User Guide

Mini-T™ GG
Multi-GNSS Disciplined Clock

For use with:

Mini-T™ GG Multi-GNSS Disciplined Clock (P/N 95959-xx)

Mini-T™ GG Multi-GNSS Disciplined Clock Starter Kit (P/N 99880-05)

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Legal Notices

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Release Notice

This is the July 2015 release (Rev. A) of the *Mini-T™ GG Multi-GNSS Disciplined Clock User Guide*, part number 94473-00

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- an explanation of the problem

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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.

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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.

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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 go to www.trimble.com/ev.shtml.

Recycling in Europe: To recycle Trimble WEEE (Waste Electrical and Electronic Equipment, products that run on electrical power.), Call +31 497 53 24 30, and ask for the "WEEE Associate". Or, mail a request for recycling instructions to:
Trimble Europe BV
c/o Menlo Worldwide Logistics
Meerheide 45
5521 DZ Eersel, NL

Declaration of Conformity

We, Trimble Navigation Limited,

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declare under sole responsibility that the product: Mini-T™ GG Disciplined Clock Starter Kit complies with Part 15B of FCC Rules.

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

Version Information

The table below shows the change history of this document.

Version	Date	Description
A	2015-07-10	Frist release version of the user guide

List of Abbreviations

Acronym	Definition
C/N_o	Carrier-to-Noise power ratio
DOP	Dilution of Precision
EGNOS	European Geostationary Navigation Overlay Service
ESD	Electrostatic Discharge
GLONASS	Globalnaya Navigatsionnaya Sputnikovaya Sistema
GND	Ground
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
LNA	Low Noise Amplifier
LVTTL	Low Voltage Transistor-Transistor Logic
MSL	Mean Sea Level
NMEA	National Marine Electronics Association
PCB	Printed Circuit Board
PDOP	Position Dilution of Precision
PPS	Pulse Per Second
RF	Radio Frequency
RMS	Root Mean Square
T-RAIM	Timing Receiver Autonomous Integrity Monitoring
TOD	Time Of Day
TSIP	Trimble Standard Interface Protocol
TTFF	Time to First Fix
UART	Universal Asynchronous Receiver Transmitter
UTC	Universal Coordinated Time
VSWR	Voltage Standing Wave Ratio
VTS	Trimble Visual Timing Studio
WNRO	Week Number Roll-Over

Safety Information

Warnings and Cautions

An absence of specific alerts does not mean that there are no safety risks involved. Always follow the instructions that accompany a Warning or Caution. The information they provide is intended to minimize the risk of personal injury and/or damage to the equipment. In particular, observe safety instructions that are presented in the following formats:

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

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

Operation and storage

CAUTION – The Mini-T™ GG is ready to accept TSIP (Trimble Standard Interface Protocol) or NMEA commands approximately 10 seconds after power-up. If a command is sent to the receiver within this 10 second window, the receiver may ignore the command. The Mini-T™ GG may not respond to commands sent within the 10 second window and may discard any associated command data.

CAUTION – Mini-T™ GG may lock up if supply voltage outside of the specified operating range is applied. Furthermore, no voltage shall be applied to any I/O pin while V_{CC} is off, as this can back-power the device and also cause a lock-up.

WARNING – Operating or storing the Mini-T™ GG outside the specified temperature range can damage it. For more information, see the product specifications on the data sheet.

Handling

CAUTION – The Mini-T™ GG Multi-GNSS Disciplined Clock is packed according to ANSI/EIA-481-B and JSTD-033A. All of the handling and precaution procedures must be followed. Deviation from following handling procedures and precautions voids the warranty.

CAUTION – Operators should not touch any part of Mini-T™ GG by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module.

CAUTION – The open board assembly is an electrostatic-sensitive device. Appropriate care and protection against ESD, according to JEDEC standard JESD625-A (EIA 625) and IEC 61340-5-1, must be taken when handling the product.

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.

AC adaptor safety

An international adaptor kit is provided with the Mini-T™ GG Starter Kit.

WARNING – Using an incorrect AC adaptor can damage your product and may void your warranty. To use AC adaptors safely:

- Use only the AC adaptor intended for the Mini-T™ GG Multi-GNSS Disciplined Clock. Using any other AC adaptor can damage your product and may void your warranty.
- Do not use the AC adaptor with any other product.
- Make certain that the input voltage on the adaptor matches the voltage and frequency in your location.
- Make certain that the adaptor has prongs compatible with your outlets.
- AC adaptors are designed for indoor use only. Avoid using the AC adaptor in wet outdoor areas.
- Unplug the AC adaptor from power when not in use.
- Do not short the output connector.
- There are no user-serviceable parts in this product.
- Should damage to the AC adaptor occur, replace it with a new Trimble AC adaptor.

Table of Content

CHAPTER

1

Introduction

In this chapter:

Welcome to the Trimble Mini-T™ GG Multi-GNSS Disciplined Clock User Guide. The user guide describes how to integrate and operate the Trimble® Mini-T™ GG.

The Trimble Mini-T™ GG is a full featured, high-performance multi-GNSS disciplined clock with precise PPS and 10 MHz output. The receiver is designed to operate on the GPS L1 and GLONASS G1 frequencies, providing standard position service (SPS) using Coarse Acquisition (C/A) code.

The Trimble Mini-T™ GG is designed for 5.5V prime power.

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

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

Overview

The Mini-T™ GG is a complete all-in-view, parallel tracking GNSS receiver designed to operate with the GPS and GLONASS frequencies 1565MHz to 1614MHz, standard position service, and Coarse Acquisition code. When connected to an external GNSS antenna, the receiver contains all the circuitry necessary to automatically acquire GNSS satellite signals, track up to 32 GNSS satellites, and compute location, speed, heading, and time. It provides an accurate one pulse-per-second (PPS) and stable 10MHz frequency output to synchronize broadband wireless, cellular base stations such as 4G LTE eNodeB's aggregation and pre-aggregation routers, Time Difference of Arrival (TDOA) applications, and many other Supervisory Control and Data Acquisition (SCADA) applications.

The Mini-T™ GG can also be used as a reference source for use in laboratories, automation, R&D facilities. In calibration laboratories, the Mini-T™ GG is fully traceable to national standards through the atomic clocks carried on GNSS satellites — this eliminates the calibration cycle required with more traditional sources.

The Mini-T™ GG automatically initiates a self-survey upon acquisition of GNSS satellites. When the survey is completed, the receiver switches into the "Over-Determined" timing mode. In this mode, the reference position from the self-survey is maintained in memory and the receiver solves only for clock error and clock bias. The receiver provides for both Position and Time Receiver Autonomous Integrity Monitoring (T-RAIM) which allows the receiver to self-determine a position change or to remove a satellite providing incorrect information to the timing solution.

Timing Features

The timing features of the Mini-T™ GG Multi-GNSS Disciplined Clock include the following:

- Automatic self-survey of position for static operation
- Over-determined timing mode
- Ultra-precise one Pulse-Per-Second (PPS, 1Hz) output, can be configured as an even-second output, 3.3V LVTTL compatible
- Separate Pulses-Per-Even-Second (PP2S, 0.5 Hz) output, 3.3V LVTTL compatible
- PPS and PP2S accuracy <15 ns (1 sigma) with respect to GPS-time or UTC-time
- Disciplined 10 MHz frequency output, sinusoidal 50 Ω and LVTTL digital
- Holdover stability ±5us over 24 hour period @25°C
- 3 SMA connectors (50 Ω) for PPS output, 10MHz output and GNSS antenna input
- T-RAIM (Timing - Receiver Autonomous Integrity Monitoring)
- Position Integrity Monitoring
- Cable delay compensation
- Anti-Jamming function
- Single satellite timing mode with anti-jamming feature turned off
- Dual satellite timing mode with anti-jamming feature turned on

Other Key features

- Capable of simultaneously tracking of up to 32 GNSS satellites
- Supports active antenna designs only
- Supports TSIP and NMEA 0183 standard protocols (TSIP is recommended for full timing diagnostic information)
- 2 serial LVTTL UART ports
- Dimensions: 76.2mm width x 70mm length (3" x 2.75")
- Extended operating temperature range (-40°C / +85°C)
- RoHS-II compliant (lead-free)
- 2x15 pin I/O interface and power supply connector

Note *– This Multi-GNSS Disciplined Clock is optimized for static timing applications. While it can be used in dynamic mode the stability of PPS may be degraded.*

Tools and Accessories

Trimble offers a starter kit for the Mini-T™ GG disciplined clock that makes it simple to evaluate its performance. It can be used as a platform for configuring the receiver software or as a platform for troubleshooting your design.

The Trimble Visual Timing Studio (VTS) software is an easy-to-use configuration and monitoring tool for use with all of Trimble's Timing products, including Mini-T™ GG.
The VTS software and product-related documentation can be downloaded from Trimble's Internet website http://www.trimble.com/timing/.

Use and Care

The Mini-T™ GG is a high-precision electronic instrument and should be treated with reasonable care.

CAUTION – There are no user-serviceable parts inside the Mini-T™ GG and any modification to the unit by the user voids the warranty.

Technical Assistance

If you have a problem and cannot find the information you need in the product documentation, contact the Trimble Technical Assistance Center at +1-408-481-7921 or email tsgsupport@trimble.com.

CHAPTER

2

System Operation

In this chapter:

This chapter describes the operating characteristics of the Mini-T™ GG Multi-GNSS Disciplined Clock including start-up, satellite acquisition, operating modes, serial data communication, the timing pulse and the frequency output.

The Mini-T™ GG acquires satellites and computes position and time solutions. It outputs data in the TSIP and NMEA protocol through its serial ports.

GNSS Timing

For many timing applications, such as time & frequency standards, site synchronization systems, and wireless voice and data networks, the Mini-T™ GG can be used as the primary reference source for time and frequency. Mini-T™ GG uses the highly accurate clock information, broadcasted from the GNSS satellites, to discipline its internal 10MHz oscillator. In addition to the stabilized 10MHz frequency output, the receiver generates highly accurate timing pulses (PPS and PP2S) from its internal clock, which is constantly corrected using the GNSS atomic clocks. This timing pulse is synchronized to GPS or UTC time within 15 nanoseconds (1 sigma) when operating in its over-determined clock mode.

In addition to serving as highly-accurate stand-alone time sources, GNSS timing sources are used to synchronize distant clocks in communication or data networks. This is possible because all GNSS satellites are corrected to common master clocks. 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.

Position and time errors are related by the speed of light. A position error of 100 meters corresponds to a time error of approximately 333 ns. This is why an accurate reference position is critical. In order to determine its accurate position, Mini-T™ GG begins a self-survey after power-on. Using software algorithms like an over-determined clock solution, the Mini-T™ GG mitigates the effects of clock errors to achieve PPS accuracy within 15ns (1 sigma) to GPS or UTC after self-survey is complete.

Time References

All GNSS satellite systems have their own master clock to which all atomic clocks inside of this system's space vehicles are synchronized. These master clocks are synchronized to the UTC (Universal Time Coordinated) clock ensemble, which consists of many individual atomic clocks in many countries. The synchronization among all those clock ensembles causes small steering offsets.

GNSS 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 GNSS master clock ensemble and the UTC clock ensemble. The large offset is the cumulative number of leap seconds since 1 January 1980, which, on 30 June 2012, was increased from 15 to 16 seconds. Historically, the offset increases by one second approximately every 18—24 months, usually just before midnight on 30 June or 31 December. System designers should note whether the output time is UTC or GNSS time.

GNSS Constellation Configuration

The Mini-T™ GG can be configured to use GPS or GLONASS, or both systems. The GNSS constellation settings determine which satellites are used while the receiver is working in self-survey mode or when it's configured for positioning mode or while it's working in over-determined Clock mode.

Pulse per Second Availability and Criteria

The PPS and PP2S signals are defaulted to always output. This is a customer selectable feature under TSIP packet 8E-4E. Other options include PPS output when one or more satellites are usable or when three or more satellites are useable. Additionally, the PPS output can be programmed to provide an Even Second output using TSIP packet 8E-4E.

Note: *Trimble cannot guarantee that the PPS and PP2S are 100% available or a pulse is generated each and every second and that the frequency is continuously disciplined. The receiver's ability to generate the PPS, PP2S and to discipline the 10MHz oscillator depends on various factors, including, but not limited to, the local signal conditions at the place of antenna installation and on the health and validity of the GNSS signals that are broadcasted by the satellites. Trimble has neither control over the GNSS systems nor over the conditions at the place of installation, therefore the PPS, PP2S and a valid 10MHz frequency may not be available at all times.*

Start-up

The first time the Mini-T™ GG is powered-up, it is searching for satellites from a cold start (no almanac, time, ephemeris, or stored position). During the satellite acquisition process, the Mini-T™ GG outputs periodic TSIP status messages. These status messages confirm that the receiver is working.

While the receiver will begin to compute position solutions in less than one minute, the receiver must continuously track satellites for approximately 15 minutes to download a complete almanac. The almanac contains, amongst others, the UTC leap second value. Mini-T™ GG can only compute UTC time after this leap second value was received from the satellites. Therefore, a complete and current almanac is essential for correct UTC output. The initialization process with almanac download should not be interrupted.

The Mini-T™ GG is ready to accept TSIP commands approximately 10 seconds after power-up. If a command is sent to the receiver within this 10 second window, the receiver may ignore the command. The Mini-T™ GG may not respond to commands sent within the 10 second window and may discard any associated command data.

Automatic operation

When the Mini-T™ GG 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 Mini-T™ GG automatically switches to a time-only mode (over-determined clock mode).

Satellite masks

The following table lists the default satellite masks used by the Mini-T™ GG. 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.

Elevation and C/No masks are operable in all receiver modes (self-survey and over-determined Clock mode). The PDOP mask, however, is only operable during self-survey mode.

Mask	Default-Setting	Description
Elevation	5°	Satellite elevation above horizon
C/No [dBHz]	29	Signal strength (Carrier-to-Noise power ratio)
PDOP	8	Position Dilution of Precision, 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. An elevation mask of 5° excludes very low satellites from position fix computations and reduces the likelihood of potential errors induced by using those signals.

C/No mask

The quality of received GNSS satellite-signals is reported as C/No value (Carrier-to-Noise power ratio). Low C/No values can result from low-elevation satellites, partially obscured signals (due to dense foliage for example), or reflected RF signals (multipath).

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. Reflected signals tend to be weak (low C/No value), since each reflection diminishes the signal.

