

Resolution SMT™ GG Multi-GNSS Timing Module

For use with:

Resolution SMT GG GNSS timing module (P/N 89999-XX)

Resolution SMT GG timing module on carrier board (P/N 99974-XX)

Resolution SMT GG Starter Kit (P/N 92233-XX)

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Legal Notices

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This is the April 2014 release (Revision G) of the *Resolution SMT™ GG multi- GNSS timing module User Guide*, part number 89996-50.

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Notices

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

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

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

Canada

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

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

Europe

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



Notice to Our European Union Customers

For product recycling instructions and more information, please 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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Sunnyvale, CA 94085-3913
United States
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declare under sole responsibility that the product: Resolution™ SMT GG Timing Module 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.

Safety Information

Warnings and Cautions

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

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

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

Operation and storage

WARNING – The Resolution SMT GG GNSS timing module is ready to accept TSIP commands approximately 2 seconds after power-up. If a command is sent to the receiver within this 2 second window, the receiver will ignore the command. The Resolution SMT GG GNSS timing module will not respond to commands sent within the 2 second window and will discard any associated command data.

WARNING – Operating or storing the Resolution SMT GG GNSS timing module outside the specified temperature range can damage it. For more information, see the product specifications on the data sheet.

Routing any cable

CAUTION – Be careful not to damage the cable. Take care to avoid sharp bends or kinks in the cable, hot surfaces (for example, exhaust manifolds or stacks), rotating or reciprocating equipment, sharp or abrasive surfaces, door and window jambs, and corrosive fluids or gases.

AC adaptor safety

An international adaptor kit is provided with the Resolution SMT 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 Resolution SMT GG multi-GNSS timing module. 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.
-

Handling

CAUTION – The Resolution SMT GG multi-GNSS timing module 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 the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

CAUTION – Do not bake the units within the tape and reel packaging. Repeated baking processes will reduce the solderability.

CAUTION – Follow the thermal reflow guidelines from IPC-JEDEC J-STD-020C.

Contents

Safety Information	4
Warnings and Cautions	4
Operation and storage	4
Routing any cable	4
AC adaptor safety	5
Handling	5
Introduction	15
Operation	16
Timing features	16
Starter kit	16
Use and care	16
Technical assistance	17
Setting up the Resolution SMT GG Starter Kit	19
System requirements	20
Hardware	20
Timing receiver performance	20
Resolution SMT GG starter kit	21
Starter kit interface unit	22
Pulse-per-second (PPS)	23
Power	23
AC/DC power converter	24
Removing the Resolution SMT GG carrier board from the motherboard	24
Features and Specifications	25
Key features	26
Block diagram	27
Specifications	27
Performance	27
Interface	28
Electrical	28
Physical	28
Environmental	28

Absolute maximum limits	28
Recommended operating conditions.....	29
ESD protection	29
Interface Characteristics	31
Pin assignment.....	32
Pin description	32
Detailed pin descriptions	33
RFIN	33
OPEN / SHORT pins	33
RESET pin.....	34
VCC pin	34
PPS pin.....	34
RXDA, RXDB pins	34
TXDA, TXDB pins.....	34
Reserved pins.....	34
Protocols	34
Serial port default settings.....	35
Serial time output	35
Acquiring the correct time	35
Assisted GPS.....	36
Enabling A-GPS with the Trimble GPS Studio Application	36
Enabling A-GPS with TSIP	38
Software Interface	39
Start-up	40
Communicating with the receiver.....	40
Software tools.....	40
Port configuration	40
Port protocol and data output options.....	41
Protocol configuration and interface.....	41
NMEA 0183 Protocol and Data Output Options	42
System Operation	43
Operation	44
Start-up	44

Automatic operation.....	44
Operating modes	45
PPS quantization error	46
GNSS timing	48
Timing operation.....	49
Customizing operations	49
Resolution SMT GG on a Carrier Board.....	51
Resolution SMT GG on a carrier board	52
Connectors.....	52
Digital IO/Power connector	52
Mating connectors	52
RF connector	52
Antenna options.....	52
Digital IO/Power connector pin-out.....	53
Power requirements	53
Serial interface	53
Pulse-per-second (PPS)	54
Mounting.....	54
GNSS antenna	54
Mechanical specification.....	55
Application Circuits	57
Active antenna – no antenna status	58
Active antenna – antenna short protection.....	58
Active antenna – antenna open and short protection.....	59
RF Layout Considerations.....	61
General recommendations	62
Design considerations for RF track topologies.....	63
PCB considerations.....	64
Microstrip transmission lines.....	64
Stripline transmission lines	65
Mechanical Specifications.....	67
Mechanical outline drawing	68
Soldering the Resolution SMT GG to a printed circuit board	68

Solder mask.....	68
Pad pattern	69
Pad pattern	69
Packaging	71
Introduction	72
Reel	72
Weight.....	73
Tapes.....	73
Shipping and Handling	75
Shipping and handling guidelines	76
Handling	76
Shipment	76
Storage	76
Moisture Indicator	76
Floor life	76
Moisture precondition.....	77
Baking procedure	77
Soldering paste	77
Solder reflow.....	77
Recommended soldering profile.....	78
Optical inspection	78
Cleaning.....	78
Soldering guidelines.....	79
Repeated reflow soldering.....	79
Wave soldering	79
Hand soldering	79
Rework	79
Conformal coating.....	79
Grounding the metal shield	79
Trimble Standard Interface Protocol	81
Introduction	82
Interface scope.....	82
Automatic output packets	82

Customizing operations parameters.....	83
Factory default settings	83
Packet I/O control	83
Serial port configuration	84
Timing outputs	84
Accurate position	84
Self-survey	84
Packets output at startup	84
Command Packets: User to Resolution SMT GG.....	85
Report packets: Resolution SMT GG to User	86
Packet structure	88
Packet descriptions	89
Command Packet 0x1C: Firmware Version 01.....	89
Report Packet 0x1C: 81	89
Command Packet 0x1C: 03 – hardware component version information	89
Report Packet 0x1C: 83 – hardware component version information	90
Command Packet 0x1E: Clear RAM then Reset	90
Command Packet 0x1F: Request Software Version.....	90
Command Packet 0x20: Almanac Request	90
Command Packet 0x21: Current Time Request.....	91
Command Packet 0x22: Request GPS Satellite Selection	91
Command Packet 0x23: Request Initial Position (XYZ)	91
Command Packet 0x24: Request GPS Satellite Selection	91
Command Packet 0x25: Soft Reset / Self-Test.....	91
Command Packet 0x26: Health Request.....	91
Command Packet 0x27: Request Signal Levels	92
Command Packet 0x29: Almanac Health Page Request	92
Command Packet 0x2B: Initial Position (Latitude, Longitude, Altitude).....	92
Command Packet 0x2D: Oscillator Offset Request.....	92
Command Packet 0x2E: Set GPS Time	92
Command Packet 0x2F: UTC Parameters Request	93
Command Packet 0x31: Accurate Initial Position (XYZ Cartesian ECEF) Command	93
Command Packet 0x32: Accurate Initial Position (Latitude, Longitude, Altitude)	93

Command Packet 0x35: Set or Request I/O Options	94
Command Packet 0x37: Request Status and Values of Last Position	95
Command Packet 0x38: Request/Load Satellite System Data	95
Command Packet 0x39: Satellite Attribute Database Command	96
Command Packet 0x3A: Request last raw Measurement	96
Command Packet 0x3C: Request Current Satellite Tracking Status	97
Command Packet 0x3D: Timing Port Configuration Command	97
Report Packet 0x2B: Initial Position (Latitude, Longitude, Altitude)	97
Report Packet 0x32: Accurate Initial Position (Latitude, Longitude, Altitude)	97
Report Packet 0x40: Almanac Data Page Report	97
Report Packet 0x41: GPS Time Report	98
Report Packet 0x42: Single-precision Position Fix	98
Report Packet 0x43 Velocity Fix, XYZ ECEF	99
Report Packet 0x45: Software Version Information	99
Report Packet 0x46: Health of Receiver Report	99
Report Packet 0x47: Signal Level for All Satellites Tracked	100
Report Packet 0x49: Almanac Health Page Report	101
Report Packet 0x4A: Single Precision LLA Position Fix	101
Report Packet 0x4B: Machine/Code ID and Additional Status Report	102
Report Packet 0x4D: Oscillator Offset	102
Report Packet 0x4E: Response to Set GPS Time	103
Report Packet 0x4F: UTC Parameters Report	103
Report Packet 0x54: Bias and Bias Rate Report	103
Report Packet 0x55 I/O Options	104
Report Packet 0x56: Velocity Fix, East-North-Up (ENU)	105
Report Packet 0x57: Information about Last Computed Fix	105
Report Packet 0x58: Satellite System Data/Acknowledge from Receiver	106
Report Packet 0x59: Satellite Attributes Database Report	109
Report Packet 0x5A: Raw Data Measurement Data	109
Report Packet 0x5B: Satellite Ephemeris Status Report	110
Report Packet 0x5C: Satellite Tracking Status	110
Report Packet 0x6C: All-in-View Satellite Selection	111
Command Packet 0x7A: Set or Request NMEA Interval and Message Mask	111

Report Packet 0x7B: Set NMEA Message Output	112
Report Packet 0x83: Double Precision XYZ	112
Report Packet 0x84: Double Precision LLA Position Fix and Bias Information	113
Command Packet 0xBB: Set Receiver Configuration	113
Report Packet 0 x BB Data Format	113
Command Packet 0xBC: Set Port Configuration	114
TSIP Superpackets	117
Command Packet 0x8E-0B: Request or Configure Superpacket Output	117
Command Packet 0x8E-14: Set or Request Datum	117
Command Packet 0x8E-15: Request current Datum values	117
Command Packet 0x8E-20: Request Last Fix with Extra Information	117
Command Packet 0x8E-26: Write Receiver Configuration to Non-volatile Memory (Flash)	118
Command Packet 0x8E-41: Request Manufacturing Parameters	118
Command Packet 0x8E-42: Stored Production Parameters	118
Command Packet 0x8E-4A: Set PPS Characteristics	119
Command Packet 0x8E-4D: Automatic Packet Output Mask	119
Command Packet 0x8E-4E: Set PPS output option	120
Command Packet 0x8E-A2: UTC/GNSS Timing	120
Command Packet 0x8E-A5: Packet Broadcast Mask	121
Command Packet 0x8E-A6: Self-Survey Command	122
Command Packet 0x8E-A9: Self-Survey Parameters	122
Command Packet 0x8E-AB : Request Primary Timing Packet	123
Command Packet 0x8E-AC: Request Supplemental Timing Packet	123
Report Packet 0x8F-20: Last Fix with Extra Information (binary fixed point)	124
Report Packet 0x8F-26: Save Receiver Configuration to Non-volatile Storage Memory	125
Report Packet 0x8F-41: Stored Manufacturing Operating Parameters	125
Report Packet 0x8F-42: Stored Production Parameters	126
Report Packet 0x8F-4A: Set PPS Characteristics	126
Report Packet 0x8F-4E: PPS Output	126
Report Packet 0x8F-A2: UTC/GPS Timing	126
Report Packet 0x8F-A5: Packet Broadcast Mask	126
Report Packet 0x8F-A6: Self-Survey Command	126
Report Packet 0x8F-A9: Self-Survey Parameters	127

Report Packet 0x8F-AB: Primary Timing Packet	128
Broadcast Control: Packet 8F-AB, Mask 0, Bit 0	129
Report Packet 0x8F-AC: Supplemental Timing Packet.....	129
Unused or miscellaneous packets.....	134
Report Packet 0x13: Unparsable Packet.....	134
Report Packet 0x13: Data Format.....	134
Legacy packets (unused)	134
Report Packet 0x54: Bias and Bias Rate	134
Report Packet 0x46: Health of Receiver.....	134
Report Packet 0x41: GPS Time	134
Report Packet 0x4B: Machine Code ID and Additional Status.....	134
NMEA 0183 Protocol.....	136
Introduction	137
NMEA 0183 communication interface.....	137
NMEA 0183 message structure	137
Field definitions.....	138
NMEA 0183 message options	140
Resolution SMT GG GNSS timing module proprietary NMEA messages	140
NMEA 0183 message formats.....	141
GGA-GPS Fix Data.....	141
GLL - Geographic Position - Latitude/Longitude.....	141
GSA - GPS DOP and Active Satellites.....	142
GSV - GPS Satellites in View	142
RMC - Recommended Minimum Specific GPS/Transit Data.....	143
VTG - Track Made Good and Ground Speed.....	144
ZDA - Time & Date.....	144
AH - Almanac Health	145
AL - Almanac Page.....	146
AS - Almanac Status	147
BA - Antenna Status	147
CR - Configure Receiver.....	148
EM - Enter Monitor Mode.....	148
EP - Ephemeris	148

IO - Ionosphere	151
KG - Set Initial Position.....	151
NM - Automatic Message Output.....	152
PS - PPS Configuration.....	153
PT - Serial Port Configuration.....	153
RT - Reset	154
TF - Receiver Status and Position Fix	155
UT - UTC	155
VR - Version.....	156
ZD – Extended Time and Date.....	157
Exception behavior	158
Interruption of GNSS signal.....	158

Introduction

In this chapter:

Operation

Timing features

Starter kit

Use and care

Technical assistance

The *Resolution SMT™ GG multi-GNSS timing module User Guide* describes how to integrate and operate the Trimble® Resolution SMT™ GG GNSS timing module.

The Trimble Resolution SMT GG multi-GNSS timing board is a full featured, high-performance GPS receiver. The receiver is designed to operate on the L1 (1598 MHz) frequency, providing standard position service (SPS) using Coarse Acquisition (C/A) code.

The Trimble Resolution SMT GG is designed for 3.3 V prime power and provides a separate pin on the I/O connector for powering the antenna with a user supplied voltage from 3.0 V to 5.5 V (antenna dependent).

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

Operation

The Resolution SMT GG multi-GNSS timing module automatically initiates a self-survey upon acquisition of GPS / GLONASS 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 from the timing solution.

Timing features

The timing features of the Resolution SMT GG multi-GNSS timing module include the following:

- Automatic self-survey
- Over-determined timing mode
- Single satellite timing mode with anti-jamming feature turned off
- Dual satellite timing mode with anti-jamming feature turned on
- Timing Superpackets
- T-RAIM (Timing Receiver Autonomous Integrity Monitoring)
- Position integrity monitoring
- Cable-delay compensation
- Accuracy <15 ns (1 sigma)

Starter kit

The starter kit makes it simple to evaluate the Resolution SMT GG timing moduler's performance. It can be used as a platform for configuring the receiver software or as a platform for troubleshooting your design.

Use and care

The Resolution SMT GG multi-GNSS timing module is a high-precision electronic instrument and should be treated with reasonable care.

CAUTION – There are no user-serviceable parts inside the Resolution SMT 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 800-767-4822 or email tsgsupport@trimble.com.

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Setting up the Resolution SMT GG Starter Kit

In this chapter:

System requirements

Timing receiver performance

Resolution SMT GG starter kit

Power

Removing the Resolution SMT GG

carrier board from the

motherboard

This chapter provides a detailed description of the starter kit components.

The starter kit provides everything you need to integrate state-of-the-art GNSS capability into your application.

For complete instructions on connecting the starter kit, download the Trimble VTS User Guide—go to <http://www.trimble.com/timing/resolution-smtx.aspx>

The hardware integration is described in Chapter 7, Resolution SMT GG on Carrier Board

System requirements

Hardware

- The Trimble Resolution SMT GG Starter Kit
- User-provided connectors and extension cords to connect the Resolution SMT GG to the computer, antenna interface, and other devices as required.
- +24 VDC power supply.
- User-provided equipment to analyze the PPS accuracy and a BNC connector to connect it to the Resolution SMT GG starter kit.

Timing receiver performance

The Resolution SMT GG GNSS timing module is a high-performance GNSS receiver, designed to operate with the L1 frequency, Standard Position Service, Coarse Acquisition code. The receiver is designed in a single board format, specially adapted for timing applications where reliability, performance, and ease of integration are desired. The receiver features Trimble's improved signal processing code, a high-gain RF section for compatibility with standard active gain GPS antennas, and a CMOS level pulse-per-second (PPS) output for timing and synchronization applications.

Timing applications are assumed to be static. The special timing software used with the Resolution SMT GG timing module configures the unit into an automatic self-survey mode at start up. The receiver will average position fixes for a specified time (one per second) and at the end of this period will save this reference location. At this time the receiver will go into an Over-determined Clock mode and no longer solve for position but only for clock error and clock bias using all of the available satellites. When combined with the precise quantization error output, this provides an accuracy of less than 15ns (1 sigma) for the 1PPS output.

User settings such as port parameters and NMEA settings can be stored in the receiver's non-volatile (flash) memory. These settings are retained without main power.

Note – To offset the delay inherent in the RF 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.

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

Resolution SMT GG starter kit

The Resolution SMT GG multi-GNSS timing module is available in a Starter Kit or as an individual receiver and associated antenna. The Starter Kit includes all the components necessary to quickly test and integrate the receiver:



The starter kit includes the Resolution SMT GG timing module on a carrier board, mounted on an interface motherboard in a durable metal enclosure. The kit also contains:

- Miniature magnetic mount antenna
- Interface cable, USB
- AC/DC power supply adapter :
 - Input: 100 – 240 VAC
 - Output: 24 VDC
- SMB to SMA adapter cable

Note – The Resolution SMT GG multi-GNSS timing module is also available as an individual receiver and associated antenna, or with the Resolution SMT GG multi-GNSS timing module mounted on a carrier board.

Starter kit interface unit

The starter kit interface unit consists of a USB interface which is compatible with most PC communication ports. Power (24 VDC) is supplied through the power connector on the front of the interface unit. The motherboard features a switching power supply which converts this voltage input to the 3.3 V required by the receiver and the antenna. The USB connector allows for an easy connection to an office computer using the USB interface cable provided in the starter kit. The metal enclosure protects the receiver and the motherboard for testing outside of the laboratory environment.

The Resolution SMT GG multi-GNSS timing module, installed in the Starter Kit interface unit, is a dual port receiver, but only port A is available from the carrier board header pins. A straight-in, panel-mount RF SMB connector supports the GNSS antenna connection.

This following figure shows the receiver in the metal enclosure:



The following figure shows the starter kit interface unit



Pulse-per-second (PPS)

The default PPS output width of the receiver is 10 microseconds, CMOS compatible Pulse-Per-Second (PPS). The PPS is a positive pulse available on the BNC connector of the interface unit. The rising edge of the pulse is synchronized to GPS. The timing accuracy is <15 nanoseconds (1 sigma) when operating in the Over-determined Timing Mode. The PPS can drive a load up to 5 mA without damaging the receiver.

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

Power

The Resolution SMT GG multi-GNSS timing module is designed for embedded applications and requires a regulated +3.3 VDC input (+3.0 to +3.6 VDC). The receiver provided in the Starter Kit is installed on a motherboard, which provides a DC power regulator which converts a 24 VDC input to the regulated 3.3 VDC required by the receiver and the antenna. Power can be applied to the interface unit using the AC/DC power converter

AC/DC power converter

The AC/DC power converter may be used as an alternate power source for the interface unit. The AC/DC power converter converts 110 or 220 VAC to a regulated 24 VDC compatible with the interface unit. The AC/DC power converter output cable is terminated with a connector compatible with the power connector on the metal enclosure. The AC supply comes with a range of clip-on adapters for international use



Removing the Resolution SMT GG carrier board from the motherboard

WARNING – Before opening the interface unit, disconnect the unit from any external power source and confirm that both you and your work surface are properly grounded for ESD protection.

The Resolution SMT GG multi-GNSS timing module is secured to a carrier board and is then attached to the motherboard standoffs with Phillips head screws, allowing for removal and integration with the user's application. Follow these steps to remove the receiver from the motherboard:

1. Disconnect power to the enclosure.
2. Remove the base plate and unplug the RF cable from the receiver.
3. Use a small Phillips screwdriver to remove the securing hardware which holds the Resolution SMT GG multi-GNSS timing module to the motherboard.
4. Gently slip the board loose from the motherboard I/O connector

Features and Specifications

In this chapter:

Key features

Specifications

Mean Time Between Failures

Recommended operating

conditions

ESD protection

This chapter describes the Resolution SMT GG multi-GNSS timing module's features and performance specifications.

