	0x26
0x47	Signal level for all satellites	0x27
0x4A	Single precision LLA position	0x37, auto
0x4B	Machine code/status	0x26
0x4F	UTC parameters	0x2F
0x54	One-satellite bias and bias rate	0x54[1]
0x55	I/O options	0x35
0x56	Velocity fix (ENU)	0x37, auto
0x57	Status and values of last position and velocity	0x37
0x58	GPS system data acknowledge	0x38
0x59	Satellite enable/disable and health heed/ignore	0x39
0x5A	Last raw measurement	0x3A
0x5B	Satellite ephemeris status	0x3B
0x5D	Current satellite tracking status	0x3C

0x6C	All-in-view satellite selection	0x24
0x7B	NMEA message output	0x7A
0x83	Double precision XYZ	0x37, auto
0x84	Double precision LLA	0x37, auto
0xBB	Receiver configuration	0xBB
0xBC	Port configuration	0xBC
0x8F-02	UTC information	0x8E-02
0x8F-0B	Comprehensive time	Auto / Event
0x8F-20	Last fix with extra information (fixed point)	0x8E-20
0x8F-26	Save configuration	0x8E-26
0x8F-41	Stored manufacturing parameters	0x8E-41
0x8F-42	Stored production parameters	0x8E-42
0x8F-4A	Set PPS characteristics	0x8E-4A
0x8F-4D	Automatic packet output mask	0x8E-4D
0x8F-4E	PPS output option	0x8E-4E
0x8F-4F	Set PPS width	0x8E-4F
0x8F-A2	UTC/GPS timing	0x8E-A2
0x8F-A5	Packet broadcast mask	0x8E-A5
0x8F-A6	Self-survey commands	0x8E-A6
0x8F-A9	Self-survey parameters	0x8E-A9
0x8F-AB	Primary timing packet	Auto
0x8F-AC	Supplemental timing packet	Auto
0x8F-AD	UTC event time	Auto / Event

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

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: Firmware version

Use the command packet 0x1C: 01 to obtain the firmware version. The product name is Acutime360. The packet format is defined in the following table:

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x1C	Packet ID 0x1C
1	Subpacket ID	UINT8	0x01	Subpacket 0x01 for software component version information request

Report packet 0x1C-81: Firmware component version information

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x1C	Packet ID 0x1C
1	Subpacket	UINT8	0x81	Subpacket 0x81 for software component version information report
2	Reserved	UINT8	Any	Reserved
3	Major version	UINT8	Any	Firmware major version
4	Minor version	UINT8	Any	Firmware minor version
5	Build number	UINT8	Any	Firmware build number
6	Month	UINT8	1-12	Firmware build month
7	Day	UINT8	1-31	Firmware build day
8…9	Year	INT16	Any	Firmware build year
10	Length of first module name	UINT8	Any	The length of the product name (L1)
11… (10+L1)	Product name	UINT8	String	Product name in ASCII

Command packet 0x1C-03: Hardware component version information

Use the command packet 0x1C-03 to obtain the hardware component version information.

The report packet is of variable length, depending on the length of the hardware ID.

The serial number, build date fields, and the hardware ID are programmed into the Acutime 360 antenna at production.

The hardware information for Acutime 360 antenna:

Hardware Code:	3032
Hardware ID:	Acutime 360 (BD8)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x1C	Packet ID 0x1C
1	Subpacket ID	UINT8	0x03	SubPacket ID 0x03 for hardware component version information request

Report packet 0x1C-83: Hardware component version information

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x1C	
1	Subpacket ID	UINT8	0x83	SubPacket ID 0x83 for hardware component version information report
2-5	Serial Number	UINT32	Any	Board serial number
6	Build day	UINT8	1-31	Day if the board's build date
7	Build month	UINT8	1-12	Month of the board's build date
8-9	Build year	UINT16	Any	Year of the board's build date
10	Build hour	UINT8	0-23	Hour of the board's build date
11-12	Hardware code	UINT16	0xBD8	Hardware code associated with the hardware ID
13	Length of hardware ID	UINT8	Any	The length of the hardware ID (L)
14 (13+L)	Hardware ID	UINT8	String	Hardware ID string in ASCII Acutime 360

Command packet 0x1E: Initiate Cold, Warm, or Factory Reset

This packet commands the Acutime 360 smart antenna to perform either a cold reset, warm reset or a factory reset.

- A cold reset will clear the GPS data (almanac, ephemeris, etc.) stored in RAM and is equivalent to a power cycle.
- A factory reset will additionally restored the factory defaults of all configuration parameters stored in flash memory. A warm reset clears ephemeris and oscillator uncertainty but retains the last position, time and almanac. This packet contains one data byte.

The data format is shown below.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x1E	
1	Reset	UINT8	"K" (0x4B)	Cold reset
			"F" (0x46)	Factory reset
			"N" (0x4E)	Clear navigation data and cold reset

NOTE – The factory reset command will delete the stored position and cause a self-survey to restart.

Command packet 0x1F: Request Software Version

This packet requests information about the version of software in Acutime 360 smart antenna. This packet contains no data. The Acutime 360 smart antenna returns packet 0x45.

Command Packet 0x21: Current Time Request

This packet requests current GNSS time. This packet contains no data. The Acutime 360 smart antenna returns packet 0x41.

Command packet 0x23: Initial Position (XYZ Cartesian ECEF) command

This packet provides the GNSS receiver with an approximate initial position in XYZ coordinates. This packet is useful if you have moved more than about 100 meters since the previous fix.

NOTE – The GNSS 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: Request GNSS satellite selection

This packet requests a list of satellites used for the current position/time fix. This packet contains no data. The Acutime 360 antenna returns packet 0x6C.

Command Packet 0x26: Health Request

This packet requests health and status information from the Acutime 360 antenna. This packet contains no data. The Acutime 360 antenna returns packets 0x46 and 0x4B.

Command packet 0x27: Request Signal Levels

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. Acutime 360 smart antenna returns packet 0x47.

Command packet 0x2B: Initial Position (Latitude, Longitude, Altitude)

This packet is used for A-GPS (GPS only) to set and approximate initial WGS-84 position (Latitude, Longitude, and Altitude coordinates) for the receiver. This packet is useful when a receiver is moved more than 1,000 Km from the location of the last position fix. The GNSS receiver returns report packet 0x2B, which indicates if the position was accepted by the receiver.

> **NOTE -** The GNSS 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 data format is shown in the tables below.

Command Packet 0x2B Data Format (Double Precision)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x2B	
1-8	Latitude	DOUBLE	Radians	+ for north, - for south
9-16	Longitude	DOUBLE	Radians	+ for east, - for west
17-24	Altitude	DOUBLE	Meters	
25-28	Horizontal Uncertainty	SINGLE	Meters	Default: 30,000 Range: 0 ~ 3,000 Km
29-32	Vertical Uncertainty	SINGLE	Meters	Default: 500 Range: 0 ~ 500 m

Command Packet 0x2B Data Format (Single Precision)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x2B	
1-4	Latitude	SINGLE	Radians	+ for north, - for south
5-8	Longitude	SINGLE	Radians	+ for east, - for west
9-12	Altitude	SINGLE	Meters	

Byte	Item	Type	Value	Description
13-16	Horizontal Uncertainty	SINGLE	Meters	Default: 30,000
17-20	Vertical Uncertainty	SINGLE	Meters	Default: 500

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 0x30: Set UTC Date and Time for future roll over date

This packet changes the Base week, to extend out the last valid WNRO number which would normally be based on the firmware build date.

Byte	Item	Type	Description
0	Packet ID	UINT8	30
1-2	Year	UINT16	Four Digits of the year
3	UTC:Month	UINT8	1-12
4	UTC:Day of Month	UINT8	1-31
5	UTC:Hour	UINT8	0-23
6	UTC:Min	UINT8	0-59
7	UTC:Sec	UINT8	0-59

NOTE - Do not use a date earlier than the current firmware date.

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

This packet is identical in content to packet 0x23; it provides an initial position to the Acutime 360 smart antenna in XYZ coordinates. However, the GNSS 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 Acutime 360 antenna 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 Acutime 360 antenna returns report packet 0x31, which indicates if the position was accepted by the receiver. The uploaded position is not stored in flash memory unless it is stored with command packet 0x8E-26. The input position is reported by packet 0x8F-AC.

Command Packet 0x31 Data Format (Single Precision)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x31	
1-4	X-axis	SINGLE	Meters	
5-8	Y-axis	SINGLE	Meters	
9-12	Z-axis	SINGLE	Meters	

Command Packet 0x31 Data Format (Double Precision)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x31	
1-8	X-axis	DOUBLE	Meters	
9-16	Y-axis	DOUBLE	Meters	
17-24	Z-axis	DOUBLE	Meters	

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

This packet provides an accurate initial position to the Acutime 360 smart antenna in latitude, longitude, and altitude coordinates. Either the single precision or the double precision version of this packet may be used, however, we recommend using the double precision version for greatest accuracy. The Acutime 360 antenna returns report packet 0x32, which indicates if the position was accepted by the receiver.

The GPS receiver uses this position for performing time-only fixes. If a survey is in progress when this command is issued, the survey is aborted, and this position data is used immediately. The coordinates entered must be in the WGS-84 datum. The Acutime 360 antenna will automatically switch to the overdetermined timing mode when this command is issued.

Note that this position is not automatically saved to flash memory. If you want to save this position, first set the position, wait at least 2 seconds and then use packet 8E-A6 to save the position.

NOTE - When converting from degrees to radians use the following value for PI: 3.1415926535898

Command Packet 0x32 Data Format (Single Precision)

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

Command Packet 0x32 Data Format (Double Precision)

Byte	Item	Type	Units
0-7	Latitude	DOUBLE	Radians, north
8-15	Longitude	DOUBLE	Radians, east
16-23	Altitude	DOUBLE	Meters

Command packet 0x35: Set or Request I/O Options

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

To request the option states without changing them, send this packet with no data bytes. To change any option states, include 4 data bytes with the values. The I/O options, their default states, and the byte values for all possible states are shown below.

These options can be set into non-volatile memory (flash ROM) with the 0x8E-26 command. The Acutime 360 antenna returns packet 0x55.

The following abbreviations apply to the following table:

- 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

Byte	Data Type	Bit	Value	Meaning	Associated Packet
0	Packet ID		0x35		

Byte	Data Type	Bit	Value	Meaning	Associated Packet
1	Position	0	0	ECEF off	0x42 or 0x83
			1	ECEF on	
		1	0	LLA off	0x4A or 0x84
			1	LLA on	
		2	0	HAE (datum)	0x4A or 0x84
			1	MSL geoid (Note 1)	
		3	0	Reserved	
		4	0	Single-precision position	0x42/4A
			1	Double-precision position	0x83/84
		5-7	0	Reserved	
2	Velocity	0	0	ECEF off	0x43
			1	ECEF on	
		1	0	ENU off	0x56
			1	ENU on	
		2-7	0	Reserved	
3	Timing	0	0	Reserved	0x42, 0x43, 0x4A
			1	Now use 0x8E-A2	0x83, 0x84, 0x56
4	Reserved	0-7		Reserved	

NOTE - When using the MSL altitude output, the current datum must be set to WGS-84

*Note that these should be enabled with great care because there can be a lot of data generated and, unless the baud rate is increased above the default 115200 baud, packets may be dropped.

Command packet 0x37: Request status and values of last position

This packet requests information regarding the last position fix (normally used when the GPS receiver is not automatically outputting fixes). The Acutime 360 antenna returns the position/velocity auto packets specified in the 0x35 message as well as message 0x57. This packet contains no data.

Command packet 0x38: Request/load Satellite System Data

This packet is used for A-GPS (GPS only). This packet requests current satellite data (almanac, ephemeris, and so on) or permits loading initialization data from an external source (for example, by extracting initialization data from an operating GNSS receiver unit through a data logger or computer and then using that data to initialize a second GNSS receiver unit). The Acutime 360 smart antenna returns packet 0x58.

NOTE – The Acutime 360 antenna can initialize itself without any data from the user; it merely requires more time.

To request data without loading data, use only bytes 0 through 2; to load data, use all bytes. Before loading data, observe the caution notice below. The data formats are located in Report Packet 0x58.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x38	
1	Operation	UINT8	1 2	Request data from GPS receiver Load data into GPS receiver
2	Type of data	UINT8	2	Almanac
			3	Health page, t_oa, WN_oa
			4	Ionosphere
			5	UTC
			6	Ephemeris
3	Sat PRN #	UINT8		Selects an individual satellite or all satellites 0: Data is not satellite specific 1-32: Data is requested for a specific satellite PRN (pseudorandom number)
4	Length (n)	UINT8		Number of bytes of data to be loaded
5 to n+3	Data	UINT8		Satellite data

WARNING – Loading all satellite data at once sends a lot of bytes to the unit, which could overwhelm the unit's serial receive buffer. Always wait for the acknowledge packet before sending the next data block.