If the Mini-T™ GG antenna has a clear view of the sky (outdoor antenna placement), a C/No mask of 29dB-Hz 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.

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.

The DOP indicates the confidence level of a position fix. Low DOP values indicate a high confidence level, while high DOP values indicate a low confidence level. High DOP values are caused by poor geometry of the visible satellites. Lowering the DOP mask will exclude fixes with poor (high) DOP and will thereby improve the quality of the reference position by only accepting fixes with high confidence level. A too low DOP mask setting may, however, cause extended self-survey times, because less position fixes will pass the mask criteria, so that it takes longer to collect the amount of position fixes to complete the self-survey. The default DOP mask of Mini-T™ GG is 8. It is configurable by the user, if needed. 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 Mini-T™ GG operates in one of the following main modes:

- Self-survey mode (position fix operating mode)
- Over-determined clock mode

After establishing a reference position in self-survey mode, the Mini-T™ GG automatically switches to over-determined (OD) clock mode

Self-survey mode

At power-on, the Mini-T™ GG performs a self-survey by averaging 2000 position fixes. The number of position fixes until survey completion is configurable. The default mode during self-survey is 2D/3D Automatic, where the receiver must obtain a three-dimensional (3-D) position solution. If fewer than four conforming satellites are visible, the Mini-T™ GG suspends the self-survey. 3-D mode may not be achieved when the receiver is subjected to frequent obscuration or when the geometry is poor due to an incomplete constellation.

Over-determined clock mode

Over-determined clock mode is used only in stationary timing applications. This is the default mode for the Mini-T™ GG once a surveyed (or user input) position is determined. After the receiver self-surveys its static reference position, it stores the surveyed reference position to non-volatile memory and automatically switches to over-determined clock mode and determines the clock solution. The timing solution is qualified by a T-RAIM algorithm, which automatically detects and rejects faulty satellites from the solution.

Using the default anti-jamming setting, a minimum of two satellites is required for a fix in over-determined clock mode. When you power-up the receiver, or after a long fix outages (longer than nine minutes), three satellites are required for the first fix.

In this mode, the Mini-T™ GG does not navigate or update positions and velocities, but maintains the PPS and PP2S outputs and 10MHz disciplining, 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.

If a stored reference position from a previous self-survey is available at startup, Mini-T™ GG will use that stored reference position and will enter the over-determined clock mode immediately after power-on. Self-survey would only be re-started if the position integrity check detects a re-location of the antenna, or if the user sends a command to change the mode or to delete the stored reference position. The over-determined clock mode can only be entered when a reference position is available to the receiver, either from a self-survey or by entering coordinates with a TSIP or NMEA command.

Integrity Monitoring

Using a voting scheme based on pseudo-range residuals, the Mini-T™ GG T-RAIM algorithm automatically removes the worst satellite with the highest residual from the solution set if that satellite's residual is above the current constellation average.

In addition to T-RAIM, Mini-T™ GG implements position integrity checking on startup, in case the receiver has been moved to a new location. When the receiver is powered up with a surveyed (or user input) position in memory, it will compare position fixes computed from the GNSS satellites to the surveyed position. If it finds that the surveyed position is off by more than 100meters (approximately) horizontally or vertically in the first 60 consecutive GNSS fixes, it will delete the surveyed position from memory (including non-volatile storage) and restart the self-survey.

Cable Delay Compensation

The Mini-T GG™'s default configuration provides optimal timing accuracy. The only item under user or host control that can affect the receiver's absolute PPS accuracy is the delay introduced by the antenna cable. For long cable runs, this delay can be significant. TSIP packet 0x8E-4A / NMEA packet PS 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 5.9 nanoseconds per meter of cable. To compensate for the cable delay, use a negative offset to advance the PPS output.

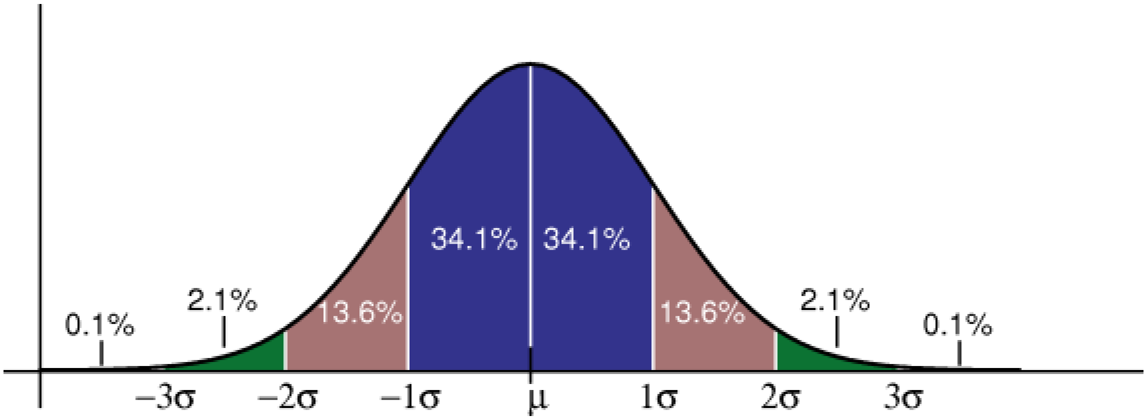
Note *– To offset the propagation delay inherent in the antenna cable typically 5.9ns per meter from the antenna to the receiver and further improve the accuracy, determine the length of the cable and enter the offset based on the specific cable type.*

Disciplined Clock Performance

Mini-T™ GG is optimized for precise time output in stationary use and will provide the best time accuracy in the over-determined clock mode. When combined with the precise cable delay compensation, this provides an accuracy of less than 15ns (1 sigma) for the PPS output with respect to GPS time or UTC time. The time reference (GNSS or UTC) can be configured by the user with the 0x8E-A2 TSIP command.

The PPS time accuracy is approximately 3 times worse, around 50ns (1 sigma), when the receiver is computing position fixes during self-survey or when it's configured for 3D mode.

The accuracy of the PPS is specified as a statistical Gaussian distribution. The plot below shows the likelihood function of a Gaussian distribution.



A definition of a parameter with 1 sigma (1σ) means that 68.2% of all samples are within the specified range, but 31.8% of all samples are outside. A definition with statistical notation also implies that there's no specified minimum or maximum. This applies also to Trimble's accuracy specifications of Mini-T™ GG.

Acquiring the correct time

It is recommended that the time information is derived from the timing messages in the TSIP or NMEA protocols. The time reported in position packets is a time-tag for this particular position fix, but not necessarily the time of the preceding PPS pulse.

Protocol	Timing message
TSIP	Report packet 0x8F-AB
NMEA	ZDA message, ZD message

- Make sure that the almanac is complete and current and the receiver is generating 3D fixes or reporting an over-determined clock mode. This will eliminate the UTC offset jump.
- The time of the PPS pulse comes in the TSIP packet 0x8F-AB or NMEA packet ZDA+ZD following the PPS pulse.
- The leading edge of the PPS occurs on-time with the UTC or GNSS second. This can be either the rising edge (when the rising edge on-time is selected in TSIP packet 0x8E-4A) or the falling edge.
- If using TSIP, capture the time from TSIP packet 0x8F-AB. If using NMEA, capture the time from NMEA packet ZDA or ZD.
- Make sure that no alarm flags are raised by the receiver, which could indicate an uncertain or invalid time output.
- Once time is acquired, on the next PPS add 1 to the whole second to read the correct time.

Note *– The smallest time resolution is 1 second.*

Holdover stability

The on-board 10MHz oscillator of Mini-T™ GG can provide holdover for 24 hours without reception of GNSS signals. After more than 72 hour of continuous GNSS disciplining and at room temperature, the PPS will be accurate within ±5µs for 24 hours without lock to GNSS satellites.

Customizing operation

The Mini-T™ GG provides a number of user configurable parameters to customize the operation of the unit. These parameters are stored in non-volatile memory (flash) to be retained during loss of power and through resets. At reset or power-up, the receiver configures itself based on the parameters stored in flash memory. A variety of TSIP packets can be used to change the values of these parameters to achieve the desired operations. The Mini-T™ GG configures itself based on the new parameter immediately, but the new parameter value is not automatically saved to flash. The save command must be manually executed to retain the changed values.

Send packet 0x8E-26 to direct the Mini-T™ GG to save the current parameter values to the flash. To save or delete the stored position, use command packet 0x8E-A6. The receiver can be set to Trimble default values by performing a factory reset by issuing TSIP command 0x1E.

In brief, to customize the Mini-T™ GG Multi-GNSS Disciplined Clock operations for your application:

- Configure the receiver using TSIP command packets until the desired operation is achieved.
- Use TSIP packet 0x8E-26 to save the settings in nonvolatile memory (flash).
- 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.

CHAPTER

3

Mini-T™ GG Features & Specifications

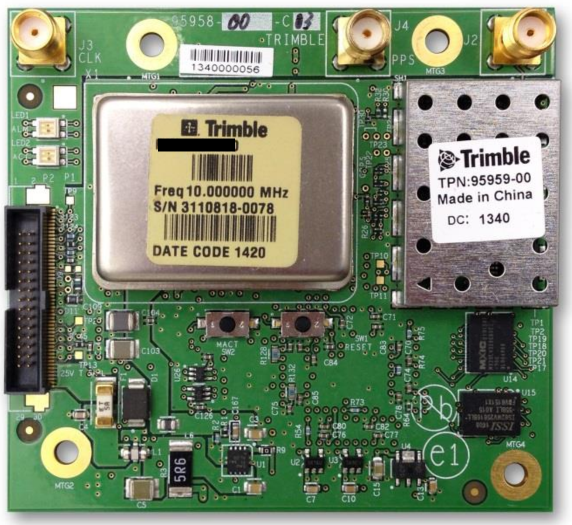
In this chapter:

This chapter describes the Mini-T™ GG disciplined clock's features and performance specifications.

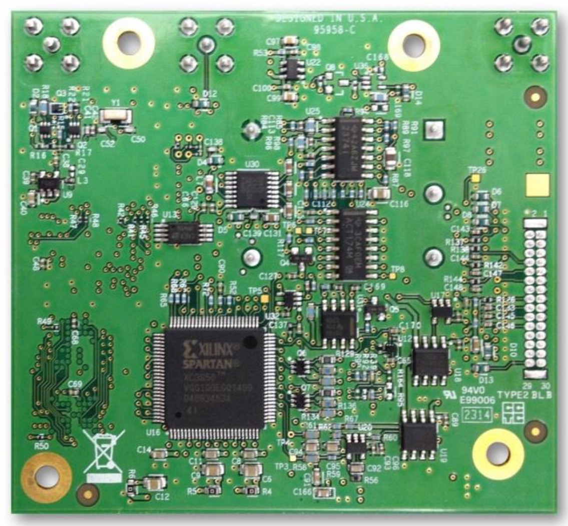
Visual Appearance

The pictures below are showing the visual appearance of Mini-T™ GG from the top side and the bottom side. The Mini-T™ GG is an open PCB assembly that comes without an enclosure. It is designed to be integrated within a host system to provide appropriate connections, interfaces and protection from environmental influences to the device.

Mini-T™ GG Top Side:



Mini-T™ GG Bottom Side:

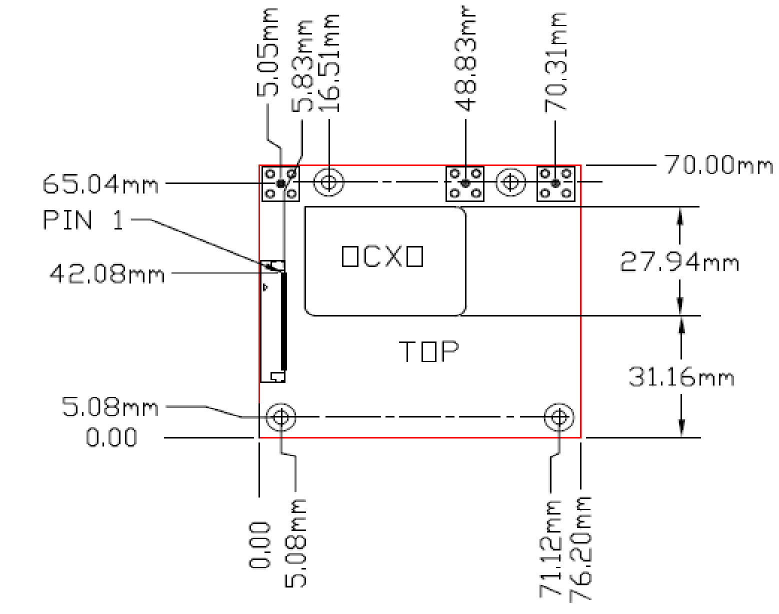


Physical Specifications

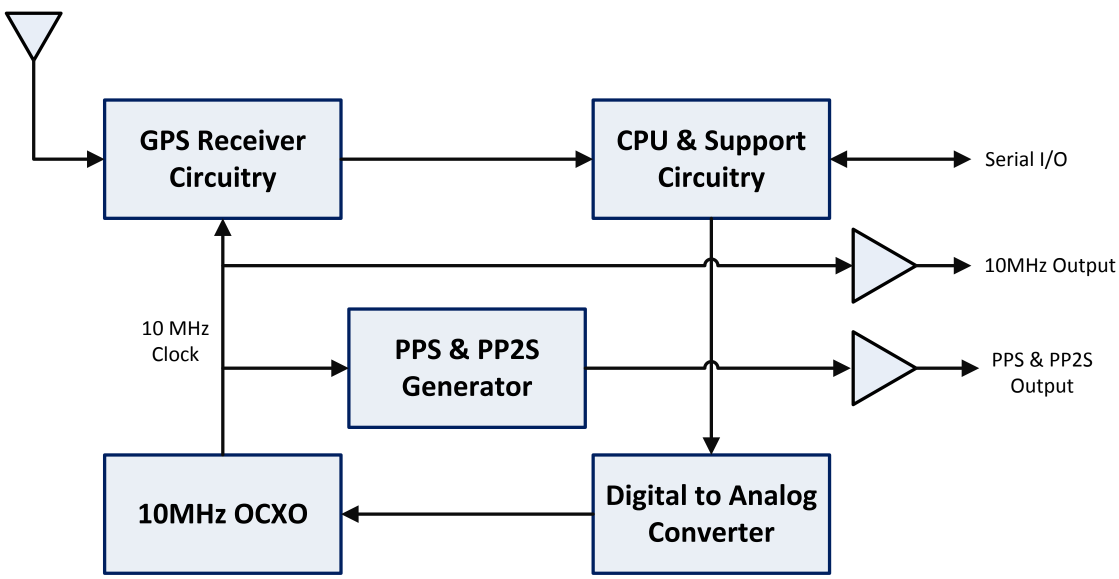
Dimensions	76.2 mm x 70 mm x 17 mm
Weight	54.5gms

Mechanical outline drawing

Mini-T™ GG Multi-GNSS Disciplined Clock, footprint:



Block diagram



Connectors

The Mini-T™ GG has four connectors to the host system; 3 coaxial SMA connectors for PPS and 10 MHz output and GNSS antenna input and one 30-pin power and I/O connector.