Key features

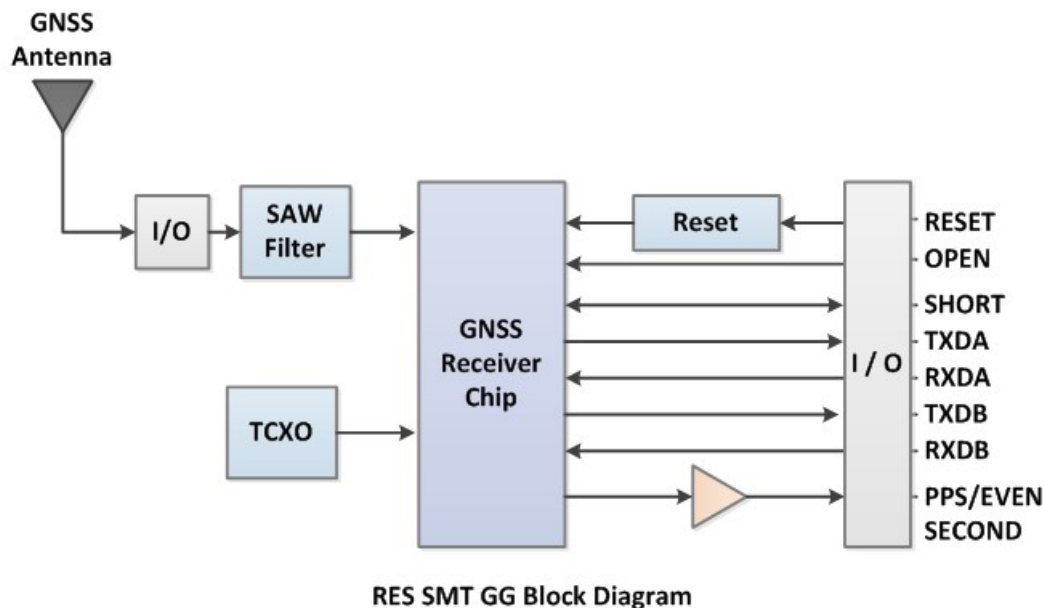
The Resolution SMT GG timing module is a high-performance multi-GNSS timing receiver in a thumbnail-sized shielded unit.

The single-sided module is packaged in tape and reel for pick and place manufacturing processes: 28 reflow-solderable edge castellations provide an interface to your design without costly I/O and RF connectors. Each module is manufactured and factory tested to Trimble's high quality standards.

- Dimensions: 19 mm width x 19 mm length (0.75" x 0.75")
- Ultra-thin: 2.54 mm (0.1")
- Pick and place assembly, tape and reel packaging, reflow solderable
- No I/O or RF connector, 28-edge castellations
- World class tracking and acquisition sensitivity
- Ultra-precise 1 PPS output (can be configured as an even-second output)
- Supports automatic self-survey of position for static operation
- Supports Assisted-GPS (A-GPS) operation.
- Supports active antenna designs only
- Capable of simultaneously tracking of up to 32 GNSS satellites
- Supports TSIP and NMEA 0183 protocols (TSIP is recommended for full timing diagnostic information)
- Carrier board and starter kit available
- RoHS-II compliant (lead-free)

Note – This multi-GNSS timing module is optimized for static timing applications. While it can be used in dynamic mode the stability of PPS cannot be guaranteed.

Block diagram



The Resolution SMT GG is a multi-GNSS timing module. It is a complete all-in-view, parallel tracking GNSS receiver capable of tracking of up to 32 GNSS satellites simultaneously and designed to operate with the L1 frequency, standard position service, and Coarse Acquisition code.

The Resolution SMT GG receives the GNSS satellite signals through the antenna feed line connector and passes them to the RF down converter. A highly stable crystal reference oscillator is used by the GNSS timing module which extracts the carrier code information as well as the navigation data.

Specifications

Performance

The Resolution SMT GG multi-GNSS timing module is an L1 (1598 MHz) frequency, C/A code, GNSS receiver capable of tracking of up to 32 GNSS satellites simultaneously.

Update rate	TSIP, 1Hz
	NMEA, 1 Hz
PPS accuracy	15 ns (1 sigma)

Interface

Connectors	28 surface mount edge castellations
Serial port	2 UARTs, 3.3 V CMOS compatible
PPS	3.0 V CMOS compatible
Protocols	<ul style="list-style-type: none">• Trimble Standard Interface Protocol (TSIP)• National Marine Electrical Association (NMEA) 0183

Electrical

Prime power	3.0 V DC to 3.6 V DC
Power consumption	100 mA at 3.3 V
Ripple noise	Max. 50 mV, peak-to-peak, 1 Hz to 1 MHz

Physical

Dimesions	19mm x 19mm x 2.54mm
Weight	1.7grams (0.06 ounce) including metal shield

Environmental

Operating temperature	-40 °C to +85 °C
Storage temperature	-40 °C to +85 °C
Vibration	0.008 g ² /Hz, 5 Hz to 20 Hz 0.05 g ² /Hz, 20 Hz to 100 Hz -3 dB/octave, 100 Hz to 900 Hz
Operating humidity	5% to 95%, R.H., non-condensing, at +60 °C

Absolute maximum limits

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.

Symbol	Parameter	Value	Unit
V _{CC}	Supply voltage (referenced to GND)	-0.3 to +3.6	V
V _I	Input voltage (referenced to GND)	-0.3 to V _{CC} + 0.3	V
V _O	Output voltage (referenced to GND)	-0.3 to V _{CC} + 0.3	V
I _{IO}	Input/Output current	25	mA
P _{ANT}	Input power at antenna input	+3	dBm

Recommended operating conditions

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

Symbol	Parameter	Min	Typ	Max	Unit
V _{CC}	DC supply voltage (referenced to GND)	3.0	3.3	3.6	V
I _{CC}	DC supply current		100		mA
V _{IL}	Low-level input voltage			0.8	V
V _{IH}	High-level input voltage	2.0			V
V _{IL}	Low-level input voltage (RESET)			0.2	V
V _{IH}	High-level input voltage (RESET)		1.2		V
V _{OL}	Low-level output voltage			0.8	V
V _{OH}	High-level output voltage	2.0			V
I _I	Input leak current			±1	μA
t _{W(RESET)}	RESET low pulse width	100			Ms
R _{PU}	Pull-up resistor (RESET input)		10		KΩ
	Supply ripple noise (1 Hz to 1 MHz)			50	mVpp
	Supply ripple noise (TCXO)			1	mVpp

ESD protection

ESD testing was performed using test standard IEC 1000-4-2. All inputs and outputs are protected to ±500 V ESD level.

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

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Interface Characteristics

In this chapter:

Pin assignments

Pin description

Serial port default settings

Serial time output

Assisted GPS

This chapter provides a detailed description of the Trimble Resolution SMT GG multi-GNSS timing module interface.

Pin assignment

GND	1	28	GND
GND	2	27	VCC
RFIN	3	26	GND
GND	4	25	RESET
OPEN	5	24	GND
SHORT	6	23	RESERVED
RESERVED	7	22	TXDB
RESERVED	8	21	RXDB
RESERVED	9	20	GND
RESERVED	10	19	PPS
RESERVED	11	18	GND
RESERVED	12	17	TXDA
RESERVED	13	16	RXDA
GND	14	15	GND

Pin description

Pin	Name	Description	Function	Note
1	GND	Ground	Ground	Signal ground. Connect to common ground.
2	GND	Ground	Ground	Connect to common ground.
3	RFIN	GNSS RF input	Input	50 Ω unbalanced (coaxial) RF input.
4	GND	Ground	Ground	Connect to common ground.
5	OPEN	Antenna OPEN	Input	Logic level from external antenna detection
6	SHORT	Antenna SHORT	Input /	Logic level from external antenna detection
7	Reserved	Reserved		
8	Reserved	Reserved		
9	Reserved	Reserved		
10	Reserved	Reserved		
11	Reserved	Reserved		
12	Reserved	Reserved		
13	Reserved	Reserved		
14	GND	Ground	Ground	Signal ground. Connect to common ground.
15	GND	Ground	Ground	Signal ground. Connect to common ground.
16	RXDA	UART Receive	Input	Logic level serial port receive
17	TXDA	UART Transmit	Output	Logic level serial port transmit
18	GND	Ground	Ground	Signal ground. Connect to common ground.

Pin	Name	Description	Function	Note
19	PPS/Even	Pulse per second	Output	Logic level timing signal at 1 Hz. Do not
20	GND	Ground	Ground	Signal ground. Connect to common ground.
21	RXDB	UART Receive	Input	Logic level serial port receive
22	TXDB	UART Transmit	Output	Logic level serial port transmit
23	Reserved	Reserved		
24	GND	Ground	Ground	Signal ground. Connect to common ground.
25	External	Reset	Input	Active low logic level reset. If not used, do
26	GND	Ground	Ground	Signal ground. Connect to common ground.
27	VCC	Supply voltage	Power	Module power supply, 3.0 - 3.6 VDC.
28	GND	Ground	Ground	Signal ground. Connect to common ground.

Detailed pin descriptions

RFIN

The RF input pin is the 50 Ω unbalanced GNSS RF input, and can be used only with active antennas. Refer to the application designs for examples of antenna power circuits.

OPEN / SHORT pins

Trimble recommends that you use an antenna detection circuit that has short-circuit protection. Two pins are provided for reporting the antenna status: OPEN and SHORT. The SHORT pin usually functions as an input to monitor for short circuits. Following a short-circuit condition, it is driven high for approximately 25 microseconds in every second to turn the antenna power circuit back on..

The logic level inputs outlined in the following table can be used with a detection circuit (with or without protection) to monitor the status of the external LNA of an active antenna by the module. These input pins also conform to the Input / Output Pin threshold levels specified in the truth table for the logic of these signals

Antenna reports	SHORT pin	OPEN pin
Antenna Open reported	1	1
Antenna Normal reported	1 ¹	0 ²
Antenna Shorted reported	0	0
Undefined	0	1

¹ If the SHORT pin is not used it should be pulled to Vcc through a 10k Ω resistor.

² If the OPEN pin is not used it should be pulled to GND.

A typical active antenna draws between 10 mA to 20 mA. The antenna's protect/detect circuit will short circuit at around 100 mA. Trimble recommends that you keep the antenna current

below 75 mA. An open circuit is determined if the antenna current falls below approximately 2 mA

RESET pin

Use this logic-level, active low input to issue hardware reset to the module. It can be connected to external logic or to a processor to issue a reset instruction. To reset the module, drive this pin to logic level 0 or “Low” for at least 100 microseconds, and then either release this signal or drive it back high. This pin has an internal pull-up resistor—if this pin is not used it should be left disconnected.

VCC pin

This is the primary voltage supply pin for the module.

PPS pin

Pulse-per-second. This logic level output provides a 1 Hz timing signal to external devices. The PPS pin can be configured to provide an Even Second output. The pulse width of this signal is 10 us.

- The cable delay compensation, enable state, and polarity can be controlled by TSIP packet 0x8E-4A.
- The PPS output options are set by TSIP packet 0x8E-4E.

RXDA, RXDB pins

This logic level input is the serial port receive line (data input to the module). The baud rate for the port is user configurable. If any of these pins are not used, they should be left disconnected.

TXDA, TXDB pins

This logic level output is the serial port transmit line (data output from the module). The baud rate for the port is user configurable.

Reserved pins

There are several reserved pins on the Resolution SMT GG multi-GNSS timing module. Do not connect these pins.

Protocols

The following protocols are available on the Resolution SMT GG multi-GNSS timing module:

Protocol	Specification	Direction
TSIP	Trimble proprietary binary protocol	Input / Output
NMEA	NMEA 0183	Input ¹ / Output

¹Requires use of Trimble-proprietary NMEA messages.

Serial port default settings

The Resolution SMT GG multi-GNSS timing module 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	17	TSIP out	115 kbps	8	Odd	1	None
	RXDA	16	TSIP in	115 kbps	8	Odd	1	None
B	TXDB	22	Not set ¹	115 kbps	8	Odd	1	None
	RXDB	21	Not set ¹	115 kbps	8	Odd	1	None

¹ 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

Serial time output

You can take the time from the timing messages in the TSIP or NMEA protocols.

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

Note – GPS time differs from UTC (Universal Coordinated Time) by a variable, integer number of seconds $UTC = (GPS\ time) - (GPS\ UTC\ offset)$. As of 30 June 2012, the GPS UTC offset is 16 seconds. The GPS week number is in reference to a base week (Week #0), starting January 6, 1980.

Acquiring the correct time

- Make sure that the almanac is complete and that 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 packet 8F-AB that follows the PPS pulse.
- The leading edge of the PPS pulse occurs on-time. This can be either the rising edge (when the rising edge on-time is selected in 8E-4A) or the falling edge.
- If using TSIP, capture the time from TSIP packet 0x8F-AB.
- 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.

Assisted GPS

The Resolution SMT GG GNSS receiver is equipped with assisted GPS (A-GPS), which allows the receiver to obtain a position fix even in very poor GPS signal conditions using almanac, ephemeris, time, and position data.

You must first download the current almanac, ephemeris, time, and position information, and then upload this data to the module using either the Trimble Visual Timing Studio (VTS) application or TSIP.

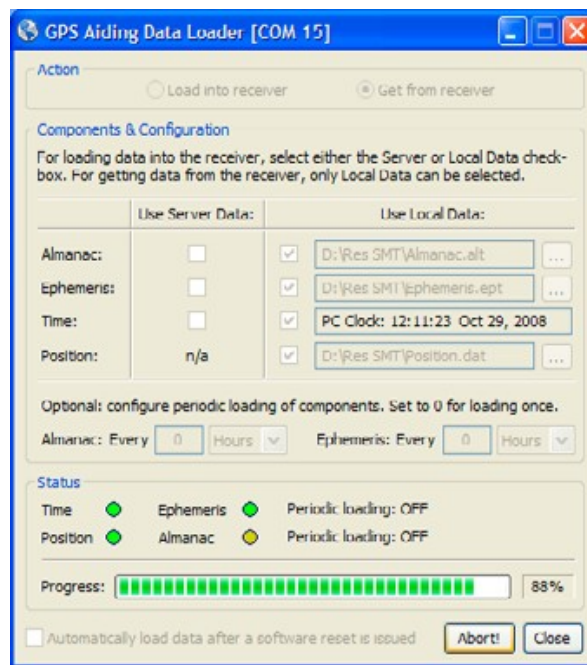
CAUTION – To ensure the proper format of the ephemeris file and almanac file, you must use a Trimble receiver to gather this data. Almanac files from non-Trimble receivers may not be in proper format and thus may not work (for example, if almanac files are downloaded from the Internet)

Enabling A-GPS with the Trimble VTS Application

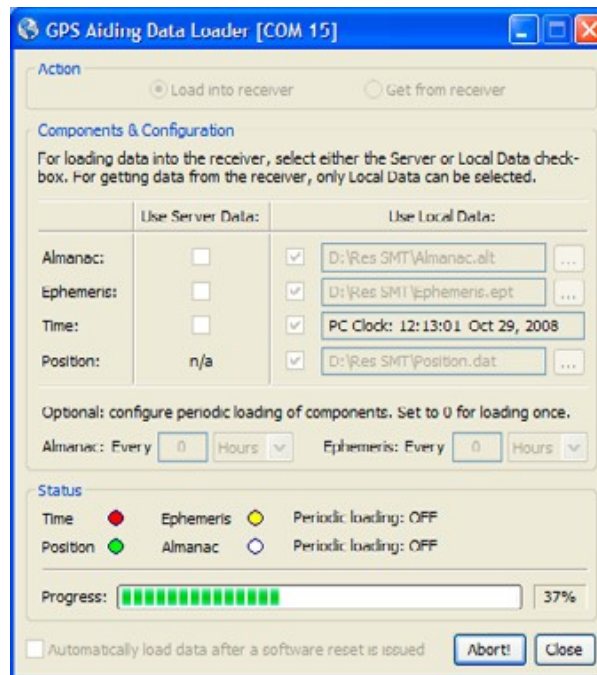
1. Attach the Resolution SMT GG GPS interface unit to your computer.
2. Place the GPS antenna where there is a clear view of sky.
3. Allow the receiver to run and calculate fixes.
4. Start VTS and then connect to the receiver.
5. On the main monitor screen, wait for the almanac field to indicate “Complete”. This confirms that the receiver has collected a current almanac.

Note – It takes the Resolution SMT GG unit 12.5 minutes of uninterrupted operation to collect an almanac from the satellites.

6. In the Monitor window, select Receiver /Load A-GPS Data. In the Action group, select Get from receiver to download the almanac, position, time, and ephemeris files to your computer:



7. When you have collected these files, use them the next time the receiver is started up to assist signal acquisition: Select *Receiver /Load A-GPS Data* again. In the *Action* group, select the *Load into receiver* option to upload the files:



Note – The collected ephemeris is only valid for approximately 2 hours.

Enabling A-GPS with TSIP

1. Allow the receiver to run long enough to collect a current almanac.

Note – It takes the Resolution SMT GG unit 12.5 minutes of uninterrupted operation to collect an almanac from the satellites.

2. Use packet 0 x 26 to request the health of the receiver. The receiver responds with packets 0x46 and 0x4B if the almanac is complete and current. Wait until packet 0x4B indicates that the almanac is complete before continuing.
3. Use packet 0x38 to request the almanac and the ephemeris for each of the 32 GPS satellites. The receiver responds with packet 0 x 58.
4. Use packet 0x8F-AB to get the current GPS time from the receiver. You can use this data to set your own off-board clock.
5. Use packet 0x8F-AC to get a position from the receiver.

To upload this information to the receiver:

1. Upload the time using packet 0x2E. Wait for upload confirmation report packet 0x4E.
2. Upload the position using packet 0x2B. The confirmation report packet 0x2B is returned.
3. Upload the ephemeris using packet 0x38. Wait for upload confirmation report packet 0x58.

See also Appendix A, Trimble Standard Interface Protocol

Software Interface

In this chapter:

Start-up

Communicating with the receiver

Port protocol and data output
options

This chapter describes the software interface and describes both 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.

Start-up

The Resolution SMT GG multi-GNSS timing module is a complete GNSS timing receiver designed to operate with the L1 frequency, 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 signals, track up to 32 satellites, and compute location, speed, heading, and time. At power-up the receiver will begin a self-survey process. Upon completion, the receiver will provide an over-determined timing solution.

The first time the receiver is powered-up, it is searching for satellites from a cold start (no almanac, time, ephemeris, or stored position). While the receiver will begin to compute position solutions in under one minute, the receiver must continuously track satellites for approximately 15 minutes to download a complete almanac and ephemeris. This initialization process should not be interrupted. The receiver will respond to commands almost immediately after power-up (see Warning below).

CAUTION – The Resolution SMT GG multi-GNSS timing module is ready to accept TSIP commands approximately 2 seconds after power-up. If a command is sent to the receiver within this 2 second window, the receiver will ignore the command. The Resolution SMT GG multi-GNSS timing module will not respond to commands sent within the 2s window and will discard any associated command data

Communicating with the receiver

The Resolution SMT GG multi-GNSS timing module supports two message protocols: TSIP and NMEA. Communication with the receiver is through a CMOS compatible serial port. The port characteristics can be modified to accommodate your application requirements. Port parameters are stored in non-volatile memory (flash) which does not require back-up power. Table 6 lists the default port characteristics.

Software tools

The software tools provided on the Trimble website include a user-friendly Windows application to facilitate communication with the receiver, via the Trimble Standard Interface Protocol (TSIP).

Port configuration

The Resolution SMT GG multi-GNSS timing module has dual I/O ports. The following tables show the default protocols and port configuration for the receiver, as delivered from the factory

Port A

TSIP Input	TSIP Output
Baud rate 115K	Baud rate 115K
Data bits 8	Data bits 8
Parity: Odd	Parity: Odd
Stop bits: 1	Stop bits: 1
No Flow Control	No Flow Control

On Port B, the Resolution SMT GG multi-GNSS timing module can be configured to output NMEA messages. See Note, for default serial port settings.

The receiver is shipped from the factory with the TSIP protocol configured on Port A. Use TSIP on Port A to configure Port B for NMEA the first time you use the receiver. The receiver Port A can be reconfigured using TSIP command packet 0xBC, in conjunction with VTS or a user-written serial interface program.

Port B

The standard port characteristics for NMEA are as follows

NMEA Output

Baud rate 115K
Data bits 8
Parity: None
Stop bits: 1
No Flow Control

Note – The Resolution SMT GG on a carrier board and starter kit only bring Port A for TSIP to the connector.

Any standard serial communications program, such as Windows Hyper-Terminal can be used to view the NMEA output messages. TSIP is a binary protocol and outputs raw binary serial data that cannot be read when using Windows Terminal. To view the output of the TSIP protocol in text format, use the Trimble VTS program.

CAUTION – When using the TSIP protocol to change 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).