Command packet 0x39: Satellite Attribute Database Command

Normally, the GNSS 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 GNSS receiver returns packet 0x59 for operation modes 3 and 6 only.

Byte	Item	Type	Value	Description
0	Operation	BYTE	1	Enable for selection (default)
			2	Disable for selection
			3	Request enable or disable status on byte 1selection
			4	Heed health on satellite
			5	Ignore health on satellite
			6	Request heed or ignore health on byte 1 selection
1	SV Type	BYTE	0	All SVs
			1	GPS
			2	GLONASS
			3	BeiDou
			4	Galileo
			5	QZSS
			6	SBAS
2	SVID	BYTE	If byte 1 value:	
			0 then 0	All SVs
			1 then 1-32	GPS
			2 then 65-96	GLONASS
			3 then 201-237	BeiDou
			4 then 97-133	Galileo
			5 then 193-195	QZSS
			6 then 33-54	SBAS

NOTE - Send a WARM start command (0x1E 0x0E) after setting new values.

Command packet 0x3A: Request last raw measurement

This packet requests the most recent raw measurement data for one specified satellite. The Acutime 360 smart antenna returns packet 0x5A if data is available.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x3A	
1	Satellite PRN Convert values to Hexadecimal	UINT8	0 1-32 65-96 97-133 183,192,193,200 201-237	All SV in current tracking set GPS GLONASS Galileo QZSS BeiDou

Command packet 0x3B: Satellite ephemeris status request (for GPS only)

This packet requests the current status of satellite ephemeris data. The Acutime 360 antenna returns packet 0x5B, if data is available.

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

Command packet 0x3C: Request satellite tracking status

This packet requests the current satellite tracking status. The GNSS receiver returns packet 0x5D if data is available.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x3C	
1	Satellite PRN Convert values to Hexadecimal	UINT8	0 1-32 65-96 97-133 193,194,195 201-237	All SV in current tracking set GPS GLONASS Galileo QZSS BeiDou

Command packet 0x7A: NMEA Interval and Message Mask command

The NMEA message 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” second. Use the values shown below to determine the NEMA interval and message mask. While fixes are being generated the output order is: ZDA, GGA, GLL, VTG, GSA, GSV, RMC.

Byte	Bit	Item	Type	Value	Description
0		Packet ID	UINT8	0x7A	
1		Subcode	UINT8	0	
2		Interval	UINT8	1-255	Fix interval in seconds
3		Reserved	UINT8	0	
4		Reserved	UINT8	0	
5	0	RMC	Bit	0 1	Off On
	1-7	Reserved	Bit	0	
6	0	GGA	Bit	0 1	Off On
	1	GGL	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 0x31: Accurate Initial Position (XYZ Cartesian ECEF)

This packet is sent in response to command packet 0x31. The packet indicates if the receiver accepted the accurate initial position.

Byte	Item	Type	Value	Description
0	Status	UINT8	0 1	Position accepted Position not accepted
1	Reserved	UINT8	0	Reserved

Report packet 0x32: Accurate Initial Position (Latitude, Longitude, Altitude)

This packet is sent in response to command packet 0x32. The packet indicates if the receiver accepted the accurate initial position.

Byte	Item	Type	Value	Description
0	Status	UINT8	0 1	Position accepted Position not accepted
1	Reserved	UINT8	0	Reserved

Report packet 0x41: GPS Time report

Legacy packet: Use 0x8F-AB or 0x8F-AC instead.

This packet provides the current GNSS time of week and the week number. The GNSS receiver sends this packet in response to packet 0x21.

Byte	Item	Type	Units
0-3	GNSS time of week	Single	Seconds
4-5	GNSS week number	Integer	Weeks
6-9	UTC offset	Single	Seconds

Report packet 0x42: Single-precision position fix

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** is set to single-precision, then the GPS receiver sends this packet each time a fix is computed and at start-up. The data format is shown below.

Byte	Item	Type	Value/Unit	Desctiption
0	Packet ID	UINT8	0x42	
1-4	X	SINGLE	meters	
5-8	Y	SINGLE	meters	
9-12	Z	SINGLE	meters	
13-16	time-of-fix	SINGLE	seconds	

The time-of-fix is in GNSS time or UTC as selected by the I/O **Timing** option in command packet 0x35. Packet 0x83 provides a double-precision version of this information.

Report packet 0x43: Velocity fix, XYZ ECEF

This packet provides current GNSS velocity fix in XYZ ECEF coordinates. If the I/O **Velocity** option (packet 0x35) is set to "XYZ ECEF", then the GNSS receiver sends this packet each time a fix is computed or in response to packet 0x37. The data format is shown below. The time-of-fix is in GPS, GLONASS or UTC as selected by the I/O **Timing** option.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x43	

Byte	Item	Type	Value/Unit	Description
1-4	X velocity	SINGLE	meters/second	
5-8	Y velocity	SINGLE	meters/second	
9-12	Z velocity	SINGLE	meters/second	
13-16	bias rate	SINGLE	meters/second	
17-20	time-of-fix	SINGLE	seconds	

Report packet 0x45: Software version information

This packet provides information about the version of firmware running on the Acutime 360 smart antenna. The GNSS receiver sends this packet after power-on in response to packet 0x1F.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x45	
1	Application Layer of the firmware	UINT8		Major version number of application
2		UINT8		Minor version number of application
3		UINT8		Month
4		UINT8		Day
5		UINT8		Year number minus 2000
6	GPS Core Layer of the firmware	UINT8		Major revision number of GNSS core
7		UINT8		Minor revision number of GNSS core
8		UINT8		Month
9		UINT8		Day
10		UINT8		Year number minus 2000

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 01 hex 03 hex 08 hex 09 hex 0A hex 0B hex 0C hex BB hex	Doing position fixes Do not have GPS time yet PDOP is too high No usable satellites Only 1 usable satellite Only 2 usable satellites Only 3 usable satellites The chosen satellite is unusable Have GPS time fix (OD mode)
1	Error codes	Byte		See Report Packet 0x46, below

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, always returned as '1'
1	Unused
2	Unused
3	Unused
4	Antenna feed line fault (open or short)
5	Antenna is shorted
6	Unused
7 (MSB)	Unused

Report packet 0x47: Signal level for all satellites tracked

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (i.e., above the elevation mask and healthy according to the almanac). The receiver sends this packet in response to packet 0x27. The data format is shown below. Up to 14 satellite number/signal level pairs may be sent, as indicated by the count field. The signal level is normally positive. If it is zero then that satellite has not yet been acquired. The absolute value of the signal level field is the last known signal level of that satellite.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x47	
1	Count	UINT8		
2	Satellite number 1	UINT8		
3-6	Signal level 1	SINGLE		
7	Satellite number 2	UINT8		
8-11	Signal level 2	SINGLE		
(etc.)	(etc.)	(etc.)		

NOTE – The signal level provided in this packet is a linear measure of the signal strength after correlation or de-spreading. Units are dB-Hz.

Report packet 0x4A: Signal precision LLA position fix

This packet provides current GNSS 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, then the receiver sends this packet each time a fix is computed. The data format is shown below.

Byte	Item	Type	Value/Unit	Description
0-3	Latitude	SINGLE	radians	+ for north, - for south
4-7	Longitude	SINGLE	radians	+ for east, - for west
8-11	Altitude	SINGLE	meters	
12-15	Clock bias	SINGLE	meters	Always relative to GPS
16-19	Time-of-fix	SINGLE	seconds	

The LLA conversion is done according to the datum selected; the default is WGS-84. Altitude is referred to the datum or the MSL Geoid, depending on which I/O LLA altitude option is selected with packet 0x35. The time of fix is in GPS, GLONASS time or UTC, depending on which I/O timing option is selected.

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

CAUTION – The MSL option is only valid with the WGS-84 datum. Do not use other datums.

Report packet 0x4B: Machine/Code ID and Additional status report

The Acutime 360 antenna transmits this packet in response to packet 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	Meaning
0	Machine ID	BYTE	32
1	Status 1	BYTE	See below for the Status 1 codes
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 & current
4-7	Not used

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 ΔTLS 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	Value
0-3	Bias	SINGLE	Meters
4-7	Bias rate	SINGLE	Meter/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 GNSS 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 m/s.

Report packet 0x55: I/O Options

This packet provides the current I/O option states in response to packet 0x35 request. The data format is the same as for packet 0x35.

Report packet 0x56: Velocity Fix, East-North-Up (ENU)

If East-North-Up (ENU) coordinates have been selected for the I/O **Velocity** option, the receiver sends this packet each time that a fix is computed or in response to packet 0x37 (last known fix). The data format for this packet is shown below.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x56	
1-4	East velocity	SINGLE	m/s	+ for east, - for west
5-8	North velocity	SINGLE	m/s	+ for north, - for south
9-12	Up velocity	SINGLE	m/s	+ for up, - for down
13-16	Clock bias rate	SINGLE	m/s	
17-20	Time-of-fix	SINGLE	seconds	

> **NOTE -** 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

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. The data format is shown below.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x57	
1	Source of info	UINT8	0 1	Old fix New fix

Byte	Item	Type	Value/Unit	Description
2	Tracking mode	UINT8	0 1 2 3 4 5 6	No previous fix Time only -SV Not used 2D 3D Over-determined clock Not used
3-6	Time of last fix	SINGLE	Seconds	
7-8	Week of last fix	UINT16	weeks	

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

This packet provides GPS data (almanac, ephemeris, and so on). The receiver sends this packet in response to packet 0x38 (acknowledging the loading of data). The data format is shown below. The table and section numbers referred to in the “Meaning” column reference the ICD-GPS-200.

Data format

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x58	
1	Operation	UINT8	2 3	Data out No data on SV
2	Type of data	UINT8	1 2 3 4 5 6	Not used Almanac Health page, t_oa, WN_oa Ionosphere UTC GPS Ephemeris
3	Sat PRN #	UINT8	0 1-32	Data is not satellite specific Data is requested for a specific satellite PRN (pseudorandom number)
4	Length (n)	UINT8		Number of data bytes to load
5 to (n+4)	Data	nBytes		

Almanac parameters

Byte	Item	Type	Definition/ ICD-GPS-200
5	t_oa_raw	UINT8	Sec 20.3.3.5.1.2
6	SV_HEALTH	UINT8	Sec 20.3.3.5.1.2
7-10	e	Single	Sec 20.3.3.5.1.2
11-14	t_oa	Single	Sec 20.3.3.5.1.2
15-18	i_o	Single	Sec 20.3.3.5.1.2
19-22	OMEGADOT	Single	Sec 20.3.3.5.1.2
23-26	sqrt_A	Single	Sec 20.3.3.5.1.2
27-30	OMEGA_0	Single	Sec 20.3.3.5.1.2
31-34	OMEGA	Single	Sec 20.3.3.5.1.2
35-38	M_0	Single	Sec 20.3.3.5.1.2
39-42	a_f0	Single	Sec 20.3.3.5.1.2
43-46	a_f1	Single	Sec 20.3.3.5.1.2
47-50	Axis	Single	Sec 20.3.3.5.1.2
51-54	n	Single	Sec 20.3.3.5.1.2
55-58	OMEGA_n	Single	Sec 20.3.3.5.1.2
59-62	ODOT_n	Single	Sec 20.3.3.5.1.2
63-66	t_zs	UINT16	Sec 20.3.3.5.1.2, see Note 2.
67-68	weeknum	UINT16	Sec 20.3.3.5.1.2
69-70	WN_oa	UINT16	Sec 20.3.3.5.1.2

NOTE - All angles are in radians. If data is not available, t_zc is set to -1.0.