GNSS antenna RF input (coaxial SMA)

The RF input connector for the GNSS antenna is a SMA (f) receptacle 50 Ω unbalanced GNSS RF input, and can be used only with an active GNSS antenna. The contact area of this connector is gold-plated. Use a mating connector according to the SMA (m) standard.

PPS Output (coaxial SMA)

The primary PPS output connector is a SMA (f) receptacle. The contact area of this connector is gold-plated. Use a mating connector according to the SMA (m) standard.

The PPS output signal is a digital LVCMOS (3.3V) logic level signal. The PPS signal is phase-locked to the 10 MHz frequency.

In addition to the PPS output on the SMA connector, there are digital PPS (1Hz) and PP2S (2Hz) output signals available on the 30-pin power and I/O connector.

10 MHz Output (coaxial SMA)

The primary 10 MHz output connector is a SMA (f) receptacle with 50Ω. The contact area of this connector is gold-plated. Use a mating connector according to the SMA (m) standard.

The 10 MHz output signal on the SMA connector is a sinusoidal analog frequency. Terminate the 10 MHz output with a 50 Ω load. The output power into 50 Ω is typ. 7dBm (min. 5dBm, max. 9dBm). The frequency output is phase-locked with the PPS pulse.

The Phase Noise of the 10 MHz frequency output is:
-90dBc/Hz @ 1Hz
-120dBc/Hz @ 10Hz
-135dBc/Hz @ 100Hz
-145dBc/Hz @ >1KHz

In addition to the 10 MHz output on the SMA connector, there's a digital low-voltage (3.3V) LVTTL logic level 10 MHz frequency output available on the 30-pin power and I/O connector.

Power and I/O connector

The power and I/O connector on the Mini-T™ GG PCB is a 30-pin (2 rows of 15 pins, 1.27 mm pitch) shrouded ICD header made by Samtec (www.samtec.com), Samtec part number SHF-115-01-L-D-TH. The mating connector is Samtec's FFSD ribbon cable series. Trimble doesn't provide the mating ribbon cable, though. Please contact Samtec or their distributors for more information about FFSD ribbon cables.

Power and I/O connector Pin Assignment

NC	1	2	RESET_IN
NC	3	4	NC
PPS_IN	5	6	NC
PPS_OUT	7	8	NC
GND	9	10	NC
GND	11	12	PP2S_OUT
GND	13	14	D_10MHz
GND	15	16	HW_ALM
GND	17	18	PWR_Status
GND	19	20	NC
NC	21	22	NC
NC	23	24	Rx_232
PWR_5.5V	25	26	Tx_232
PWR_5.5V	27	28	Rx_TOD
PWR_5.5V	29	30	Tx_TOD

***Note** – The pin 5 is used when an external PPS is provided as secondary reference source.*

Status & Alarm Indicator (LED)

Mini-T GG has two LEDs on board to indicate status and alarm of the unit.

State	Status (LED1)	Alarm (LED2)
Start up	ON RED	ON RED
Sync to GNSS signal	ON Green (Blinking 1Hz)	OFF
Holdover (no GNSS)	ON Green (Blinking 2Hz)	OFF
Hardware Alarm	ON Green	ON RED

Pin description

Pin	Name	Description	Function	Note
1	NC	Not connected	N/A	Do not connect
2	RESET_IN	Reset	Input	Active low logic level reset. If not used, do not connect.
3	NC	Not connected	N/A	Do not connect
4	NC	Not connected	N/A	Do not connect
5	PPS_IN	External PPS	Input	External PPS input for secondary reference
6	NC	Not connected	N/A	Do not connect
7	PPS	Pulse per second	Output	LVTTL Timing pulse at 1 Hz, 50µs pulse width

Pin	Name	Description	Function	Note
8	NC	Not connected	N/A	Do not connect
9	GND	Ground		Signal ground. Connect to common ground.
10	NC	Not connected	N/A	Do not connect
11	GND	Ground	Ground	Signal ground. Connect to common ground.
12	PP2S_OUT	Even PPS	Output	LVTTL Even second Timing pulse at 0.5Hz.
13	GND	Ground	Ground	Signal ground. Connect to common ground.
14	D_10MHz	System Clock	Output	LVTTL Frequency (10MHz)
15	GND	Ground	Ground	Signal ground. Connect to common ground.
16	HW_ALM	Hardware Alarm	Output	LVTTL Hardware Alarm Normal = Low, Failure = High
17	GND	Ground	Ground	Signal ground. Connect to common ground.
18	PWR_Status	Power Status	Output	Normal = Low / Input 5.5V Failure = High.
19	GND	Ground	Ground	Signal ground. Connect to common ground.
20	NC	Not connected	N/A	Do not connect
21	Reserved	Reserved	N/A	Do not connect
22	NC	Not connected	N/A	Do not connect
23	NC	Not connected	N/A	Do not connect
24	Rx_232	UART Receive	Input	RS232 serial port (receive)
25	PWR_5.5V	Supply Voltage	Input	Power.
26	Tx_232	UART Transmit	Output	RS232 serial port (transmit)
27	PWR_5.5V	Supply Voltage	Input	Power.
28	Rx_TOD	TOD Receive	Input	LVTTL TOD port receive
29	PWR_5.5V	Supply Voltage	Input	Power.
30	Tx_TOD	TOD Transmit	Input	LVTTL TOD port transmit

Reserved pins

There are several reserved pads on the Mini-T™ GG multi-GNSS timing module.

***CAUTION** – Do not connect these pins! Connecting any of the reserved pins to supply voltage or GND or any logic level may bring the Mini-T™ GG into an undefined condition that may impact the function and performance of the receiver or may cause damage to the module.*

Absolute Maximum Ratings

Pin	Signal	Description	Condition	Min	Max
25,27,29	VCC	Receiver Power Supply Input	Referenced to GND	-0.3V	6.0V
All I/O pins	VI	Input Voltage	Referenced to GND	-0.3V	VCC + 0.3V

Pin	Signal	Description	Condition	Min	Max
All I/O pins	VO	Output Voltage	Referenced to GND	-0.3V	VCC + 0.3V
All I/O pins	IIO	Input/Output Current			25mA
RF-IN	PANT	Input Power at Antenna Input			+3dBm

CAUTION *– Absolute maximum ratings indicate conditions beyond which permanent damage to the device may occur. Electrical specifications do not apply when you are operating the device outside its rated operating conditions.*

Electrical Specifications

Minimum and maximum limits apply over the full operating temperature range unless otherwise noted.

Power requirements

The operating power for the Mini-T™ GG is supplied through pins 25, 27 and 29 of the power and I/O connector and the supply current return path is through pins 9, 11, 13, 15, 17 and 19. All of the PWR and GND pins shall be connected to the external power source.

The receiver requires +5.5 V DC ±5% supply voltage. The power dissipation when cold started is ≤6 W. The power dissipation when warm started is ≤3W (active antenna power consumption not included).

Ideally, you should provide a separate low-noise *linear* voltage regulator for the Mini-T™ GG supply. Switching voltage regulators can generate so much supply voltage ripple noise that the performance of GNSS receivers might be negatively affected.

Pad	Signal	Description	Condition	Min	Typ	Max
25,27,29	V_{CC}	*Receiver Power Supply Input*				
	V_{CC}	Receiver Operating Voltage (see Note)		5.22V	5.50V	5,77V
	P_{SUP}	Receiver Power Consumption	V_{CC} =5.50V		3W	6W

Note *– Mini-T™ GG may not work as expected if supply voltage outside of the specified operating range is applied. At power-on, V_{CC} shall ramp-up straight from zero to +5.5 VDC ±5%, without dwelling in the range of less than 5.22V. Furthermore, no voltage shall be applied to any I/O pad while V_{CC} is off, as this can back-power the device and also cause unexpected behavior.*

Grounding

There is a common ground plane on the Mini-T™ GG board. The Mini-T™ GG Multi-GNSS Disciplined Clock is designed with numerous ground pins that, along with the metal shield, provide the best immunity to EMI and noise. All ground pins of the Mini-T™ GG board shall be connected to the common ground of the power supply unit. Any alteration by adding ground wires to the metal shield is done at the customer's risk and will void the warranty.

Supply voltage control

If you want to be able to power-cycle the module, you should use tri-state gates at all signal lines and PPS and SYSCLK during power-down. No I/O pin should be actively driven or being pulled-high during power-down. The board may not start up as expected if pads are driven before supply voltage is switched-on.

Trimble recommends that the Off-time in case of a power-cycle is not shorter than 1s in order to allow all capacitors on the board to discharge sufficiently before the next power-on.

Mounting

There are four mounting holes on the PCB that accept 3/16" hex or round standoffs, and #2-2-56 or M3 mounting screws. Space constrained environments may require a different standoff. All four mounting holes are non-isolated vias which are connected to common GND.

Serial interfaces

The Mini-T™ GG provides one direct low-voltage (3.3V) LVTTL/CMOS compatible serial Input / Output (I/O) for the Time of Day (TOD) information. The RxD and TxD signals are driven directly by the UART on the Mini-T GG™. Interfacing these signals directly to a 3.3V LVTTL-level UART in the application circuitry provides direct serial communication without the need for RS-232 or RS-422 line drivers.

A second serial port with standard RS232 levels is provided as control and monitor interface. The RxD and TxD signals are driven by RS232 line drivers and can be connected to a standard RS232 COM port. The protocols on both serial ports can be either Trimble's native TSIP protocol or the standardized NMEA protocol. Refer to the chapter 'Software Interface' in this User Guide for more information about the software interface.

Pulse-per-second (PPS and PP2S)

The Mini-T™ GG provides a 50µs wide, low-voltage (3.3V) LVTTL compatible Pulse-Per-Second (PPS). The PPS is available on pin 7 and on the SMA connector PPS. The leading edge of the PPS pulse is synchronized to the selected time reference (either GNSS or UTC-time). The timing accuracy is within 15 nanoseconds (1 sigma) to UTC when valid position fixes are being reported in the Over-determined Mode. See also packet 0x8E-A2 to change PPS reference to GNSS time.

Furthermore, the Mini-T™ GG provides a low-voltage (3.3V) LVTTL compatible Pulse-Per-Even-Second (PP2S). The PP2S is available on pin 12. The leading edge of the PP2S pulse is synchronized to the selected time reference (either GNSS or UTC-time). The timing accuracy is within 15 nanoseconds (1 sigma) to UTC when valid position fixes are being reported in the Over-determined Mode. See also packet 0x8E-A2 to change PP2S reference to GNSS time.

A PPS pulse has to be seen in conjunction with the corresponding time tag, which is a TSIP or NMEA message that is provided through the serial port. The leading edge of a PPS pulse is synchronized to the start of a full second of the selected time base with high accuracy. The TSIP message 0x8F-AB or NMEA message ZDA, that follows a PPS pulse, contains the time and date information for this particular pulse.

If TSIP message 0x8F-AB or NMEA message ZDA is configured for automatic output, it will be generated shortly after the pulse that it belongs to. If TSIP message 0x8F-AB or NMEA message ZDA, or any other packet with time information, is configured for silent mode (no automatic output), the packet that is generated in response to a query command will always refer to the PPS pulse that was preceding this packet in a 1s interval.

Environmental Specifications

Parameter	Condition
Operating temperature	-40°C to + 85°C
Storage temperature	-55°C to + 105°C
Vibration, operating	1.5g sine sweep from 10Hz - 1200Hz
	random vibration 3.06 GRMS
Vibration, non-operating	1.5g from 10Hz to 500Hz
Mechanical shock	±40g operational, ±75g non-operational
Operating humidity	5% to 95% R.H., non-condensing at +60°C
Operating altitude	-400m to 10000m Mean Sea Level

Protection against Electrostatic Discharge (ESD)

ESD testing was performed using test standard IEC 61000-4-2. All input and output pins are protected to ±500V ESD level (contact discharge).

The RF IN pin is protected up to 1 kV contact discharge. If a higher level of compliance is required, you must add additional electrostatic and surge protection.

The PCB and component areas of the Mini-T™ GG module were not tested for ESD sensitivity. The open board assembly is an electrostatic sensitive device. Appropriate care and protection against ESD, according to JEDEC standard JESD625-A (EIA 625) and IEC 61340-5-1, must be taken when handling the product.

EMI

The unit meets all requirements and objectives of FCC Part 15 Subpart J Class B.

CHAPTER

4

GNSS Antenna

In this chapter:

A good GNSS antenna, together with a good installation site, is the key for getting the best performance from a GNSS receiver.

This chapter explains the requirements for the antenna and provides recommendations for a good installation.

GNSS Antenna

The antenna receives the GNSS satellite signals and passes them to the receiver. The GNSS signals are spread spectrum signals in the 1564MHz to 1614MHz range and do not penetrate conductive or opaque surfaces. Therefore, the antenna must be located outdoors with a clear view of the sky. The Mini-T™ GG requires an active antenna with integrated LNA. The received GNSS signals are very low power, approximately -130dBm, at the surface of the earth. Trimble's active antenna includes a preamplifier that filters and amplifies the GNSS signals before delivery to the receiver.

The onboard circuit of the Mini-T™ GG provides DC supply voltage on the SMA connector for the external, active GNSS antenna.

Antenna requirements

The Mini-T™ GG requires an active GNSS antenna with built-in Low-Noise Amplifier (LNA) for optimal performance. The antenna LNA amplifies the received satellite signals for two purposes:

a) Compensation of losses on the cable
b) Lifting the signal amplitude in the suitable range for the receiver frontend.

Task b) requires an amplification of at least 15dB, while 20dB is the sweet spot for the Mini-T GG™. This would be the required LNA gain if the antenna was directly attached to the receiver without cable in between.