Port protocol and data output options

Protocol configuration and interface

The factory default protocol for the Resolution SMT GG multi-GNSS timing module is the Trimble Standard Interface Protocol (TSIP), for both input and output. The serial port setting is 115 kbps 8-odd-1. The receiver protocol can be re-configured using TSIP command packet 0xBC, VTS, or a user-written serial interface program.

VTS, a Windows-based GUI, provides a versatile graphical interface for monitoring TSIP 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.

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

NMEA 0183 Protocol and Data Output Options

The National Marine Electronics Association (NMEA) protocol is an industry standard data protocol which was developed for the marine industry. Trimble has chosen to adhere stringently to the NMEA 0183 data specification as published by the NMEA.

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 Resolution SMT GG multi-GNSS timing module, 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 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.

System Operation

In this chapter:

Operation

PPS quantization error

GPS timing

Customizing operations

This chapter describes the operating characteristics of the Resolution SMT GG multi-GNSS timing module including start-up, satellite acquisition, operating modes, serial data communication, and the timing pulse. The Resolution SMT GG multi-GNSS timing module acquires satellites and computes position and time solutions. It outputs data in the TSIP (or NMEA) protocol through its serial port.

Operation

Start-up

When the Resolution SMT GG is turned on, it automatically begins to acquire and track

GPS satellite signals. It obtains its first fix in under one minute.

During the satellite acquisition process, the Resolution SMT GG outputs periodic TSIP status messages. These status messages confirm that the receiver is working.

Automatic operation

When the Resolution SMT 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 position fixes (configurable), the self-survey is complete. At that time, the Resolution SMT GG automatically switches to a time-only mode (Over-determined Clock mode).

Satellite masks

Satellite masks are only operable when the receiver is in over-determined mode. By default the masks are disabled and all usable satellites are included in the solution.

The Resolution SMT GG continuously tracks and uses up to 32 satellites in an over-determined clock solution. The satellites must pass the mask criteria to be included in the solution.

The following table lists the default satellite masks used by the Resolution SMT 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, Trimble Standard Interface Protocol

Mask	Setting	Notes
Elevation	0°	SV elevation above horizon
SNR	0	Signal strength

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

SNR mask

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

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

If the Resolution SMT GG antenna has a clear view of the sky (outdoor antenna placement), an SNR mask of 35 is recommended for optimal results. However, for indoor use or operation with an obscured view of the sky, the mask must be low enough to allow valid weak signals to be used. For indoor operation, an SNR mask of 0 (zero) is recommended.

Operating modes

The Resolution SMT 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 Resolution SMT GG automatically switches to Over-determined (OD) Clock mode

Self-survey mode

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

The default mode during self-survey is 2D/3D Automatic, where the receiver must obtain a 3-D solution. If fewer than four conforming satellites are visible, the Resolution SMT 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 Resolution SMT GG once a surveyed (or user input) position is determined. After the receiver self-surveys its static reference position, it automatically switches to Over-determined Clock Mode and determines the clock solution. The timing solution is qualified by a Time-Receiver Autonomous Integrity Monitoring algorithm, which automatically detects and rejects faulty satellites from the solution.

Using the default Anti Jamming setting, a minimum of two satellites is required for 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.

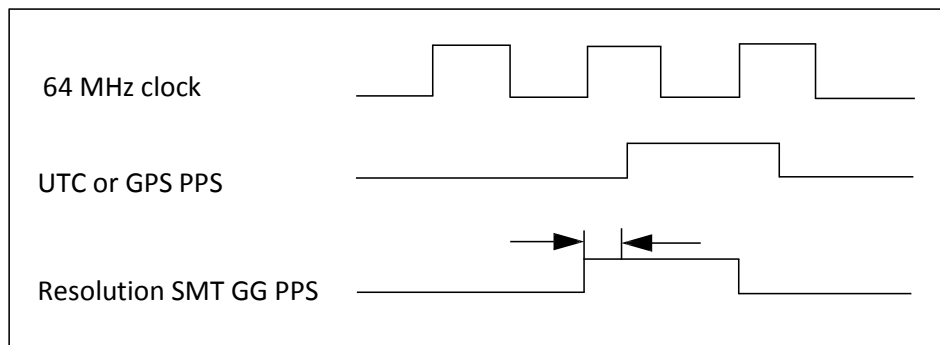
In this mode, the Resolution SMT GG does not navigate or update positions and velocities, but maintains the PPS output, solving only for the receiver clock error (bias) and error rate (bias

rate). If the Anti Jamming setting is disabled, only one satellite is required for a fix. To set Anti Jamming, see Command Packet 0xBB: Set Receiver Configuration.

PPS quantization error

The Resolution SMT GG timing module uses a high-precision, fixed frequency oscillator as the timing source to down-convert and decode the GNSS signal and to generate the PPS output signal. Since a fixed-frequency oscillator is used, the Resolution SMT GG must place the PPS output on the clock edge that it determines is closest to UTC, GPS or GLONASS time. This situation results in a quantization error on the placement of the PPS whose magnitude is equal to the period of the fixed frequency oscillator. The oscillator frequency is 64 MHz which is equivalent to a period just over 15 nanoseconds. The quantization error on the PPS output is between ± 15 ns.

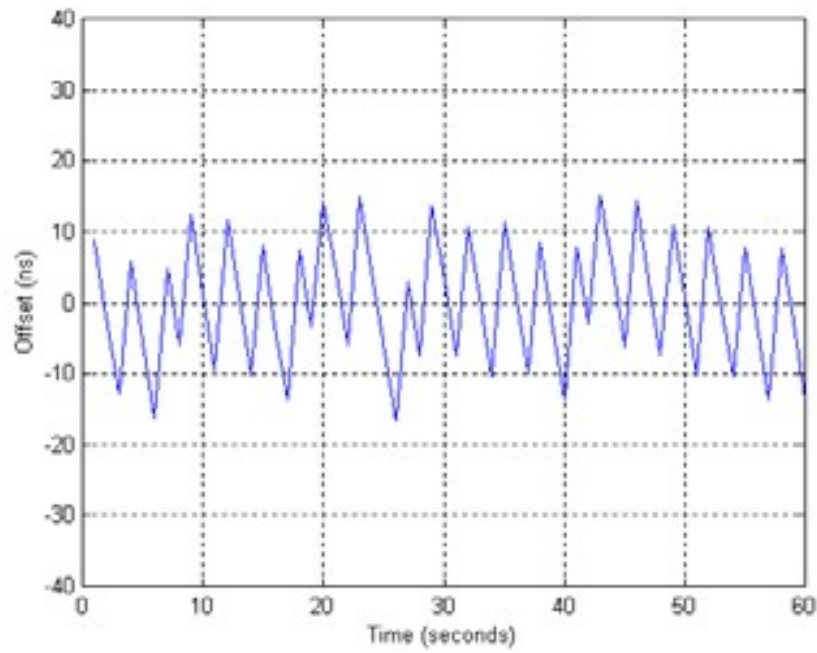
The quantization error is illustrated below. The top waveform represents the 64 MHz clock. The Resolution SMT GG output must be placed on one of the edges of this clock. The middle waveform represents the UTC/GPS on-time mark as determined by the receiver's electronics. The bottom waveform represents the Resolution SMT GG PPS output which is output on the clock edge closest to the actual UTC/GPS on-time mark.



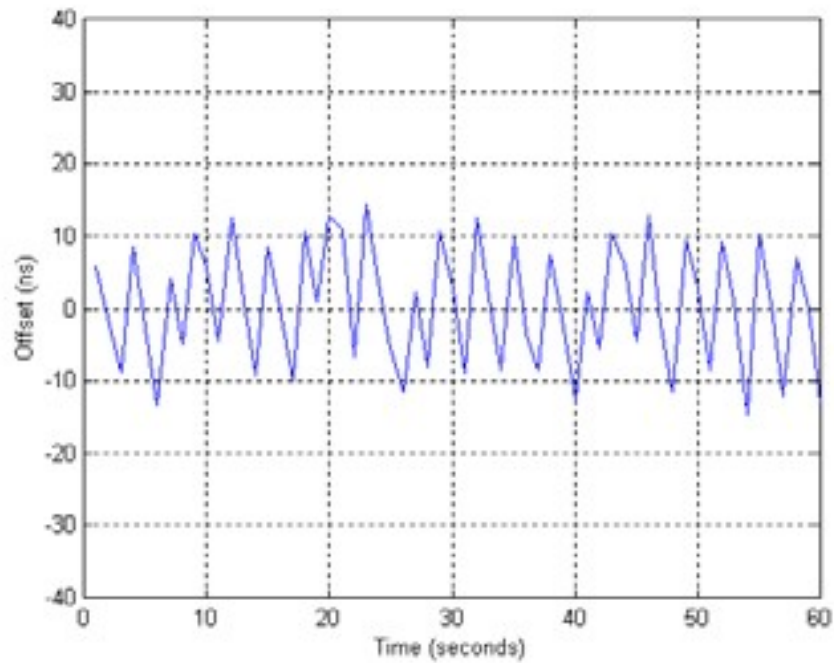
The amount of quantization error present on each PPS output pulse is reported in packet 0x8F-AC. This quantization error information can be used to reduce the effective amount of jitter on the PPS pulse.

The figures below illustrate the result of removing the quantization error from the PPS output in a user system. The top slot shows the offset of the PPS output pulse relative to a stable standard such as a Cesium atomic clock. The quantization error is responsible for the jagged appearance of the waveform. The middle plot shows the quantization error as reported by the Resolution SMT GG in packet 0x8FAC. The bottom plot is the result of subtracting the quantization error from the PPS offset

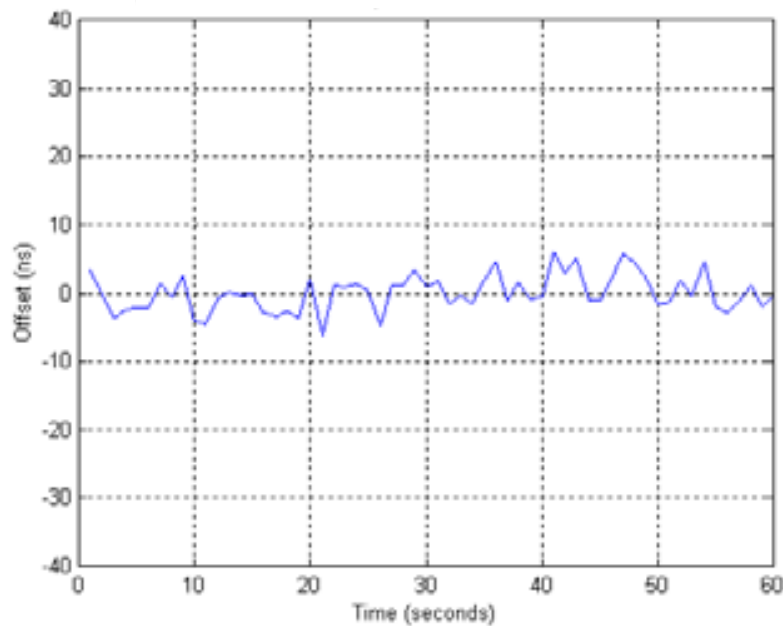
Resolution SMT GG Raw PPS Output



Resolution SMT GG Quantization Error



Resolution SMT GG with Quantization Error removed



GNSS timing

For many timing applications, such as time/frequency standards, site synchronization systems, and wireless voice and data networks, the Resolution SMT GG can be used to steer a local reference oscillator. The steering algorithm combines the short-term stability of the oscillator with the long-term stability of the GPS PPS. An accurate GPS PPS allows the use of cost-effective crystal

A Trimble GNSS receiver uses the signals from these GPS "clocks" to correct its internal clock, which is not as stable or accurate as the GPS atomic clocks. A GPS receiver like the Resolution SMT GG outputs a highly accurate timing pulse (PPS) generated by its internal clock, which is constantly corrected using the GPS clocks. In the case of the Resolution SMT GG, this timing pulse is synchronized to GPS/UTC time within 15 nanoseconds (1 sigma) after the survey is completed

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

Position and time errors are related by the speed of light. This is why an accurate reference position is critical. A position error of 100 meters corresponds to a time error of approximately 333 ns.

The GNSS receiver's clocking rate and software affect PPS accuracy. Using software algorithms like an over-determined clock solution, the Resolution SMT GG mitigates the effects of clock error to achieve a PPS accuracy within 15 ns (1 sigma) to GPS/UTC after survey is complete.

Timing operation

The Resolution SMT GG automatically outputs a PPS and time tag. With an accurate reference position, the receiver automatically switches to an over-determined clock mode, activates its TRAIM algorithm and outputs a precise PPS. Using a simple voting scheme based on pseudo-range residuals, the Resolution SMT GG integrity algorithm automatically removes the worst satellite with the highest residual from the solution set if that satellite's residual is above a certain threshold.

In addition to TRAIM, Resolution SMT GG implements position integrity checking on startup, in case the receiver has been moved to a new location. When the receiver power up with a surveyed (or user input) position in memory, it will compare fixes computed from the GNSS satellites to the surveyed position. If it finds that the surveyed position is off by more than 100 meters horizontally or vertically in the first 60 consecutive GNSS fixes, it will delete the surveyed position from memory (including non-volatile storage) and restart the self-survey provided the self-survey is enabled, and the "position save flag" is set to 1 using the 0x8E-A9 command.

The Resolution SMT 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 (1.8 ns per foot). TSIP packet 8Ex4A sets the cable delay parameter, which is stored in non-volatile memory. For the best absolute PPS accuracy, adjust the cable delay to match the installed cable length (check with your cable manufacturer for the delay for a specific cable type). Generally, the cable delay is about 1.8 nanoseconds per foot of cable. To compensate for the cable delay, use a negative offset to advance the PPS output.

Note – GPS time differs from UTC (Universal Coordinated Time) by a small, sub- microsecond offset and an integer-second offset. The small offset is the steering offset between the GPS DoD clock ensemble and the UTC (NIST) clock ensemble. The large offset is the cumulative number of leap seconds since 1 January 1980, which, on 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 GPS time.

Customizing operations

The Resolution SMT GG timing module provides a number of user configurable parameters that allow you 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. You can

change the values of these parameters to achieve the desired operations using a variety of TSIP packets. The Resolution SMT GG configures itself based on the new parameter immediately, but the new parameter value is not automatically saved to Flash. You must direct the receiver to save the parameters to Flash.

To change the parameter values stored in Flash memory, send packet 0x8E-26 to direct the Resolution SMT GG to save the current parameter values to the Flash. To save or delete the stored position, use command packet 0x8E-A6. You can also direct the receiver to set the parameter values to their factory default settings (and to erase the stored position) with packet 0x1E.

In brief, to customize the Resolution SMT GG multi-GNSS timing module 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

Resolution SMT GG on a Carrier Board

In this chapter:

Resolution SMT GG carrier board

Connectors

Power requirements

Serial interface

Pulse-per-second (PPS)

Mounting

GNSS antenna

Mechanical specification

The Trimble Resolution SMT GG multi-GNSS timing module delivers accurate timing solutions for use in all applications where precision timing is needed.

Resolution SMT GG on a carrier board



Connectors

Digital IO/Power connector

The Resolution SMT GG on a carrier board uses a single 8-pin (2x4) male header connector for both power and data I/O. The power and I/O connector, J4, is a surface mount micro terminal strip. This connector uses 3.2 mm (0.126 inch) high pins on 2 mm (0.079 inch) spacing. The manufacturer of this connector is Samtec, part number TMM104-01-T-D-SM

Mating connectors

A surface mount mating connector from those specified by Samtec as compatible to Samtec TMM-104-01-T-D-SM is recommended.

RF connector

The RF connector mounted on the Resolution SMT GG carrier board is a right-angle SMB.

Antenna options

Trimble offers either a 3.3 V DC or a 5.0 V DC rooftop antenna and cable for use with the Resolution SMT GG multi-GNSS timing module.

Digital IO/Power connector pin-out

The digital IO/Power connector pin-out information is provided in the following table

Pin#	Function	Description
1	Antenna power input	3.0 V DC to 5.5 V DC, 55 mA max
2	Prime power input	+3.3 V DC \pm 0.3 V DC
3	TXDA	Port A transmit, CMOS
4	Reserved	Reserved
5	RXDA	Port A receive, CMOS
6	1PPS	One Pulse-Per-Second, CMOS
7	No connect	Not used
8	GND	Ground, Power and Signal

Power requirements

The Resolution SMT GG multi-GNSS timing module requires +3.3 V DC \pm 0.3 V DC at 110 mA, typical excluding the antenna. The on-board capacitance is approximately 65 μ F. An important design consideration for power is the receiver's internal clock frequency at 64 MHz \pm 3 KHz. Interference spurs on prime power in this narrow frequency band should be kept to less than 1 mV.

The receiver does not require any special power up or down sequencing. The receiver power is supplied through pin 2 of the I/O connector. See the following table for the power specifications

CAUTION – The Resolution SMT GG multi-GNSS timing module is ready to accept TSIP commands approximately 2 seconds after power-up. If a command is sent to the receiver within this 2 second window, the receiver will ignore the command. The Resolution SMT GG multi-GNSS timing module will not respond to commands sent within the 2 second window and will discard any associated command data.

Signal	Voltage	Current	J4 Pin #
VCC	3.0 - 3.6	110 mA	2
Ground	0		8

Serial interface

The Resolution SMT GG multi-GNSS timing module provides direct CMOS compatible serial I/O. The RX and TX signals on the J4 I/O connector are driven directly by the UART on the Resolution SMT GG GNSS timing module. Interfacing these signals directly to a UART in your application circuitry provides direct serial communication without the complication of RS-232 or RS-422 line drivers.

Pulse-per-second (PPS)

The Resolution SMT GG multi-GNSS timing module provides a 10 microsecond wide, CMOS compatible Pulse-Per-Second (PPS). The PPS is a positive pulse available on pin 6 of the power and I/O connector. The rising edge (which can be configured to negative edge with the 0x8E-4A packet) of the PPS pulse is synchronized with respect to UTC. 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 GPS time.

Mounting

There are four mounting holes at the corners of the PCB that accept 3/16" hex or round standoffs with a 3/8" height, and #2-2-56 or M2 mounting screws. Space constrained environments may require a different standoff

GNSS antenna

Trimble offers the following two antenna options for use with the Resolution SMT GG multi-GNSS timing module.

- A 3.3V DC Bullet GG rooftop antenna

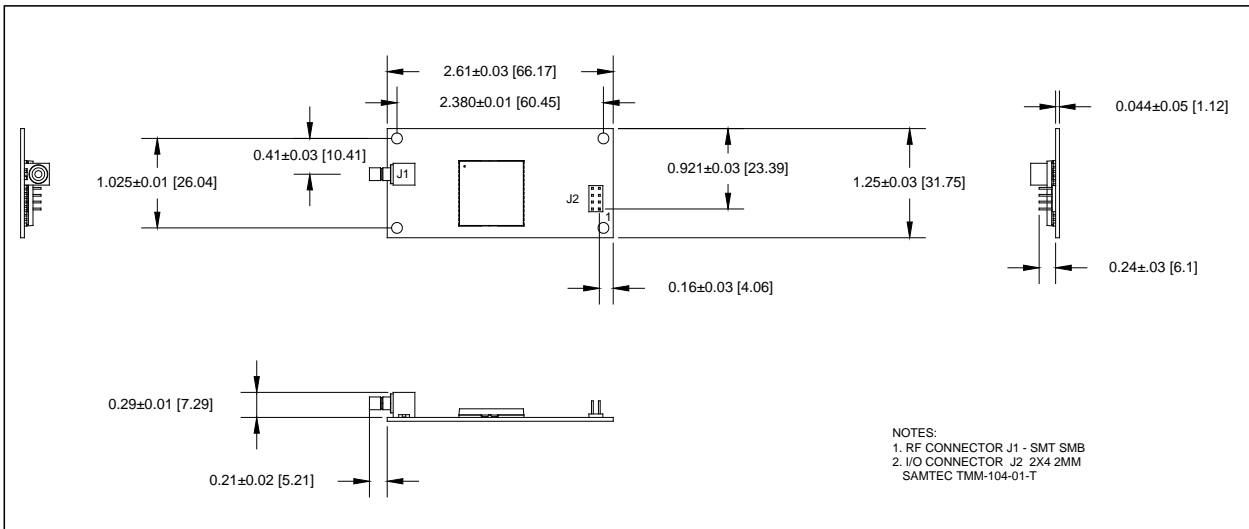


- A magnetic mount antenna



The antenna receives the GNSS satellite signals and passes them to the receiver. The GNSS signals are spread spectrum signals in the 1598 MHz range and do not penetrate conductive or opaque surfaces. Therefore, the antenna must be located outdoors with a clear view of the sky. The Resolution SMT GG multi-GNSS timing module requires an active antenna. The received GNSS signals are very low power, approximately -130 dBm, 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

Mechanical specification



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Application Circuits

In this chapter:

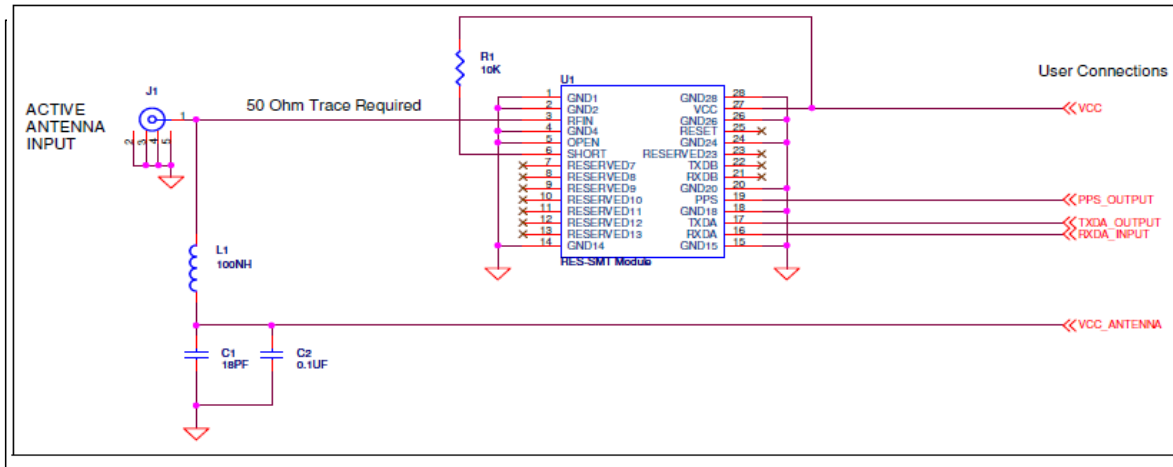
Active antenna – no antenna status

Active antenna – antenna short protection

Active antenna – antenna open and short protection

This chapter describes the Resolution SMT GG multi-GNSS timing module with active antenna connections.