Satelite health

Byte	Item	Type	Definition/ ICD-GPS-200
5	week number for health	UINT8	Sec 20.3.3.5.1.3
6-37	SV health	UINT8	Sec 20.3.3.5.1.3
38	t_oa for health	UINT8	Sec 20.3.3.5.1.3
39	current t_oa	UINT8	units = seconds/2048
40-41	current week #	UINT16	

Ionosphere parameters

Byte	Item	Type	Definition/ ICD-GPS-200
5-12	not used		
13-16	α0	Single	Sec 20.3.3.5.1.9
17-20	α1	Single	Sec 20.3.3.5.1.9
21-24	α2	Single	Sec 20.3.3.5.1.9
25-28	α3	Single	Sec 20.3.3.5.1.9
29-32	β0	Single	Sec 20.3.3.5.1.9
33-36	β1	Single	Sec 20.3.3.5.1.9
37-40	β2	Single	Sec 20.3.3.5.1.9
41-44	β3	Single	Sec 20.3.3.5.1.9

UTC parameters

Byte	Item	Type	Meaning
5-17	Not used		
18-25	A0	Double	Sec 20.3.3.5.1.8
26-29	A1 ΔtLS	Single S16	Sec 20.3.3.5.1.8 Sec 20.3.3.5.1.8
30-31	tot	Single	Sec 20.3.3.5.1.8
32-35	WNt	UINT16	Sec 20.3.3.5.1.8
36-37	WNLSF	UINT16	Sec 20.3.3.5.1.8
38-39	DN	UINT16	Sec 20.3.3.5.1.8
40-41	ΔtLSf	S16	Sec 20.3.3.5.1.8

Ephemeris data

Byte	Item	Type	Meaning
5	SV number UINT8 SV PRN number		
6-9	t_ephem	Single	Time of collection (note, if data is missing or invalid, t_ephem will be negative)
10-11	week number	UINT16	GPS week number 0 thru 1023
12	codeL2		Sec 20.3.3.3, Table 20-I

Byte	Item	Type	Meaning
13	L2Pdata		Sec 20.3.3.3, Table 20-I
14	SV accuracy raw	UINT8	Sec 20.3.3.3, Table 20-I
15	SV health	UINT8	Sec 20.3.3.3, Table 20-I
16-17	IODC	UINT16	Sec 20.3.3.3, Table 20-I
18-21	tGD	Single	Sec 20.3.3.3, Table 20-I
22-25	toc	Single	Sec 20.3.3.3, Table 20-I
26-29	af2	Single	Sec 20.3.3.3, Table 20-I
30-33	af1	Single	Sec 20.3.3.3, Table 20-I
34-37	afo	Single	Sec 20.3.3.3, Table 20-I
38-41	SV accuracy	Single	Sec 20.3.3.3, Table 20-I
42	IODE	UINT8	Sec 20.3.3.4
43	fit_interval	UINT8	Sec 20.3.3.4
44-47	Crs	Single	Sec 20.3.3.4
48-51	Δn	Single	Sec 20.3.3.4
52-59	M0	Double	Sec 20.3.3.4
60-63	Cuc	Single	Sec 20.3.3.4, radians
64-71	e	Double	Sec 20.3.3.4
72-75	CUS	Single	Sec 20.3.3.4, radians
76-83	sqrt(A)	Double	Sec 20.3.3.4
84-87	toe	Single	Sec 20.3.3.4
88-91	Cic	Single	Sec 20.3.3.4
92-99	OMEGA_0	Double	Sec 20.3.3.4
100-103	Cis	Single	Sec 20.3.3.4
104-111	io	Double	Sec 20.3.3.4
112-115	Crc	Single	Sec 20.3.3.4
116-123	OMEGA	Double	Sec 20.3.3.4

Byte	Item	Type	Meaning
124-127	OMEGADOT	Single	Sec 20.3.3.4
128-131	IDOT	Single	Sec 20.3.3.4
132-139	Axis	Double	= $(sqrt\_A)^2$
140-147	n	Double	derived from delta_n
148-155	r1me2	Double	= sqrt $(1.0\text{-}e^2)$
156-163	OMEGA_n	Double	derived from OMEGA_0, OMEGADOT
163-171	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 GNSS 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	Description
0	Operation	BYTE	3 6	Request enable or disable status on byte 1 selection Request heed or ignore health on byte 1 selection

Byte	Item	Type	Value	Description
1	SV Type	BYTE	1 then 1-32	GPS
			2 then 65-96	GLONASS
			3 then 201-237	BeiDou
			4 then 97-133	Galileo
			5 then 193-1956 then 33-54	QZSS SBAS
2~38	SVID	BYTE	1 byte per SV (depends on byte 0 value)	
			0	Enable SV selection or head SV health
			1	Disable SV selection or ignore SV health

Report packet 0x5A: Raw Data Measurement Data

This packet provides raw GNSS measurement data. If the packet 0x35 auxiliary option byte bit 1 is set, this packet is sent automatically as measurements are taken.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x5A	
1	SV PRN #	SINGLE		
2-5	Sample length	SINGLE	milliseconds	
6-9	Signal level	SINGLE	dB-Hz	
10-13	Code phase	SINGLE	1/16th chip	
14-17	Doppler	SINGLE	Hertz @ L1	
18-25	Time of measurement	DOUBLE	seconds	

NOTE - The sample length is the number of milliseconds over which the sample was averaged.

NOTE - The code phase 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.

Signal level

The Signal Level (byte 6) is a linear approximation of C/N0 which is stated in antenna amplitude measurement units (AMUs), a Protempis 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 10) 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 14) 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 18) 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 (GPS only)

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	Packet ID	U8	0x5B
1	Satellite PRN number	Byte	
2-5	Time of Collection	Single	seconds
6	Health	Byte	
7	IODE	Byte	
8-11	toe	Single	seconds
12	Fit Interval Flag	Byte	
13-16	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 0x5D: Satellite Tracking Status

The receiver sends this packet in response to command packet 0x3C.

Byte	Bit	Item	Type	Value	Description
0		Packet ID	UINT8	0x5D	
1		SV PRN number	UINT8		See table in 0x3C description
2		Channel number	UINT8		Channel number minus 1
3		Acquisition flag	UINT8	0 1 2	Never acquired Acquired Re-opened search
4		SV used in Position or Time calculation	UINT8	0 1	Not Used Used
5-8		Signal level	SINGLE		dB-Hz
9-12		Time of last measurement	SINGLE	seconds	GPS TOW
13-16		Elevation angle	SINGLE	radians	

Byte	Bit	Item	Type	Value	Description
17-20		Azimuth angle	SINGLE	radians	
21		Old measurement flag	UINT8	0 >0	Flag not set Measurement is old
22		Integer msec flag	UINT8	0 1 2 3 4	Don't know msec Known from subframe Verified by bit crossing Verified by good fix Suspect msec error
23		Bad data flag	UINT8	0 1 2	Flag not set Bad parity Bad ephemeris health
24		Data collection flag	UINT8	0 >0	Flag not set Collection in progress
25		Used flags	Bit field	Bit 0 Bit 1 Bit 2-7	Satellite used in timing fix Satellite used in position fix Reserved
26		SV Type	UINT8	0 1 2 3 4 5 6 7	GPS GLONASS BeiDou Galileo Reserved QZSS Reserved Reserved

Report packet 0x6C: All-in-View Satelite selection

This packet provides a list of satellites used for position or time-only fixes by the GNSS receiver. The packet also provides the PDOP, HDOP, VDOP and TDOP of that set and provides the current mode (automatic or manual, 3D or 2D, overdetermined clock, etc.) This packet has variable length equal to 17+nsvs where **nsvs** is the number of satellites used in the solution.

The GNSS receiver sends this packet in response to packet 0x24 when the selection list is updated. If enabled with packet 8E-A5, the receiver will send this packet whenever the selection is updated. The data format is shown below.

Byte	Bit	Item	Type	Value	Description
0		Packet ID	UINT8	0x6C	

Byte	Bit	Item	Type	Value	Description
1	0-2	Fix dimension	Bit field		
				3	2D fix
				4	3D fix
				5	OD clock fix
	3	Fix mode	Bit field	0	Auto
				1	Manual
2-5		PDOP	SINGLE		PDOP
6-9		HDOP	SINGLE		HDOP
10-13		VDOP	SINGLE		VDOP
14-17		TDOP	SINGLE		TDOP
18		No. of SVs in fix	UINT8		Count
19-n		SV PRN	UINT8	(1-224)	

Report packet 0x7B: Set NMEA Message Output

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

Report packet 0x83: Double Precision XYZ

This packet provides current GNSS position fix in XYZ ECEF coordinates. If the I/O “position” option is set to “XYZ ECEF” and the I/O double position option is selected, the receiver sends this packet each time a fix is computed.

Byte	Item	Type	Units
0	Packet ID		0x83
1-8	X	DOUBLE	meters
9-16	Y	DOUBLE	meters
17-24	Z	DOUBLE	meters
25-32	clock bias	DOUBLE	meters
33-36	time-of-fix	SINGLE	seconds

NOTE - The time-of-fix is in GPS, GLONASS or UTC time, as selected by the I/O “timing” option. 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 GNSS position fix in LLA coordinates. If the I/O “position” option is set to “LLA” and the double position option is selected (see packet 0x35), the receiver sends this packet each time a fix is computed.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x84	
1-8	latitude	DOUBLE	radians	
9-16	longituda	DOUBLE	radians	+ for north, - for south
17-24	altitude	DOUBLE	meters	+ for east, - for west
25-32	clock bias	DOUBLE	meters	
33-36	time-of-fix	SINGLE	seconds	

NOTE - The time-of-fix is in GPS, GLONASS, or UTC time, as selected by the I/O “timing” option.

CAUTION - When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant p (PI). The value of the constant PI as specified in ICDGPS-200 is 3.1415926535898.

NVS Configuration (0x91-02)

Use TSIP packet 0x91-02 to set the NVS(Non-volatile storage) configuration. User can save the current configuration in the internal flash memory.

NOTE - To start up the user configuration from power cycles, please use TSIP packet to save the user configuration.

Set

Byte	Item	Type	Value	Description
0	Start Byte	UINT8	0x10	Start of packet
1	Packet ID	UINT8	0x91	Packet ID
2	Subpacket ID	UINT8	0x02	Subpacket ID
3-4	Length	UINT16	Any	Total length of mode + data + checksum

Byte	Item	Type	Value	Description
5	Mode	UINT8	1	1: Set
6	Save User Config to NVS	UINT8	0-1	1: Save user config to NVS
7-10	Reserved	UINT32	Any	
11	Checksum	UINT8	Any	
12	Delimiter 1	UINT8	0x10	End of packet 1
13	Delimiter 2	UINT8	0x03	End of packet 2

Response

Byte	Item	Type	Value	Description
0	Start Byte	UINT8	0x10	Start of packet
1	Packet ID	UINT8	0x91	Packet ID
2	Subpacket ID	UINT8	0x02	Subpacket ID
3-4	Length	UINT16	Any	Total length of mode + data + checksum
5	Mode	UINT8	2	2: Response
6	Save User Config Status	UINT8	0-1	0: Save failed 1: User config save successful
7-10	Reserved	UINT32	Any	
12	Checksum	UINT8	Any	
13	Delimiter 1	UINT8	0x10	End of packet 1
14	Delimiter 2	UINT8	0x03	End of packet 2

Command packet 0xBB: Set Receiver Configuration

In query mode, packet 0xBB is sent with a single data byte and returns report packet 0xBB in the format shown below.

Data Format (Query Only)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0xBB	
1	Subpacket ID	UINT8	0x00	Query mode

TSIP packet 0xBB is used to set the GNSS Processing options. The table below lists the individual fields within the 0xBB packet.

Byte	Item	Type	Value	Description	Default
0	Packet ID	UINT8	0xBB		
1	Subpacket ID	UINT8	0x00	Receiver configuration block	
2	Receiver mode	UINT8	0 1 3 4 5 6 7	Automatic Time only (1SV) Horizontal (2D) Full position (3D) Reserved Reserved Over-determined clock	#0
3	Reserved	UINT8		N/A	
4	Reserved	UINT8		N/A	
5	Reserved	UINT8		N/A	
6-9	Elevation mask	SINGLE	0- π/2	Lowest satellite elevation for fixes	0 degrees
10-13	AMU Mask	SINGLE	0-55	Minimum signal level for fixes	4.0
14-17	PDOP mask	SINGLE		Maximum PDOP for position fixes, only active during self-survey and in PVT mode	6
18-21	PDOP switch	SINGLE		***Unused, value ignored***	
22	Reserved	UINT8		N/A	
23	Anti-Jam Mode	UINT8	0 1	Disabled Enabled	 1
24-25	Reserved	UINT8		N/A	
26	Measurement rate	UINT8	0	1 Hertz	1Hz
27	Position Fix rate	UINT8	0	1 Hertz	1Hz

Byte	Item	Type	Value	Description	Default
28	Constellation	Bit	0 1 2 3 4 5 6 7	GPS GLONASS Reserved BeiDou Galileo QZSS Reserved Reserved	
29-40	Reserved	UINT8		N/A	

NOTE - Byte 28 is used for enabling/disabling use of a constellation. For GPS only mode the 1st bit position is set to 1 (0001), for GLONASS only mode the 2nd bit position is set to 1 (e.g., 0010) and for GPS & GLONASS mode both 1st and 2nd bits are set to 1 (0011).