The cable and connector between the antenna and the receiver cause signal loss. The overhead over the minimum required 15 dB and the actual LNA gain of the antenna is available for task a). So in case of a 30dB LNA gain in the antenna, 15 dB are available for compensating losses.

Or in other words, the attenuation of all elements (cables and connectors) between the antenna and the receiver can be up to a total of 15dB with a 30dB LNA. With a different antenna type, take the difference between 15dB and the antenna's LNA gain as the available compensation capability. Subtract the insertion losses of all connectors from the 15dB (or whatever the number is) and the remainder is the maximum loss, which your cable must not exceed.

As the GNSS signals are hidden in the thermal noise floor, it is very important that the antenna LNA doesn't add more noise than necessary to the system; therefore a low noise figure is even more important than the absolute amplification.

Trimble does not recommend having more than 35dB remaining gain (LNA gain minus all cable and connector losses) at the antenna input of the receiver module. The recommended range of remaining LNA gain at the connector of the receiver module is 20dB to 30dB with a minimum of 15dB and a maximum of 35dB.

Antenna OPEN/SHORT Detection

The Mini-T™ GG module has an integrated antenna feed circuit for providing the required operating power to the active GNSS antenna. This circuit generates the ANTOPEN and ANTSHORT hardware signals for the GNSS processor, which generates the antenna status reports in the TSIP and NMEA protocol from these hardware signals.

The antenna monitoring circuit is basically a current monitor with current limiting. The current limiting of Mini-T™ GG may begin above 120mA up to approx. 190mA in a full short-circuit condition, but it's not a sharp cut-off. You will see an increasing drop of the supply voltage that goes up with the supply current. The values in the table below are dependent on component tolerances and operating temperature and are therefore only approximate numbers and not very precise.

Antenna Voltage Feed Conditions:

V_{ANT}	Condition
+5.0V	Open: Below the 8mA to 4mA range
	Short: Above 150mA
	Current Limiting: Above 190mA

The antenna power output is only specified up to 55 mA. The reason for the 55 mA upper limit is basically the voltage drop. Exceeding 55 mA will not damage the receiver, but the antenna supply might be insufficient.

Note *- If you're using antennas with high current consumption, the voltage drop across the sensing resistor will increase and the supply voltage at the RF-connector may drop too low to provide sufficient power to the antenna LNA. In that case, Trimble recommends using either antennas with lower operating current (preferred), or antennas with wider supply voltage range.*

Antenna Placement

Sky-Visibility

GNSS signals can only be received on a direct line of sight between antenna and satellite. The antenna should see as much as possible of the total sky. Seen from the northern hemisphere of the earth, more satellites will be visible in the southern direction rather than in northern direction. The antenna should therefore have open view to the southern sky. If there are obstacles at the installation site, the antenna should be placed south of the obstacles, preferably, in order not to block sky-view to the south.

If the installation site is in the southern hemisphere of the earth, then the statements above are reversed – more satellites will be visible in the northern direction. Near to the equator, it doesn't matter.

Partial sky visibility causes often poor DOP values due to the geometry of the visible satellites in the sky. If the receiver can only see a small area of the sky, the DOP has a high degree of uncertainty and will be worse compared to a condition with better geometric distribution. It may happen that a receiver is seeing 6 satellites, all close together, and still get a much worse DOP than a receiver which sees 4 satellites, but all in different corners of the sky. The receiver’s DOP filter rejects fixes with high DOP (high uncertainty), it can take longer to get the first acceptable fix if sky visibility is partly obstructed.

Multipath-reflections

Multipath occurs when the GNSS signals are reflected by objects, such as metallic surfaces, walls and shielded glass for example. The antenna should not be placed near a wall, window or other large vertical objects if it can be avoided.

Jamming

Jamming occurs when the receiver function is disturbed by external RF sources that interfere with GNSS signals or saturate the antenna LNA or receiver front-end. A good indicator to detect jamming is switching off all other equipment except the GNSS. Watch the satellite signal levels in this condition. Then switch on other equipment and see if the signal levels go down. A drop of signal levels indicates interference to GNSS from the other equipment. This method cannot, however, detect all possible kinds of jamming. Spurious events are hard to catch. Low frequency fields, like 50 Hz, are unlikely to jam the receiver. Broadband sparks are a potential source of spurious jamming. There's no general installation rule or specification though, because the effect of jamming highly depends on the nature of the jamming signal and there are uncountable many variations possible, so that it's not possible to standardize a test scenario.

Ground Plane

A metal plate or surface under the antenna can block signal reflections from below. This is a good method to mitigate reflections, if the receiver is mounted on high masts or other elevated sites.

Trimble’s GNSS antenna

Trimble offers the following antenna options for use with the Mini-T™ GG.

A 3.3V DC or a 5.0 V DC Bullet GG rooftop antenna or A magnetic mount antenna

CHAPTER

5

Software Interface

In this chapter:

This chapter describes the software interface and describes communication with the receiver, port protocol, and data output options.

Note: Trimble recommends that the TSIP protocol is used for all timing functions due to the availability of timing specific status and alert messages.

NMEA is made available for the convenience of the user but this protocol does not provide the same status and alert features.

Communicating with the receiver

The Mini-T™ GG Multi-GNSS Disciplined Clock supports two message protocols: TSIP and NMEA. Communication with the receiver is through serial ports. The port characteristics can be modified to accommodate your application requirements. The protocol settings and options are stored in Random Access Memory (RAM). They can be saved into the non-volatile memory (Flash), which does not require back-up power, if required, using command 0x8E-26.

Protocols

The following protocols are available on the Mini-T™ GG Multi-GNSS Disciplined Clock:

Protocol	Specification	Direction
TSIP	Trimble proprietary binary protocol	Input / Output
NMEA	NMEA 0183 v4.1	Input[1] / Output

[1]Requires use of Trimble-proprietary NMEA messages.

Serial port default settings

The Mini-T™ GG Multi-GNSS Disciplined Clock supports two serial ports. The default settings are as follows:

Port	Port Directions	Pin #	Protocol	Characteristic				
				Baud rate	Data bits	Parity	Stop bits	Flow control
A	TXDA	24	TSIP out	115 kbps	8	No	1	None
	RXDA	26	TSIP in	115 kbps	8	No	1	None
B	TXDB	28	TSIP out	115 kbps	8	No	1	None
	RXDB	30	TSIP out	115 kbps	8	No	1	None

Use the TSIP 0xBC command on Port A to configure protocol for Port B, and then use the TSIP 0x8E-26 command to save the configuration.

- Baud rate, data bits, parity, and stop bits are user configurable.
- Flow control is not available on the serial ports.

Detailed descriptions of these protocols are defined in the Appendices A and B of this User Guide

CAUTION *– When changing port assignments or settings, confirm that your changes do not affect the ability to communicate with the receiver (e.g., selecting the PC COM port settings that do not match the receiver's, or changing the output protocol to TSIP while not using VTS).*

Software tools

Any standard serial communications program can be used to view the ASCII NMEA output messages. TSIP is a binary protocol and outputs raw binary serial data that cannot be read when using a Terminal program. To view the output of the TSIP protocol in text format, use the Trimble Visual Timing Studio (VTS) program.

Trimble VTS, a Windows-based GUI, provides a versatile graphical interface for monitoring TSIP an NMEA data. This application allows the user to view complete receiver operations including data output, status and configuration. In this application, the entry of command packets is replaced by traditional point and click pull-down menus.

APPENDIX

A

Trimble Standard Interface Protocol

In this chapter:

The Trimble Standard Interface Protocol (TSIP) may be characterized as a set of data packets used to transmit information to and receive information from a Trimble GNSS receiver. Trimble products commonly support a version of TSIP which is customized to the attributes of the product. This appendix describes the Mini-T™ GG customization.

WARNING – The Mini-T™ GG Multi-GNSS Disciplined Clock is ready to accept TSIP commands approximately 10 seconds after power-up. If a command is sent to the receiver within this 10 second window, the receiver will ignore the command. The Mini-T™ GG Multi-GNSS Disciplined Clock will not respond to commands sent within the 10 second window and will discard any associated command data.

Note – This appendix has been generated and reviewed with care, however, history has shown that it is surprisingly difficult to generate a TSIP appendix which is entirely free of errors. There is no reason to believe that this appendix will be an exception. Trimble is always grateful to receive reports of any errors in either products or documentation.

Introduction

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 Trimble 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 Mini-T™ GG Multi-GNSS Disciplined Clock has one configurable serial I/O communication port, which is a bi-directional control and data port utilizing a Trimble 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 that identifies the meaning and format of the data that follows. Each packet begins and ends with control characters.

TSIP (Trimble Serial Interface Protocol) Packet Structure

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

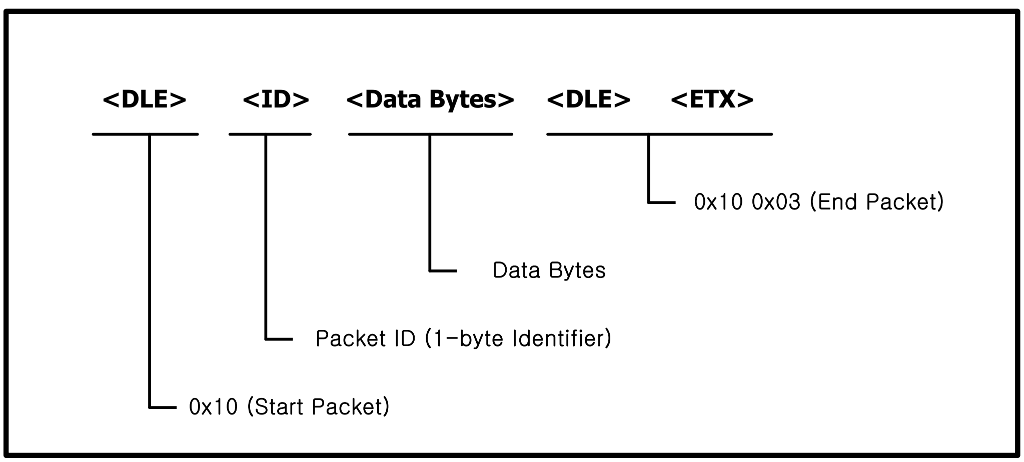


Figure 1-1: TSIP Packet Structure

<DLE> is the byte 0x10

<ETX> is the byte 0x03 and

<ID> is a packet ID byte, which can have any value with the exception of <ETX> and <DLE>.

The values of the data bytes vary and are dependent on the function performed by the packet. To prevent confusion with the starting and ending frame sequences, <DLE> <ID> and <DLE> <ETX> respectively, every <DLE> byte in the <data bytes> of a packet is preceded by an extra

<DLE> stuffing byte. These extra <DLE> bytes must be added (stuffed) before sending a packet and removed (unstuffed) 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.*

Subpackets

Several packets support multiple functions which are processed using subpackets. Subpackets are treated as and behave like separate packets (see Figure 1-2).

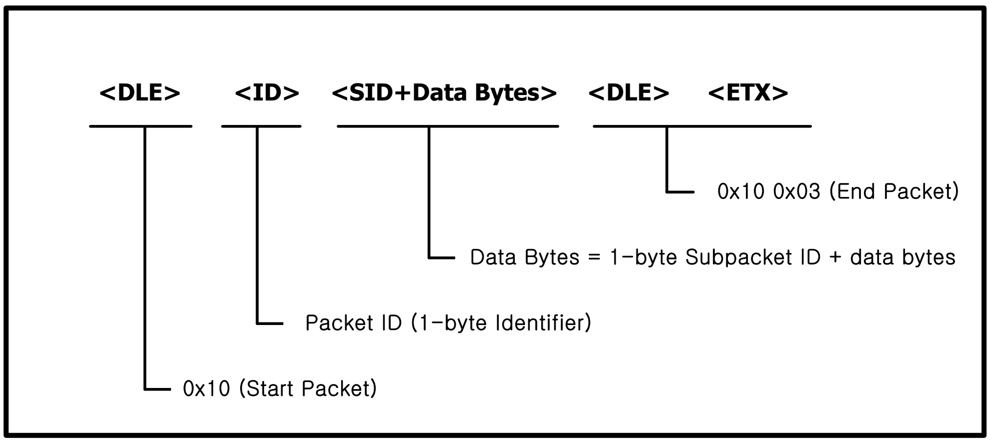


Figure 1-2 TSIP SubPacket Structure

To identify these subpackets, a 1-byte hexadecimal Subpacket ID (SID) is included as the first byte of data. Hexadecimal notation is used to identify the subpackets associated with a packet.

Data Types

Multiple-byte data types follow the ANSI / IEEE Standard and the IEEE-754 Standard for binary Floating-Point Arithmetic. These values are sent most-significant byte first and results in the switching the order of the bytes as they are normally stored. Only the fractional part of the mantissa for real numbers, Single and Double, is reported because the leading bit on the mantissa is always 1. TSIP supports the following data types:

Data Type	Description
UINT8	An 8-bit unsigned integer (0 to 255) -
SINT8	An 8-bit signed integer (-128 to 127)
INT16	An 16-bit unsigned integer (0 to 65,535)
SINT16	An 16-bit signed integer (-32,768 to 32,767)
UINT32	An 32-bit unsigned integer (o to 4,294,967,295)

SINT32	An 32-bit signed integer (-2,147,483,648 to 2,147,483,647)
SINGLE	Single-precision float (4 bytes) (1.2×10^{-38} to 3.4×10^{38})
DOUBLE	Double-precision float (8 bytes) (2.2×10^{-308} to 1.8×10^{308})

Configuration Parameters

The following tables list the factory default settings for all MINI-T™ GG configuration parameters. Also listed are the packets IDs used to set, request and report these parameters.

