

# User Guide

## Resolution SMT™x GPS Timing Module

*For use with:*

*Resolution SMTx GPS timing module (P/N 99889-XX)*

*Resolution SMTx timing module on carrier board (P/N 66974-XX)*

*Resolution SMTx Starter Kit (P/N 99890-XX)*

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### Corporate Office

Trimble Navigation Limited  
Component Technologies  
935 Stewart Drive  
Sunnyvale, CA 94085  
U.S.A.  
1-800-767-4822 (toll-free in the USA)

+1-408-481-7921  
[www.trimble.com](http://www.trimble.com)

Email: [trimble\\_support@trimble.com](mailto:trimble_support@trimble.com)

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- 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.

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### 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.



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We, Trimble Navigation Limited,

935 Stewart Drive  
Sunnyvale, CA 94085-3913  
United States  
+1-408-481-8000

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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx Starter Kit.

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**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 SMTx 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 SMTx GPS 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.

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# Introduction

## In this chapter:

Operation

Timing features

Starter kit

Use and care

Technical assistance

The *Resolution SMTx GPS Timing Module User Guide* describes how to integrate and operate the Trimble® Resolution SMTx™ GPS timing module.

The Trimble Resolution SMTx embedded timing board, is a full featured, high-performance GPS receiver. The receiver is designed to operate on the L1 (1575.42 MHz) frequency, providing standard position service (SPS) using Coarse Acquisition (C/A) code.

The Trimble Resolution SMTx 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 SMTx automatically initiates a self-survey upon acquisition of GPS 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 SMTx GPS 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
- Cable-delay compensation
- Accuracy <15 ns (1 sigma)

## Starter kit

The starter kit makes it simple to evaluate the Resolution SMTx receiver'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 SMTx GPS timing module is a high-precision electronic instrument and should be treated with reasonable care.

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**CAUTION** – There are no user-serviceable parts inside the Resolution SMTx and any modification to the unit by the user voids the warranty.

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## 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 [ctsupport@trimble.com](mailto:ctsupport@trimble.com).



# Setting up the Resolution SMTx Starter Kit

## In this chapter:

- System requirements
- Timing receiver performance
- Resolution SMTx starter kit
- Power
- Removing the Resolution SMTx 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 GPS capability into your application.

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

The hardware integration is described in Chapter 7, Resolution SMTx Carrier Board

## System requirements

### Hardware

- The Trimble Resolution SMTx Starter Kit, see page 19.
- User-provided connectors and extension cords to connect the Resolution SMTx 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 SMTx starter kit.

### Timing receiver performance

The Resolution SMTx GPS timing module is a high-performance GPS 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 SMTx receiver 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 SMTx starter kit

The Resolution SMTx GPS 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 SMTx timing module on a carrier board, mounted on an interface motherboard in a durable metal enclosure. The kit also contains:

- Two antenna options:
  - Bullet™ III GPS antenna, 5 V, F connector
  - Miniature magnetic mount antenna
- Two additional sample Resolution SMTx receivers
- 50 feet (20 m) RG-59 antenna cable, terminated with F connectors (M-M))
- Interface cable, USB
- AC/DC power supply adapter :
  - Input: 100 – 240 VAC
  - – Output: 24 VDC
- SMB to F adapter cable (RG-316 antenna transition cable)

*Note – The Resolution SMTx GPS timing module is also available as an individual receiver and associated antenna, or with the Resolution SMTx GPS 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 5 V required by 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 SMTx GPS 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 GPS antenna connection.

The center conductor of the SMB connector also supplies +5.5 VDC for the Low Noise Amplifier of the active antenna.

*Note – A 3.3 VDC antenna can also be supported on the Resolution SMTx GPS timing module, an 8-pin (2x4), 2 mm header (J4) supports the interface (CMOS level), the pulse-per-second (PPS) signal (CMOS level), and the input power (+3.3 VDC).*

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 SMTx GPS 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 regulated 5 VDC required by 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 SMTx carrier board from the motherboard

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**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 SMTx GPS 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 SMTx GPS 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 SMTx GPS timing module's features and performance specifications.



## Key features

The Resolution SMTx module is a high-performance GPS timing receiver in a thumbnail-sized shielded unit.