NOTE - The only limitation on satellite selection is that both GLONASS and BeiDou cannot be enabled at the same time. If they are both enabled then the unit will disable BeiDou and use GLONASS only.

CAUTION - The operation of the Acutime 360 antenna can be affected adversely if incorrect data is entered in the fields associated with packet 0xBB.

NOTE - When sending packet 0xBB, fields that are specified as “N/A” or if you do not want to alter a specified field, send a value of 0xFF for UINT8 types and a value of -1.0 for floating point types. The Acutime 360 antennawill ignore these values.

Command packet 0xBC: Set Port Configuration

TSIP packet 0xBC is used to set and query the port characteristics. In query mode, packet 0xBC is sent with a single data byte and returns report packet 0xBC.

NOTE - The input and output baud rates must be the same.

Command packet 0xBC Data Format (Query Mode)

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0xBC	
1	Port Number	UINT8	0 1 FF	Port Port B Current port

The table below lists the individual fields within the packet 0xBC when used in the set mode and when read in the query mode.

Command and Report packet 0xBC Field Data Format

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0xBC	
1	Port to Change	UINT8	0 1 0xFF	Port Port B Current port
2	Input Baud Rate	UINT8	6 7 8 9 10 11	4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud
3	Output Baud Rate	UINT8	As above	As above
4	# Data bits	UINT8	2 3	7 bits 8 bits
5	Parity	UINT8	0 1 2	None Odd Even
6	# Stop bits	UINT8	0 1	1 bit 2 bits
7	Flow Control	UINT8	0	
8	Input Protocols	UINT8	 2 4	 TSIP NMEA
9	Output Protocols	UINT8	 2 4	 TSIP NMEA
10	Reserved	UINT8	0	

TSIP superpackets

Several packets have been added to the core TSIP protocol to provide additional capability for the receivers. In packets 0x8E and their 0x8F responses, the first data byte is a subcode which indicates the superpacket type. For example, in packet 0x8E-A6, A6 is the subcode that indicates the superpacket type. Therefore the ID code for these packets is 2 bytes long followed by the data.

Command packet 0x8E-02: Request UTC Information

This packet allows the user to query UTC Information. The module responds to a query with packet 0x8F-02

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	8E	
1	Subpacket ID	UNIT8	02	
2	Type of data	UNIT8	01 02 03	GPS BeiDou Galileo

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-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, a 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	Units
0	Packet ID	UINT8	0x8E
1	Subpacket ID	BYTE	0x20
2	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: Set or Request I/O Options, page 63. This packet must also be enabled with packet 0x8E-A5.

Command packet 0x8E-26: Write Receiver Configuration to Non-volatile Memory (Flash)

This command packet causes the current configuration settings to be written to non-volatile storage. This packet contains only a single byte: the sub-packet ID. Upon receiving the command, the receiver will write the configuration and send a report packet 0x8F-26 when the operation is completed. It typically takes about one second to write the user configuration.

CAUTION – If the user application needs to power down the receiver after issuing this command, it must wait until 0x8F-26 report packet is received.

Command packet 0x8E-41: Request Manufacturing Parameters

This packet is used to request the manufacturing parameters stored in non-volatile memory. Send this packet with no data (don't forget the subpacket ID) to request packet 0x8F-41.

Command packet 0x8E-42: Stored Production Parameters

This packet is used to request the production parameters stored in non-volatile memory. Send this packet with no data (don't forget the subpacket ID) to request packet 0x8F-42.

Command packet 0x8E-4A: Set PPS characteristics

This packet allows you to query (by sending the packet with no data bytes) or set Acutime 360 antenna PPS characteristics. Acutime 360 antenna responds to a query or set command with packet 0x8F-4A.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subcode	UINT8	0x4A	Always
2	PPS driver switch	UINT8	0 1	off on
3	Reserved	UINT8		Reserved
4	PPS polarity	UINT8	0 1	positive negative
5-12	PPS offset of cable delay (see note)	DOUBLE		seconds
13-16	Reserved			Reserved

NOTE – Negative offset values advance the PPS, and are normally used to compensate for cable delay

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.

Bit	Output packet	Default A2K	When output	Description
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.
23	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	6D, 46, 4B, 82	1	Constellation	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 listed in Table A-52. The current driver switch value can be requested by sending the packet with no data bytes except the subcode byte.The response packet is 0x8F-4E.

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

The Acutime 360 smart antenna can also be configured to generate an Even Second pulse in place of the PPS pulse by setting the value as shown in the table below.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
0	Subpacket ID	UINT8	0x4E	
1	PPS Driver Switch	UINT8	2	PPS is always on. PPS is generated every second.
			3	PPS is output when at least one satellite is tracking. PPS is generated every second.
			4	PPS is output when at least three satellites are tracking. PPS is generated every second.
			130	PPS is always on. PPS is generated every even second PPS is output when at least one satellite is tracking. PPS is generated every even second.
			131	PPS is output when at least three satellites are tracking.
			132	PPS is generated every even second

Command packet 0x8E-4F: Set PPS width

This command packet sets the PPS width to a value in the range of 10 milliseconds 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 subpacket byte.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subcode	UINT8	0x4F	
2-9	PPS width	UINT16		seconds

Command packet 0x8E-A2: UTC/GNSS Timing

This command packet sets the UTC/GNSS timing mode (time and data fields) in packet 0x8F-AB, and the temporal location of the Acutime 360 antenna output PPS. Send packet 0x8E-A2 with no data to request the current settings. The Acutime 360 antenna replies with response packet 0x8F-A2.

Byte	Item	Type	Bit	Value	Description
0	Packet ID	UINT8		0x8E	
1	Subpacket ID	UINT8		0xA2	Subpacket ID
2	Time Flag	Bit field	0	0 1	GPS time (Default) UTC or GNSS time
			1	0 1	GPS PPS (Default) UTC or GNSS PPS
			2		Reserved
			3		Reserved
			4-5	0 1 2 3	UTC (USNO) time GLONASS time BeiDou time Galileo time
			6-7	0 1 2 3	UTC (USNO) PPS GLONASS PPS BeiDou PPS Galileo PPS

Command packet 0x8E-A5: Packet Broadcast Mask

Use command packet 0x8E-A5 to set the packet broadcast masks or to request the current mask settings. The Acutime 360 antenna replies to request with response packet 0x8F-A5. The broadcast mask is bitwise encoded to enable turning on and off the broadcast of certain packets.

For those broadcast packets that have multiple format, the Acutime 360 antenna 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 masked on will be sent and the rest will not.

For each bit in the mask that is used, the coding is as follows:

0: Turn off broadcast of this packet

1: Turn on broadcast of this packet

Byte	Item	Type	Bit	Value	Description
0	Subpacket ID	UINT8		0xA5	Subpacket ID

Byte	Item	Type	Bit	Value	Description
1-2	Mask 0	Bit field	0	1	8F-20 on Port B
			1	0	Reserved
			2	0	Reserved
			3	0	Reserved
			4	0	Reserved
			5	1	Enable auto TSIP outputs
	0x8F-AB		6	0	0x8F-AB Primary timing packet output
	0x8F-AC		7	0	0x8F-AC Supplemental timing packet output
	0x8F-0B		8	0	Synchronous 0x8F-0B (1Hz) on Port A
	0x8F-0B		9	1	Event output of 0x8F-0B on Port A
	0x8F-0B		10	0	Event output of 0x8F-0B on Port B
	0x8F-AD		11	0	Synchronous 0x8F-0B (1Hz) on Port B
	0x8F-AD		12	1	Synchronous 0x8F-AD (1Hz) on Port A
	0x8F-AD		13	1	Event output of 0x8F-AD on Port A
	0x8F-AD		14		Event output of 0x8F-AD on Port B
	0x8F-AD		15		Synchronous 0x8F-AD (1Hz) on Port B
3-4	Mask 2	Bit field			Reserved

Command packet 0x8E-A6: Self-Survey Command

Use command packet 8E-A6 to issue a self-survey command, to save the current position in flash or to delete the position saved in flash. The GNSS receiver returns report packet 0x8F-A6, which indicates the result of the requested operation.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA6	
2	Self-survey command	UINT8	0 1 2	Restart self-survey Save position to Flash Delete position from Flash

Command packet 0x8E-A9: Self-Survey parameters

Use command packet 8E-A9 to set the self-survey parameters or to request the current settings. The Acutime 360 replies to requests with response packet 8F-A9.

Data fields

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

  0: Disable the self-survey mechanism

  1: Enable the self-survey mechanism

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

  0: Don't automatically save the surveyed position when the self-survey is complete.

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

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

  Limits: 1 to (2^{32} - 1) fixes

- **Uncertainty threshold**. An index from 1 to 100. The smaller the number the higher degree of certainty of the self-survey fix will be used to fix the position of the unit for OD mode. Depending on the constellation and position of the satellites a small index number can lead to survey times of many hours as the unit may only qualify a small rate of fixes to complete the designated survey length (default 2000).

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0xA9	
1	Self-Survey Enable	UINT8	0 1	Disabled Enabled
2	Position Save Flag	UINT8	0 1	Don't save position Save self-surveyed position at the end of the survey
3-6	Self-Survey Length	UINT32	see above	Number of fixes
7-10	Horizontal Uncertainty	Float	>0<=100	Horizontal position uncertainty. Default: 100
11-14	Vertical Uncertainty	Float	>0<=100	Vertical position uncertainty. Default: 100

Command packet 0x8E-AB: Request Primary Timing packet

Use this command packet to request the Primary Timing packet 0x8F-AB. By default, the Acutime 360 antenna automatically sends packet 0x8F-AB once per second so it is not

necessary to request it. To receive 0x8F-AB information by request only, use packet 0x8E-A5 to disable the automatic output.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xAB	
2	Request Type	UINT8	0 1 2	Send 0x8F-AB immediately Send 0x8F-AB on-time next second Send 0x8F-AB and 0x8F-AC on-time next second

The Request Type item determines how the Acutime 360 antenna will reply to this command:

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

Command packet 0x8E-AC: Request Supplemental Timing packet

Use command packet 0x8E-AC to request the Supplemental Timing packet 0x8F-AC. By default, the Acutime 360 antenna automatically sends packet 0x8F-AC once per second so it is not necessary to request it. To receive 0x8F-AC information by request only, use packet 0x8E-A5 to disable the automatic output.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xAC	
2	Request Type	UINT8	0 1 2	Send 0x8F-AC immediately Send 0x8F-AC on-time next second Send 0x8F-AB and 0x8F-AC on-time next second

The Request Type item determines how the Acutime 360 antenna will reply to this command:

Type	Description
0	The most current primary timing values will be sent in packet 0x8F-AC immediately.

Type	Description
1	The response is not sent immediately. Instead packet 0x8F-AC is sent after the next PPS output. This is the same time that the packet would be automatically sent if enabled.
2	Same as type 1 except that both 0x8F-AB and 0x8F-AC are sent after the next PPS output.

Command packet 0x8E-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	Description
0	Subcode	Byte	AD	Required	Superpacket ID
1	Flag	Byte	0	3	Disable packet output on port A
			1		Output packet on port A only at PPS
			2		Output packet on port A only at event input
			3		Output at both event input and PPS

Report packet 0x8F-02: UTC information

This packet is sent in response to 0x8E-02.

Byte	Item	Type	Value	GPS	BeiDou	Galileo
0	Packet ID	UINT8	8F			
1	Subpacket ID	UINT8	02			
2	Constellation	UINT8		1	2	3
3-10	A_0	Double				
11-14	A_1	Single				
21-22	WN_t	UINT16			NA / 0	
23-24	WN_LSF	UINT16			NA / 0	

Byte	Item	Type	Value	GPS	BeiDou	Galileo
25-26	DN	UINT16				
27-28	Delta_t_LSF	SINT16				

Report packet 0x8F-0B: Comprehensive Time

The output of the packet is synchronized with the PPS. 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	Units
0	Packet ID	UINT8	
1	Subpacket ID	UINT8	Subcode 0x0B
2-3	Event Count	INTEGER	Zero for PPS.
4 -11	UTC/GPS TOW	DOUBLE	UTC/GPS time of week (seconds)
12	Date	BYTE	Date of PPS or event
13	Month	BYTE	Month of PPS or event
14 -15	Year	INTEGER	Year of PPS or event
16	Receiver Mode	BYTE	Receiver operating dimensions 0: Horizontal (2D) 1: Full Position (3D) 2: Single Satellite (OD) 3: Automatic (2D/3D) 4: N/A 5: Clock hold (2D) 6: OD clock mode (default)
17-18	UTC Offset	INTEGER	UTC offset value (seconds)
19-26	Reserved	DOUBLE	Reserved
27-34	Reserved	DOUBLE	Reserved
35-38	Reserved	SINGLE	Reserved
39-42	Reserved	SINGLE	Reserved
43-50	Latitude	DOUBLE	Latitude in radians
51-58	Longitude	DOUBLE	Longitude in radians
59-66	Altitude	DOUBLE	Altitude according to current datum, meters

Byte	Item	Type	Units
67-74	Satellite ID	8 BYTES	Identification numbers of tracking and usable satellites

Bytes 67 through 74 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 cannot 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.