GNSS Configuration

Parameter	Factory Default	Set	Request	Report
Receiver mode	Over-determined Clock Mode	0xBB	0xBB	0xBB
Sensitivity	Indoor (maximum sensitivity)			
Constellation	All available			
Anti-jamming	Enabled			
Elevation mask	5°			
Signal level mask	29.0 C/No (sets minimum level)			

Packet I/O Control

Parameter	Factory Default	Set	Request	Report
Packet broadcast mask Mask0 Mask1	 0x05 0x00	0x8E-A5	0x8E-A5	0x8E-A5
Packet 0x35 I/O Options Position Velocity Timing Auxiliary	 0x12 0x02 0x00 0x08	0x35	0x35	0x35

Serial Port Configuration

Parameter	Factory Default	Set	Request	Report
Input baud rate	115200 bps	0xBC	0xBC	0xBC
Output baud rate	115200 bps			
Data bits	8 bits			
Parity	NONE			
Stop bits	1 bit			
Input / Output Protocol	TSIP (Trimble Standard Interface Protocol)			

Timing Outputs

Parameter	Factory Default	Set	Request	Report
PPS enable	1 (Enabled)	0x8E-4A	0x8E-4A	0x8F-4A
PPS sense	1 (Rising Edge)			
PPS offset	0.0 seconds			
Bias uncertainty threshold	150.0 meters	0x8E-4A	0x8E-4A	0x8F-4A
PPS output qualifier	2 (Always on)	0x8E-4E	0x8E-4E	0x8F-4E
UTC/GPS Date/Time	0 (GPS)	0x8E-A2	0x8E-A2	0x8F-A2
UTC/GPS PPS alignment	0 (GPS)	0x8E-A2	0x8E-A2	0x8F-A2

Automatic Output Packets

The following table lists the packets that can be automatically sent by the MINI-T™ GG to the user and under what conditions these packets will be sent.

Broadcast Packet ID	Description	Masking Packet ID	Request Packet ID	When Sent
0x2E	Request GPS Time	0x8E-B0	None	When needed
0x32	Request Unit Position	0x8E-B0	None	When needed
0x38	Request SV System Data	0x8E-B0	None	At programmed interval
0x42	Position XYZ(ECEF), single precision	0x35 and 0x8E-A5 (bit 6)	0x37	When a position fix is computed
0x43	Velocity XYZ, single precision	0x35 and 0x8E-A5 (bit 6)	0x37	When a position fix is computed
0x47	Signal Levels	0x8E-A5 (bit 6)	0x27	Once per second
0x4A	Position LLA, single precision	0x35 and 0x8E-A5 (bit 6)	0x37	When a position fix is computed
0x56	Velocity ENU, single precision	0x35 and 0x8E-A5 (bit 6)	0x37	When a position fix is computed
0x5A	Raw Measurements	0x35 and 0x8E-A5 (bit 6)	0x3A	When new measurements are available
0x6C	Satellite list, DOPS, mode	0x8E-A5 (bit 6)	0x24	Once per second
0x83	Position XYZ(ECEF), double precision	0x35 and 0x8E-A5 (bit 6)	0x37	When a position fix is computed
0x84	Position LLA, double precision	Position LLA, single precision	0x37	When a position fix is computed
0x8F-AB	Primary timing packet	0x8E-A5 (bit 0)	0x8E-AB	Once per second

Broadcast Packet ID	Description	Masking Packet ID	Request Packet ID	When Sent
0x8F-AC	Secondary timing packet	0x8E-A5 (bit 2)	0x8E-AC	Once per second

Packets Output at Reset

The following packets are automatically sent by the MINI-T™ GG to the user after a Reset event, which can be triggered either by a hardware signal on the Reset pin or by a software command.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x45	
1	Application	UNIT8		Major version number of application
2		UNIT8		Minor version number of application
3		UNIT8		Month
4		UNIT8		Day
5		UNIT8		Year number minus 2000
6	GNSS Core	UNIT8		Major revision number of GNSS core
7		UNIT8		Minor revision number of GNSS core
8		UNIT8		Month
9		UNIT8		Day
10		UNIT8		Year number minus 2000

Input Packets Supported

The following table lists the packets that can be sent the MINI-T™ GG by the user.

Input ID	Packet Description	Output ID
0x1C	Firmware/Hardware version	0x1C
0x1E	Initiate cold, warm or factory reset	0x45 (after reset)
0x1F	Request software version	0x45
0x24	Request GPS satellite selection	0x6C
0x25	Initiate hot reset	0x45 (after reset)
0x27	Request signal levels	0x47
0x2E	Set GPS Time	0x4E
0x31	Set accurate position (XYZ ECEF)	-
0x32	Set accurate position (Lat, Long, Alt)	-
0x35	Set/request I/O options	0x55
0x37	Request status and value of last position and velocity fixes	0x57 (and other enabled packets)
0x38	Load/request satellite system data	0x58
0x3A	Request last raw measurement	0x5A
0x3C	Request current satellite tracking status	0x5C
0xBB	Set/request receiver configuration	0xBB
0xBC	Set/request serial port configuration	0xBB
0x8E-26	Save configuration	0x45 (after reset)
0x8E-41	Request manufacturing parameters	0x8F-41
0x8E-42	Request production parameters	0x8F-42
0x8E-4A	Set/request PPS characteristics	0x8F-4A
0x8E-4E	Set/request PPS output options	0x8F-4E
0x8E-A0	Set/request DAC value	0x8F-A0
0x8E-A2	Set/request UTC/GPS timing	0x8F-A2
0x8E-A3	Issue oscillator disciplining command	0x8F-A3
0x8E-A5	Set/request packet broadcast mask	0x8F-A5
0x8E-A8	Set/request oscillator disciplining parameters	0x8F-A8
0x8E-AB	Request primary timing packet	0x8F-AB
0x8E-AC	Request supplemental timing packet	0x8F-AC
0x8E-B0	Set/request MINI-T™ GG configuration	0x8F-B0

Output Packets Supported

The following table lists the packets that can be sent to the user by the Mini-T™ GG.

Output ID	Packet Description	Input ID
0x13	Invalid packet	Any
0x1C	Firmware/Hardware version	0x1C
0x2E	Request GPS Time	Auto
0x32	Request Unit Position	Auto
0x38	Request SV System data	Auto
0x42	Single-precision XYZ position	0x37, auto
0x43	Velocity fix (XYZ ECEF)	0x37, auto
0x45	Software version information	0x1E, 0x1F
0x47	Signal level for all satellites	0x27, auto
0x4A	Single-precision LLA position	0x37, auto
0x4E	Response to Set GPS Time	0x2E
0x55	I/O options	0x35
0x56	Velocity fix (ENU)	0x37, auto
0x57	Information about last computed fix	0x37
0x58	GPS system data/acknowledge	0x38
0x5A	Raw measurement data	0x3A
0x5C	Satellite tracking status	0x3C
0x6C	Satellite selection list	0x24, auto
0x83	Double-precision XYZ	0x37, auto
0x84	Double-precision LLA	0x37, auto
0xBB	Receiver configuration	0xBB
0xBC	Serial port configuration	0xBC
0x8F-41	Stored manufacturing operating parameters	0x8E-41
0x8F-42	Stored production parameters	0x8E-42
0x8F-4A	PPS characteristics	0x8E-4A
0x8F-4E	PPS output options	0x8E-4E
0x8F-A0	DAC value	0x8E-A0
0x8F-A2	UTC/GPS timing	0x8E-A2
0x8F-A3	Oscillator disciplining command	0x8E-A3
0x8F-A5	Packet broadcast mask	0x8E-A5
0x8F-A8	Oscillator disciplining parameters	0x8E-A8
0x8F-AB	Primary timing packet	0x8E-AB, auto
0x8F-AC	Supplemental timing packet	0x8E-AC, auto
0x8F-B0	Report MINI-T™ GG configuration	0x8E-B0

Packet Descriptions

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.

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

Command packet 0x1C-03: Hardware component version information

The command packet 0x1C-03 may be issued 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 Mini-T GG at production.

The hardware code is 3035 (0xBDB)
The hardware ID is "Mini-T GG"

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	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	0xBDB	HW 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 Mini-T GG

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

This packet commands Mini-T™ GG 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	0x4B 0x0E 0x46	Cold reset Warm reset Factory 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 Mini-T™ GG. This packet contains no data. Mini-T™ GG returns packet 0x45.

Command packet 0x24: Request GPS satellite Selection

This packet requests a list of satellites used for the current position/time fix. This packet contains no data. MINI-T™ GG returns packet 0x6C.

Command packet 0x25: Initiate Hot Reset

This packet commands the GPS receiver to perform a hot reset. This is not equivalent to cycling the power; RAM is not cleared. This packet contains no data.

Command packet 0x27: Request Signal Levels

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. Mini-T™ GG returns packet 0x47.

Command packet 0x2B: Set Approximate Initial Position

This packet is used 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 1000Km from the location of the last position fix. This packet causes an immediate search for the visible SVs starting at the approximate initial position and widens the search to all SVs if the receiver cannot acquire enough SVs to generate a position. The receiver can initialize without any data from you, but it takes more time to generate a position.

This packet does not perform a software reset and is ignored when the receiver is already generating position.

Command Packet 0x2B Data Format (Double Precision)

Byte	Item	Type	Value/Unit	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:30K Range: 0 ~ 3000Km
29-32	Vertical Uncertainty	SINGLE	meters	Default:500 Range: 0 ~ 500m

Command Packet 0x2B Data Format (Single Precision)

Byte	Item	Type	Value/Unit	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	
13-16	Horizontal Uncertainty	SINGLE	meters	Default: 30000
17-20	Vertical Uncertainty	SINGLE	meters	Default: 500

Command packet 0x2E: Set GPS Time

This packet sets the approximate GPS time of week and the week number in receiver memory, and the receiver responds by sending Report Packet 0x4E. The GPS week number reference is Week #0 starting January 6, 1980. The seconds count being at midnight each Sunday morning.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x2E	
1-4	GPS time	SINGLE	seconds	GPS time of week
5-6	GPS week	INTEGER	weeks	GPS week number

Command packet 0x2E-00: Request GPS Time (Mini-T™ GG→Server only)

This packet requests GPS time to server if aiding data request mode is 1.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x2E	
1	Subpacket ID	UINT8	0x00	

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

This packet provides an accurate initial position to the GPS receiver in XYZ 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. Mini-T™ GG uses this position for performing time-only fixes. If a survey is in progress when this command is sent, the survey is aborted and this position data is used immediately. Mini-T™ GG will automatically switch to the over-determined timing mode when this command is issued.

Command Packet 0x31 Data Format (Single Precision)

Byte	Item	Type	Value/Unit	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/Unit	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 (Lat, Long, Altitude)

This packet provides an accurate initial position to the GPS receiver 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 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. Mini-T™ GG will automatically switch to the over-determined timing mode when this command is issued.

Command Packet 0x32 Data Format (Single Precision)

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x32	
1-4	Latitude	SINGLE	Radians	+ for north, - for south
5-8	Longitude	SINGLE	Radians	+ for east, - for west
9-12	Altitude	SINGLE	Meters	

Command Packet 0x32 Data Format (Double Precision)

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x32	
1-8	Latitude	DOUBLE	Radians	+ for north, - for south
9-16	Longitude	DOUBLE	Radians	+ for east, - for west
17-24	Altitude	DOUBLE	Meters	

Command packet 0x32-00: Request GPS Position (Mini-T™ GG →Server only)

This packet requests GPS position to server if aiding data request mode is 1.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x32	
1	Subpacket ID	UINT8	0x00	

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, the user sends this packet with no data bytes. To change any option states, the user includes 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 GPS receiver returns packet 0x55. These 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: Mean Sea Level
- UTC: Universal coordinated Time

Byte	Data Type	Bit	Value	Meaning	Associated Packet
0	Packet ID		0x35		
1	Position	0	0 1	ECEF off ECEF on	0x42 or 0x83
		1	0 1	LLA off LLA on	0x4A or 0x84
		2	0 1	HAE (datum) MSL geoid (Note 1)	0x4A or 0x84
		3	0	Reserved	
		4	0 1	Single-precision position Double-precision position	0x42/4A 0x83/84
		5-7	0	Reserved	
2	Velocity	0	0 1	ECEF off ECEF on	0x43
		1	0 1	ENU off ENU on	0x56
		2-7	0	Reserved	
3	Timing	0	0 1	GPS time reference UTC time reference	0x42, 0x43, 0x4A 0x83, 0x84, 0x56
4	Auxiliary	0	0 1	Packet 5A off Packet 5A on	0x5A
		1	0	Reserved	
		2	0	Reserved	
		3	0 1	Output AMU Output dB-Hz	0x5A, 0x5C, 0x47
		4-7	0	Reserved	

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

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 GPS receiver 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 Satellite System Data

This packet requests current satellite data.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x38	
1	Operation	UINT8	Flag	Must be always “1”
2	Type of data	UINT8	2 3 4 5 6	Almanac Health page, t_oa, WN_oa Ionosphere UTC Ephemeris
3	Sat PRN #	UINT8		Selects an individual satellite or all satellites 0: Data is not satellite specific 1-32 (GPS): Data is requested for a specific satellite PRN (pseudorandom number) FF (Mini-T™ GG uses only): Data is requested for almanac or ephemeris of all satellites.

Command packet 0x38: Upload Satellite System Data

Command packet 0x38 uploads GPS data (almanac, ephemeris, etc.) to GPS receiver (Mini-T™ GG). The receiver acknowledges a download operation by sending the requested data in report packet 0x58.