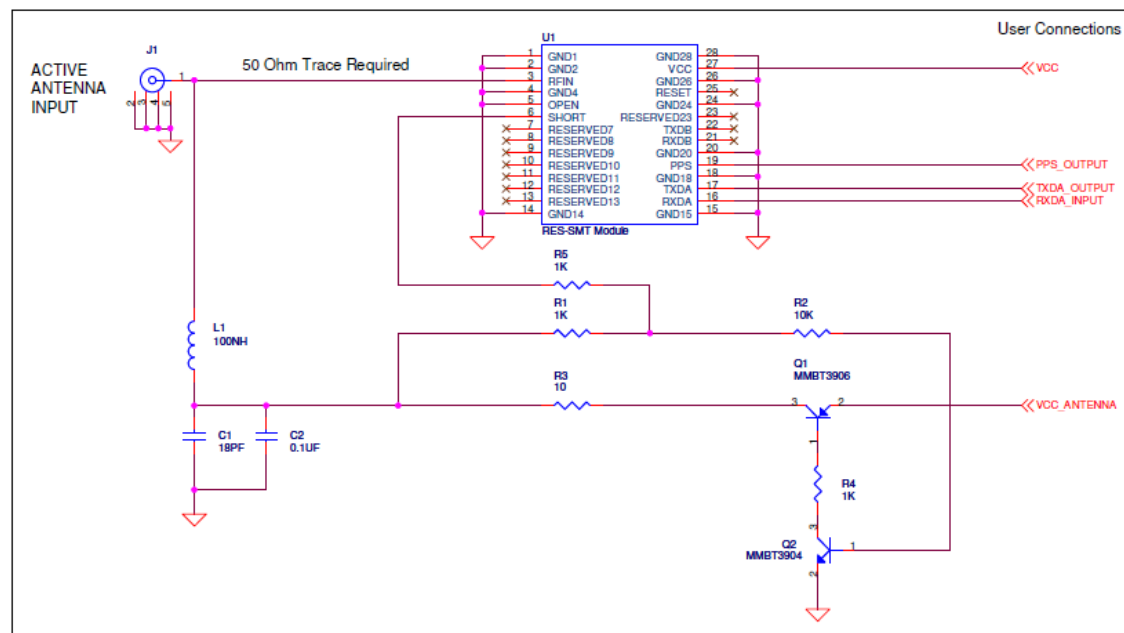
Active antenna – no antenna status



In the schematic without antenna detection:

- An active antenna is used.
- There is no hardware reset ability through the External Reset pin, as this is left disconnected.
- Antenna open and short detection or protection is not provided. If pin 5 and pin 6 are left floating, the unit reports an antenna open condition. To avoid this, pull SHORT high with a 10 kΩ resistor and pull OPEN low.

Active antenna – antenna short protection



In the schematic with antenna short detection:

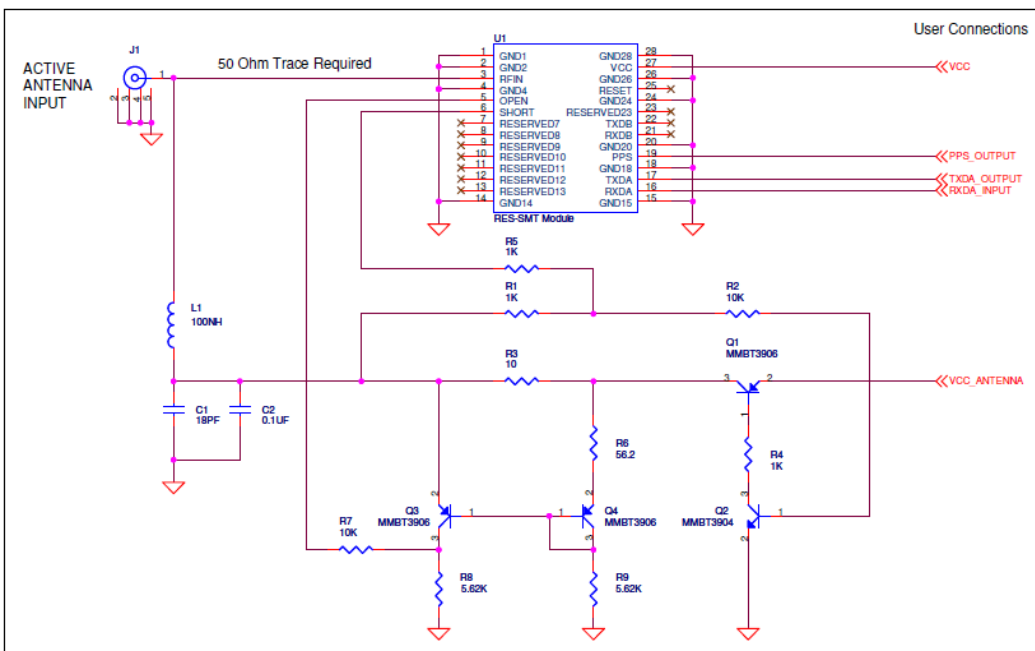
- An active antenna is used.

- There is no hardware reset ability through the External Reset pin, as this is left disconnected.
- Antenna short detection and protection is provided. The combination of the OPEN and SHORT pins (pins 5 and 6) report the antenna status.

The following table shows the component information

Component	Description	Manufacturer	Part Number
C1	18 PF, 0402 capacitor, C0G	KEMET	C0402C180J5GAC
C2	0.1 μ F, 0402 capacitor, X7R	CAL-CHIP	GMC04X7R104K16NTLF
J1	SMB Connector	Chin Nan	24-12-11-TGG
L1	100 nH, 0603 inductor, surface	Coil Craft	0603CS-R10XJLU
Q1	PNP Transistor	Philips	MMBT3906
Q2	NPN Transistor	Philips	MMBT3904

Active antenna – antenna open and short protection



In the schematic with open and short antenna detection:

- An active antenna is used.
- There is no hardware reset ability through the External Reset pin, as this is left disconnected.
- Antenna open and short detection and protection is provided. The combination of the OPEN and SHORT pins (pins 5 and 6) report the antenna status.

The following table shows the component information:

Component	Description	Manufacturer	Part Number
C1	18 PF, 0402 capacitor	KEMET	C0402C180J5GAC
C2	0.1 μ F, 0402 capacitor	CAL-CHIP	GMC04X7R104K16NTLF
J1	SMB Connector	Chin Nan	24-12-11-TGG
L1	100 nH, 0603 inductor, surface	Coil Craft	0603CS-R10XJLU
Q1	PNP Transistor	Philips	MMBT3906
Q2	NPN Transistor	Philips	MMBT3904
Q3	PNP Transistor	Philips	MMBT3906
Q4	PNP Transistor	Philips	MMBT3906

RF Layout Considerations

In this chapter:

General recommendations

Design considerations for RF track topologies

PCB considerations

This chapter outlines RF design considerations for the layout of the Resolution SMT GG multi-GNSS timing module.

General recommendations

The design of the RF transmission line that connects the GNSS antenna to the Resolution SMT GG multi-GNSS timing module is critical to system performance. If the overall RF system is not implemented correctly, the Resolution SMT GG GNSS timing module performance may be degraded.

The radio frequency (RF) input on the Resolution SMT GG is 50 Ω , unbalanced. There are ground castellations (pins 2 and 4) on both sides of the RF input castellation (pin 3). This RF input should be connected to the output of an LNA which has a GNSS antenna at its input.

If the GNSS antenna must be located any significant distance from the Resolution SMT GG GNSS timing module, the use of an LNA at the antenna location is necessary to overcome the transmission losses from the antenna to the Resolution SMT GG GNSS timing module.

Determine the specifications for the external LNA as follows:

- The noise figure for the external LNA should be as low as possible, with a recommended maximum of 1.5 dB. Trimble recommends that the gain of the LNA exceeds the loss that is measured from the LNA output to the module input by 10 dB. For example, if the loss from the external LNA output is 10 dB, the recommended minimum gain for the LNA is 20 dB. In order to keep losses at the LNA input to a minimum, Trimble recommends that you connect the antenna directly to the LNA input, to ensure the minimum loss.
- To connect to the LNA output, use a 50 Ω , unbalanced transmission system. This transmission system may take any form, such as microstrip, coaxial, stripline, or any other 50 Ω characteristic impedance unbalanced, low-loss system.

You must keep noise sources with frequencies at or near 1598 MHz away from the RF input. You can use a shielded transmission line system (stripline, coaxial) to route the signal if noise ingress is a concern.

When using an active antenna and if you want to power this antenna from the RF transmission line, you will need a bias-tee connector at the Resolution SMT GG GNSS timing module end. A simple series inductor (parallel resonant at 1598 MHz), and shunt capacitor (series resonant at 1598 MHz) to which the bias voltage is supplied is sufficient. Alternatively, you can use an open/short detection and over current protection circuit. See Chapter 8, Application Circuits.

In the printed circuit board (PCB) layout, Trimble recommends that you keep the copper layer on which the Resolution SMT GG GNSS timing module is mounted clear of solder mask and copper (vias or traces) under the module. This is to insure mating of the castellations between the Resolution SMT GG GPS module and the board to which it is mounted, and that there is no interference with features beneath the Resolution SMT GG GNSS timing module that will cause it to lift during the re-flow solder process.

For a microstrip RF transmission line topology, Trimble recommends that the layer immediately below the one to which the Resolution SMT GG GNSS timing module is mounted is ground plane:

- Pins 2 and 4 should be directly connected to the ground plane with low inductance connections.
- Pin 3, the RF input, can be routed on the top layer using the proper geometry for a 50Ω system.

Design considerations for RF track topologies

You must take the following into consideration when designing the RF layout for the Resolution SMT GG multi-GNSS timing module:

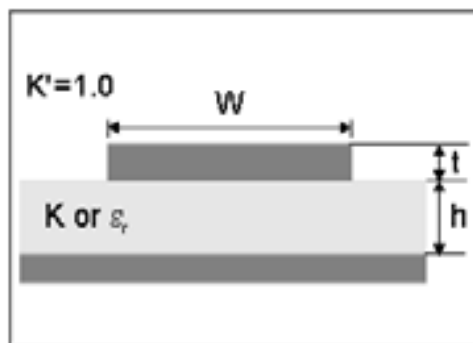
- The PCB track connection to the RF antenna input must:
 - Have a 50 Ω impedance.
 - Be as short as possible.
 - Be routed away from potential noise sources such as oscillators, transmitters, digital circuits, switching power supplies, and other sources of noise.
 - Transition from the circuit board to the external antenna cable, which is typically a RF connector, if an external antenna is used.
- The PCB track connection to the RF antenna input must not have:
 - Sharp bends.
 - Components overlaying the track.
 - Routing between components (to avoid undesirable coupling).
- RF and bypass grounding must be direct to the ground plane through its own low-inductance via
- As a general guideline to prevent radiation and coupling, it helps to think of voltages and currents as electrical and magnetic fields. The electric field forms between a positive and negative charge. The magnetic field forms around a trace with current flow. You can minimize the radiation by keeping the fields under control, which means minimizing the area in which the fields form out and by separating areas with stronger fields
- Keep the path of supply currents and their GND return currents together as close as possible. The same applies for signal currents and their GND return currents.
- Keep signal traces, which are likely to interfere with each other, apart and separate them with GND areas.
- Route supply traces and their corresponding GND return paths to separate functional blocks with separate traces and connect them only at the feed point.
- Have at least one uninterrupted GND plane on or in your PCB. The GND plane should be separated by functional blocks, but within a functional block, do not route signals across the GND plane. Route signals on another layer.

- Signal traces on a GND plane can block the way for GND return currents, thereby opening up current loops and increasing radiation. Even worse, slots in a GND plane can act as a slot-antenna structure and radiate or receive radiation on the resonating frequency.
- Surround the PCB edges with GND on top and bottom and stitch them together with multiple vias. This reduces edge radiation from traces nearby the PCB edge. On a PCB with separated GND planes, do the same on every GND area to prevent radiation from one area into another.
- Do not route signal traces across the borders of GND areas. Route them first to the GND star point and from there back to another GND area. In this way you will reduce GND coupling between the functional groups and reduce the size of the current loop, thereby reducing radiation.
- In digital circuits, lower the rising time of edges if possible. Fast rising edges (sharp square wave signals) generate many harmonics at higher frequencies. Lowering the rising time of digital outputs at the source, for example by inserting series resistors near digital output pins of ICs, will reduce the generated harmonics and therefore reduce the radiation of high frequencies.
- Always aim to minimize the sources of radiation. It is much easier and less costly to not generate radiation than to try to get rid of radiation by shielding

PCB considerations

The minimum implementation is a two-layer PCB substrate with all the RF signals on one side and a solid ground plane on the other. You may also use multilayer boards. Two possible RF transmission line topologies include microstrip and stripline.

Microstrip transmission lines



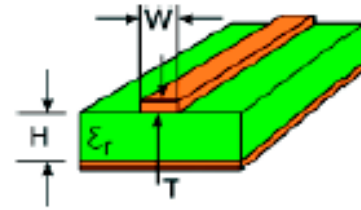
Ground plane design recommendation

Use a complete ground plane immediately under the PCB layer on which the Resolution SMT GG timing module is mounted. On the same layer as the module, flood or “copper pour” around the signal tracks and then connect to the ground plane using low inductance vias. A single ground plane is adequate for both analog and digital signals.

Designing a microstrip transmission line

Use a 50 Ω unbalanced transmission system for connections to the LNA output. The following PCB parameters affect impedance:

- Track width (W)
- PCB substrate thickness (H)
- PCB substrate permittivity (ϵ_r)
- PCB copper thickness (T) and proximity of same layer ground plane (to a lesser extent)



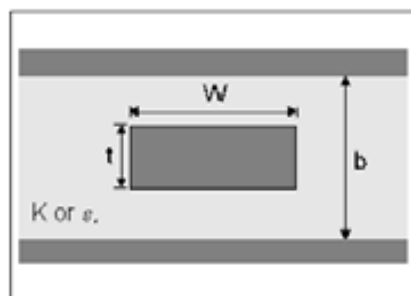
The following table shows typical track widths for an FR4 material PCB substrate (permittivity ϵ_r of 4.6 at 1.5 GHz) and different PCB thickness. The thickness of the top layer is assumed as being one ounce copper. If using a multi-layer PCB, the thickness is the distance from the signal track to the nearest ground plane.

Substrate	Permittivity	Substrate thickness H	Track width W (mm)
FR4	4.6	1.6	2.91
		1.2	2.12
		1.0	1.81
		0.8	1.44
		0.6	1.07
		0.4	0.71
		0.2	0.34

Microstrip design recommendations

Trimble recommends that the antenna connection PCB track is routed around the outside of the module outline, kept on a single layer, and that it has no bends greater than 45 degrees. For production reasons, Trimble recommends that you do not route the track under the module

Stripline transmission lines



Ground plane design recommendation

The stripline topology requires three PCB layers: two for ground planes and one for signal. One of the ground plane layers may be the layer to which the Resolution SMT GG multi-GNSS timing module is mounted. If this is the case:

- The top layer must be flooded with ground plane and connected to all ground castellations on the Resolution SMT GG GNSS timing module.
- The RF input should be connected to the signal layer below using a via.
- The layer below the signal layer is the second ground plane.
- Connect the two ground planes with vias, typically adjacent to the signal trace.
- Other signals of the Resolution SMT GG GNSS timing module may be routed to additional layer using vias

For the symmetric stripline topology where the signal trace is an equal distance from each ground plane, the following applies:

Substrate	Permittivity	Substrate thickness H	Track width W (mm)
FR4	4.6	1.6	0.631
		1.2	0.438
		1.0	0.372
		0.8	0.286
		0.6	0.2
		0.4	0.111
		0.2	N/A

Mechanical Specifications

In this chapter:

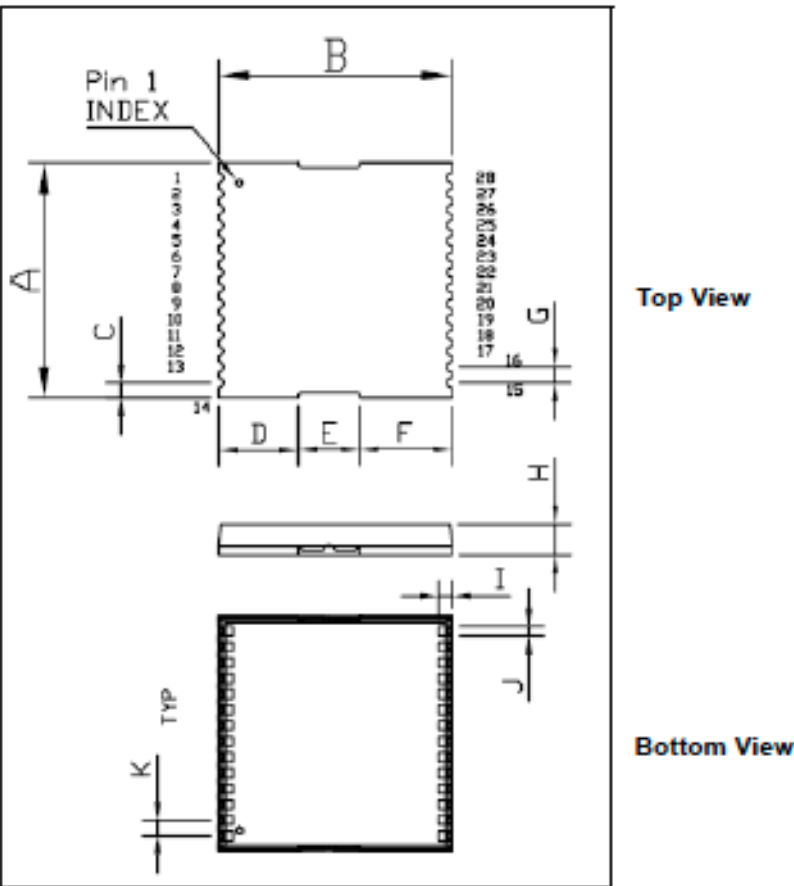
[Mechanical outline drawing](#)

[Soldering the Resolution SMT GG multi-GNSS timing module to a printed circuit board](#)

This chapter provides product drawings and instructions for soldering the Resolution SMT GG multi-GNSS timing module to a printed circuit board.