NOTE- The information reported in the 0x8F-0B message relates to only the GPS constellation. This message should no longer be used and considered obsolete for future projects.

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

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	Description
0	Subpacket ID	Byte	ID for this subpacket (always 0x20)
1	Key Byte	Byte	N/A
2-3	east velocity	Integer	Units 0.005m/s or 0.020m/s (see Byte 24). Overflow =0x8000
4 -5	north velocity	Integer	Units 0.005m/s or 0.020m/s (see Byte 24). Overflow =0x8000

Byte	Item	Type	Description
6-7	up velocity	Integer	Units 0.005m/s or 0.020m/s (see Byte 24). Overflow = 0x8000
8-11	Time of Week	Unsigned long	GPS Time in milliseconds
12-15	Latitude	Long integer	Latitude, units = 2^31 semicircle, according to current datum. Range = -2^30 to 2^32
16-19	Longitude	Unsigned long	Longitude east of meridian, units = 2^31 semicircle, according to current datum. Range = 0 to 2^32
20-23	Altitude	Long integer	Altitude above ellipsoid, mm, according current datum.
24	Velocity scaling		When bit 0 is set to 1, velocities in bytes 2-7 have been scaled by 4
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 SV used for fix. 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)

Byte	Item	Type	Description
32-115	Fix SVs	Fix SVs	Repeated groups of 2 bytes, one for each satellite. The bytes are 0 if group N/A.
	Byte 0: PRNX	Byte	Satellite number and IODC-IODE. PRN = lower six bits of PRNX
	Byte 1: IODE	Byte	IODC = (PRNX/64)x256 + IODE
116-123	Iono Param	8 Bytes	The broadcast ionospheric parameters

Report packet 0x8F-26: Save Receiver Configuration to Non-volatile Storage Memory

This packet is returned in response to save configuration to flash memory packet 0x8F-26.

The packet indicates whether the receiver configuration has been successfully saved to non-volatile memory.

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0x26	Packet subpacket
1-4	Status	UINT32	0 1	successfully stored receiver failed to store receiver configuration

Report packet 0x8F-41: Stored manufacturing operating parameters

This packet is sent in response to a command 0x8E-41.

Byte	Item	Type	Value/Unit
0	Packet ID	UINT8	0x8F
1	Subpacket ID	UINT8	0x41
2-3	Board serial number prefix	UINT16	
4-7	Board serial number	UINT32	
8	Year of build	UINT8	
9	Month of build	UINT8	
10	Day of build	UINT8	
11	Hour of build	UINT8	
12-15	Reserved	SINGLE	
16-17	Reserved	UINT16	

Report packet 0x8F-42: Stored Production parameters

This packet is sent in response to 0x8E-42.

Byte	Item	Type	Value/Unit
0	Packet ID	UINT8	0x8F
1	Subpacket ID	UINT8	0x42
2	Production options prefix	UINT8	
3	Production number extension	UINT8	
4-5	Case serial number prefix	UINT16	
6-9	Case serial number	UINT32	
10-13	Production number	UINT32	
14-15	Reserved	UINT16	
16-17	Machine identification number	UINT16	
18-19	Reserved	UINT16	

Report packet 0x8F-4A: Set PPS characteristics

This packet is sent in response to a query by packet 0x8E-4A. See the corresponding command packet for information about the data format.

Byte	Item	Type	Units
0	Packet ID	UINT8	0x8F
1	Subpacket ID	Byte	0x42
2	PPS Driver Switch	Byte	0: Off 1: On
3	Time Base	Byte	0: GPS 1: UTC (default)
4	PPS Polarity	Byte	0: Positive (default) 1: Negative
5-12	PPS Offset or Cable Delay	Double	Seconds
13-16	Reserved		Reserved

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	Packet ID	UINT8	0x8F
1	Subpacket ID	Byte	ID for this sub-packet is always 0x4D
2-5	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 packet	When output	Meaning
0	0x40	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		Almanac health page collected from satellite
6			Reserved
7			Reserved
8	0x41	New Fix	Partial & full fix complete and packet output timer has expired
9			Reserved
10			Reserved
11	0x6C	Constellation change	New satellite selection
12			Reserved
13-29			Reserved

Bit	Output packet	When output	Meaning
30	4A, 8F-20, 42, 43, 54, 56, 83, 84	New fix update	
31[1]	0x5A	New Fix	

[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: PPS output

This report packet is output after the command packet 0x8E-4E has been executed. See the corresponding command packet for information about the data format.

Report packet 0x8F-4F: PPS width

This report packet is output after the command packet 0x8E-4F has been executed. See Report Packet 0x8F-4A: PPS Characteristics.

Report packet 0x8F-A2: UTC/GPS Timing

This packet is sent in response to command packet 0x8E-A2. See the corresponding command packet for information about the data format.

Report packet 0x8F-A5: Packet Broadcast Mask

This packet is sent in response to 0x8E-A5 command and describes which packets are currently automatically broadcast. A '0' in a bit field turns off broadcast, and a '1' in a bit field enables broadcast. See the corresponding command packet for information about the data format.

Report packet 0x8F-A6: Self-Survey Command

This packet is sent in response to command packet 0x8E-A6. The packet indicates the result of the requested self-survey operation.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8F	
1	Sub-code	UINT8	0xA6	Packet sub-code
2		UINT8	0 1 2	Restart self-survey Save position to Flash memory Delete position from Flash memory
3	Status	UINT8	0 1	Requested command successful Requested command failed

Report packet 0x8F-A9: Self-Survey Parameters

Packet 0x8F-A9 is sent in response to command packet 0x8E-A9 and describes the current self-survey parameters. See the corresponding command packet for information about the data format.

Report packet 0x8F-AB: Primary Timing Packet

This 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, data and time-of-delay (TOD) information is provided. This packet can be requested with packet 0x8E-AB. If enabled, this packet will begin transmission within 30 ms after the PPS pulse to which it refers.

Byte	Item	Type	Bit	Value	Description
0	Packet ID	UINT8		0x8F	
1	Subpacket ID	UNIT8		0xAB	
2-5	Time of week	UINT32			GPS seconds of week or from 0x8E-A2 time selection
6-7	Week Number	UINT16			GPS Week Number or from 0x8E-A2 time selection
8-9	UTC Offset	SINT16			UTC Offset (seconds) from chosen constellation time reference. Always = 0 when GLONASS time is selected.
10	Time Flag	Bit field	0	0 1	GPS time (Default) UTC or GNSS time
			1	0 1	GPS PPS (Default) UTC or GNSS PPS
			2	0 1	Time is set Time is not set
			3	0 1	Have UTC info No UTC info
			4-5	0 1 2 3	UTC time GLONASS time BeiDou time Galileo time
			6-7	0 1 2 3	UTC PPS GLONASS PPS BeiDou PPS Galileo PPS

Byte	Item	Type	Bit	Value	Description
11	Seconds	UINT8	0-59		Seconds
12	Minutes	UINT8	0-59		Minutes
13	Hours	UINT8	0-23		Hours
14	Day of Month	UINT8	1-31		Day of Month
15	Month	UINT8	1-12		Month of Year
16-17	Year	UINT16			Four digits of Year

Data Field	Description
Time of Week	This field represents the number of seconds since Sunday at 00:00:00 GPS, GLONASS and Galileo time for the current week. For BeiDou it is for the number of seconds since Monday at 00:00:00. Time of week is often abbreviated as TOW.
Week Number	This field represents the current GNSS week number.
UTC Offset *	UTC (USNO) offset = GPS time - UTC (USNO) time UTC (INRIM) offset = Galileo time - UTC (INRIM) time UTC (NTSC) offset = BeiDou time - UTC (NTSC) time UTC (SU) offset = 0

Data Field	Description
Timing Flags	This field is bitwise encoded to provide information about the timing outputs. Unused bits should be ignored. Bit 0: 0 – the date and time fields broadcast in packet 8F-AB (Primary Timing Message) are in the GPS time scale 1 – these fields are in the UTC time scale and are adjusted for leap seconds Use command packet 8E-A2 to select either GPS or UTC time scales. Bit 1: 0 – the PPS output is aligned to GPS. 1 – the PPS output is aligned to UTC. Use command packet 8E-A2 to select either GPS or UTC PPS alignment. Bit 2: 0 – time has been set. 1 – time has not yet been set Bit 3: 0 – UTC offset information has been received 1 – UTC offset information is not yet known Bit 4: 0 – time is coming from GPS/UTC 1 – the Acutime 360 antenna time is coming from GLONASS Bit 5: 0 – PPS output is aligned to GPS/UTC 1 – the PPS output is aligned to GLONASS
Time of Day	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 occur. In this case the time will transition from 23:59:59 to 23:59:60 to 00:00:00.
Date	The date is sent in day-month-year format.

*NOTE: Due to limitations in the GLONASS signal generation the unit will drop satellites during a leap second event if using GLONASS only.

Report packet 0x8F-AC: Supplemental Timing Packet

This packet provides supplemental timing information once per second. Information regarding position, unit status and health, and the operational state of the unit.This packet cannot be requested.

When enabled, this packet is transmitted once per seconds shortly after packet 0x8F-AB.

The position sent in packet 8F-AC depends on the Receiver Operating Mode and on self-survey activity. When a self-survey is in progress, the position sent is the running average of all of the position fixes collected so far. When the self-survey ends or whenever the receiver is using a time-only operating mode, then the position sent is the accurate 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	Description
0	Packet ID	UINT8	0x8F	
1	Subpacket ID	UINT8	0xAC	
2	Receiver Mode	UINT8	0 1 3 4 5 6 7	Automatic (2D/3D) Single Satellite (Time) Horizontal (2D) Full Position (3D) Not used Not used Over-determined Clock
3	Reserved	UINT8	Reserved	Reserved
4	Self-Survey Progress	UINT8	0-100%	Percent complete
5-8	Reserved	UINT32	0	Reserved
9-10	Reserved	UINT16	0	Reserved
11-12	Minor Alarms	UINT16	Bit field	Bit 0 :Not used Bit 1 : Antenna Open Bit 2 : Antenna shorted Bit 3 : Not tracking satellites Bit 4 :Not used Bit 5 : Survey-in progress Bit 6 : No stored position Bit 7 : Leap second pending * Bit 8 : In test mode Bit 9 : Position is questionable Bit 10 : Not used Bit 11 : Almanac not complete Bit 12 : PPS not generated
13	GNSS Decoding Status	UINT8	0x00 0x01 0x02 0x08 0x09 0x0A 0x0B 0x0C	Doing fixes Don’t have GPS time No Fix No usable satellites Only 1 usable satellite Only 2 usable satellites Only 3 usable satellites The chosen satellite is unusable
14	Reserved	UINT8	Reserved	Reserved
15	PPS indication	UINT8	0 1	PPS Good indication PPS Not Good indication

Byte	Item	Type	Value	Description
16	Reserved	UINT8		Reserved
17-20	PPS Offset	SINGLE		ns
21-24	Clock Offset	SINGLE		ppb
25-28	Reserved	UINT32		Reserved
29-32	Reserved	SINGLE		Reserved
33-36	Temperature	SINGLE		Degrees C
37-44	Latitude	DOUBLE		Radians
45-52	Longitude	DOUBLE		Radians
53-60	Altitude	DOUBLE		Meters
61-64	Reserved		0	Always 0
65-68	Reserved			Reserved

Data Field	Description
Receiver Mode	This field shows the fix mode that the GNSS receiver is currently configured for.
Self-Survey Progress	When a self-survey procedure is in progress, this field shows the progress of the survey as a percentage of fixes collected so far. The self-survey will be complete when the self-survey progress reaches 100%.