The table and section numbers referred to in the “Meaning” column reference the ICD-GPS-200.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x38	
1	Operation	UINT8	2	Uploads satellite data into receiver if the receiver supports satellite data uploads
2	Type of data	UINT8	2 3 4 5 6	Almanac Health page, t_oa, WN_oa Ionosphere UTC 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	UNINT8		Number of data bytes to load

Byte	Item	Type	Value/Unit	Description
5 to (n+4)	Data			Data to be loaded Type 2: Almanac (see Table 1) Type 3: Health page, t_oa, WN_oa (see Table 2) Type 4: Ionosphere (see Table 3) Type 5: UTC (see Table 4) Type 6: Ephemeris (see Table 5)

Table 1. Data Type 2: Almanac

Byte	Item	Type	Meaning
5	t_oa_raw	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
6	SV_HEALTH	UNIT8	Refe to ICD-GPS-200, Sec 20.3.3.5.1.2
7-10	e	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
11-14	t_oa	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
15-18	i_o	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
19-22	OMEGADOT	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
23-26	sqrt_A	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
27-30	OMEGA_0	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
31-34	OMEGA	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
35-38	M_0	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
39-42	a_f0	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
43-46	a_f1	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
47-50	Axis	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
51-54	n	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
55-58	OMEGA_n	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
59-62	ODOT_n	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
63-66	t_zc	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
67-68	Week number	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2
69-70	WN_oa	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.2

***Note** –All angles are in radians*

Table 2. Data Type 3: Almanac Health

Byte	Item	Type	Meaning
5	Week number for health	UNIT8	Refer to ICD-GPS-200, Sec 20.3.3.5.1.3
6-37	SV_health	UNIT8 (32Bytes)	Refer to ICD-GPS-200, Sec 20.3.3.5.1
38	t_oa for health	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.5.1

Byte	Item	Type	Meaning
39	Current t_oa	UINT8	Units = seconds/4096
40-41	Current week #	UINT16	

Table 3. Data Type 4: Ionosphere

Byte	Item	Type	Meaning
5-12			Not used
13-16	Alpha_0	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
17-20	Alpha_1	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
21-24	Alpha_2	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
25-28	Alpha_3	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
29-32	Beta_0	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
33-36	Beta_1	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
37-40	Beta_2	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9
41-44	Beta_3	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.9

Table 4. Data Type 5: UTC

Byte	Item	Type	Meaning
5-17			Not used
18-25	A_0	Double	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
26-29	A_1	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
30-31	Dalta_t_LS	SINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
32-35	t_ot	Single	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
36-37	WN_t	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
38-39	WN_LSF	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
40-41	DN	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8
42-43	Delta_t_LSF	SINT16	Refer to ICD-GPS-200, Sec 20.3.3.5.1.8

Table 5. Data Type 6 : Ephemeris

Byte	Item	Type	Meaning
5	SV_number	UINT8	SV PRN number
6-9	t_ephem	Single	Time of collection
10-11	week number	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
12	CodeL2	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
13	L2Pdata	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
14	SVacc_raw	UNIT8	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I

Byte	Item	Type	Meaning
15	SV_health	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
16-17	IODC	UINT16	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
18-21	t_GD	Single	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
22-25	t_oc	Single	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
26-29	a_f2	Single	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
30-33	a_f1	Single	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
34-37	a_f0	Single	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
38-41	SVacc	Single	Refer to ICD-GPS-200, Sec 20.3.3.3, Table 20-I
42	IODE	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.4
43	fit_interval	UINT8	Refer to ICD-GPS-200, Sec 20.3.3.4
44-47	C_rs	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
48-51	Dalta_n	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
52-59	M_0	Double	Refer to ICD-GPS-200, Sec 20.3.3.4
60-63	C_uc	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
64-71	e	Double	Refer to ICD-GPS-200, Sec 20.3.3.4
72-75	C_us	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
76-83	aqrt_A	Double	Refer to ICD-GPS-200, Sec 20.3.3.4
84-87	t_oe	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
88-91	C_ic	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
92-99	OMEGA_0	Double	Refer to ICD-GPS-200, Sec 20.3.3.4
100-103	C_is	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
104-111	i_0	Double	Refer to ICD-GPS-200, Sec 20.3.3.4
112-115	C_rc	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
116-123	Omega	Double	Refer to ICD-GPS-200, Sec 20.3.3.4
124-127	OMEGADOT	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
128-131	IDOT	Single	Refer to ICD-GPS-200, Sec 20.3.3.4
132-139	Axis	Double	= $(sqrt\_A)^2$
140-147	n	Double	Derived from delta_n
148-155	r1me2	Double	= $sqrt(1.0-e^2)$
156-163	OMEGA_n	Double	Derived from OMEGA_0, OMEGADOT
164-171	ODOT_n	Double	Derived from OMEGADOT

***Note** –All angles are in radians*

Command packet 0x3A: Request Last Raw Measurement

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

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x3A	
1	Satellite PRN	UINT8	0 1-32 (GPS) 65-96 (GLO)	All SV in current tracking set Specific desired satellite

Command packet 0x3C: Request Satellite Tracking Status

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

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x3C	
1	Satellite PRN	UINT8	0 1-32 (GPS) 65-96 (GLO)	All SV in current tracking set Specific desired satellite

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 or in response to packet 0x37. The data format is shown below. The time-of-fix is in GPS or UTC as selected by the I/O "timing" option in packet 0x35. Packet 0x83 provides a double-precision version of this information.

Byte	Item	Type	Value/Unit	Description
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	

Report packet 0x43: Velocity Fix, XYZ ECEF

This packet provides current GPS velocity fix in XYZ ECEF coordinates. If the I/O "velocity" option (packet 0x35) is set to "XYZ ECEF", then the GPS 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 or UTC as selected by the I/O “timing” option.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x43	
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 Mini-T™ GG. The GNSS receiver sends this packet after power-on in response to packet 0x1E.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x45	
1	Application Layer of the firmware	UNIT8		Major version number of application
2		UNIT8		Minor version number of application
3		UNIT8		Month
4		UNIT8		Day
5		UNIT8		Year number minus 2000
6	GPS Core Layer of the firmware	UNIT8		Major revision number of GPS core
7		UNIT8		Minor revision number of GPS core
8		UNIT8		Month
9		UNIT8		Day
10		UNIT8		Year number minus 2000

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 or automatically as listed in the Automatic Output Packets section. The data format is shown below. Up to 12 satellite number/signal level pairs may be sent as indicated by the count field. Signal level is normally positive. If it is zero then that satellite has not you been acquired. If it is negative then that satellite is not currently in lock. The absolute value of signal level field is the last known signal level if that satellite.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x47	
1	Count	UINT8		
2	Satellite number1	UINT8		
3-6	Signal level1	SINGLE		
7	Satellite number2	UINT8		
8-11	Signal level2	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 either AMU or dB-Hz as controlled by packet 0x35.*

Report packet 0x4A: Single Precision LLA position Fix

This packet provides current GPS position fix in LLA 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	Packet ID	UINT8	0x4A	
1-4	Latitude	SINGLE	radians	+ for north, - for south
5-8	Longitude	SINGLE	radians	+ for east, - for west
9-12	Altitude	SINGLE	meters	
13-16	Clock bias	SINGLE	meters	
17-20	Time-of-fix	SINGLE	seconds	

The LLA conversion is done using WGS-84 datum. 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 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. When using other datums, only the HAE option is valid.

Report packet 0x4E: GPS Time Command Verification

This packet reports whether or not the receiver accepted the time given in a Set GPS Time Packet (0x2E). This packet contains one data byte.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x4E	
1	Result	UINT8	0x4E	The receiver did not accept the time in Command Packet 0x2E, but the receiver did receive the time from a satellite and is using that time. The receiver ignores the time setting in Command Packet 0x2E.

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 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. 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.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x57	
1	Source of info	UINT8	0 1	Old fix New fix
2	Fix mode	UINT8	0 1	No previous fix Time only 1-SV2D

Byte	Item	Type	Value/Unit	Description
			2 3 4 5 6	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: GPS System Data from Receiver

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

Data format is the same as command packet 0x38: Upload Satellite System Data.

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	2 3 4 5 6	Almanac Health page, t_oa, WN_oa Ionosphere UTC 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	UNINT8		Number of data bytes to load
5 to (n+4)	Data			Data to be loaded Type 2: Almanac (see Table 1) Type 3: Health page, t_oa, WN_oa (see Table 2) Type 4: Ionosphere (see Table 3) Type 5: UTC (see Table 4) Type 6: Ephemeris (see Table 5)

Report packet 0x5A: Raw Data Measurement Data

This packet provides raw GPS measurement data. This packet is sent in response to packet 0x3A or automatically if enabled with packet 0x35.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x5A	
1	SV PRN #	SIGNLE		
2-5	Sample length	SIGNLE	milliseconds	
6-9	Signal level	SIGNLE	AMU or dB-Hz	
10-13	Code phase	SIGNLE	1/16th chip	
14-17	Doppler	SIGNLE	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.*

Report packet 0x5C: GNSS Satellite Tracking Status

The receiver sends this packet in response to command packet 0x3C, when the unit is configured for multi-GNSS operation.

Byte	Bit	Item	Type	Value	Description
0		Packet ID	UINT8	0x5D	
1		SV PRN #	UINT8	1-32	GPS
				65-97	GLONASS
2	3-7	Channel number	UINT8	bit field	1-32
3		acquisition flag	UINT8	0 1 2	Never acquired Acquired Re-opened search
4		ephemeris flag	UINT8	0 >0	Flag not set Good ephemeris
5-8		signal level	SINGLE		dB-Hz
9-12		time of last measurement	SINGLE	seconds	GPS time of week
13-16		elevation angle	SIGNLE	radians	
17-20		azimuth angle	SINGLE	radians	
21		old measurement flag	UINT8	0 >0	Flag not set Measurement old

Byte	Bit	Item	Type	Value	Description
22		Reserved	UINT8	0	Reserved
23		Reserved	UINT8	0	Reserved
24		Reserved	UINT8	1	Reserved

Report packet 0x6C: Satellite Selection List

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, 3-D or 2-D, over-determined clock, etc.) This packet has variable length equal to 17+nsvs where “nsvs” is the number of satellites used in the solution. If an SV is rejected for use by the T-RAIM algorithm then the SV PRN value will be negative. The GNSS receiver sends this packet in response to packet 0x24 or automatically.

Byte	Bit	Item	Type	Value	Description
0		Packet ID	UINT8	0x6C	
1	0-2	fix dimension	bit field	001 011 100 101	1D clock fix 2D fix 3D fix OD clock fix
	3	fix mode	bit field	0 1	Auto Manual
	4-7	# of SVs in fix	bit field	0-12	Count
2-5		PDOP	SINGLE		
6-9		HDOP	SINGLE		
10-13		VDOP	SINGLE		
14-17		TDOP	SINGLE		
18-n		SV PRN	SINT8	(1-32), (65-96)	GPS 1-32 GLONASS 65-96

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.

Byte	Bit	Item	Type	Value	Description
0		Packet ID	UINT8	0x7A	
1		Subpacket ID	UINT8	0x00	
2		Interval	UINT8	1-255	Fix interval in seconds
3-6		Bit Mask Values (See below)			

Bit Mask is the hexadecimal numbers that are OR'ed together to produce the combined output mask.

Message		Bit Mask
GGA	GPS fix data	0x00000001
GLL	Position fix, time of position fix, and status	0x00000002
VTG	Course over ground and Ground speed	0x00000004
GSV	Satellites in View	0x00000008
GSA	GPS DOP and Active Satellites	0x00000010
ZDA	Time and Date	0x00000020
RMC	Recommended Minimum Specific GPS Data	0x00000080
GRS	GNSS Range Residuals	0x00000100
GBS	GNSS Satellite Fault Detection	0x00000200
GST	GPS Pseudo range Noise statistics	0x00000400
PTNLAG001	Text Transmission	N/A
DTM	Datum Reference	
	Poll Message	

Report packet 0x83: Double Precision XYZ

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 double position option is selected, the receiver sends this packet each time a fix is computed.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x83	
1-8	X	DOUBLE	meters	
9-16	Y	DOUBLE	meters	
17-24	Z	DOUBLE	meters	
15-32	clock bias	DOUBLE	meters	
33-36	time-of-fix	SINGLE	seconds	

***Note** –The time-of-fix is in GPS time or UTC, 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 GPS 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/Unit	Description
0	Packet ID	UINT8	0x84	
1-8	latitude	DOUBLE	radians	+ for north, - for south
9-16	longitude	DOUBLE	radians	+ for east, - for west
17-24	altitude	DOUBLE	meters	
15-32	clock bias	DOUBLE	meters	
33-36	time-of-fix	SINGLE	seconds	

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

Command Packet 0x8E-A0: Set DAC Value

Use Command packet 0x8E-A0 to set the DAC output voltage or to request the current DAC output voltage plus the parameters describing the DAC. The DAC output voltage is used to control the frequency of the OCXO. Send this packet with no data to request the DAC voltage. Mini-T™ GG responds with packet 0x8F-A0.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA0	
2	Voltage/Value Flag	UINT8	0 1	Set DAC voltage Set DAC value
3-6	DAC Voltage Value	SINGLE/ UINT32		DAC voltage/Value

Field	Description	Setting
Voltage/ Value flag	Use this field to specify that the DAC is to be Set either by value or by voltage	0: Set DAC by voltage 1: Set DAC by value
DAC Voltage Value	When the Voltage/Value Flag is set to voltage, use this field to specify the numeric value of the DAC as the 32-bit unsigned number	

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.

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

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

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0xBB	
1	Subpacket ID	UINT8	0x00	Primary receiver configuration block
2	receiver mode	UINT8	0 1 3 4 7	Automatic (2D/3D) Single satellite (1 SV time) Horizontal (2D) Full position (3D) Over-determined clock
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 (radians), only when the receiver is operating in OD clock mode.
10-13	C/No mask	SINGLE	0-55	Minimum signal level for fixes, only when unit operating in OD mode
14-17	PDOP mask	SIGNLE		*Unused, value ignored*
18-21	PDOP switch	SINGLE		*Unused, value ignored*
22	Reserved	UINT8		*N/A*
23	Anti-Jam Mode	UINT8	0 1	Disabled Enabled
24-27	Reserved	UINT8		*N/A*
28	Constellation – see note	Bit	0 1 2 3 4 5 6 7	GPS GLONASS Reserved Reserved Reserved Reserved Ignored Ignored
29-40	reserved	UINT8	0xFF	*do not alter*

CAUTION – The operation of Mini-T™ GG 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 "do not alter" 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. Mini-T™ GG will 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/Unit	Description
0	Packet ID	UINT8	0xBC	
1	Port Number	UINT8	0 1 0xFF	Port 1 (Standard) Port 2 (not available) 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/Unit	Description
0	Packet ID	UINT8	0xBC	
1	Port to Change	UINT8	0 1 0xFF	Port 1 (Standard) Port 2 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	Input Protocols	UINT8	0 2 4	None TSIP NMEA
8	Output Protocols	UNIN8	0 2	None TSIP

Byte	Item	Type	Value/Unit	Description
			4	NMEA
9	Reserved	UINT8	0	

Command packet 0x8E-26: Request Configuration to Flash ROM

This command packet causes the current configuration settings to be written to the flash ROM. This packet contains only a single byte: the subpacket ID.

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 the user to query (by sending the packet with no data bytes) or set Mini-T™ GG PPS characteristics. Mini-T™ GG responds to a query or set command with packet 0x8F-4A.