Mechanical outline drawing

Resolution SMT GG GNSS timing module, footprint



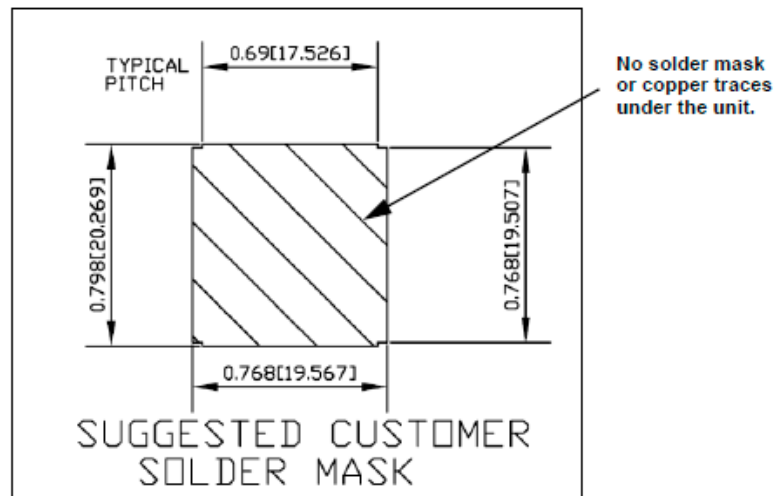
Outline Dimensions (Inch ± 0.004)										
mm ± 0.10										
A	B	C	D	E	F	G	H	I	J	K
0.75	0.75	0.049	0.256	0.197	0.295	0.050	0.100	0.045	0.030	0.050
19.00	19.00	1.25	6.50	5.00	7.50	1.27	2.54	1.14	0.76	1.27

Soldering the Resolution SMT GG to a printed circuit board

Note – All units shown are in millimeters.

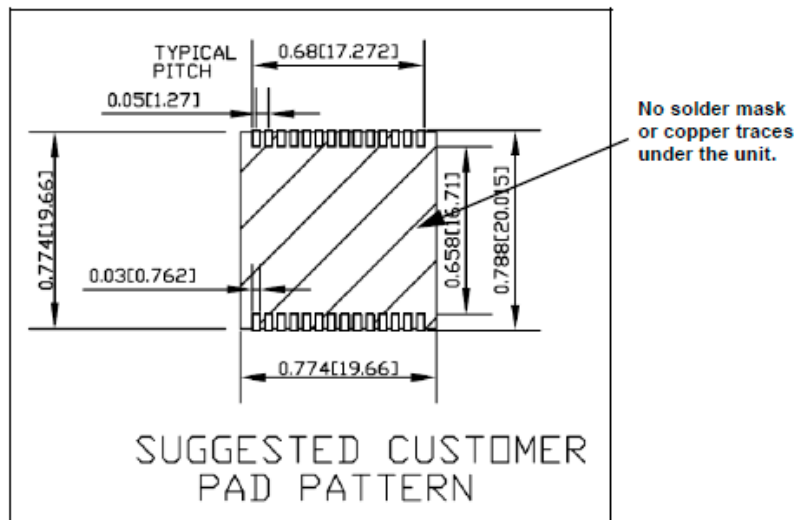
Solder mask

When soldering the Resolution SMT GG multi-GNSS timing module to a PCB, keep an open cavity underneath the Resolution SMT GG module (that is, do not place copper traces or solder mask underneath the module). The diagram below illustrates the required solder mask.



Pad pattern

The required user pad pattern is shown below.



Pad pattern

To ensure good mechanical bonding with sufficient solder to form a castellated solder joint use a solder mask ratio of 1:1 with the solder pad. When using a 5 ± 1 Mil stencil to deposit the solder paste, we recommend a 4 Mil toe extension on the stencil.

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Packaging

In this chapter:

[Introduction](#)

[Reel](#)

[Weight](#)

[Tapes](#)

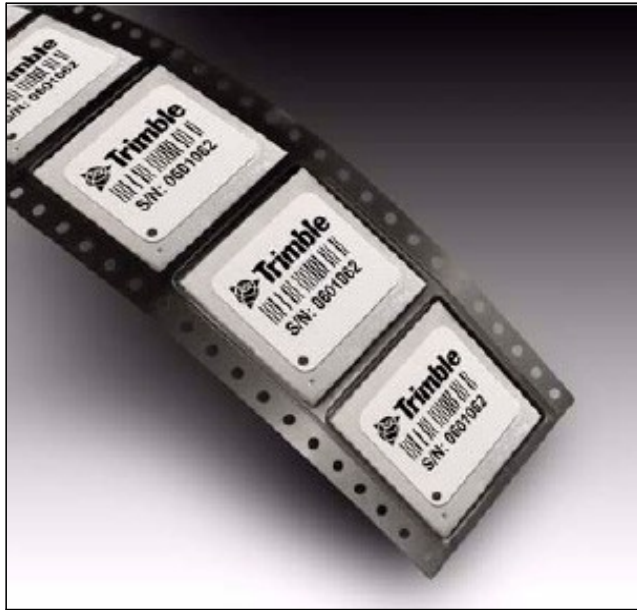
Follow the instructions in this chapter to ensure the integrity of the packaged and shipped Resolution SMT GG multi-GNSS timing module modules.

Introduction

The Resolution SMT GG multi-GNSS timing modules are packaged in tape and reel for mass production.

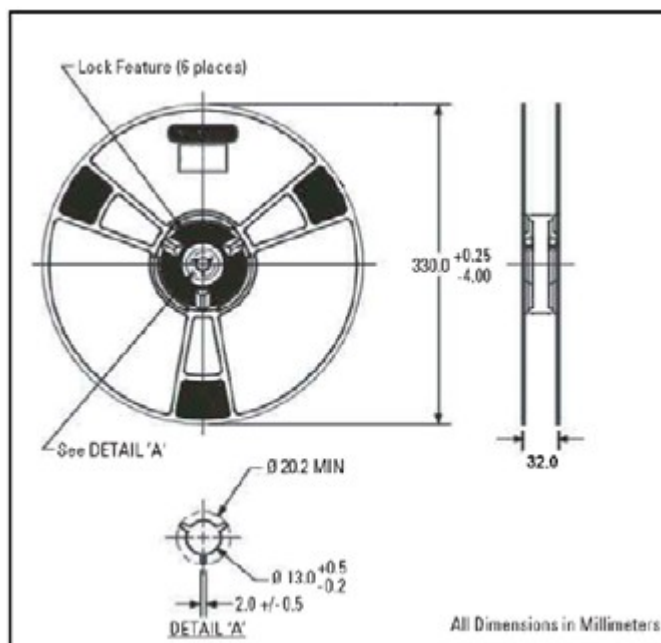
CAUTION – The reel is sealed in a moisture proof Dry Pac bag. Please follow all the directions printed on the package for handling and baking.

The Resolution SMT GG GNSS timing modules are packaged in a reel with 500 pieces.



Reel

You can mount the 13-inch reel in a standard feeder for the surface mount pick and place machine

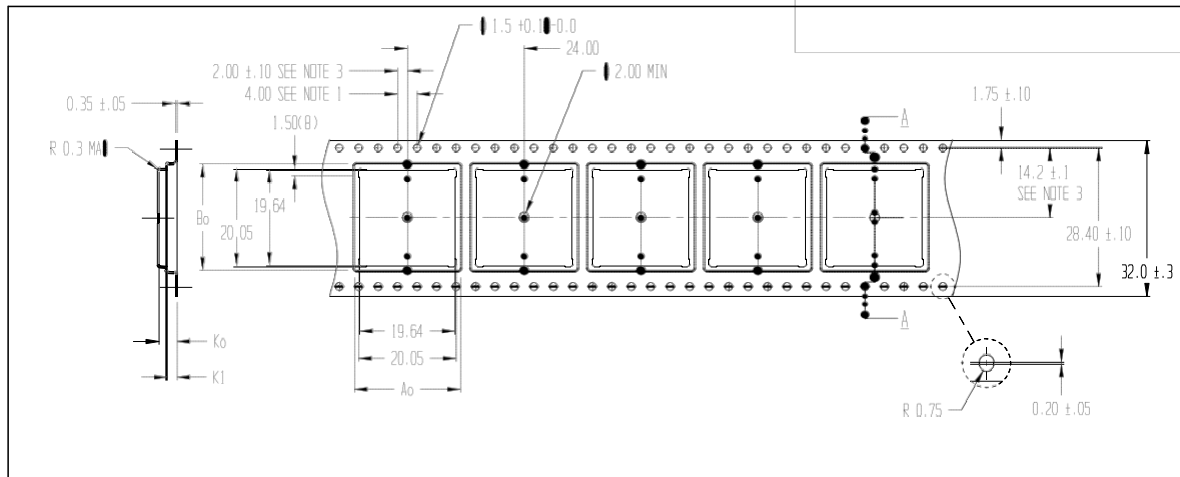


Weight

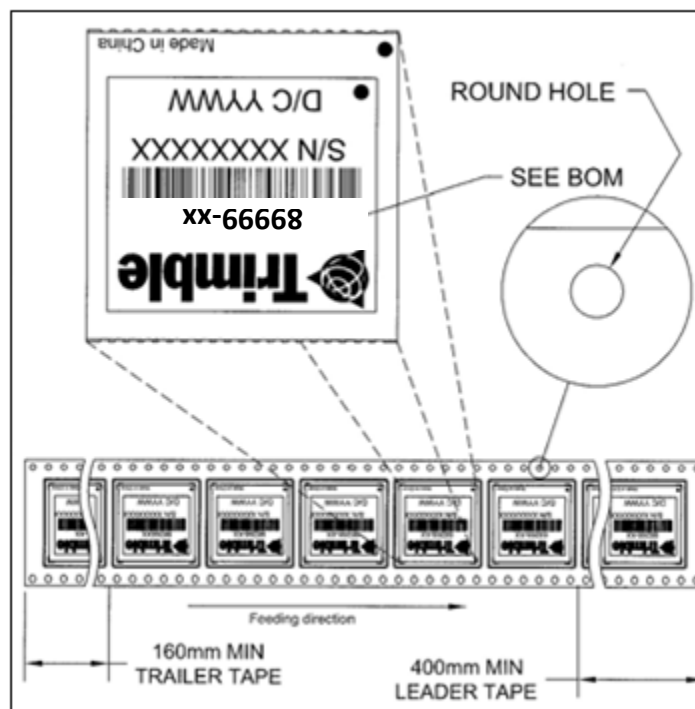
Unit description	Weight (approx.)
500 pieces with reel packaging, desiccant, and humidity indicator	1.47 Kg (3.52lb)
500 pieces with reel packaging, desiccant, humidity indicator & white	1.70 Kg (3.74lb)

Tapes

The tape dimensions illustrated in the diagram below are in inches. The metric units appear in brackets [].



The feeding direction is illustrated below



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Shipping and Handling

In this chapter:

Shipping and handling guidelines

Moisture precondition

Baking procedure

Soldering paste

Solder reflow

Recommended soldering profile

Optical inspection

Cleaning

Soldering guidelines

Rework

Conformal coating

Grounding the metal shield

This chapter provides detailed guidelines for shipping and handling the Resolution SMT GG multi-GNSS timing module to ensure compliance with the product warranty.

Shipping and handling guidelines

Handling

The Resolution SMT GG multi-GNSS timing module is shipped in tape and reel for use with an automated surface mount machine. This is a lead-free module with gold plating. Do not allow bodily fluids or lotions to come in contact with the bottom of the module.

CAUTION – The Resolution SMT GG GNSS timing module is packed according to ANSI/EIA-481-B and JSTD-033A. All of the handling and precautions procedures must be followed. Deviation from following handling procedures and precautions voids the warranty.

Shipment

The reel of Resolution SMT GG GNSS timing modules is packed in a hermetically sealed moisture barrier bag (DryPac) then placed in an individual carton. Handle with care to avoid breaking the moisture barrier.

Storage

The shelf life for the sealed DryPac is 12 months if stored at <40 °C and with <90% relative humidity.

Moisture Indicator

A moisture indicator is packed individually in each DryPac to monitor the environment – it has five indicator spots that are blue when the pack leaves the factory. If the indicator changes to pink, follow the instructions printed on the moisture barrier and bake as required.

Floor life

The reel of Resolution SMT GG is vacuum sealed in a moisture barrier bag (DryPac). Once the bag is opened, moisture will bond with the modules. In a production floor environment, an open reel needs to be processed within 72 hours, unless it is kept in a nitrogen-purged dry chamber. If the moisture indicator changes to pink, follow the baking instructions printed on the moisture barrier.

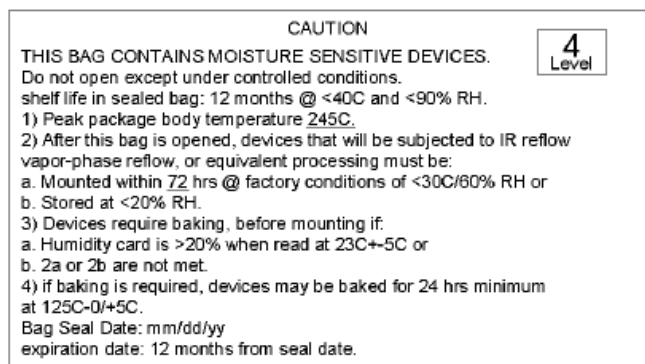
The Resolution SMT GG multi-GNSS timing module is a lead-free component and is RoHS compliant. This unit is also plated with immersion gold that makes soldering easier.

CAUTION – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

Moisture precondition

You must take precautions to minimize the effects of the reflow thermal stress on the module. Plastic molding materials for integrated circuit encapsulation are hygroscopic and absorb moisture. This is dependent on the time and the environment.

Absorbed moisture will vaporize during the rapid heating of the solder reflow process, generating pressure to all the interface areas in the package, followed by swelling, delamination, and even cracking of the plastic. Components that do not exhibit external cracking can have internal delamination or cracking which affects yield and reliability.



Baking procedure

If baking is necessary, Trimble recommends baking in a nitrogen purge oven.

Temperature	125 °C
Duration	24 hours
After baking	Store in a nitrogen-purged cabinet or dry box to prevent absorption of moisture

CAUTION – Do not bake the units within the tape and reel packaging. Repeated baking processes will reduce the solderability.

Soldering paste

The Resolution SMT GG multi-GNSS timing module itself is not hermetically sealed. Trimble strongly recommends using the “No Clean” soldering paste and process. The castellation solder pad on this module is plated with gold plating. Use Type 3 or above soldering paste to maximize the solder volume.

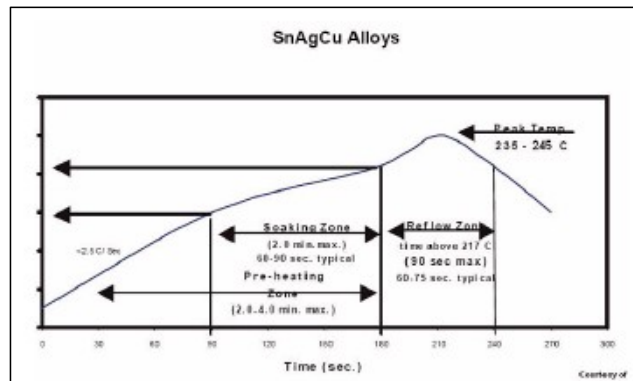
Solder reflow

A hot air convection oven is strongly recommended for solder reflow. For the lead-free solder reflow, we recommend using a nitrogen-purged oven to increase the solder wetting. Reference IPC-610D for the lead-free solder surface appearance.

CAUTION – Follow the thermal reflow guidelines from the IPC-JEDEC J-STD-020C.

The size of this module is 916.9 mm³. According to J-STD-020C, the peak component temperature during reflow is 245 +0 °C.

Recommended soldering profile



Select the final soldering thermal profile very carefully. The thermal profile depends on the choice of the solder paste, thickness and color of the carrier board, heat transfer, and the size of the penalization.

CAUTION – For a double-sided surface-mount carrier board, the unit must be placed on the secondary side to prevent falling off during reflow.

Optical inspection

After soldering the Resolution SMT GG timing module to the carrier board, follow the IPC-610 specification and use a 3x magnification lens to verify the following:

- Each pin is properly aligned with the mount pad.
- The pads are properly soldered.
- No solder is bridged to the adjacent pads. X-ray the bottom pad if necessary.

Cleaning

When the Resolution SMT GG GNSS timing module is attached to the user board, a cleaning process voids the warranty. Please use a “no-clean” process to eliminate the cleaning process. The gold-plated Resolution SMT GG timing module may discolor with cleaning agent or chlorinated faucet water. Any other form of cleaning solder residual may cause permanent damage and will void the warranty.

Soldering guidelines

Repeated reflow soldering

The Resolution SMT GG lead-free gold plated module can withstand two re-flow solder processes. If the unit must mount on the first side for surface-mount re-flow, add glue on the bottom of the module to prevent it falling off when processing the second side.

Wave soldering

The Resolution SMT GG timing module cannot soak in the solder pot. If the carrier board is mixed with through-hole components and surface mount devices, it can be processed with one single lead-free wave process. The temperature of the unit will depend on the size and the thickness of the board. Measure the temperature on the module to ensure that it remains under 180 °C.

Hand soldering

For the lead-free Resolution SMT GG timing module, use a lead-free solder core, such as Kester 275 Sn96.5/Ag3/Cu0.5. When soldering the module by hand, keep the soldering iron below 260 °C.

Rework

The Resolution SMT GG timing module can withstand one rework cycle. The module can heat up to the re-flow temperature to precede the rework. Never remove the metal shield and rework on the module itself.

Conformal coating

Conformal coating on the Resolution SMT GG GNSS timing module is not allowed and will void the warranty

Grounding the metal shield

The Resolution SMT GG GNSS timing module is designed with numerous ground pins that, along with the metal shield, provide the best immunity to EMI and noise. Any alteration by adding ground wires to the metal shield is done at the customer's own risk and may void the warranty.

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Trimble Standard Interface Protocol

In this chapter:

Introduction

Customizing operations parameters

Packets output at startup

Report packets: Resolution SMT GG to User

Command Packets: User to Resolution SMT GG

Packet structure

Packet descriptions

TSIP Superpackets

Unused or miscellaneous packets

Legacy packets (unused)

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 GPS receiver. Trimble products commonly support a version of TSIP which is customized to the attributes of the product. This appendix describes the Resolution SMT GG customization.

WARNING – The Resolution SMT GG multi-GNSS timing module is ready to accept TSIP commands approximately 2 seconds after power-up. If a command is sent to the receiver within this 2 second window, the receiver will ignore the command. The Resolution SMT GG GNSS timing module will not respond to commands sent within the 2 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 Resolution SMT GG GNSS timing module 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.

Automatic output packets

The Resolution SMT GG multi-GNSS timing module is configured to automatically output the 0x8F-AB and 0x8F-AC packets. For most system implementations these output packets provide all of the information required for operation including time, position, GPS status, and health. The following packets can be broadcast if enabled with packet 0x8E-A5 and 0x35. By default, only packets 0x8F-AB and 0x8F-AC are enabled for output. This table shows the broadcast output packets:

Broadcast	Description	Masking	Request	When Sent
0x42	Position XYZ (ECEF), single	0x35	0x37	When a position fix is computed
0x43	Velocity XYZ, single precision	0x35	0x37	When a position fix is computed
0x4A	Position LLA, single precision	0x35	0x37	When a position fix is computed
0x56	Velocity ENU, single precision	0x35	0x37	When a position fix is computed
0x58	Satellite system data	none	0x38	When new system data is received
0x6D	Satellite list, DOPS, mode	none	0x24	When the satellite selection list is
0x83	Position XYZ (ECEF), double	0x35	0x37	When a position fix is computed
0x84	Position LLA, double precision	0x35	0x37	When a position fix is computed
0x8F-AB	Primary timing packet	0x8E-A5	None	Once per second
0x8F-AC	Secondary timing packet	0x8E-A5	None	Once per second

Customizing operations parameters

The Resolution SMT GG provides a number of user configurable parameters that allow the user to customize the operation of the Resolution SMT GG. These parameters are stored in flash memory to be retained during loss of power and through resets. At reset or power up, the Resolution SMT GG configures itself based on the parameters stored in the flash. The user can change the values of these parameters to achieve the desired operation using a variety of TSIP packets. The Resolution SMT GG configures itself based upon the new parameters immediately, but the new parameter is not automatically saved to flash. The user must direct the Resolution SMT GG to save the parameters to flash. To change the parameter values stored in flash, the user sends packet 0x8E-26 to direct the Resolution SMT GG to save the current parameters in the flash. Users can also direct the Resolution SMT GG to set the parameter values to their factory default with packet 0x1E.

To customize the Resolution SMT GG output for your application:

1. Set up the Resolution SMT GG using TSIP commands until the desired operation is achieved.
2. Use command 0x8E-26 to store the settings in nonvolatile memory.

These settings will control Resolution SMT GG operations whenever it is cold-started. The following tables illustrate how the user configurable data is mapped. The Trimble factory defaults are also provided. See packet 0x1E.