Data Field	Description
Minor Alarms	This field is bitwise encoded with several minor alarm indicators. A minor alarm indicates a condition that the user should be alerted to, but does not indicate an immediate (or necessarily any) impairment of functionality. For each bit, a value of 0 means that the condition is not indicated. Bits not described below should be ignored. A value of 1 indicates the following: Bit 1: The antenna input connection is open. More precisely, this bit indicates that the antenna input is not drawing sufficient current. Bit 2: The antenna input is shorted. More precisely, this bit indicates that the antenna input is drawing too much current. Bit 3: 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: A self-survey procedure is in progress. Bit 6: There is no accurate position stored in Flash ROM. Bit 7: The GNSS system has alerted theAcutime 360 antennathat a leap second transition is pending.* Bit 8: TheAcutime 360 antennais operating in one of its test modes. Bit 9: The accuracy of the position used for time only fixes is questionable.This alarm may indicate that the unit has been moved since the unit completed the last self-survey. If this alarm persists, resurvey the position of the unit. Bit 11: The Almanac is not current or complete. Bit 12: The PPS was not generated this second. This could mean there wasn't enough usable satellites to generate an accurate PPS output.It could also mean that the unit is generating an Even Second output (see Packet 8E-4E) and the unit did not output a PPS on the odd second.
GNSS Decoding Status	This field indicates the decoding status of theGNSSreceiver.
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".

Data Field	Description
PPS Indication	The "PPS good" indicator is composed of: 1. Unit has achieved a 'first fix'. 2. Unit has resolved the millisecond ambiguity. This is done with a proprietary algorithm. 3. The unit has at least one satellite that is has passed all Protempis proprietary timing integrity checks (TRAIM). These include, but are not limited to: • Satellite is in the constellation list of allowed timing sources • Satellite millisecond ambiguity has been established • Satellite signal strength is above the user setting for signal strength • Satellite elevation is above the elevation mask • Satellite tracking filter has settled 4. PPS has been generated for at least 4 seconds after GNSS system restart
Latitude	This field carries the latitude of the position being shown. The units are in radians and vary from -pi/2 to +pi/2. Negative values represent southern latitudes. Positive values represent northern latitudes.
Longitude	This field carries the longitude of the position being shown. The units are in radians and vary from -pi to +pi. Negative values represent western longitudes. Positive values represent eastern longitudes.
Altitude	This field carries the altitude of the position being shown. The units are in meters (WGS-84.)

*NOTE: Due to limitations in the GLONASS signal generation the unit will drop satellites during a leap second event if using GLONASS only.

Report packet 0x8F-AD: Primary UTC Time

The output of the 0x8F-AD packet is synchronized with the PPS. 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	Units
0	Packet ID	UINT8	0x8F
1	Subpacket ID	Byte	0xAD

Byte	Item	Type	Units
2-3	Event Count	Integer	Zero for PPS.
4-11	Fractional Second	Double	Time elapsed in current second (seconds)
12	Hour	Byte	UTC Hour
13	Minute	Byte	UTC Minute
14	Second	Byte	Second (0-59; 60 = leap)
15	Day	Byte	Date (1-31)
16	Month	Byte	Month (1-12)
17-18	Year	Integer	Year (4 digit)
19	Receiver Status	Byte	Tracking Status (see definition below)
20	UTC Flags	Byte	Leap Second Flags (see definition below)
21	Reserved	Byte	Contains 0xFF
22	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	Description
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

Flag value	Status	Description
6	BAD_1SV	Satellite is unusable
7	0SVs	No satellites usable
8	1SV	Only 1 satellite usable
9	2SVs	Only 2 satellites usable
10	3SVs	Only 3 satellites usable
11	NO_INTEGRITY	Invalid solution
12	DCORR_GEN	Differential corrections
13	OVERDET_CLK	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	Leap second date is not in the past
5	Leap Pending	24-hour warning
6	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 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

Unused or miscellaneous packets

Report packet 0x13: Unparsable packet

This packet is sent in response to a received packet that was unparsable. A packet is unparsable if the packet ID is not recognized or if the length or content of the packet is not correct for the packet ID.

Data format:

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x13	Packet ID of unparsable packet
1-N	Data	UINT8		Packet data bytes of unparsable packet

B

NMEA 0183 Protocol

This appendix provides a brief overview of the NMEA 0183 protocol, and describes both the standard and optional messages offered by the Acutime 360 antenna.

Introduction

The National Marine Electronics Association (NMEA) protocol is an industry standard data protocol which was developed for the marine industry.

NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. The NMEA 0183 protocol was originally established to allow marine navigation equipment to share information. 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 GNSS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The Acutime 360 antenna is available with firmware that supports a subset of the NMEA 0183 messages: GGA, GLL, GSA, GSV, RMC, VTC, and ZDA. For a nominal fee, Protempis can offer custom firmware with a different selection of messages to meet your application requirements.

For a complete copy of the NMEA 0183 standard, contact:

NMEA National Office

Seven Riggs Avenue, Severna Park, MD 21146

Phone: +1-410-975-9425 or 800-808-6632 (NMEA)

Fax: +1-410-975-9450

NMEA 0183 communication interface

The NMEA 0183 protocol allows a single source (talker) to transmit serial data over a single twisted wire pair to one or more receivers (listeners). The table below lists the standard characteristics of the NMEA 0183 data transmissions.

Signal	NMEA Standard
Baud rate	115 kbps
Data bits	8
Parity	None
Stop bits	1

NMEA 0183 message structure

The NMEA 0183 protocol covers a broad array of navigation data. This broad array of information is separated into discrete messages which convey a specific set of information. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to a GPS receiver like the Acutime 360. The NMEA message structure is described below.

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

Where:

$	Signifies the start of a message
ID	The talker identification is a two letter mnemonic which describes the source of the navigation information. The GP identification signifies a GPS source while GL will signify a GLONASS source. In the event that the information in the sentence is agnostic the ID will be GP.
MSG	The message identification is a three letter mnemonic which describes the message content and the number and order of the data fields.
,	Commas serve as delimiters for the data fields.
Dn	Each message contains multiple data fields (Dn) which are delimited by commas.
*	The asterisk serves as a checksum delimiter.
CS	The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR][LF]	The carriage return [CR] and line feed [LF] combination terminate the message.

NMEA-0183 messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the "$" and the [CR][LF]. The data field block, including delimiters, is limited to 74 characters or less.

Talker IDs

The message talker ID, which is the two characters immediately following the starting marker ($) in a standard NMEA message, describes the source of data in a particular message. Specifically, it indicates the GNSS constellation to which the data is applicable. The following table lists talker IDs.

Talker ID	Constellation	Description
GN	ALL	Data combines all supported and enabled constellations on a given device.
GP	GPS	Data from GPS
BD	BEIDOU	Data from BEIDOU
GA	GALILEO	Data from GALILEO
GL	GLONASS	Data from GLONASS

Field definitions

Many of the NMEA date fields are of variable length, and the user should always use the comma delineators to parse the NMEA message date field. The following table specifies the definitions of all field types in the NMEA messages supported by Protempis:

Type	Symbol	Definition
Status	A	Single character field: A=Yes, data valid, warning flag clear V=No, data invalid, warning flag set.
Special Format Fields		
Latitude	llll.lll	Fixed/variable length field: Degreesminutes.decimal-2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeroes always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal- fraction are optional if full resolution is not required.

Type	Symbol	Definition
Longitude	yyyyy.yyy	Fixed/Variable length field: Degreesminutes.decimal-3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeroes always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal- fraction are optional if full resolution is not required.
Time	hhmmss.ss	Fixed/Variable length field: hoursminutesseconds.decimal-2 fixed digits of minutes, 2 fixed digits of seconds and a variable number of digits for decimal-fraction of seconds. Leading zeroes always included for hours, minutes, and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Defined		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following, that are used to indicated field types within this standard: "A", "a", "c", "hh", "hhmmss.ss", "llll.ll", "x", "yyyyy.yy".
Numeric Value fields		
Variable	x.x	Variable length integer or floating numeric field. Optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required (example: 73.10=73.1=073.1=73).
Fixed HEX	hh	Fixed length HEX numbers only, MSB on the left.
Information fields		
Fixed Alpha	aa	Fixed length field of upper-case or lower-case alpha characters.
Fixed Number	xx	Fixed length field of numeric characters.

NOTE -

- Spaces are only to be used in variable text fields.
- Units of measure fields are appropriate characters from the **Symbol** column, unless a specified unit of measure is indicated.

- Fixed length field definitions show the actual number of characters. For example, a field defined to have a fixed length of 5 HEX characters is represented as hhhhh between delimiters in a sentence definition.

NMEA 0183 message options

The Acutime 360 antenna can output any or all of the messages listed in the table below. In its default configuration (as shipped from the factory), the Acutime 360 antenna outputs only TSIP messages. Typically, NMEA messages are output at a one second interval with the "GP" talker ID and checksums. These messages are output at all times during operation, with or without a fix. If a different set of messages has been selected (using Packet 0x7A), and this setting has been stored in flash memory (using Packet 0x8E-26), the default messages are permanently replaced until the receiver is returned to the factory default settings. If a different set of messages has been selected (using Packet 0x91-13), and this setting has been stored in flash memory (using Packet 0x91-02), the default messages are permanently replaced until the receiver is returned to the factory default settings.

NOTE – You can configure a custom mix of the messages listed in the following table.

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

Message	Description
GGA	GPS fix data
GLL	Geographic position Latitude/Longitude
GSA	GPS DOP and active satellites
GSV	GPS satellites in view
RMC	Recommended minimum specific GPS/Transit data
VTG	Track made good and ground speed
ZDA	Time and date

Acutime 360 antenna proprietary NMEA messages

Message	Description
AH	Query or set almanac health
AL	Query or set almanac data for a specific satellite
AS	Query or set almanac status
BA	Query and response to antenna status

Message	Description
CR	Query or set GPS receiver configuration information.
EM	Set receiver into Monitor Mode. Set only.
EP	Query or set ephemeris data for a specific satellite.
IO	Query or set ionosphere data.
KG	Set initial position and time info data for to aid navigation startup.
NM	Query or set NMEA automatic message output control.
PS	Query or set PPS configuration.
PT	Query or set serial port configuration.
RT	Set Reset Type (cold)
TF	Query or set receiver status and position fix information.
UT	Query or set UTC data
VR	Query and response to version information
ZD	Extended Time and Date

NMEA 0183 message formats

GGA - GPS Fix Data

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

$
aa
GGA,hhmmss.s,llll.lllx,d,yyyyy.yyyx,d,q,s,xh.hx,xaaaaa,**M**,xggg,**M**,xxx,xxxx*hh<CR><LF>

Field	Description
aa	Talker ID
hhmmss.s	Hours, minutes, seconds, sub-seconds of position in UTC.
llll.lllx	Latitude
d	N | S
yyyy,yyyx	Longitude
d	E | W

Field	Description
q	Quality indicator (see Section 3.1 for more info): 0 = fix not available 1 = autonomous GNSS mode, fix valid 2 = differential/SBAS-aided GNSS mode, fix valid 4 = RTK (fixed) or RTX 5 = RTK (float) 6 = estimated/dead reckoning mode (DR)
s	Number of satellites in use
xh.hx	HDOP
xaaaaa	Antenna altitude, meters MSL
xggg	Geoidal separation, meters. This is the difference between the earth ellipsoid and mean-sea-level (geoid) defined by the reference datum used in the position solution. A negative value indicates the mean-sea-level is below ellipsoid.
xxx	Age of differential corrections data
xxxx	Differential reference station ID
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.

$aa**GLL**,llll.lllx,d,yyyyy.yyyx,d,hhmmss.s,s,a*hh<CR><LF>

Field	Description
aa	Talker ID
llll.lllx	Latitude
d	N | S
yyyyy.yyyx	Longitude
d	E | W
hhmmss.s	Hours, minutes, seconds, sub-seconds of position in UTC.
s	Status: A = data valid V = data invalid

Field	Description
a	Mode indicator: N = data not valid A = autonomous mode D = differential/SBAS-aided mode F = RTK (float) R = RTK (fixed) P = RTX or PPP E = estimated/DR M = manual mode
hh	checksum

GSA - GPS DOP and Active Satellites

The GSA messages indicate the GNSS receiver's operating mode and lists the satellites used for navigation and the DOP values of the position solution.

`$idGSA,a,v,ww,ww,ww,ww,ww,ww,ww,ww,ww,ww, , ,x.xx,y.yy,z.zz*h-h<CR><LF>`

Where *id* is GP, GL or GN, dependent on if the sentence contains GPS, GLONASS or both constellations respectively.

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 - 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 GNSS 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 4 satellites are in view. Fields #1 and #2 indicate the total number of messages being sent and the number of each message respectively.