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0x4A	
2	PPS driver switch	UINT8	0 1	off on (default)
3	Reserved	UINT8		
4	PPS polarity	UINT8	0 1	positive negative (default)
5-12	PPS offset of cable delay (see note)	DOUBLE	seconds	
13-16	Bias uncertainty threshold	SINGLE	150.0 meters	

Note –*Negative offset values advance the PPS, and are normally used to compensate for cable delay. Useful values for the PPS offset are between ±50ms.*

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

This command packet sets the PPS driver switch to one of the values listed in Table of command packet 0x8E-A2. The current driver switch value can be requested by sending the packet with no data bytes except the subpacket ID. Driver switch values 3 and 4 only make sense in over-determined Timing mode. In any position fix mode the effective choice are always on or during fixes which you get if you set the driver switch to 3 or 4.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0x4E	Subpacket ID
2	PPS Driver Switch	UINT8	Bit Field	One or more aiding data types Bits 2-0 : 1PPS/PP2S qualifier 010: 1PPS/PP2S is always on (default) 011: 1PPS/PP2S is on when at least 1 SV is usable 100: 1PPS/PP2S is on when at least 3SV are usable Bits 5-3: Not used , set to 0 Bit 6: Not used , set to 0 Bit 7: 1PPS/PP2S selection 0 : Generate 1PPS output 1: Generate PP2S output (default)

Command packet 0x8E-A0: Set DAC Value

Use command packet 0x8E-A0 to set the DAC output or to request the current DAC output voltage plus the parameters describing the DAC. The DAC output voltage is used to control the frequency of the OCXO. Send this packet with no data to request the DAC voltage. Mini-T™ GG responds with packet 0x8F-A0.

This command packet data fields are as follows:

Field	Description	Setting
Voltage/Value Flag	Use this field to specify that the DAC is to be set either by value or by voltage	0: Set DAC by voltage 1: Set DAC by value
DAC Voltage Value:	When the Voltage/Value Flag is set to voltage, use this field to specify the numeric value of the DAC as the 32-bit unsigned number.	

To set the DAC voltage, send packet 0x8E-A0 in the format shown below:

***Note** – Oscillator disciplining must be disabled (see packet 0x8E-A3) to use this command to set the DAC voltage.*

Byte	Item	Type	Bit	Value	Description
0	Packet ID	UINT8		0x8E	
1	Subpacket ID	UINT8		0xA0	Subpacket ID
2	Voltage/Value Flag	UINT8		0 1	Set DAC voltage Set DAC value
3-6	DAC Voltage/ Value	SINGLE/ UINT32			DAC Voltage/Value

Command packet 0x8E-A2: UTC/GPS Timing

This command packet sets the UTC/GPS timing mode (time and data fields) in packet 0x8F-AB, and the temporal location of Mini-T™ GG output PPS. Send packet 0x8E-A2 with no data to request the current settings. Mini-T™ GG 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	UTC/GPS time	bit field	0	0 1	GPS time/data in packet 0x8F-AB UTC time/data in packet 0x8F-AB
			1	0 1	PPS reference to GPS time PPS reference to UTC time

Command packet 0x8E-A3: Issue Oscillator Disciplining Command

Use command packet 0x8E-A3 to issue an oscillator disciplining command. Mini-T™ GG responds with Packet 0x8F-A3 in the same format as packet 0x8E-A3.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA3	
2	Disciplining Command	UINT8	0 1 2 3 4 5	Place PPS on time (jam sync) Transition to recovery state Transition to manual holdover Transition from manual holdover Disable oscillator disciplining Enable oscillator disciplining

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. Mini-T™ GG replied to request with response packet 0x8F-A5. The broadcast mask is bitwise encoded to allow the use to turn on and off the broadcast of certain packets. 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	Packet ID	UINT8		0x8E	
1	Subpacket ID	UINT8		0xA5	Subpacket ID

Byte	Item	Type	Bit	Value	Description
2-3	Mask 0	bit field	0		0x8F-AB, Primary Timing Information
			1		Reserved
			2		0x8F-AC, Supplemental Timing Information
			3		Reserved
			4		Reserved
			5		Reserved
			6		Automatic Output Packets
4-5	Mask 1	bit field			Reserved

Command packet 0x8E-A8: Set or Request Disciplining Parameters

***Note** – This packet allows the user to change key disciplining parameters in the* I *GG.*

This packet is usually intended to be used only when instructed by the factory. Incorrect use of this packet will most likely cause Mini-T™ GG timing outputs to be degraded severely. However, the "Type 2" (Recovery Mode) parameters are intended to be set by the user to suit the application. Send this packet with the type field only to request the current setting. MINI-T™ GG replies to sets and requests with the packet 0x8F-A8.

Type	Data field	Description
0	Type	A "0" in this field indicates that the packet contains loop dynamics information.
	Time Constant	This field carries the time constant of the disciplining control loop
	Damping Factor	This field carries the damping of the disciplining control loop.
1	Type	A "1" in this field indicates that the packet contains 10MHz oscillator parameters.
	OCXO Constant	This field carries the OCXO constant into Hz/Volt.
	OCXO Min. Control Voltage	This field carries the minimum (most negative) control voltage that can be applied to the 10MHz oscillator's control voltage input.
	OCXO Max. Control Voltage	This field carries the maximum (most positive) control voltage that can be applied to the 10MHz oscillator's control voltage input.
2	Type	A "2" in this field indicates that the packet contains Recovery Mode parameters. These parameters allow the user to control the recovery process. During Recovery, MINI-T™ GG will remove any PPS offset accumulated during period of Holdover by either shifting the PPS into alignment or by shifting the frequency of the 10MHz oscillator by a specified amount until the PPS has slewed back into alignment or by using both methods. The following tow parameters control these methods: - If a fast recovery is desired, allow jam syncs to be used - If it is important to maintain 10 million clock cycles per PPS pulse,

Type	Data field	Description
		then disable jam syncs and set the maximum frequency offset to a tolerable value.
	Jam Sync Threshold	This field carries the jam sync threshold in nanoseconds used during Recovery mode. While in Recovery Mode, if the PPS offset is above this threshold, Mini-T™ GG will automatically perform a jam sync to shift the PPS into alignment with GPS. The minimum allowed value is 50 ns. Setting a value less than or equal to 0ns will disable automatic jam syncs during Recovery (though the user can still issue a jam sync command with packet 0x8E-A3).
	Max. Frequency Offset	This field carries the maximum allowable frequency offset in ppb (parts per billion or 1E-09) of the 10MHz oscillator during Recovery Mode. While in Recovery Mode, Mini-T™ GG will remove any PPS offset accumulated during periods of Holdover by shifting the frequency of the oscillator by an amount up to the value specified. The minimum allowed value is 5ppb.
3	Type	A "3" in this field indicates that the packet contains the initial DAC voltage parameter.
	Initial DAC Voltage	At reset, the oscillator's frequency control voltage is set to this value.

Command Packet 0x8E-A8 Type 0 Data Format

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA8	
2	Type	UINT8		0 = Loop dynamics
3-6	Time Constant	SINGLE		Seconds
7-10	Damping Factor	SINGLE		Dimensionless

Command Packet 0x8E-A8 Type 1 Data Format

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA8	
2	Type	UINT8		1 = Oscillator parameters
3-6	Oscillator Gain Constant	SINGLE		Hz/Volt
7-10	Min. Control Voltage	SINGLE		Volts
11-14	Max. Control Voltage	SINGLE		Volts

Command Packet 0x8E-A8 Type 2 Data Format

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA8	
2	Type	UINT8		2 = Recovery mode parameters
3-6	Jam sync threshold	SINGLE		nanosecond
7-10	Max. Frequency Offset	SINGLE		ppb

Command Packet 0x8E-A8 Type 3 Data Format

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8E	
1	Subpacket ID	UINT8	0xA8	
2	Type	UINT8		3 = Initial DAC voltage
3-6	Initial DAC Voltage	SINGLE		Volts

Command packet 0x8E-AB: Request Primary Timing Packet

Use this command packet to request the Primary Timing packet 0x8F-AB. By default, the Mini-T™ GG 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 Mini-T™ GG 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 Mini-T™ GG 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 Mini-T™ GG will reply to this command:

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

Report packet 0x8F-41: Stored Manufacturing Operating Parameters

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

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x8F	
1	Subpacket ID	UINT8	0x41	
2-3	Reserved	UINT16		
4-7	Board serial #	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	Description
0	Packet ID	UINT8	0x8F	
1	Subpacket ID	UINT8	0x42	
2	Reserved	UINT8		

3	Reserved	UINT8		
4-5	Reserved	UINT16		
6-9	Reserved	UINT32		
10-13	Reserved	UINT32		
14-15	Reserved	UINT16		
16-17	Reserved	UINT16		
18-19	Reserved	UINT16		

Report packet 0x8F-4A: Set PPS Characteristics

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

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-A0: DAC Value

This packet is sent in response to packet 0x8E-A0.

Data Field	Description
DAC Value	The current numeric value of the DAC.
DAC Voltage	The current output voltage of the DAC in Volts
DAC Resolution	The number of bits used in the DAC
DAC Data Format	The format of the DAC value
Min. DAC Voltage	The minimum (most negative) voltage that the DAC can produce
Max. DAC Voltage	The maximum (most positive) voltage that the DAC can produce

Report Packet 0x8F-A0 Data Format

Byte	Item	Type	Value/Unit	Description
0	Packet ID	UINT8	0x8F	
1	Subpacket ID	UINT8	0xA0	
2-5	DAC Value	UINT32		Value
6-9	DAC Voltage	SINGLE		Volts
10	DAC Resolution	UINT8		Number of bits
11	DAC Data Format	UINT8	0 1	Offset binary 2's complement
12-15	Min. DAC Voltage	SINGLE		Volts
16-19	Max. DAC Voltage	SINGLE		Volts

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-A3: Oscillator Disciplining Command

This packet is sent in response to command packet 0x8E-A3. 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-A8: Oscillator Disciplining Parameters

This packet is sent in response to command packet 0x8E-A8. 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. 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 or enabled for automatic broadcast once per second. If enabled, this packet will be transmitted shortly after the PPS pulse to which it refers.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8F	
1	Subpacket ID	UINT8	0xAB	
2-5	Time of week	UINT32		GPS seconds of week
6-7	Week Number	UINT16		GPS Week Number
8-9	UTC Offset	SINT16		UTC Offset (seconds)

<table>
<tr><th>Byte</th><th>Item</th><th>Type</th><th>Value</th><th>Description</th></tr>
<tr><td>10</td><td>Time Flag</td><td>Bit Field</td><td></td><td>
<table>
<tr><th>Bit</th><th>Vale</th><th>Description</th></tr>
<tr><td rowspan="2">0</td><td>0</td><td>GPS time (Default)</td></tr>
<tr><td>1</td><td>UTC time</td></tr>
<tr><td rowspan="2">1</td><td>0</td><td>GPS PPS (Default)</td></tr>
<tr><td>1</td><td>UTC PPS</td></tr>
<tr><td rowspan="2">2</td><td>0</td><td>Time is set</td></tr>
<tr><td>1</td><td>Time is not set</td></tr>
<tr><td rowspan="2">3</td><td>0</td><td>Have UTC info</td></tr>
<tr><td>1</td><td>No UTC info</td></tr>
<tr><td rowspan="2">4</td><td>0</td><td>Time from GPS (Default)</td></tr>
<tr><td>1</td><td>Time from UTC</td></tr>
</table>
</td></tr>
<tr><td>11</td><td>Seconds</td><td>UINT8</td><td>0-59</td><td>Seconds</td></tr>
<tr><td>12</td><td>Minutes</td><td>UINT8</td><td>0-59</td><td>Minutes</td></tr>
<tr><td>13</td><td>Hours</td><td>UINT8</td><td>0-23</td><td>Hours</td></tr>
<tr><td>14</td><td>Day of Month</td><td>UINT8</td><td>1-31</td><td>Day of Month</td></tr>
<tr><td>15</td><td>Month</td><td>UINT8</td><td>1-12</td><td>Month of Year</td></tr>
<tr><td>16-17</td><td>Year</td><td>UINT16</td><td></td><td>Four digits of Year</td></tr>
</table>

Data Field	Description
Time of Week	This field represents the number of seconds since Sunday at 00:00:00 GPS time for the current GPS week. Time of week is often abbreviated as TOW.
Week Number	This field represents the current GPS week number. GPS week number 0 started on January 6, 1980.
UTC Offset	This field represents the current integer leap second offset between GPS and UTC according to the relationship: Time (UTC) = Time (GPS) – UTC Offset. The UTC offset information is reported to the MINI-T™ GG by the GPS system and can take up to 12.5 minutes to obtain if there is no adding data from server. Before MINI-T™ GG has received UTC information from the GPS system, it is only capable of representing time in GPS time scale, and the UTC offset will be shown as 0.
Timing Flags	This field is bitwise encoded to provide information about the timing outputs. Unused bits should be ignored. Bit 0: When 0, the date and time fields broadcast in packet 8F-AB (Primary Timing Message) are in the GS time scale. When 1, these fields are in the UTC time scale and are adjusted for leap seconds. Bit 1: When 0, the PPS output is aligned to GPS. When 1, the PPS output is aligned to UTC. Bit 2: When 0, time has been set from GPS. When 1, time has not yet been set from GPS.

Data Field	Description
	Bit 3: When 0, UTC offset information has been received. When 1, UTC offset information is not yet known.
Date	The date is sent in day-month-year format.

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 f the unit is provided. This packet can be requested or enabled for automatic broadcast once per second. When enabled, this packet is transmitted once per seconds shortly after packet –x8F-AB.