Factory default settings

Parameter	Factory Default	Set	Request	Report
Receiver mode	0 (automatic)	0xBB	0xBB	0xBB
Elevation mask	0 radians	0xBB	0xBB	0xBB
Signal level mask	0	0xBB	0xBB	0xBB

Packet I/O control

Parameter	Factory Default	Set	Request	Report
Packet broadcast mask		0x8E-A5	0x8E-A5	0x8F-A5
mask 0	0x05			
mask 1	0x00			
Packet 0x35		0x35	0x35	0x35
data position (byte 0)	0x12			
velocity (byte 1)	0x02			
timing (byte 2)	0x00			
auxiliary (byte 3)	0x08			

Serial port configuration

Parameter	Factory Default	Set	Request	Report
Input baud rate	7 (115 kbps)	0xBC	0xBC	0xBC
Output baud	7 (115 kbps)			
Data bits	3 (8 data bits)			
Parity	1 (odd)			
Stop bits	0 (1 stop bit)			
Input protocol	2 (TSIP)			
Output protocol	2 (TSIP)			

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)			
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

Accurate position

Parameter	Factory Default	Set	Request	Report
Position	No stored position	0x32	0x8E-AC	0x8F-AC

Self-survey

Parameter	Factory Default	Set	Request	Report
Self-survey enable	1 (enabled)	0x8E-A9	0x8E-A9	0x8F-A9
Position save flag	1 (save)			
Self-survey count	2000 (fixes)			

Packets output at startup

After completing its self-diagnostics, the Resolution SMT GG automatically outputs the following packets. The following table shows the packet power-up output messages:

Output ID	Description	Notes
0x45	Software version	

Command Packets: User to Resolution SMT GG

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

Input ID	Packet Description	Output ID
0x1C-01	firmware version	0x1C-81
0x1C-03	hardware component information	0x1C-83
0x1E	initiate cold reset or factory reset	¹
0x1F	software version	0x45
0x20	Almanac	0x40
0x21	Current GPS time	0x41
0x22	Fix Mode select	²
0x23	Initial position (XYZ)	
0x24	request GPS satellite selection	0x6C
0x25	Soft reset and self-test	0x45
0x26	Receiver health	0x46, 0x4B
0x27	request signal levels	0x47
0x29	Almanac health page	0x49
0x2B	initial position (LLA)	0x2B
0x2D	Oscillator offset	0x4D
0x2E	set GPS time	0x4E
0x2F	UTC parameters	0x4F
0x31	Accurate initial position (XYZ Cartesian ECEF)	0x31
0x32	set accurate initial position (lat, long, Alt)	0x32
0x35	set/request I/O options	0x55
0x37	status and values of last position and velocity	0x57 ³
0x38	load or request satellite system data	0x58
0x39	Satellite enable/disable and health heed/ignore	0x59 ⁴
0x3A	request last raw measurement	0x5A
0x3B	Satellite ephemeris status	0x5B
0x3C	request current satellite tracking status	0x5C
0x3D	Timing port configuration	0x3D
0x7A	NMEA Set/Request	0x7B
0xBB	set receiver configuration	0xBB
0xBC	set port configuration	0xBC
0x8E-14	Set new datum	0x8F-14
0x8E-15	Current datum values	0x8F-15
0x8E-20	Last fix (fixed point)	0x8F-20

Input ID	Packet Description	Output ID
0x8E-26	save configuration	
0x8E-41	request manufacturing parameters	0x8F-41
0x8E-42	request production parameters	0x8F-42
0x8E-4A	set PPS characteristics	0x8F-4A
0x8E-4D	Packet Output Mask	0x8F-4D
0x8E-4E	PPS output option	0x8F-4E
0x8E-A2	UTC/GPS timing	0x8F-A2
0x8E-A5	packet broadcast mask	0x8F-A5
0x8E-A6	self-survey commands	0x8F-A6
0x8E-A9	self-survey parameters	0x8F-A9
0x8E-AB	Set/request primary timing packet	0x8F-AB
0x8E-AC	Set/request supplemental timing packet	0x8F-AC
0x8F-14	Current datum values	0x8F-14

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

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

³Output is determined by packet 0x35 settings.

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

Report packets: Resolution SMT GG to User

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

Output ID	Packet Description	Input ID
0x13	unparsable packet	error
0x1C-81	firmware version	0x1C-01
0x1C-83	hardware component information	0x1C-03
0x2B	initial position (LLA)	0x2B
0x32	accurate initial position (lat, long, Alt)	0x32
0x40	Almanac data for one satellite	0x20
0x41	GPS time	0x21
0x42	single precision XYZ ECEF position fix	0x35
0x43	velocity fix (XYZ ECEF)	0x37, auto
0x45	software version	0x1E,0x1F, power up
0x46	Health of receiver	0x26
0x47	signal level for all satellites	0x27

Output ID	Packet Description	Input ID
0x49	Almanac health for all satellites	0x29
0x4A	single precision LLA position	0x37, auto
0x4B	Machine code/status	0x26
0x4D	Oscillator offset	0x2D
0x4E	set GPS time	0x2E
0x4F	UTC parameters	0x2F
0x55	I/O options	0x35
0x56	velocity fix (ENU)	0x37, auto
0x57	status and values of last position and velocity	0x37
0x58	GPS system data acknowledge	0x38
0x59	Satellite enable/disable and health heed/ignore	0x39
0x5A	last raw measurement	0x3A
0x5B	Satellite ephemeris status	0x3B
0x5C	current satellite tracking status	0x3C
0x6C	All-in-view satellite selection	0x24
0x7B	NMEA message output	0x7A
0x83	double precision XYZ	0x37, auto
0x84	double precision LLA	0x37, auto
0xBB	receiver configuration	0xBB
0xBC	port configuration	0xBC
0x8F-14	Current datum values	0x8E-14
0x8F-20	Last fix with extra information (fixed point)	0x8E-20
0x8F-26	save configuration	0x8E-26
0x8F-41	stored manufacturing parameters	0x8E-41
0x8F-42	stored production parameters	0x8E-42
0x8F-4A	set PPS characteristics	0x8E-4A
0x8F-4D	Automatic packet output mask	0x8E-4D
0x8F-4E	PPS output option	0x8E-4E
0x8F-A2	UTC/GPS timing	0x8E-A2
0x8F-A5	packet broadcast mask	0x8E-A5
0x8F-A6	self-survey commands	0x8E-A6
0x8F-A9	self-survey parameters	0x8E-A9
0x8F-AB	primary timing packet	auto
0x8F-AC	supplemental timing packet	Auto

Packet structure

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

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

Where:

<DLE> is the byte 0x10

<ETX> is the byte 0x03

<id> is a packet identifier byte, which can have any value excepting

<ETX> and

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

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

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

The data types used in the Resolution SMT GG TSIP are as follows:

Data type	Description
UNIT8	An 8- bit unsigned number (0 to 255)
SINT8	An 8-bit signed number (-128 to 127)
INT16	A 16-bit unsigned number (0 to 65,535)
SINT16	An 16-bit signed number (-32,768 to 32,767)
UINT32	A 32-bit unsigned number (0 to 4,294,967,295)
SINT32	A 32-bit signed number (-2,147,483,648 to 2,147,483,647):
	Single - Float (4 bytes) (3.4x10 ⁻³⁸ to 1.7x10 ³⁸) (24 bit precision)
	Double - Float (8 bytes) (1.7x10 ⁻³⁰⁸ to 3.4x10 ³⁰⁸) (53 bit precision)

Note – Default settings are 115 kbps-8-odd-1.

Packet descriptions

Command Packet 0x1C: Firmware Version 01

The command packet 0x1C: 01 may be issued to obtain the firmware version. The product name is *Resolution SMT GG*. The packet format is defined in the following table:

Byte	Item	Type	Value	Meaning
0	Packet ID	UINT8	0x1C	Packet ID 0x1C
1	Sub-code	UINT8	0x01	Sub-code 0x01 for software component version information request

Report Packet 0x1C: 81

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

Command Packet 0x1C: 03 – hardware component version information

- 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 Resolution SMT GG at production.
- The hardware code for the Resolution SMT GG is 3015.
- ID for Resolution SMT GG timing module is Resolution SMT GG.

The packet format is defined in the following table:

Byte	Item	Type	Value	Meaning
0	Packet ID	UINT8	0x1C	Packet ID 0x1C
1	Sub-code	UINT8	0x03	Sub-code 0x03 for hardware component version information request

Report Packet 0x1C: 83 – hardware component version information

Byte	Item	Type	Value	Meaning
0	Packet ID	UINT8	0x1C	Packet ID 0x1C
1	Sub-code	UINT8	0x83	Sub-code 0x83 for hardware component version information report
2 ... 5	Serial number	UINT32	Any	Board serial number
6	Build day	UINT8	1-31	Day of the board's build date
7	Build month	UINT8	1-12	Month of the board's build date
8...9	Build year	INT16	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	INT16	Any	Hardware code associated with 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

Command Packet 0x1E: Clear RAM then Reset

This packet commands the Resolution SMT GG to perform either a cold reset, or a factory reset:

- A cold reset will clear the GNSS data (almanac, ephemeris, etc.) stored in RAM and is equivalent to a power cycle.
- A factory reset will additionally restore the factory defaults of all configuration parameters stored in flash memory.

Byte	Item	Type	Value	Meaning
0	Reset	UINT8	0x4B	Cold reset
			0x46	Factory reset

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

Command Packet 0x1F: Request Software Version

This packet requests information about the version of software in the Resolution SMT GG. This packet contains no data. The GNSS receiver returns packet 0x45.

Command Packet 0x20: Almanac Request

This packet requests almanac data for one satellite from the GNSS receiver. This packet contains one data byte specifying the satellite PRN number. The GNSS receiver returns packet 0x40 hex.

Command Packet 0x21: Current Time Request

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

Command Packet 0x22: Request GPS Satellite Selection

Command Packet 0x22 configures the receiver to operate in a specific position fix mode and stores the new mode setting in memory. One data byte is included in the packet to select the position fix mode.

Byte	Item	Type	Value	Meaning
1	Position Fix Mode	BYTE	Flag	Position fix mode: 0 Automatic 2D/3D (default) 1.....Time only (0D) 3.....Horizontal (2D) 4.....Full position (3D) 10.....Overdetermined Clock mode

Command Packet 0x23: Request Initial Position (XYZ)

Command Packet 0x23 sends an approximate initial position, in Cartesian ECEF (Earth Centered, Earth Fixed) WGS-84 coordinates, to the receiver. Table shows the format of the data bytes for setting initial position in XYZ Cartesian ECEF

Byte	Item	Type	Units	Meaning
0-3	X	Single	Meters	X coordinate position along X-axis of Earth-Centered, Earth-Fixed (ECEF) coordinate system
4-7	Y	Single	Meters	Y coordinate position along Y-axis of ECEF coordinate system
8-11	Z	Single	Meters	Z coordinate position along Z-axis of ECEF coordinate system

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. The GNSS receiver returns packet 0x6C.

Command Packet 0x25: Soft Reset / Self-Test

Command Packet 0x25 initiates a software reset for the receiver, causing the receiver to perform the equivalent of powering off and then on. The receiver performs a self-test during the reset routine. Command Packet 0x25 contains no data bytes.

Command Packet 0x26: Health Request

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

Command Packet 0x27: Request Signal Levels

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

Command Packet 0x29: Almanac Health Page Request

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

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

This packet provides the GNSS receiver with an approximate initial position in latitude and longitude coordinates (WGS-84). This packet is useful if the user has moved more than about 1,000 miles since the previous fix. The GNSS receiver returns report packet 0x2B, which indicates if the position was accepted by the receiver.

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

This packet is ignored if the receiver is already calculating positions. The data format is shown in the table below.

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

Command Packet 0x2D: Oscillator Offset Request

This packet requests the calculated offset of the GNSS receiver master oscillator. This packet contains no data. The GNSS receiver returns packet 0x4D hex. This packet is used mainly for service.

Command Packet 0x2E: Set GPS Time

This packet provides the approximate GNSS time of week and the week number to the GNSS receiver. The GNSS receiver returns Packet 0x4E. The GPS week number reference is Week #0, starting on 6 January 1980. The seconds count begins at midnight on each Sunday morning. This packet is usually not required when the battery back-up voltage is applied as the internal clock keeps time to sufficient accuracy. *This packet is ignored if the receiver has already calculated the time from tracking a GNSS satellite.*

Note – See report Packet 41 for information on the Extended GPS week number.

Byte	Item	Type	Units
------	------	------	-------

0-3	GPS time of week	Single	Seconds
4-5	Extended GNSS week number	INT16	Weeks

Command Packet 0x2F: UTC Parameters Request

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

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

This packet is identical in content to packet 0x23; it provides an initial position to the GNSS receiver in XYZ coordinates. However, the GNSS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the GNSS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters. T-RAIM flags come on if this position is not accurate enough.

Entering an accurate position sets the self-survey completion state to 100%. The uploaded position is not stored in EEPROM unless it is stored with command packet 0x8E-26. The input position is reported by packet 0x8F-AC.

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

This packet provides an accurate initial position to the GNSS 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 GNSS receiver returns report packet 0x32, which indicates if the position was accepted by the receiver. The GNSS receiver uses this position for performing time-only fixes. If a survey is in progress when this command is issued, the survey is aborted, and this position data is used immediately. The coordinates entered must be in the WGS-84 datum. The Resolution SMT GG will automatically switch to the over-determined timing mode. Note that this position is not automatically saved to flash memory. If you want to save this position, first set the position, wait at least 2 seconds and then use packet 8E-A6 to save the position.

Note – When converting from degrees to radians use the following value for PI:

3.1415926535898

Single precision data format

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

Double precision data format

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

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

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

To request the option states without changing them, 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 geoid (Earth (mean sea level) mode)

UTC (coordinated universal time)

Byte	Data Type	Bit	Default	Value	Meaning	Associated Packet
0	Position	0	0	0	ECEF off	0x42 or 0x83
				1	ECEF on	
		1	1	0	LLA off	0x4A or 0x84
				1	LLA on	
		2	0	0	HAE (datum)	0x4A or 0x84
				1	MSL geoid (Note 1)	
		3	0	0	reserved	0x42 / 4A 0x83 / 84
		4	1	0	single-precision position	
		5:7	0	1	double-precision position	
					reserved	
1	velocity	0	0	0	ECEF off	0x43
				1	ECEF on	

Byte	Data Type	Bit	Default	Value	Meaning	Associated Packet
		1	1	0	ENU off	0x56
				1	ENU on	
		2:7	0		reserved	
2	timing	0	0	0	GPS time reference	0x42, 0x43, 0x4A, 0x83,
				1	UTC time reference	0x84, 0x56,
3	auxiliary	0	0	0	packet 5A off	0x5A
				1	packet 5A on	
		1	0	0	reserved	
		2			reserved	
		3	1	1	reserved	
		4:7	reserved	0	0	

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 GNSS receiver is not automatically outputting fixes). The GNSS 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/Load Satellite System Data

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

Note – The GNSS receiver can initialize itself without any data from the user; it merely requires more time.

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

Byte	Item	Type	Value	Meaning
0	Operation	UINT8	1	Request data from GPS receiver
			2	Load data into GPS receiver
1	Type of data	UINT8	2	Almanac
			3	Health page, T_oa, WN_oa
			4	Ionosphere
			5	UTC

			6	Ephemeris
2	Sat PRN#	UINT8	0	Data that is not satellite - ID specific
			1-32	Satellite PRN number
3	Length (n)	UINT8		Number of bytes of data to be loaded
4 to n+3	Data	UINT8		Satellite data

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

Command Packet 0x39: Satellite Attribute Database Command

Normally, the GNSS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) that satisfy all mask values for use in the position solution. This packet allows you to override the internal logic and force the receiver to either unconditionally disable a particular satellite or to ignore a bad health flag. The GNSS receiver returns packet 0x59 for operation modes 3 and 6 only.

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

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

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.

Command Packet 0x3B: Satellite Ephemeris Status Request

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

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

Command Packet 0x3C: Request Current 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	Meaning
0	Satellite number	INT8	0	All satellites in current tracking set
			1-32	Specific GPS desired satellite
			65-97	Specific GLONASS desired SV satellite

Command Packet 0x3D: Timing Port Configuration Command

This packet is superseded by 0xBC.

Report Packet 0x2B: Initial Position (Latitude, Longitude, Altitude)

This packet is sent in response to command packet 0x2B and indicates if the receiver accepted the approximate initial position.

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

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

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

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

Report Packet 0x40: Almanac Data Page Report

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

Byte	Item	Type	Units
0	satellite	Byte	(identification number)
1-4	T_zc	Single	seconds
5-6	week number	Integer	weeks
7-10	eccentricity	Single	(dimensionless)
11-14	T_oa	Single	seconds

Byte	Item	Type	Units
15-18	i_o	Single	radians
19-22	OMEGA_dot	Single	radians/second
23-26	square_root_A	Single	√meters
27-30	OMEGA_0	Single	radians
31-34	Omega	Single	radians
35-38	M_0	Single	radians

T_{zc} is normally positive. However, if no almanac data is available for this satellite, then T_{zc} is negative. T_{zc} and the week number in this packet refer to the Z-count time and week number at the time the almanac was received. The remaining items are described in the ICD-GPS-200.

Report Packet 0x41: GPS Time Report

This packet provides the current GPS time of week and the week number. The GNSS receiver sends this packet in response to packet 0x21 and during an update cycle, which occurs approximately every 16 seconds when not doing fixes and approximately every 150 seconds when doing fixes.

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

Report Packet 0x42: Single-precision Position Fix

This packet provides current GNSS position fix in XYZ ECEF coordinates. If the I/O "position" option is set to "XYZ ECEF" and the I/O "Precision-of-Position output" is set to single-precision, then the GNSS receiver sends this packet each time a fix is computed and at start-up. The data format is shown below.

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

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

Report Packet 0x43 Velocity Fix, XYZ ECEF

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

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

Report Packet 0x45: Software Version Information

This packet provides information about the version of software in the Resolution SMT GG. The GNSS receiver sends this packet after power-on and in response to packet 0x1F.

Byte	Item	Type
0	Major version number of application	UINT8
1	Minor version number	UINT8
2	Month	UINT8
3	Day	UINT8
4	Year number minus 2000	UINT8
5	Major revision number of GPS core	UINT8
6	Minor revision number	UINT8
7	Month	UINT8
8	Day	UINT8
9	Year number minus 2000	UINT8

Note – Bytes 0 through 4 are part of the application layer of the firmware, while bytes 5 through 9 are part of the GNSS core layer of the firmware.

Report Packet 0x46: Health of Receiver Report

This packet provides information about the satellite tracking status and the operational health of the receiver. The receiver sends this packet after power-on or software-initiated resets, in response to packet 0x26, during an update cycle, when a new satellite selection is attempted, and when the receiver detects a change in its health. Packet 0x4B is always sent with this packet. The data format is shown below:

Byte	Item	Type	Value	Meaning
0	Status code	Byte	00 hex	Doing position fixes (3D mode)
			01 hex	Do not have GPS time yet(OD mode)
			03 hex	PDOP is too high
			08 hex	No usable satellites
			09 hex	Only 1 usable satellite
			0A hex	Only 2 usable satellites
			0B hex	Only 3 usable satellites
			0C hex	The chosen satellite is unusable
			BB hex	Have GPS time fix (OD mode)
1	Error codes	Byte		See Report Packet 0x46

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

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

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

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

Report Packet 0x47: Signal 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 only in response to packet 0x27. The data format is shown below. Up to 14 satellite number/signal level pairs may be sent, indicated by the count field. Signal level is normally positive. If it is zero then that satellite has not yet been acquired. The absolute value of signal level field is the last known signal level of that satellite.

Byte	Item	Type
0	count	UINT8
1	satellite number 1	UINT8
2- 5	signal level 1	Single
6	satellite number 2	UINT8
7-10	signal level 2	Single
(etc.)	(etc.)	(etc.)

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

Report Packet 0x49: Almanac Health Page Report

This packet provides health information on all 32 satellites. Packet data consists of 32 bytes, each of which contains the 6-bit health from almanac page 25. The first byte is for satellite #1, and so on. The receiver sends this packet in response to packet 0x29 and when this data is received from a satellite.

Byte	Item
0	Health of satellite #1
1	Health of satellite #2
~...~	~...~
31	Health of satellite #31

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

Report Packet 0x4A: Single Precision LLA Position Fix

The packet provides current GNSS position fix in LLA (latitude, longitude, and altitude) coordinates. If the I/O position option is set to "LLA" and the I/O precision of position output is set to single precision, then the receiver sends this packet each time a fix is computed. The data format is shown below:

Byte	Item	Type	Units
0-3	latitude	Single	radians: + for north, - for south
4-7	longitude	Single	radians: + for east, - for west
8-11	altitude	Single	meters
12-15	clock Bias	Single	meters (always relative to GPS)
16-19	time of fix	Single	seconds

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

CAUTION – When converting from radians to degrees, significant and readily 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 ICDGPS-200 is 3.1415926535898.