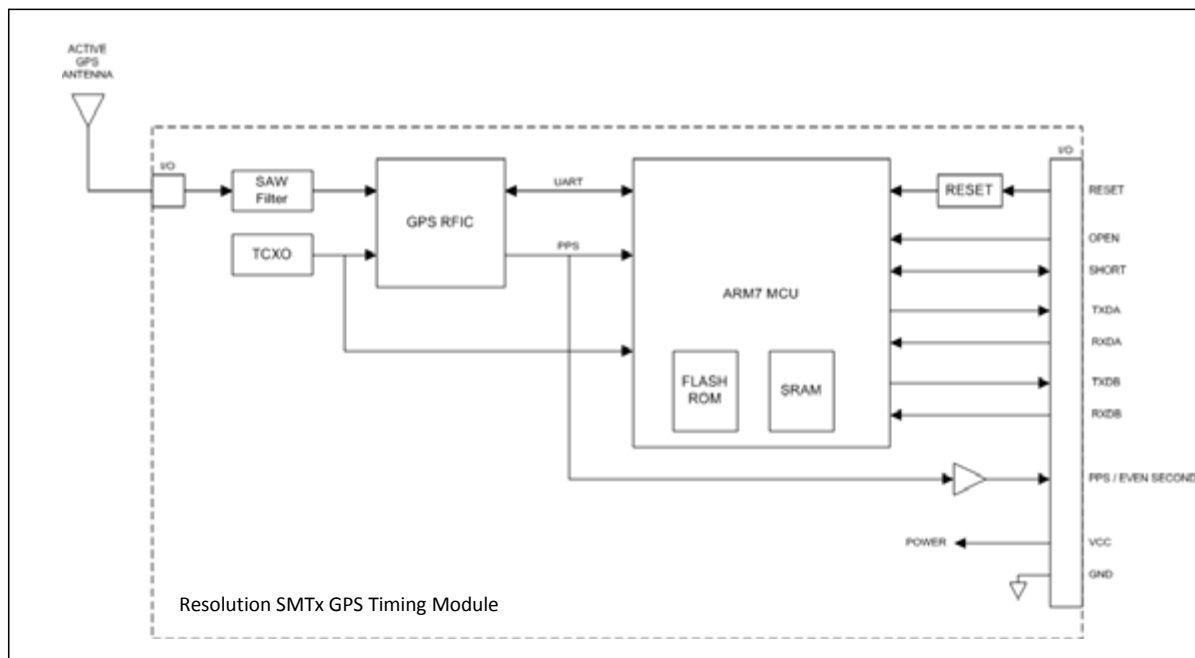
The single-sided module is packaged in tape and reel for pick and place manufacturing processes: 28 reflow-solderable edge castellations provide an interface to your design without costly I/O and RF connectors. Each module is manufactured and factory tested to Trimble's high quality standards.

- 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 14 GPS 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 GPS timing receiver 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 SMTx is a GPS timing receiver. It is a complete all-in-view, parallel tracking GPS receiver capable of tracking of up to 14 GPS satellites simultaneously and designed to operate with the L1 frequency, standard position service, and Coarse Acquisition code.

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

## Specifications

### Performance

The Resolution SMTx GPS embedded module is an L1 (1575.42 MHz) frequency, C/A code, GPS receiver capable of tracking of up to 14 GPS satellites simultaneously.

<b>Update rate</b>	TSIP, 1Hz
	NMEA, 1 Hz
<b>PPS accuracy</b>	15 ns (1 sigma)