$*id*GSV,t,u,vv,ww,ww,www,ww,xx,xx,xxx,xx,yy,yy,
yyy,yy,zz,zz,zzz,zz*hh<CR><LF>

Where *id* is GP or GL, dependent on if the sentence contains GPS or GLONASS satellites.

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/N0), 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 GNSS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed 2 seconds. All data fields must be provided unless the data is temporarily unavailable. Null fields may be used when data is temporarily unavailable. This message is output automatically if selected in the NMEA message output mask.

$aa**RMC**,hhmmss.s,s,llll.lllx,d,yyyyy.yyyx,d,xs.sx,xc.cx,ddmmyy,xm.vx,d,a*hh<CR><LF>

Field	Description
aa	Talker ID
hhmmss.s	Hours, minutes, seconds, sub-seconds of position in UTC.
s	Status (see Section 3.1 for more info): A = data valid V = data invalid
llll.lllx	Latitude
d	N | S

Field	Description
yyyyy,yyyx	Longitude
d	E | W
xs.sx	Speed Over Ground in Knots
xc.cx	Course Over Ground in Degrees True
ddmmyy	Day, month, year of date
xm.vx	Magnetic Variation in Degrees
d	E | W
a	Mode indicator: N = data not valid A = autonomous mode D = differential/SBAS-aided mode F = RTK (float) R = RTK (fixed) P = RTX or PPP E = estimated/DR M = manual mode
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).

This message is output automatically if selected in the NMEA message output mask.

$aa**VTG**,xc.cx,**T**,xc.cx,**M**,xs.sx,**N**,xs.sx,**K**,a*hh<CR><LF>

Field	Description
aa	Talker ID
xc.cx	Course Over Ground in Degrees True
xc.cx	Course Over Ground in Degrees Magnetic
xs.sx	Speed Over Ground in knots
xs.sx	Speed Over Ground in km/hr

Field	Description
a	Mode indicator: N = data not valid A = autonomous mode D = differential/SBAS-aided mode F = RTK (float) R = RTK (fixed) P = RTX or PPP E = estimated/DR M = manual mode
hh	Checksum

ZDA - Time & Date

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

This message is output automatically if selected in the NMEA message output mask.

$aa**ZDA**,hhmmss.s,dd,mm,yyyy,zh,zm*hh<CR><LF>

Field	Description
aa	Talker ID
hhmmss.s	Hours, minutes, seconds, sub-seconds of position in UTC.
dd	Day (01 to 31)
mm	Month (01 to 12)
yyyy	Year
zh	Local Zone Hour, offset from UTC to obtain Local time
zm	Local Zone Minute
hh	Checksum

NOTE - Fields #5 and #6 are null fields in the Acutime 360Acutime 720 output. A GNSS receiver cannot independently identify the local time zone offsets.

CAUTION - If UTC offset is not available, time output will be in GPS time until the UTC offset value is collected from the GPS satellites. When the offset becomes available, the time will update to UTC time.

NOTE - GPS time can be used as a time tag for the 1PPS. The ZDA message comes out 100-500 msec after the PPS.

AH - Almanac Health

Use this message to query or set almanac health data. Since the maximum number of bytes that can be contained in a single NMEA sentence is less than the total almanac health length, the almanac health must be sent in two parts that have to be sent or received together in the correct sequence. After receiving the query, the receiver sends out two messages.

Message 1

```
$PTNLaAH,1,h-
h,hhhhhhhh,hhhhhhhh,hhhhhhhh,hhhhhhhh,hh*hh<CR><LF>
```

Field	Description
a	Mode: Q - Query S - Set R - Response
hh	Week number for health, variable length integer, 4 digits maximum
hhhhhhhh	Satellite 1 - 4 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hhhhhhhh	Satellite 5 - 8 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hhhhhhhh	Satellite 9 - 12 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hhhhhhhh	Satellite 13 - 16 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hh	Checksum

Message 2

```
$PTNLaAH,2,h-
h,hhhhhhhh,hhhhhhhh,hhhhhhhh,hhhhhhhh,hh*hh<CR><LF>
```

Field	Description
a	Mode: Q - Query S - Set R - Response
hh	Week number for health, variable length integer, 4 digits maximum
hhhhhhhh	Satellite 17 - 20 health, one byte for each satellite, HEX data conforming to GPS ICD 200

Field	Description
hhhhhhhh	Satellite 21 - 24 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hhhhhhhh	Satellite 25 - 28 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hhhhhhhh	Satellite 29 - 32 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hh	Checksum

AL - Almanac Page

Use this message to query or set almanac data for a specific satellite. The query format is:

```
$PTNLQAL,xx*hh<CR><LF>
```

Field	Description
xx	Satellite ID

The set or response format is as follows:

Field	Description
a	Mode: S - Set R - Response
xx	Satellite ID, 01-32
x.x	GPS week number, variable length integer, 4 digits maximum.
hh	SV health, HEX data conforming to GPS ICD 200
hhhh	Eccentricity, HEX data conforming to GPS ICD 200
hh	t_oa, almanac reference time, HEX data conforming to GPS ICD 200
hhhh	sigma_I,HEX data conforming to GPS ICD 200
hhhh	OMEGADOT, HEX data conforming to GPS ICD 200
hhhhhh	root_a, HEX data conforming to GPS ICD 200
hhhhhh	Omega, HEX data conforming to GPS ICD 200
hhhhhh	Omega_0, HEX data conforming to GPS ICD 200
hhhhhh	M_O, HEX data conforming to GPS ICD 200
hhh	a_fO, HEX data conforming to GPS ICD 200
hhh	a_fl, HEX data conforming to GPS ICD 200

Field	Description
hh	Checksum

AS - Almanac Status

Use this sentence to query or set almanac status. The query format is:

`$PTNLaAS,hh,xxxx,hh,hh,hh,hh,hh*hh<CR><LF>`

Field	Description
a	Mode: Q - Query S - Set R - Response
hh	Time of almanac
xxxx	Week of number of almanac
hh	Reserved
hh	Reserved
hh	Reserved
hh	Reserved
hh	Almanac Status 0 - almanac incomplete 1 - almanac complete and current
hh	Checksum

The corresponding response for the set is:

`$PTNLRAS,a*hh<CR><LF>`

Where “a” is the action status: A = success; V= failure.

CR - Configure Receiver

Use this sentence to query or set receiver configuration information.

The Query sentence format is:

$PTNLQCR*hh<CR><LF>

The Response to query or Set sentence format is:

$PTNLaCR,x.x,x.x,x.x,x.x,x.x,x.x,a,a,a,a,*hh<CR><LF>

Field	Description
a	Mode (S = set; R = response)
x.x	Signal Level Mask (default = 0.6 AMU)
x.x	Elevation mask in degrees (default = 5 degrees)
x.x	PDOP mask (default = 12)
x.x	PDOP switch (default = 6) (unused in Onix)
x.x	Max Oscillator Offset (unused in Onix)
a	Constellation Mode, default is 0 0 - AUTO
a	Dynamics, default is 0 1 - Land 2 - Sea 3 - Air
a	Reserved, set to 1.
a	SBAS mode, default is 0

Field	Description
a	Bitmap of Constellation track/use mask: Bit 0 - GPS L1C Bit 1 - GPS L2 (Not supported, for future use) Bit 2 - GPS L5 Bit 3 - Reserved Bit 4 - Glonass G1 Bit 5 - Glonass G2 Bit 6,7 - Reserved Bit 8 - SBAS Bit 9 - Reserved Bit 10 - Reserved Bit 11 - Reserved Bit 12 - Beidou B1 Bit 13 - Beidou B2i (Not supported, for future use) Bit 14 - Beidou B2a Bit 15 - Reserved Bit 16 - Galileo E1 Bit 17 - Galileo E5a Bit 18 - Galileo E5b (Not supported, for future use) Bit 19 - Galileo E6 (Not supported, for future use) Bit 20 - Reserved Bit 21 - QZSS L1C Bit 22 - QZSS L2C (Not supported, for future use) Bit 23 - QZSS L5 Bit 24 - Reserved Bit 25 - Reserved Bit 26 - Navic L5 Bit 27 - Reserved Bit 28 - Reserved Bits 29-31 - Reserved
a	Jamming enable/disable (1 default): 0 - disable 1 - enable
hh	Checksum

The Response to set format is:

$PTNLRCR,a*hh<CR><LF>

Field	Description
a	Status (A - success; V - failure)
hh	Checksum

EM - Enter Monitor mode

This sentence is used to set the Acutime 360 antenna multi-GNSS timing module into Monitor mode. This is Set only, no query supported. The sentence format is:

```
$PTNLSEM*hh<CR><LF>
```

This sentence is used by the Firmware Uploading Program.

EP - Ephemeris

Use this sentence to query or set ephemeris data for a specific satellite. Since the maximum number of bytes that can be contained in a single NMEA sentence is less than the total ephemeris data length, the ephemeris data must be sent in three sentences. The three sentences have to be sent or received together in correct sequence. The query format is:

```
$PTNLQEP,xx*hh<CR><LF>
```

Field	Description
Q	Query
xx	Satellite ID

After receiving the query, the receiver sends out three messages.

Message 1

```
$PTNLaEP,1,xx,x.x,x.x,hh,hh,hh,hh,hhh,hh,hhhh,hh,hhhh,hh hhh-
h,x .x*hh<CR><LF>
```

Field	Description
a	Mode: S - Set R - Response
1	Message number for EP, message 1 must be sent or received before message 2, and message 2 must be sent or received before message 3. All three messages must be sent together in the correct sequence.
xx	Satellite id
x.x	T_ephem, This is a double-precision floating point number.
x.x	Week number for health, variable length integer, 4 digits maximum.

Field	Description
hh	CodeL2, HEX data conforming to GPS ICD 200
hh	L2Pdata, HEX data conforming to GPS ICD 200
hh	Svacc_raw, HEX data conforming to GPS ICD 200
hh	SV_health, HEX data conforming to GPS ICD 200
hhh	IODC, HEX data conforming to GPS ICD 200
hh	T_GD, HEX data conforming to GPS ICD 200
hhhh	T_oc, HEX data conforming to GPS ICD 200
hh	A_f2, HEX data conforming to GPS ICD 200
hhhh	A_f1, HEX data conforming to GPS ICD 200
hhhhhh	A_f0, HEX data conforming to GPS ICD 200

Message 2

```
$PTNLaEP,2,xx,hh,hh,hhhh,hhhh,hhhhhhhh,hhhh,hhhhhhhh,hhh h,h-
hhhhhhh,hhhh* hh<CR><LF>
```

Field	Description
a	Mode: S - Set R - Response
2	Sentence number for EP, sentence 1 must be sent or received before sentence 2, and sentence 2 must be sent or received before sentence 3. All three sentences must be sent together.
xx	Satellite id
hh	IODE, Hex data conforming to GPS ICD 200
hh	Fit_interval, Hex data conforming to GPS ICD 200
hhhh	C_rs, Hex data conforming to GPS ICD 200
hhhh	Delta_n, Hex data conforming to GPS ICD 200
hhhhhhhh	M_0, Hex data conforming to GPS ICD 200
hhhh	C_uc, Hex data conforming to GPS ICD 200
hhhhhhhh	E, Hex data conforming to GPS ICD 200
hhhh	C_us, Hex data conforming to GPS ICD 200

Message 3

```
$PTNLaEP,3,xx,hhhh,hhhhhhhh,hhhh,hhhhhhhh,hhhh,hhhhhhhh, hhh-
hhh,hhhh*hh< CR><LF>
```

Field	Description
a	Mode: S - Set R - Response
3	Sentence number for EP, sentence 1 must be sent or received before sentence 2, and sentence 2 must be sent or received before sentence 3. All three sentences must be sent together.
xx	Satellite id
hh	C_ic, Hex data conforming to GPS ICD 200
hh	OMEGA_0, Hex data conforming to GPS ICD 200
hhhh	C_ri, Hex data conforming to GPS ICD 200
hhhh	I_O, Hex data conforming to GPS ICD 200
hhhhhhhh	C_rc, Hex data conforming to GPS ICD 200
hhhh	OMEGA, Hex data conforming to GPS ICD 200
hhhhhhhh	OMEGA_DOT, Hex data conforming to GPS ICD 200
hhhh	IDOT, Hex data conforming to GPS ICD 200

IO - Ionosphere

This sentence can be used to query or set ionosphere data.

```
$PTNLaIO,hh,hh,hh,hh,hh,hh,hh,hh*hh,<CR><LF>
```

Field	Description
a	Mode: Q - Query S - Set R - Response
hh	Alpha_0, HEX data conforming to GPS ICD 200
hh	Alpha_1, HEX data conforming to GPS ICD 200
hh	Alpha_2, HEX data conforming to GPS ICD 200
hh	Alpha_3, HEX data conforming to GPS ICD 200
hh	Beta_0, HEX data conforming to GPS ICD 200

Field	Description
hh	Beta_1, HEX data conforming to GPS ICD 200
hh	Beta_2, HEX data conforming to GPS ICD 200
hh	Beta_3, HEX data conforming to GPS ICD 200

KG - Set Initial Position

Use this sentence to set initial position or time info data or both for accelerating navigation startup:

- To set time only, send valid time fields and NULL position fields.
- To set position only, send valid position fields and NULL time fields. Query is not supported.