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

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

The receiver transmits this packet in response to packets 0x25 and 0x26 and following a change in state. This packet identifies the receiver and may present error messages. Packet 0x46 is always sent with this packet. The machine ID can be used by equipment communicating with the receiver to determine the type of receiver to which the equipment is connected. Then the interpretation and use of packets can be adjusted accordingly.

Byte	Item	Type	Meaning
0	Machine ID	BYTE	0x01 Reports Machine ID
1	Status 1	BYTE	See below for the Status 1 codes
2	Status 2	BYTE	Superpackets are supported

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

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

Report Packet 0x4D: Oscillator Offset

This packet provides the current value of the receiver master oscillator offset in Hertz at carrier. This packet contains one SINGLE number (4 bytes). The receiver sends this packet in response to packet 0x2D

Report Packet 0x4E: Response to Set GPS Time

Indicates whether the receiver accepted the time given in a Set GNSS time packet. The receiver sends this packet in response to Packet 0x2E. This packet contains one byte.

Value	Meaning
ASCII "Y"	The receiver accepts the time entered via Packet 2E. The receiver has not yet received the time from a satellite.
ASCII "N"	The receiver does not accept the time entered via Packet 2E. The receiver has received the time from a satellite and uses that time. The receiver disregards the time in Packet 0x2E

Report Packet 0x4F: UTC Parameters Report

This packet is sent in response to command packet 0x2F and contains 26 bytes. It reports the UTC information broadcast by the GPS system. For details on the meanings of the following parameters, consult ICD-200, Sections 20.3.3.5.2.4, 20.3.3.5.1.8, and Table 20-IX.

On the simplest level, to get UTC time from GPS time, subtract ΔT_{LS} seconds. The other information contained in this packet indicates when the next leap second is scheduled to occur.

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

Report Packet 0x54: Bias and Bias Rate Report

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

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

The bias is the offset of the receiver internal time clock from GPS time. Bias is expressed as meters of apparent range from the satellites, and corrects the 1 PPS output. Bias rate is the frequency error of the receiver internal oscillator. It is expressed as apparent range rate. Time-of-fix is in GPS or UTC time as selected by the I/O “timing” option in packet 0x35.

CAUTION – For accurate interpretation of the propagation delay, the precise constant for the speed of light must be used. The ICD-200 value for the speed of light is 299,792,458 m/s.

Report Packet 0x55 I/O Options

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

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 geoid (Earth (mean sea level) mode) UTC (coordinated universal time)

Byte	Data Type	Bit	Default	Value	Meaning	Associated Packet
0	UINT8 Position	0	0	0	ECEF on	0x42 or 0x83
				1	ECEF off	
		1	1	0	LLA off	0x4A or 0x84
				1	LLA on	
		2	0	0	HAE (datum)	0x4A or 0x84
				1	MSL geoid	
		3	0	0	reserved	
		4	1	0	single-precision position	0x42 / 4A
1	UINT8 velocity			1	double-precision position	0x83 / 84
		5:7	0		reserved	
		0	0	0	ECEF off	0x43
				1	ECEF on	
		1	1	0	ENU off	0x56
				1	ENU on	
		2:7	0		reserved	
2	UINT8 timing	0	0	0	GPS time reference	0x42, 0x43, 0x4A, 0x83,
				1	UTC time reference	0x84, 0x56,
3	UINT8 auxiliary	0	0	0	packet 5A off	0x5A

		1	packet 5A on
2	reserved		
3	reserved	1	reserved
4:7	reserved	0	0

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

If East-North-Up (ENU) coordinates have been selected for the I/O "velocity" option, the receiver sends this packet under the following conditions:

- Each time that a fix is computed
- In response to packet 0x37 (last known fix) The data format is shown below.

Byte	Item	Type	Units
0-3	East Velocity	Single	m/s; + for east, - for west
4-7	North Velocity	Single	m/s; + for north, - for south
8-11	up velocity	Single	m/s; + for up, - for down
12-15	clock bias rate	Single	m/s
16-19	time-of-fix	Single	seconds

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

Report Packet 0x57: Information about Last Computed Fix

This packet provides information concerning the time and origin of the previous position fix. The receiver sends this packet, among others, in response to packet 0x37. The data format is shown below.

Byte	Item	Type	Value	Meaning
0	source of info	UINT8	0	none
			1	regular fix initialization
1	Tracking mode	UINT8	0	No previous fix
			1	Time only -SV
			2	2D clock hold
			3	2D
			4	3D
			5	over-determined clock
			6	DGPS reference
2-5	time of last fix	Single		seconds GPS time
6-7	week of last fix	UINT16		weeks

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

This packet provides GNSS data (almanac, ephemeris, and so on). The receiver sends this packet in response to Packet 0x38 (acknowledging the loading of data). The data format is shown below.

Data Format

Byte	Item	Type	Value	Definition
0	Operation	Byte	1	Acknowledgement
			2	Data Out
1	Type of data	Byte	1	Not used
			2	Almanac
			3	Health page, T_oa, WN_oa
			4	Ionosphere
			5	UTC
			6	GPS Ephemeris
			7	GLONASS Almanac
			8	GLONASS Ephemeris
2	Sat PRN #	Byte	0	Data that is not satellite ID-specific
			1 to 32	Satellite PRN number
3	Length (n)	Byte		Byte count
4 to n+3	Data	nBytes		

Almanac parameters

Byte	Item	Type	Definition / ICD-GPS-200
4	t_oa_raw	UINT8	Sec 20.3.3.5.1.2
5	SV_HEALTH	UINT8	Sec 20.3.3.5.1.2
6-9	e	Single	Sec 20.3.3.5.1.2
10-13	t_oa	Single	Sec 20.3.3.5.1.2
14-17	i_o	Single	Sec 20.3.3.5.1.2
18-21	OMEGADOT	Single	Sec 20.3.3.5.1.2
22-25	sqrt_A	Single	Sec 20.3.3.5.1.2
26-29	OMEGA_0	Single	Sec 20.3.3.5.1.2
30-33	OMEGA	Single	Sec 20.3.3.5.1.2
34-37	M_0	Single	Sec 20.3.3.5.1.2
38-41	a_f0	Single	Sec 20.3.3.5.1.2
42-45	a_f1	Single	Sec 20.3.3.5.1.2
46-49	Axis	Single	Sec 20.3.3.5.1.2
50-53	n	Single	Sec 20.3.3.5.1.2

Byte	Item	Type	Definition / ICD-GPS-200
54-57	OMEGA_n	Single	Sec 20.3.3.5.1.2
58-61	ODOT_n	Single	Sec 20.3.3.5.1.2
62-65	t_zs	UINT16	Sec 20.3.3.5.1.2, see Note 2.
66-67	weeknum	UINT16	Sec 20.3.3.5.1.2
68-69	WN_oa	UINT16	Sec 20.3.3.5.1.2

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

Satellite health

Byte	Item	Type	Definition / ICD-GPS-200
4	week number for health	UINT8	Sec 20.3.3.5.1.3
5-36	SV health	UINT8	Sec 20.3.3.5.1.3
37	t_oa for health	UINT8	Sec 20.3.3.5.1.3
38	current t_oa	UINT8	units = seconds/2048
39-40	current week #	INT16	

Ionosphere parameters

Byte	Item	Type	Definition / ICD-GPS-200
4-11	not used		
12-15	α_0	Single	Sec 20.3.3.5.1.9
16-19	α_1	Single	Sec 20.3.3.5.1.9
20-23	α_2	Single	Sec 20.3.3.5.1.9
24-27	α_3	Single	Sec 20.3.3.5.1.9
28-31	β_0	Single	Sec 20.3.3.5.1.9
32-35	β_1	Single	Sec 20.3.3.5.1.9
36-39	β_2	Single	Sec 20.3.3.5.1.9
40-43	β_3	Single	Sec 20.3.3.5.1.9

UTC parameters

Byte	Item	Type	Meaning
4-16	not used		
17-24	A0	Double	Sec 20.3.3.5.1.8
25-28	A1	Single	Sec 20.3.3.5.1.8
29-30	Δt_{LS}	SINT16	Sec 20.3.3.5.1.8
31-34	tot	Single	Sec 20.3.3.5.1.8
35-36	WNt	UINT16	Sec 20.3.3.5.1.8
37-38	WNLSF	UINT16	Sec 20.3.3.5.1.8

39-40	DN	UINT16	Sec 20.3.3.5.1.8
41-42	Δt_{LSf}	SINT16	Sec 20.3.3.5.1.8

Ephemeris data

Byte	Item	Type	Meaning
4	SV number	UINT8	SV PRN number
5-8	t_ephem	Single	time of collection (note, if data is missing or invalid, t_ephem will be negative)
9-10	week number	UINT16	GPS week number 0 thru 1023
11	codeL2		Sec 20.3.3.3, Table 20-I
12	L2Pdata		Sec 20.3.3.3, Table 20-I
13	SV accuracy raw	UINT8	Sec 20.3.3.3, Table 20-I
14	SV health	UINT8	Sec 20.3.3.3, Table 20-I
15-16	IODC	UINT16	Sec 20.3.3.3, Table 20-I
17-20	tGD	Single	Sec 20.3.3.3, Table 20-I
21-24	toc	Single	Sec 20.3.3.3, Table 20-I
25-28	af2	Single	Sec 20.3.3.3, Table 20-I
29-32	af1	Single	Sec 20.3.3.3, Table 20-I
33-36	afo	Single	Sec 20.3.3.3, Table 20-I
37-40	SV accuracy	Single	Sec 20.3.3.3, Table 20-I
41	IODE	UINT8	Sec 20.3.3.4
42	fit_interval	UINT8	Sec 20.3.3.4
43-46	Crs	Single	Sec 20.3.3.4
47-50	Δn	Single	Sec 20.3.3.4
51-58	M0	Double	Sec 20.3.3.4
59-62	Cuc	Single	Sec 20.3.3.4, radians
63-70	e	Double	Sec 20.3.3.4
71-74	CUS	Single	Sec 20.3.3.4, radians
75-82	sqrt(A)	Double	Sec 20.3.3.4
83-86	toe	Single	Sec 20.3.3.4
87-90	Cic	Single	Sec 20.3.3.4
91-98	OMEGA_0	Double	Sec 20.3.3.4
99-102	Cis	Single	Sec 20.3.3.4
103-110	io	Double	Sec 20.3.3.4
111-114	Crc	Single	Sec 20.3.3.4
115-122	OMEGA	Double	Sec 20.3.3.4

Byte	Item	Type	Meaning
123-126	OMEGADOT	Single	Sec 20.3.3.4
127-130	IDOT	Single	Sec 20.3.3.4
131-138	Axis	Double	= (sqrt_A)2
139-146	n	Double	derived from delta_n
147-154	r1me2	Double	= sqrt (1.0-e2)
155-162	OMEGA_n	Double	derived from OMEGA_0, OMEGADOT
163-170	ODOT_n	Double	derived from OMEGADOT

Report Packet 0x59: Satellite Attributes Database Report

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

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

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

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

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

Report Packet 0x5A: Raw Data Measurement Data

Packet 0x5A provides raw GNSS measurement data. If the packet 0x35 auxiliary option byte bit 1 is set, this packet is sent automatically as measurements are taken.

Byte	Item	Type	Units
0	SV PRN number	UINT8	
1-4	sample length	single	milliseconds
5-8	signal level	single	dB/Hz

9-12	code phase	single	1/16th chip
13-16	doppler	single	Hertz @ L1
17-24	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 0x5B: Satellite Ephemeris Status Report

This packet is sent in response to packet 0x3B and optionally, when a new ephemeris (based on IODE) is received. It contains information on the status of the ephemeris in the receiver for a given satellite.

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

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

Report Packet 0x5C: Satellite Tracking Status

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

Byte	Bit	Item	Type	Value	Meaning
0		SV PRN number	UINT8	1-32 65-97	GPS GLONASS
1	3-7	channel number	bit field	0-31	Channels 1-32
2		acquisition flag	UNIT8	0 1 2	never acquired acquired re-opened search
3		ephemeris flag	UNIT8	0 >0	flag not set good ephemeris
4-7		signal level	single		dBHz

Byte	Bit	Item	Type	Value	Meaning
8-11		time of last measurement	single	secs	GPS time of week
12- 15		elevation angle	single		radians
16- 19		azimuth angle	single		radians
20		old measurement flag	UINT8	0	measurement is current
				>0	measurement is old
21		reserved	UINT8	0	reserved
22		reserved	UINT8	0	reserved
23		reserved	UINT8	1	reserved

Report Packet 0x6C: All-in-View Satellite Selection

This packet provides a list of satellites used for position or time only fixes by the GNSS receiver. The packet also provides the PDOP, HDOP, and VDOP 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.

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

Byte	Bit	Item	Type	Value	Meaning
0	0-2	fix dimension	bit field	3	2D fix
				4	3D fix
				5	OD clock fix
	3	fix mode	bit field	0	auto
				1	manual
1-4		PDOP	Single		PDOP
5-8		HDOP	Single		HDOP
9-12		VDOP	Single		VDOP
13-16		TDOP	Single		TDOP
17		No. of SV in fix	UINT8		Count
18 - n		SV PRN	SINT8	(1-128)	PRN

Command Packet 0x7A: Set or Request NMEA Interval and Message Mask

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" seconds. To determine the NMEA interval and message mask, use the values shown below. While fixes are being generated the output order is: ZDA, GGA, GLL, VTG, GSA, GSV, RMC.

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	UINT8	0	
1		Interval	UINT8	1-225	Fix interval in seconds
2		Reserved	UINT8	0	
3		Reserved	UINT8	0	
4	0	RMC	Bit	0	Off
				1	On
5	1-7	Reserved	Bit	0	
5	0	GGA	Bit	0	Off
				1	On
5	1	GGL	Bit	0	Off
				1	On
5	2	VTG	Bit	0	Off
				1	On
5	3	GSV	Bit	0	Off
				1	On
5	4	GSA	Bit	0	Off
				1	On
5	5	ZDA	Bit	0	Off
				1	On
5	6-7	Reserved	Bit	0	

Report Packet 0x7B: Set NMEA Message Output

This packet is sent in response to command packet 7A and has the same data format as 0x7A.

Report Packet 0x83: Double Precision XYZ

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

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

Note – The time-of-fix is in GPS, GLONASS 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 GNSS position fix in LLA coordinates. If the I/O "position" option is set to "LLA" and the double position option is selected (see packet 0x35), the receiver sends this packet each time a fix is computed.

Byte	Item	Type	Units
0-7	latitude	Double	radians; + for north, - for south
8-15	longitude	Double	radians; + for east, - for west
16-23	altitude	Double	meters
24-31	clock bias	Double	meters (always relative to GPS)
32-35	time-of-fix	Single	seconds

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

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

Command Packet 0xBB: Set Receiver Configuration

In query mode, packet 0xBB is sent with a single data byte and returns report packet

0xBB in the format shown below:

Data Format (Query Only)

Byte	Item	Type	Value	Meaning	Default
0	Subcode	UINT8	0	Query mode	

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

Report Packet 0 x BB Data Format

Byte	Item	Type	Value	Meaning	Default
0	Subcode	UINT8	0x00	Receiver configuration block	
1	Receiver mode	UINT8	0	Automatic	#0
			1	Time only (1SV)	
			3	Horizontal (2D)	
			4	Full Position (3D)	

Byte	Item	Type	Value	Meaning	Default
			5	Reserved	
			6	2D clock hold	
			7	Over Determined Clock	
2	reserved	UINT8		N/A	
3	reserved	UINT8		reserved	
4	Reserved	UINT8		Reserved	
5-8	Elevation Mask	Single	0- $\pi/2$	Lowest satellite elevation for fixes only when the receiver is operating in the Over Determined Clock mode.	0 degrees
9-12	AMU Mask	Single	0 - 55	Min. signal level for fixes. Used when 4.0 receiver is operating in OD mode.	
13-16	PDOP Mask	Single		Maximum PDOP for fixes	8
17-20	PDOP Switch	Single		Selects 2D/3D mode	6
21	reserved	UINT8		N/A	
22	Anti-jamming mode	UINT8	0	Disabled	
			1	Enabled	1
23	reserved	UINT8		N/A	
24	reserved	UINT8		N/A	
25	Measurement rate	UINT8	0	1 Hertz	1Hz
26	Position Fix rate	UINT8	0	1 Hertz	1Hz
27	Constellation	Bit	1	GPS	See note
			2	GLONASS	
28-39	reserved	UINT8		N/A	

Note – Byte 27 is used for constellation setting. For GPS only mode 1st bit position is set to 1 (0001), for GLONASS only mode 2nd bit position is set to 1 (eg. 0010) and for GPS & GLONASS mode both 1st and 2nd bits are set to 1 (0011).

CAUTION – The operation of the Resolution SMT GG can be affected adversely if incorrect data is entered in the fields associated with packet 0xBB. Know what you are doing.

Note – When sending packet 0xBB, fields that are specified as "do not alter" or if you do not want to alter a specific field, send a value of 0xFF for UINT8 types and a value of - 1.0 for floating point types. The Resolution SMT 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.

Byte	Item	Type	Value	Meaning
0	Port Number	UINT8	0	Port A (standard)
			1	Port B
			FF	Current Port

Field data format

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

Byte	Item	Type	Value	Meaning
0	Port to Change	UINT8	0	Port A (standard)
			1	Port B
			0xFF	Current port
1	Input Baud Rate	UINT8	6	4800 bps
			7	9600 bps
			8	19200 bps
			9	38400 bps
			10	57600 bps
2	Output Baud Rate	UINT8	11	115200 bps
			As above	As above
			As above	As above
			As above	As above
			As above	As above
3	# Data Bits	UINT8	2	7 bits
			3	8 bits
			As above	As above
4	Parity	UINT8	0	None
			1	Odd
			2	Even
5	# Stop Bits	UINT8	0	1 bit
			1	2 bits
6	Flow Control	UINT8	0	none
7	Input Protocols	UINT8	2	TSIP
			4	NMEA
8	Output Protocols	UINT8	2	TSIP
			4	NMEA
9	Reserved	UINT8	0	

TSIP Superpackets

Several packets have been added to the core TSIP protocol to provide additional capability for the receivers. In packets 0x8E and their 0x8F responses, the first data byte is a subcode which indicates the superpacket type. For example, in packet 0x8E-14, 14 is the subcode that indicates the superpacket type. Therefore the ID code for these packets is 2 bytes long followed by the data.

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

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

Command Packet 0x8E-14: Set or Request Datum

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

This packet allows you to change the default datum from WGS-84 to one of 180 selected datums or to a user-entered custom datum. The datum is a set of 5 parameters that describe an ellipsoid to convert the GPS receiver's internal coordinate system of XYZ ECEF into latitude, longitude, and altitude (LLA). This will affect all calculations of LLA in packets 0x4A and 0x84, and 0x8F-AC and 0x8F-0B. The receiver responds with packet 0x8F-14.

Command Packet 0x8E-15: Request current Datum values

This packet contains only the subpacket ID, 0x15. The response to this packet is 0x8F-15.

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

This packet requests packet 0x8F-20 or marks it for automatic output. If only the first byte (20) is sent, a 0x8F-20 report containing the last available fix will be sent immediately. If two bytes are sent, the packet is marked / unmarked for auto report according to the value of the second byte.

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

Note – Auto-report requires that Superpacket output is enabled. See Command Packet 0x35: I/O Option Flags Command. This packet must also be enabled with packet 0x8E-4D.

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

This command packet causes the current configuration settings to be written to non-volatile storage. This packet contains only a single byte: the sub-packet ID. Upon receiving the command, the receiver will write the configuration and send a report packet 0x8F-26 when the operation is completed. It typically takes about 1 second to write the user configuration.

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

Command Packet 0x8E-41: Request Manufacturing Parameters

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

Command Packet 0x8E-42: Stored Production Parameters

This packet is used to request the production parameters stored in nonvolatile memory. Send this packet with no data bytes (don't forget the subcode) 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 the Resolution SMT GG PPS characteristics. The Resolution SMT GG responds to a query or set command with packet 8F-4A.