Byte	Item	Type	Value	Description
0	Packet ID	UINT8	0x8F	
1	Subpacket ID	UINT8	0xAC	
2	Receiver Mode	UINT8	0 1 3 4 7	Automatic (2D/3D) Single Satellite (Time) Horizontal (2D) Full Position (3D) Over-determined Clock
3	Disciplining Mode	UINT8	0 1 2 3 4 5 6	Normal (Locked to GPS) Power Up Auto Holdover Manual Holdover Recovery Not used Disciplining Disabled
4	Self-Survey Progress	UNIN8		0-100%
5-8	Holdover Duration	UINT32		Seconds
9-10	Critical Alarms	UINT16	Bit Field	Bit 4 : DAC at rail
11-12	Minor Alarms	UINT16	Bit Field	Bit 0 : DAC near rail Bit 1 : Antenna Open Bit 2 : Antenna shorted Bit 3 : Not tracking satellites Bit 4 : Not disciplining oscillator 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

Byte	Item	Type	Value	Description
				Bit 10 : Not used Bit 11 : Almanac not complete Bit 12 : PPS not generated
13	GPS Decoding Status	UINT8	0x00 0x01 0x03 0x08 0x09 0x0A 0x0B 0x0C 0x10	Doing fixes Don't have GPS time PDOP is too high No usable satellites Only 1 usable sat Only 2 usable sats Only 3 usable sats The chosen sat is unusable TRAIM rejected the fix
14	Disciplining Activity	UINT8	0x00 0x01 0x02 0x03 0x04 0x05 0x06 0x07 0x08 0x09	Phase Locking Oscillator warm-up Frequency locking Placing PPS Initializing loop filter Compensating OCXO (Holdover) Inactive Not used Recovery mode Calibration/control voltage
15	PPS indication	UINT8	0	PPS Good indication
			1	PPS Not Good indication
16	Spare Status 2	UINT8		0x00
17-20	PPS Offset	Single		ns
21-24	Clock Offset	Single		ppb
25-28	DAC Value	UINT32		
29-32	DAC Voltage	Single		Volts
33-36	Temperature	Single		Degrees C
37-44	Latitude	Double		Radians
45-52	Longitude	Double		Radians
53-60	Altitude	Double		Meters
61-64	PPS Quantization Error	Single		ns
65-68	Spare			Future expansion

Data Field	Description
Receiver Mode	This field shows the fix mode that the GNSS receiver is currently configured for.
Self-Survey	When a self-survey procedure is in progress, this field shows the progress of the

Data Field	Description
Progress	survey as a percentage of fixes collected so far. The self-survey will be complete when the self-survey progress reaches 100%. This field only has meaning while a self-survey is in progress.
Holdover Duration	When in the Manual or Auto Holdover state, this field show the amount of time spent in holdover in seconds. When the unit is not in a holdover state, this field shows the amount of time the Mini-T™ GG spent the last time it was in a holdover state.
Critical Alarm	Bit 4 : When 1, indicates that the oscillator control voltage is at a rail. If this condition persists then the Mini-T™ GG can no longer bring the frequency of the oscillator into alignment with GPS and is most likely in need of a new oscillator.
Minor Alarms	This field is bitwise encoded with several minor alarm indicators. A minor alarm indicates a condition that the user should be alerted to, but does not indicate an immediate (or necessarily any) impairment of functionality. For each bit, a value of 0 means that the condition is not indicated. Bits not described below should be ignored. Bit 0: When 1, indicates that the oscillator control voltage is near a rail. If this condition persists, then the oscillator is within specific time of becoming un-tunable. (It depends on oscillator used for Mini-T™ GG) Bit 1: When 1, indicates that the antenna input connection is open. More precisely, this bit indicates that the antenna input is not drawing sufficient current. Bit 2: When 1, indicates that the antenna input is shorted. More precisely, this bit indicates that the antenna input is drawing too much current. Bit 3: When 1, indicates that no satellites are usable. Bit 4: When 1, indicates that the oscillator is not being disciplined to GNSS reference. Before the Mini-T™ GG can begin disciplining the oscillator, it must begin 0receiving information from the GPS receiver. Bit 5: When 1, indicates that a self-survey procedure is in progress. Bit 6: When 1, indicates that there is no accurate position stored in Flash ROM. Bit 7: When 1, indicates that the GPS system has alerted Mini-T™ GG that a leap second transition is pending. Bit 8: When 1, indicates that Mini-T™ GG is operating in one of its test modes. Bit 9: When 1, indicates that the accuracy of the position used for time only fixes is questionable. Bit 11: When 1, indicates that the Almanac is not current or complete. Bit 12: When 1, indicates the PPS was not generated this second. This could mean there wasn't enough usable satellites to generate an accurate PPS output.

Data Field	Description
GPS Decoding Status	This field indicates the decoding status of the GPS receiver.
Disciplining Activity	This field indicates the current activity of the disciplining mechanism.
PPS Offset	This field carries the estimate of the offset of the PPS output relative to UTC or GPS as reported by the GPS receiver in nanoseconds. Positive values indicate that the Mini-T™ GG's PPS is coming out late relative to GPS or UTC.
Frequency Offset	This field carries the estimate f the frequency offset of the SCLK output relative to UTC or GPS as reported by the GPS receiver in ppb. Positive values indicate that the Mini-T™ GG's clock is running slow relative to GPS or UTC.
DAC Value	This field shows the numeric value of the DAC used to produce the voltage that controls the frequency of the SCLK oscillator.
DAC Voltage	This field show the voltage output of the DAC.
Temperature	This field show the temperature (in Celsius) as reported by Mini-T™ GG's on-board temperature sensor.
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.)
PPS Quantization Error	This field carries the PPS quantization error in units of nanoseconds of an internal PPS signal. This value is not useful on a Mini-T since the PPS output is derived from a disciplined oscillator and therefore does not have any quantization error.

APPENDIX

B

NMEA 0183 Protocol

In this chapter:

This appendix provides a brief overview of the NMEA 0183 protocol, and describes both the standard and optional messages offered by the Mini-T GG.

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.

NMEA data is output in standard ASCII sentence formats. Message identifiers are used to signify what data is contained in each sentence. Data fields are separated by commas within the NMEA sentence. In the Mini-T™ GG Multi-GNSS Disciplined Clock, NMEA is a bi-directional protocol. Because NMEA 0183 does not specify input sentences, a set of Trimble-proprietary input messages is provided. See Appendix B, NMEA 0183 Protocol.

The Mini-T™ GG 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, Trimble can offer custom firmware with a different selection of messages to meet your application requirements.

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

If NMEA is to be permanent for the application, the protocol configuration (0xBC) and NMEA message output setting (0x7A) can be stored in the non-volatile memory (on- board flash) using TSIP command 0x8E-26.

NMEA 0183 communication interface

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

Signal	NMEA Standard
Baud rate	115 kbps
Data bits	8
Parity	None (Disabled)
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 Mini-T GG. 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.

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 Trimble:

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.
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 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 Mini-T™ GG can output any or all of the messages listed in the table below. In its default configuration (as shipped from the factory), the Mini-T™ GG outputs only TSIP messages. Typically NMEA messages are output at a 1 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.

Note – *The user can configure a custom mix of the messages listed in the table below. See Chapter 3, and TSIP command packets 0xBC, 0x7A, and 8E-26 in Appendix A for details on configuring NMEA output.*

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

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

Mini-T™ GG Multi-GNSS Disciplined Clock 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.
FS	Query or set GPS receiver acquisition sensitivity.
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

NMEA 0183 message formats

GGA-GPS Fix Data

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

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

Field	Description
1	UTC of Position
2, 3	Latitude, N (North) or S (South)
4, 5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0 = No GPS, 1 = GPS,
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters, M = Meters
11, 12	Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference
13	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 update
14	Differential Reference Station ID (0000 to 1023)
hh	checksum

GLL - Geographic Position - Latitude/Longitude

The GLL message contains the latitude and longitude of the present vessel position, the time of the position fix and the status.

$GPGLL,llll.lllll,a,yyyyy.yyyyyy,b,hhmmss.sss,c,d*hh <CR> <LF>

Field	Description
1	UTC of Position
2, 3	Latitude, N (North) or S (South)
4, 5	Longitude, E (East) or W (West)
6	Status, A=Valid, V=Invalid
7	Mode Indicator:
	Mode A=Autonomous
	Mode D=Differential
	Mode E=Estimated (dead reckoning).
	Mode M=Manual Input
	Mode S=Simulated
	Mode N=Data Not Valid
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.

$***id***GSA,a,v,ww,ww,ww,ww,ww,ww,ww,ww,ww,ww, , ,x.xx,y.yy,z.zz*hh<CR><LF>

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

Field	Description
1	Mode: M = Manual, A = Automatic. In manual mode, the receiver is forced to operate in
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
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/No), null when not tracking
8, 9, 10, 11	PRN, elevation, azimuth and SNR for second satellite
12, 13, 14, 15	PRN, elevation, azimuth and SNR for third satellite
16, 17, 18, 19	PRN, elevation, azimuth and SNR for fourth satellite
hh	checksum

RMC - Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the 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.

$GPRMC,hhmmss.ss,a,llll.lllll,b,nnnnn.nnnnnn,c,x.xx,yyy,ddmmyy,,,d*hh<CR><LF>

Field	Description
1	UTC of Position Fix.
2	Status: A – Valid, V - Navigation receiver warning
3, 4	Latitude, N (North) or S (South).
5, 6	Longitude, E (East) or W (West).
7	Speed over the ground (SOG) in knots
8	Track made good in degrees true.
9	Date: dd/mm/yy
10, 11	Magnetic variation in degrees, E = East / W= West
12	Position System Mode Indicator
	A - Autonomous
	D - Differential
	E - Estimated (Dead Reckoning)
	M - Manual Input
	S - Simulation Mode
	N - Data Not Valid
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).

$GPVTG,xxx,T,,M,y.yyy,N,z.zzz,K,a*hh<CR><LF>

Field	Description
1,2	Track made good in degrees true.
3,4	Track made good in degrees magnetic.
5,6	Speed over the ground (SOG) in knots
7,8	Speed over the ground (SOG) in kilometer per hour
9	Position System Mode Indicator

Field	Description
	A - Autonomous
	D - Differential
	E - Estimated (Dead Reckoning)
	M - Manual Input
	S - Simulation Mode
	N - Data Not Valid
hh	Checksum

ZDA - Time & Date

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

$GPZDA,hhmmss.sss,dd,mm,yyyy,,*hh<CR><LF>

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

Note *– Fields #5 and #6 are null fields in the Mini-T™ GG 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 jump to UTC time.

Note *– GPS time can be used as a timetag 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,hh,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,hh,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.
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 sentence 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:

$PTNLaAL,xx,x.x,hh,hhhh,hh,hhhh,hhhh,hhhhhh,hhhhhh,hhhhh h,hhhhhh,hhh,hhh*
hh<CR><LF>

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.

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

The corresponding response for the set is:

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

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

BA - Antenna Status

Use this sentence to query the antenna connection status. Only issue it when the antenna detection circuit is implemented. The query format is:

$PTNLQBA*hh<CR><LF>

The Response to query sentence format is:

$PTNLRBA,a,b*hh<CR><LF>

Field	Description
a	Status (0 = status unavailable, 1 = status available)
b	Antenna feedline fault: 0 = normal 1 = open 2 = short

CR - Configure Receiver

Use this sentence to query or set NMEA receiver configuration information.

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

Field	Description
a	Mode Q – Query S – Set R – Response
x.x	Signal level mask in dB-Hz (default = 29 dB-Hz). The signal level mask is used only when the receiver is operating in the Over Determined Clock mode
x.x	Elevation mask in degrees (default = 5 degrees). The elevation mask is used only when the receiver is operating in the Over Determined Clock mode.
x.x	Reserved
x.x	Reserved
x.x	Reserved
A	Receiver Mode 0 – automatic 7 – over-determined clock
a	Reserved
A	Reserved

EM - Enter Monitor Mode

This sentence is used to set the Mini-T™ GG Multi-GNSS Disciplined Clock 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 should send out three messages.

Message 1

$PTNLaEP,1,xx,x.x,x.x,hh,hh,hh,hh,hhh,hh,hhhh,hh,hhhh,hh hhhh,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, and all three messages must be sent together with 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.
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.

Field	Description
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,hhhhhhhh,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, and 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, hhhhhh,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, and 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.
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 - Automatic Message Output

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

$PTNLQNM*hh<CR><LF>

The Response to query sentence or Set sentence format is:

$PTNLaNM,hhhh,xx*hh<CR><LF>

Field	Description
a	Mode Q - Query S – Set R – Response
hhhh	Bit 0 -GGA Bit 1 -GLL Bit 2 -VTG Bit 3 -GSV Bit 4 -GSA Bit 5 -ZDA Bit 8 -RMC Bit 9 -TF Bit 10 -GST Bit 13 -BA
xx	Automatic Report Interval (1 – 99)

Examples

GGA Only	0001
GLL Only	0002
VTG Only	0004

GSV Only	0008
GSA Only	0010
ZDA Only	0020
RMC Only	0100
TF Only	0200
GST Only	0400
BA Only	2000
GGA and GLL	0003
GGA and TF	0201
RMC and TF	0300
GGA, GLL and TF	0203

PS - PPS Configuration

This sentence can query or set PPS configuration data.

$PTNLaPS,b,x...x,6,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, e.g. to compensate for cable delay Field value range is -100000000...100000000 (±100 milliseconds)

PT - Serial Port Configuration

This sentence may be issued by the user for configuring the current serial port. The Query sentence format is:

$PTNLQPT*hh<CR><LF>

The Response to query or Set sentence format is:

$PTNLRPT,xxxxxx,b,b,b,h,h*hh<CR><LF>

When the Set is issued, the first Response sentence is sent using the old parameters and the second response sentence is sent using the new parameters. If there is an error, an error response is sent. If there is no error, no additional response is sent.

Field	Description
a	Mode Q - Query S – Set R – Response
xxxxxx	Baud rate (4800, 9600, 19200, 38400, 57600, 115200). Default baud rate is 4800
b	# of data bits (7 or 8)
b	Parity (N - none, O - odd, E - even)
b	# of stop bits (1 or 2)
h	Input protocol, hex value (bit 0: reserved, bit1: TSIP, bit2: NMEA, bit 3: Reserved). Bits
h	Output protocol, hex value (bit 0: reserved, bit1: TSIP, bit2: NMEA, bit 3: reserved). It

RT - Reset

This sentence can be used to Set the reset type. No query is supported.

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

Field	Description
a	Mode S – Set R – Response
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

Field	Description
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

***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 user configuration to flash memory, send command $PTNLSRT,C,2*22.*

TF - Receiver Status and Position Fix

This sentence may be issued by the user to get 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.lllll,d,yyyyy.yyyyy,e,xxxx x,x.x,x.x,x.x*hh<CR><LF>

Field	Description
a	Mode Q - Query 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)
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)

Field	Description
llll.lllll	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)

UT - UTC

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

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>

where a is S = Application firmware, H=Hardware information
The Response to query sentence format is:

$PTNLRaVR,b,c..c,xx.xx.xx,xx,xx,xxxx*hh<CR><LF>

Application firmware

Field	Description
a	Mode
	Q - Query
	R – Response
b	Application firmware (A)
c..c	Receiver Name
xx	Major version
xx	Minor version
xx	Build version
xx	Month
xx	Day
xxxx	Year

Hardware version

Field	Description
a	Mode
	Q - Query
	R – Response
b	Hardware information indicator (H)
xxxx	Hardware ID
xxxxxxx	Serial number
xx	Build month
xx	Build day
xxxx	Build year
xx	Build hour

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

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.

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