`$PTNLaKG,x.x,x.x,llll.lllll,a,yyyyy.yyyyy,a,x.x*hh<CR><LF>`

> **NOTE -** When uploading a position, it should be within 100 Km of the actual position and time within 5 minutes of UTC.

Field	Description
a	Mode: S - Set R - Response
x.x	GPS week number, maximum 4 digits
x.x	GPS time of week in milliseconds llll.lllll Latitude
a	N | S
yyyyy.yyyyy	Longitude
a	E | W
x.x	Altitude from the sea level in meters (maximum 5 digits)

NM - NMEA Configuration

This sentence may be issued by the user to configure NMEA message output. The Query sentence format is:

`$PTNLQNM,``x*hh<CR><LF>`

Field	Description
x	Port, default is current port if field is left null. 0 - Port A 1 - Port B 255 - Current port

The Response sentence to query or Set sentence format is:

$PTNLa**NM,**hhhhhhhh,x.x,x,x*hh<CR><LF>

Field	Description
a	Mode (S = set; R = response)
hhhhhhhh	Message Flags (32 bits maximum), one bit for each message: Bit 0 - GGA Bit 1 - GLL Bit 2 - VTG Bit 3 - GSV Bit 4 - GSA Bit 5 - ZDA Bits 6,7 - Reserved Bit 8 - RMC Default is 0x3D
x.x	Automatic Report Interval (1 - 255 seconds), default is 1 if field is left null. Default is 1 second
x	Position fix data source. This field indicates the source of fix data in messages containing position fix information (GGA, RMC). 255 - position fix data source not supported (fix data always comes from DR for DR-capable products or from GNSS for non-DR products) This is output by default. Users can set any values or null.
x	Port, default is current port if field is left null. 0 - Port A 1 - Port B 255 - Current port

The Response sentence to set format is:

$PTNLRNM,a*hh<CR><LF>

Field	Description
a	Status (A - success; V - failure)
hh	Checksum

PS - PPS Configuration

This sentence can query or set PPS configuration data.

`$PTNLaPS,b,x...x,c,x...x*hh<CR><LF>`

Field	Description
a	Mode: Q - Query S - Set R - Response
b	PPS mode, default is 1 0 - PPS_OFF (Always Off) 1 - PPS_ON (Always On or Early PPS) 2 - Reserved 3 - Reserved
x...x	Reserved
c	Output pulse polarity, default is 1 0 - Output pulse is active low 1 - Output pulse is active high
x...x	Antenna Cable Length Compensation. Default = 0, Units in nanoseconds. Can be positive or negative. Negative value will mean PPS comes out earlier, for example, to compensate for cable delay. Field value range is -100000000...100000000 (±100 milliseconds)

PT - Serial Port Configuration

Use this sentence to configure the current serial port. The Query sentence format is:

$PTNLQPT*hh<CR><LF>

The Response sentence to query or Set sentence format is:

$PTNLaPT,xxxxxx,a,a,a*hh<CR><LF>

In the case of Set, the Response message with new parameters is sent using the old parameters first, and then the switch to the new parameters is made.

If the switch fails for any reason, an NMEA error response is sent. If the switch succeeds, no additional response is sent.

Field	Description
a	Mode (S = set, R = response)
xxxxxx	Baud rate (4800, 9600, 19200, 38400, 57600, 115200). Default baud rate is 4800
a	Number of data bits (7 or 8)
a	Parity (N = None, O = Odd, E = Even)
a	Number of stop bits (1 or 2)
h	Input protocol. This is a hex bit-map but only one protocol in use. This field may not be 0. Bit 0: NONE (TBD) Bit 1: TSIP Bit 2: NMEA
h	Output protocol. This is a hex bit-map (same as input). Bit 0: NONE (TBD) Bit 1: TSIP Bit 2: NMEA
hh	Checksum

The Response sentence to set format is:

$PTNLRPT,a*hh<CR><LF>

Field	Description
a	Status (A - success; V - failure)
hh	Checksum

RT - Reset

Use this sentence to Set the reset type. No query is supported.

`$PTNLaRT,b,c*hh<CR><LF>`

Field	Description
a	Mode: S - Set R - Response

Field	Description
b	Command C = Cold software reset, Erases RAM (including the customer configuration in RAM) and restarts F = Factory software reset. Erases the customer configuration, the almanac, ephemeris and last position in Flash Memory and in SRAM
c (decimal integer)	Flash operation 0 - Do not do any Flash operation 1 - Reserved 2 - Store user configuration to Flash Memory 3 - Reserved 4 - Reserved 5 - Erase user configuration from Flash Memory 6 - Reserved
hh	Checksum

NOTE - A successful command is followed by a $PTNLRRT,A*3F response. An incorrect command will be followed by a $PTNLRRT,V*28 response.

NOTE - To save the user configuration to flash memory, send command $PTNLSRT,C,2*22.

TF - Receiver Status and Position Fix

Use this sentence to get the receiver status and position fix. The Query sentence format is:

```
$PTNLQTF*hh<CR><LF>
```

The Response to query sentence format is:

```
$PTNLaTF,b,c,xxxxxx,xx,x,llll.llllll,d,yyyyy.yyyyy,e,xxxx
x,x.x,x.x,x.x*hh<CR><LF>
```

Field	Description
a	Mode: Q - Query S - Set R - Response
b	BBRAM status on startup (A = valid; V = invalid)
c	Almanac completion status (A = complete; V = incomplete)
xxxxxx	GPS time of week (in seconds)

Field	Description
xx	Number of satellites in use, 00 - 12, may be different from the number in view.
x	Position fix source (0 = no fix; 1 = Stationary Mode, 2 = 2D fix; 3 = 3D fix)
llll.llllll	Latitude of the current position fix d
yyyyy.yyyyy	Longitude of the current position fix
e	E | W
xxxxx	Antenna altitude re: mean-sea-level (MSL geoid, meters)
x.x	'East' component of ENU velocity (m/s)
x.x	'North' component of ENU velocity (m/s)
x.x	'Up' component of ENU velocity (m/s)
hh	Checksum

UT - UTC data

Use this sentence to query or set UTC data.

`$PTNLaUT,hhhhhhhh,hhhhhh,hh,hh,hhhh,hhhh,hh,hh*hh<CR><LF>`

Field	Description
a	Mode: Q - Query S - Set R - Response
hhhhhhhh	A_0, HEX data conforming to GPS ICD 200
hhhhhh	A_1, HEX data conforming to GPS ICD 200
hh	Delta_t_ls, HEX data conforming to GPS ICD 200
hh	T_oa, HEX data conforming to GPS ICD 200
hhhh	Wn_t, HEX data conforming to GPS ICD 200
hhhh	Wn_LSF, HEX data conforming to GPS ICD 200
hh	DN, HEX data conforming to GPS ICD 200
hh	Delta_t_LSF, HEX data conforming to GPS ICD 200
hh	Checksum

VR - Version

This sentence may be issued by the user to get application version information.

The Query sentence format is:

$PTNLQVR,a*hh<CR><LF>

Field	Description
a	Component ID for which to query the version: S - system (application firmware) version H - hardware info
hh	Checksum

The Response to query sentence format for all components versions except the hardware (H).

$PTNLRVR,a,a..a,b...b,xx,xx,xxxx*hh<CR><LF>

Application firmware

Field	Description
a	Component ID (same as in Query format)
a..a	Component name (variable length character string)
b...b	Version number in the format xx.yy.zz where xx - major version number (2 digits, prepend 0 if the number is less than 10) yy - minor version number (2 digits, prepend 0 if the number is less than 10) zz - build version number (2 digits, prepend 0 if the number is less than 10) **NOTE -** There must be a period character separating the major/minor and minor/build numbers.
xx	Month (1-12)
xx	Day (1-31)
xxxx	Year
hh	Checksum

The Response to query sentence format for the Hardware version (H)information is:

$PTNLRVR,**H**,xxxx,a..a,xxxxxxxx,xx,xx,xxxx,xx*hh<CR><LF>

Field	Description
xxxx	Hardware code
a..a	Hardware ID (variable length character string)

Field	Description
xxxxxxxx	Serial number
xx	Build month (1-12)
xx	Build day (1-31)
xxxx	Build year
xx	Build hour (0-23)
hh	Checksum

ZD - Extended Time and Date

This message reports extended time and date information - UTC, day, month, year, local time zone and UTC to GPS leap second.

Setting the data is not supported.

This message is output automatically if selected in the NMEA message output mask.

Query format:

```
$PTNLQZD*hh<CR><LF>
```

Response to query format:

```
$PTNLRZD, hhmmss.s,dd,mm,yyyy,zh,zm,ls,lsp*hh<CR><LF>
```

Field	Description
hhmmss.s	Hours, minutes, seconds, sub-seconds of position in UTC.
dd	Day (01 to 31)
mm	Month (01 to 12)
yyyy	Year
zh	Local Zone Hour, offset from UTC to obtain Local time
zm	Local Zone Minute
ls	Current leap second offset between GPS and UTC time
lsp	Pending leap second. If non-zero (+/- 1) then a leap second is scheduled to occur at the end of the day. The sign indicates the direction of the leap second.
hh	Checksum

Exception behavior

When no position fix is available, some of the data fields in the NMEA messages will be blank. A blank field has no characters between the commas.

Interruption of GNSS signal

If the GNSS signal is interrupted temporarily, the NMEA will continue to be output according to the user-specified message list and output rate. Position and velocity fields will be blank until the next fix, but most other fields will be filled.

C

Acutime 360 Antenna GPS-only Variant

This appendix describes the difference between the GPS-only and the standard Acutime 360 product.

Introduction

The Acutime 360 antenna provides the user with the ability to track multiple constellations. This ability meant that some existing messages had to be modified and extra messages added to deal with the new constellation options. The default baud rate also had to be increased from 9600 to 115200 to allow for the extra data.

A “GPS-only” version of the Acutime 360 antenna is made available to customers who require a replacement for the legacy Acutime Gold.

A user may need the “GPS-only” variant if:

a) The customer host computer cannot be reprogrammed with the new message structure

b) The customer has to use a default baud rate of 9600 and cannot change either the host or the standard Acutime 360 antenna baud settings.

c) The customer hardware cannot use the faster communication baud rate.

Note that both the standard and GPS-only Acutime 360 antenna use identical hardware and firmware. The differences described in this section are enabled at the factory. Once programmed the user cannot change the parameter values of the default settings.

Default communication interface

	Acutime 360 standard	Acutime 360 GPS-only	Acutime Gold
	106406-00	106406-05	55238-00
Port B	115200, 8, odd,1	9600, 8, odd, 1	9600, 8, odd, 1
Port A	115200, 8, odd,1	9600, 8, odd, 1	9600, 8, odd, 1

You can still change the communication settings to other values and save them for later use, after a power cycle for instance. However, after a factory reset the unit will return to the defaults listed in the table above.

PPS pulse width

	Acutime 360 standard	Acutime 360 GPS-only	Acutime Gold
	106406-00	106406-05	55238-00
Minimum pulse width	10ms	10ms	10us (micro seconds)

Default constellations

	Acutime 360 standard	Acutime 360 GPS-only	Acutime Gold
	106406-00	106406-05	55238-00
Default constellation	GPS and GLONASS	GPS only	GPS only

The user can still change the constellation settings to other values and save them for later use, after a power cycle for instance. However after a factory reset the unit will return to the defaults listed in the table above.

Default messages

The messages in the table below are fixed to the part number of Acutime 360 antenna that the user possesses. For instance a GPS-only Acutime 360 antenna will only output the 0x5C and 0x6D messages no matter what constellation is selected.

	Acutime 360 standard	Acutime 360 GPS-only	Acutime Gold
	106406-00	106406-05	55238-00

	Acutime 360 standard	Acutime 360 GPS-only	Acutime Gold
Satellite Tracking Status request/response	0x3C/0x5D	0x3C/0x5C	0x3C/0x5C
Satellite Selection List request/response	0x24/0x6C	0x24/0x6D	0x24/0x6D