Byte	Item	Type	Value	Meaning
0	Subcode	UINT8	0x4A	Always
1	PPS driver switch	UINT8	0	off
			1	on
2	Time Base	UINT8	0	GPS
			1	UTC
3	PPS polarity	UINT8	0	positive
			1	negative
4-11	PPS offset or cable delay	Double		seconds
12-15	Bias uncertainty threshold	Single	0	meter

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

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

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

- To request the current mask, send this packet with no data bytes except the subcode byte. The receiver returns packet 0x8F-4D.
- To set the automatic packet output mask, send this packet with 4 data bytes. This mask only disables automatic packet output. Packets generated in response to TSIP set or query commands will always be output by the receiver.

Bit	Output packet	Default A2K	When output	Meaning
0 (LSB)	0x40	0	After Decode	Almanac data collected from satellite.
1	0x58, 0x5B	0	After Decode	Ephemeris data collected from satellite.
2	0x4F	0	After Decode	UTC data collected from satellite.
23	0x58	0	After Decode	Ionospheric data collected from satellite.
4	0x48	0	After Decode	GPS Message.
5	0x49	0	After Decode	Almanac health page collected from satellite.
6	Reserved	1		Reserved
7	Reserved	1		Reserved
8	0x41	1	New Fix	Partial and full fix complete and packet output timer has expired.
9	Reserved	1		Reserved

Bit	Output packet	Default A2K	When output	Meaning
10	Reserved	1		Reserved
11	6D, 46, 4B,	1	Constellation	New satellite selection
12-29	Reserved	1		Reserved
30	42, 43, 4A, 54, 56, 83, 84, 8F-20	1	New Fix Update	Kinetic and Timing information. Output must be enabled using I/O options
31	5A	1	New Fix	Raw Measurement Data Output must be enabled using I/O options

Command Packet 0x8E-4E: Set PPS output option

This command packet sets the PPS driver switch to one of the values listed in Table A-52. The current driver switch value can be requested by sending the packet with no data bytes except the subcode byte. The response packet is 0x8F-4E.

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

The Resolution SMT GG can also be configured to generate an Even Second pulse in place of the PPS pulse by setting the value as shown in the table below.

Byte	Item	Type	Value	Meaning
0	Subcode	UINT8	0x4E	
1	PPS driver switch	UINT8	2	PPS is always on. PPS is generated every second
			3	PPS is output when at least one satellite is tracking. PPS is generated every second
			4	PPS is output when at least three satellites are tracking. PPS is generated every second
			130	PPS is always on. PPS is generated every even second
			131	PPS is output when at least one satellite is tracking. PPS is generated every even second
			132	PPS is output when at least three satellites are tracking PPS is generated every even second

Command Packet 0x8E-A2: UTC/GNSS Timing

Command packet 8E-A2 sets the UTC/GNSS timing mode (time and date fields) in packet 0x8F-AB, and the temporal location of the Resolution SMT GG output PPS. Send packet 8E-A2 with no data to request the current settings. The Resolution SMT GG replies with response packet 8F-A2.

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	UINT8	0xA2	
1	0	UTC/GPS time	bit field	0	GPS time/date in packet 0x8F-AB
				1	UTC time/date in packet 0x8F-AB
	1			0	PPS referenced to GPS time
				1	PPS referenced to UTC time
	2	GLONASS time	Bit field	0	Time base as indicated in Bit 0
				1	GLONASS time /date
	3			0	PPS reference as indicated in Bit 1
				1	PPS referenced to GLONASS time

Command Packet 0x8E-A5: Packet Broadcast Mask

Use command packet 8E-A5 to set the packet broadcast masks or to request the current mask settings. The Resolution SMT GG replies to requests with response packet

8F-A5. The broadcast mask is bitwise encoded to allow the user to turn on and off the broadcast of certain packets. For those broadcast packets that have multiple format, the Resolution SMT GG will broadcast only one of the formats. If more than one of the formats is masked on for broadcast, then the format with the greatest precision of content masked on will be sent and the rest will not. For each bit in the mask that is used, the coding is as follows:

0: Turn off broadcast of this packet

1: Turn on broadcast of this packet

Byte	Bit	Item	Type	Description
0		Subcode	UINT8	0xA5
1-2	0	Mask 0	bit field	8F-AB, Primary Timing Information
	1			Reserved
	2			8F-AC, Supplemental Timing Information
	3			Reserved
	4			Reserved
	5			Reserved
	6			Automatic Output Packets
	7-15			reserved
3-4		Mask 2	bit field	reserved

Command Packet 0x8E-A6: Self-Survey Command

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

Byte	Item	Type	Value	Meaning
0	Subcode	UINT8	0xA6	
1	Self-survey command	UINT8	0	Restart self-survey
			1	Save position to Flash
			2	Delete position from Flash

Command Packet 0x8E-A9: Self-Survey Parameters

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

Data fields

- Self-Survey Enable: Use this field to enabled or disabled the self-survey mechanism.
 - 0: Disable the self-survey mechanism
 - 1: Enable the self-survey mechanism
- Position Save Flag: Use this field to tell the self-survey mechanism to automatically save (or to not save) the self-surveyed position at the end of the self-survey procedure.
 - 0: Don't automatically save the surveyed position when the self-survey is complete
 - 1: Automatically save the surveyed position when the self-survey is complete.
- Self-Survey Length: Use this field to specify the number of position fixes that are to be averaged together to form the self-surveyed position used for clock-only fixes.
 - Limits: 1 to (232 - 1) fixes

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0xA9	
1	Self-Survey Enable	UINT8	0	Disabled
			1	Enabled
2	Position Save Flag	UINT8	0	Don't save position
			1	Save self-surveyed position at the end of the survey
3-6	Self-Survey Length	UINT3 2	see above	Number of fixes
7-10	Reserved	UINT3 2	0	0

Command Packet 0x8E-AB : Request Primary Timing Packet

Use this command packet to request the Primary Timing packet 0x8F-AB. By default, the Resolution SMT 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	Send 0x8F-AB immediately
			1	Send 0x8F-AB on-time next second
			2	Send 0x8F-AB and 0x8F-AC on-time next second

The Request Type item determines how the Resolution SMT 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 Resolution SMT 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	Send 0x8F-AC immediately
			1	Send 0x8F-AC on-time next seconds
			2	Send 0x8F-AB and 0x8F-AC on-time next second

The Request Type item determines how the Resolution SMT 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-14: Current Datum Values

This packet contains 43 data bytes with the values for the datum currently in use and is sent in response to packet 0x8E-14. If a built-in datum is being used, both the datum index and the five double-precision values for that index are returned. If the receiver is operating on a custom user-entered datum, the datum index is set to -1 and the five values are displayed. These five values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA

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

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

This packet provides information about the time and origin of the previous position fix. This is the last-calculated fix; it could be quite old. The receiver sends this packet in response to Packet 0x8E-20; it also can replace automatic reporting of position and velocity packets. Automatic output of 0x8F-20 must also be enabled by setting bit 5 of byte 0 in command packet 0x0x35 and bit 0 of bytes 1-2 in command packet 0x8E-A5

Byte	Item	Type	Meaning
0	Subpacket ID	Byte	ID for this subpacket (always 0x20)
1	Key Byte	Byte	N/A
2-3	east velocity	Integer	Units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
4-5	north velocity	Integer	Units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
6-7	up velocity	Integer	Units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
8-11	Time of Week	Unsigned	longGPS Time in milliseconds
12-15	Latitude	Long integer	Latitude, units = 2-31 semicircle, according to current
16-19	Longitude	Unsigned	Longitude east of meridian, units = 2-31 semicircle,
20-23	Altitude	Long integer	Altitude above ellipsoid, mm, according current datum.

Byte	Item	Type	Meaning
24	Velocity scaling		When bit 0 is set to 1, velocities in bytes 2-7 have been
25	Reserved		0
26	Datum		Datum index + 1
27	Fix Type	Byte	Type of fix. This is a set of flags. 0 (LSB) 0: Fix was available 1: No fix available 1 0: Fix is autonomous 1: N/A 2 0: 3D fix 1: 2D fix 3 0: 2D fix used last-circulated altitude 1: 2D fix used entered altitude 4 0: Unfiltered 1: Position or altitude filter on 5-7 Unused (always 0)
28	Num SVs	Byte	Number of satellites used for fix. Will be zero if no fix was
29			Number of leap seconds between UTC time and GPS time.
30-31	UTC Offset	Byte	GPS time of fix (weeks)

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

This packet is sent in response to command packet 0x8E-26. The packet indicates whether the receiver configuration has been successfully saved to non-volatile memory.

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

Report Packet 0x8F-41: Stored Manufacturing Operating Parameters

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

Byte	Item	Type	Units
0	Subcode	UINT8	0x41
1-2	board serial number prefix	SINT16	
3-6	Board serial number	UINT32	
7	Year of build	UINT8	
8	Month of build	UINT8	

Byte	Item	Type	Units
9	Day of build	UINT8	
10	Hour of build	UINT8	
11-14	Oscillator offset	Single	
15-16	Test code identification number	UINT16	

Report Packet 0x8F-42: Stored Production Parameters

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

Byte	Item	Type	Units
0	Subcode	UINT8	0x42
1	Production options prefix	UINT8	
2	Production number extension	UINT8	
3-4	Case serial number prefix	UINT16	
5-8	Case serial number	UINT32	
9-12	Production number	UINT32	
13-14	Reserved	UINT16	
15-16	Machine identification number	UINT16	
17-18	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 8E-4E has been executed. See the corresponding command packet for information about the data format.

Report Packet 0x8F-A2: UTC/GPS Timing

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

Report Packet 0x8F-A5: Packet Broadcast Mask

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

Report Packet 0x8F-A6: Self-Survey Command

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

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

Report Packet 0x8F-A9: Self-Survey Parameters

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

Report Packet 0x8F-AB: Primary Timing Packet

This broadcast packet provides time information once per second. GNSS week number, GNSS time-of-week (TOW), UTC integer offset, time flags, date and time-of-day (TOD) information is provided. This packet cannot be requested.

Data fields

- Time of Week: This field represents the number of seconds since Sunday at 00:00:00 GNSS time for the current GNSS week. Time of week is often abbreviated as TOW
- Week Number: This field represents the current GNSS week number. GNSS 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: $\text{Time (UTC)} = \text{Time (GPS)} - \text{UTC Offset}$. The UTC offset information is reported to Resolution SMT GG by the GPS system and can take up to 12.5 minutes to obtain. Before the Resolution SMT GG has received UTC information from the GPS system, it is only capable of representing time in the GPS time scale, and the UTC offset will be shown as 0.
- Timing Flags: This field is bitwise encoded to provide information about the timing outputs. Unused bits are should be ignored.
 - Bit 0: When 0, the date and time fields broadcast in packet 8F-AB are in the GPS time scale. When 1, these fields are in the UTC time scale and are adjusted for leap seconds. Use command packet 8E-A2 to select either GPS or UTC time scales.
 - Bit 1: When 0, the PPS output is aligned to GPS. When 1, the PPS output is aligned to UTC. Use command packet 8E-A2 to select either GPS or UTC PPS alignment.
 - Bit 2: When 0, time has been set from GPS. When 1, time has not yet been set from GPS.
 - Bit 3: When 0, UTC offset information has been received. When 1, UTC offset information is not yet known.
 - Bit 4: When 0, time is coming from GPS/UTC. When 1, the Acutime GG time is coming from GLONASS.
 - Bit 5: When 0, PPS output is aligned to GPS/UTC. When 1, the PPS output is aligned to GLONASS.
- Time of Day: The time of day is sent in hours-minutes-seconds format and varies from 00:00:00 to 23:59:59, except when time is in UTC and a leap second insertion occurs. In this case the time will transition from 23:59:59 to 23:59:59 to 00:00:00. Use command packet 8E-A2 to select either the GPS or UTC time scale.

- Date: The date is sent in day-month-year format. Use command packet 8E-A2 to select either the GPS or UTC time scale.

Broadcast Control: Packet 8F-AB, Mask 0, Bit 0

Byte	Bit	Item	Type	Value	Description
0		Subcode	UINT8		0xAB
1-4		Time of week	UINT32		GPS seconds of week
5-6		Week number	UINT16		GPS week number (see above)
7-8		UTC Offset	SINT16		UTC Offset (seconds)
9	0	Timing flag	bit field	0	GPS time
				1	UTC time
	1			0	GPS PPS
				1	UTC PPS
	2			0	time is set
				1	time is not set
	3			0	have UTC info
				1	no UTC info
	4			0	No GLONASS time
				1	GLONASS time
	5			0	No GLONASS PPS
				1	GLONASS PPS
10		Seconds	UINT8	0-59	Seconds
11		Minutes	UINT8	0-59	Minutes
12		Hours	UINT8	0-23	Hours
13		Day of Month	UINT8	1-31	Day of month
14		Month	UINT8	1-12	Month of year
15-16		Year	UINT16		Four digits of year (e.g. 2013)

Note – When the output time format is GLONASS then TOW will be GLONASS TOW, which is +3 hours from UTC.

Report Packet 0x8F-AC: Supplemental Timing Packet

This broadcast packet provides supplemental timing information once per second. Information regarding position, unit status and health, and the operational state of the unit is provided. This packet cannot be requested. When enabled, this packet is transmitted once per second shortly after packet 8F-AB.

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

Data fields

- **Receiver Mode:** This field shows the fix mode that the GNSS receiver is currently configured for. The Resolution SMT GG spends most of its time in the Over-determined Clock mode where it uses all available satellites to perform the best time-only fix possible. See packet BB for a description of all available receiver modes.
- **Self-Survey Progress:** When a self-survey procedure is in progress, this field shows the progress of the survey as a percentage of fixes collected so far. The self-survey will be complete when the self-survey progress reaches 100 percent.
- **Minor Alarms:** This field is bitwise encoded with several minor alarm indicators. A minor alarm indicates a condition that the user should be alerted to, but does not indicate an immediate (or necessarily any) impairment of functionality. For each bit, a value of 0 means that the condition is not indicated. Bits not described below should be ignored.
 - **Bit 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. Normally, the Resolution SMT GG provides power to the antenna's LNA (Low Noise Amplifier) through the center conductor of the antenna cable. On-board circuitry senses this current draw, and if low, this condition will be indicated. However, when the antenna is powered elsewhere (e.g. when using a splitter) then an antenna open condition is expected and does not imply a fault nor does it impair the operation of the Resolution SMT GG.
 - **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. Onboard protection circuitry prevents any damage to the Resolution SMT GG when its antenna input is shorted to ground. This condition tends to indicate a fault in either the antenna cable or the antenna itself.

- Bit 3: When 1, indicates that no satellites are yet usable. In order for a satellite to be usable, it must be tracked long enough to obtain ephemeris and health data.
- Bit 5: When 1, indicates that a self-survey procedure is in progress.
- Bit 6: When 1, indicates that there is no accurate position stored in flash ROM.
- Bit 7: When 1, indicates that the GNSS system has alerted the Resolution SMT GG that a leap second transition is pending.
- Bit 8: When 1, indicates that the Resolution SMT 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. This alarm may indicate that the unit has been moved since the unit completed the last self-survey. If this alarm persists, resurvey the position of the unit.

Note: The position is only checked on power up as this is not a positioning receiver.

- Bit 11: When 1, indicates that the Almanac is not current or complete.
 - Bit 12: When 1, indicates that the PPS was not generated this second. This could mean that there wasn't enough usable satellites to generate an accurate PPS output. It could also mean that the unit is generating an Even Second output (see Packet 8E-4E) and the unit did not output a PPS on the odd second.
- GPS Decoding Status: This field indicates the decoding status of the GPS receiver.
 - Local Clock Bias: This field contains the bias of the local clock. Note that this data cannot be used to increase the accuracy of the PPS output.
 - Local Clock Bias Rate: This field contains the bias rate of the local clock. Note that this data cannot be used to increase the accuracy of the PPS output.
 - 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 seconds.

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0xAC	
1	Receiver Mode	UINT8	1	Automatic (2D/3D)
			2	Single satellite time
			3	Horizontal (2D)
			4	Full position (3D)
			5	N/A
			6	Clock hold (2D)
			7	Over-determined Clock
2	Reserved	UINT8	0	Reserved
3	Self-Survey Progress	UINT 8	0-100	Percent completed
4-7	Reserved	UINT 32	0	Reserved
8-9	Reserved	UINT16	0	Reserved
10-11	Minor Alarms	UINT16	0	Not used
			1	Antenna open
			2	Antenna shorted
			3	Not tracking satellites
			4	Not used
			5	Survey-in progress
			6	No stored position
			7	Leap second pending
			8	In test mode
			9	Position is questionable
			10	EEPROM segment status
			11	Almanac not complete
			12	PPS not generated
12	GPS Decoding Status	UINT8	0	Doing fixes
			1	Don't have GPS time
			2	No Fix
			3	PDOP is too high
			8	No usable satellites
			9	Only 1 usable satellite
			0x0A	Only 2 usable satellites
			0x0B	Only 3 usable satellites
			0x0C	The chosen satellite is unusable

Byte	Item	Type	Value	Description
			0x10	T-RAIM rejected the fix
13	Reserved	UINT8	0	Reserved
14	PPS indication	UINT8	0	PPS Good indication
			1	PPS Not Good indication
15	Reserved	UINT8	0	Reserved
16-19	Local clock bias	Single		ns
20-23	Local clock bias rate	Single		ppb
24-27	Reserved	UINT32		Reserved
28-31	Reserved	Single		Reserved
32-35	Reserved	Single		Reserved
36-43	Latitude	Double		radians
44-51	Longitude	Double		radians
52-59	Altitude	Double		meters
60-63	PPS Quantization Error	Single		PPS quantization error (ns)
64-67	Reserved	UINT8		Reserved

Unused or miscellaneous packets

Report Packet 0x13: Unparsable Packet

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

Report Packet 0x13: Data Format

Byte	Type	Item
0	UINT8	Packet ID of unparsable packet
1-N	UINT8	Packet data bytes of unparsable packet

Legacy packets (unused)

The four packets below will be sent, for historical reasons, when the Automatic Output Packets are enabled with packet 0x8E-A5, but the same information contained in these packets is contained in packets 0x8E-AB and 0x8E-AC and these old packets should be ignored.

Report Packet 0x54: Bias and Bias Rate

Information contained in super packets 8F-AB or 8F-AC

Report Packet 0x46: Health of Receiver

Information contained in super packets 8F-AB or 8F-AC

Report Packet 0x41: GPS Time

Information contained in super packets 8F-AB or 8F-AC

Report Packet 0x4B: Machine Code ID and Additional Status

Information contained in super packets 8F-AB or 8F-AC.

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NMEA 0183 Protocol

In this chapter:

Introduction

NMEA 0183 communication
interface

NMEA 0183 message structure

Field definitions

NMEA 0183 message options

NMEA 0183 message formats

Exception behavior

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

Introduction

NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. The NMEA 0183 protocol was originally established to allow marine navigation equipment to share information. Since it is a well-established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics.

For those applications requiring output only from the GNSS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The Resolution SMT 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.

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

NMEA National Office

Seven Riggs Avenue, Severna Park, MD 21146

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

Fax: +1-410-975-9450

NMEA 0183 communication interface

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 Resolution SMT 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 data fields are of variable length, and the user should always use the comma delineators to parse the NMEA message data 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	III.III	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 zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal- fraction are optional if full resolution is not required.

Type	Symbol	Definition
Longitude	yyyyy.yyy	Fixed/Variable length field: Degreesminutes.decimal-3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros 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 zeros 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 Resolution SMT GG can output any or all of the messages listed in the table below. In its default configuration (as shipped from the factory), the Resolution SMT 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

Resolution SMT GG GNSS timing module 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
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.

Message	Description
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.

\$idGSA,a,v,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.

\$idGSV,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.llll,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 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 Resolution SMT 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, 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
hhhhhhh	Satellite 1 - 4 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhh	Satellite 5 - 8 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhh	Satellite 9 - 12 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhh	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, 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
hhhhhhh	Satellite 17 - 20 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhh	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,hhhhhh 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.
hhhhh	root_a, HEX data conforming to GPS ICD 200.
hhhhh	Omega, HEX data conforming to GPS ICD 200.
hhhhh	Omega_0, HEX data conforming to GPS ICD 200.
hhhhh	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:

```
$PTNLAS, hh, xxxx, 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 = 0 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 = 0 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 Resolution SMT GG GNSS timing module into Monitor mode.

This is Set only, no query supported. The sentence format is:

\$PTNLSEM*hh<CR><LF>

This sentence is used by the Firmware Uploading Program.

EP - Ephemeris

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

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

Field	Description
-------	-------------

Q	Query
xx	Satellite ID

After receiving the query, the receiver 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.
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

Field	Description
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.

\$PTNLalO,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,IIII.IIIII,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
IIII.IIIII	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

PS - PPS Configuration

This sentence can query or set PPS configuration data.

```
$PTNLPS,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.

\$PTNLrT,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
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,IIII.IIIII,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)
IIII.IIIII	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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