## Interface

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

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

## Environmental

<b>Operating temperature</b>	-40 °C to +85 °C
<b>Storage temperature</b>	-40 °C to +85 °C
<b>Vibration</b>	0.008 g <sup>2</sup> /Hz, 5 Hz to 20 Hz 0.05 g <sup>2</sup> /Hz, 20 Hz to 100 Hz -3 dB/octave, 100 Hz to 900 Hz
<b>Operating humidity</b>	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 <sub>CC</sub>	Supply voltage (referenced to GND)	-0.3 to +3.6	V
V <sub>I</sub>	Input voltage (referenced to GND)	-0.3 to V <sub>CC</sub> + 0.3	V
V <sub>O</sub>	Output voltage (referenced to GND)	-0.3 to V <sub>CC</sub> + 0.3	V
I <sub>IO</sub>	Input/Output current	25	mA
P <sub>ANT</sub>	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 <sub>CC</sub>	DC supply voltage (referenced to GND)	3.0	3.3	3.6	V
I <sub>CC</sub>	DC supply current		100		mA
V <sub>IL</sub>	Low-level input voltage OPEN, SHORT, RXDA, RXDB			0.8	V
V <sub>IH</sub>	High-level input voltage OPEN, SHORT, RXDA, RXDB	2.0			V
V <sub>IL</sub>	Low-level input voltage RESET			0.2	V
V <sub>IH</sub>	High-level input voltage RESET		1.2		V
V <sub>OL</sub>	Low-level output voltage (I <sub>O</sub> = -100 $\mu$ A) TXDA, TXDB, SHORT, PPS			0.3	V
V <sub>OH</sub>	High-level output voltage (I <sub>O</sub> = +100 $\mu$ A) TXDA, TXDB, SHORT, PPS	V <sub>CC</sub> -0.3			V
I <sub>I</sub>	Input leakage current			$\pm 1$	$\mu$ A
t <sub>W(RESET)</sub>	RESET low pulse width for guaranteed proper reset	100			$\mu$ s
R <sub>PU</sub>	Pull-up resistor (RESET input)		10		k $\Omega$
	Supply ripple noise (1 Hz to 1 MHz)			50	mV <sub>pp</sub>
	Supply ripple noise (GPS TCXO frequency 16.368 MHz $\pm$ 10 kHz)			1	mV <sub>pp</sub>
	GPS TCXO frequency		16.368		MHz
	Input Gain at RF Input	22	25		dB

## ESD protection

ESD testing was performed using test standard IEC 1000-4-2. All inputs and outputs are protected to  $\pm 500$  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.

## 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 SMTx GPS 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 $\Omega$ unbalanced (coaxial) RF input.
4	GND	Ground	Ground	Connect to common ground.
5	OPEN	Antenna OPEN	Input	Logic level from external antenna detection circuit. See “Antenna Detect Truth Table”
6	SHORT	Antenna SHORT	Input / Output	Logic level from external antenna detection circuit. See “Antenna Detect Truth Table”
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.
19	PPS/Even Second	Pulse per second	Output	Logic level timing signal at 1 Hz. Do not connect if not used
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	Reset	Input	Active low logic level reset. If not used, do not connect.
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  $\Omega$  unbalanced GPS 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 <sup>1</sup>	0 <sup>2</sup>
Antenna Shorted reported	0	0
Undefined	0	1

<sup>1</sup> If the SHORT pin is not used it should be pulled to Vcc through a 10kΩ resistor.

<sup>2</sup> 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 μs.

- 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 SMTx GPS timing module. Do not connect these pins.

## Protocols

The following protocols are available on the Resolution SMTx GPS timing module:

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

<sup>1</sup>Requires use of Trimble-proprietary NMEA messages.

## Serial port default settings

The Resolution SMTx GPS timing module supports two serial ports. The default settings are as follows:

Port	Port Direction	Pin #	Protocol	Characteristic				
				Baud rate	Data bits	Parity	Stop bits	Flow control
A	TXDA	17	TSIP out	9600	8	Odd	1	None
	RXDA	16	TSIP in	9600	8	Odd	1	None
B	TXDB	22	Not set <sup>1</sup>	4800	8	Odd	1	None
	RXDB	21	Not set <sup>1</sup>	4800	8	Odd	1	None

<sup>1</sup> 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 SMTx GPS 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 GPS Studio (TGS) 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)

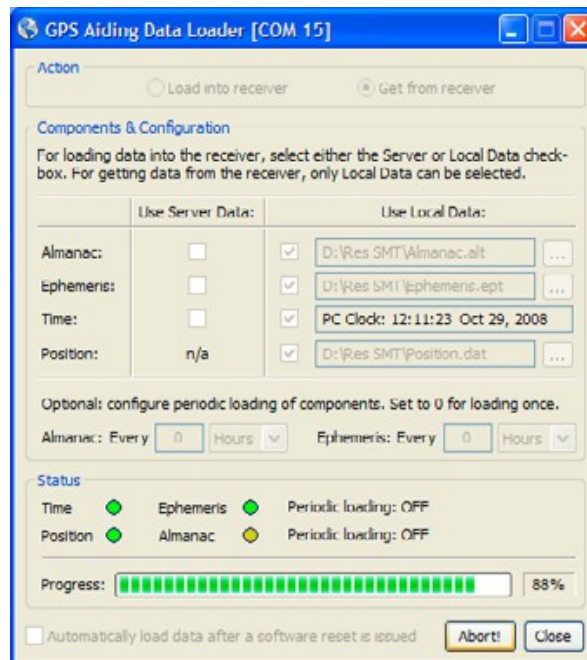
---

## Enabling A-GPS with the Trimble GPS Studio Application

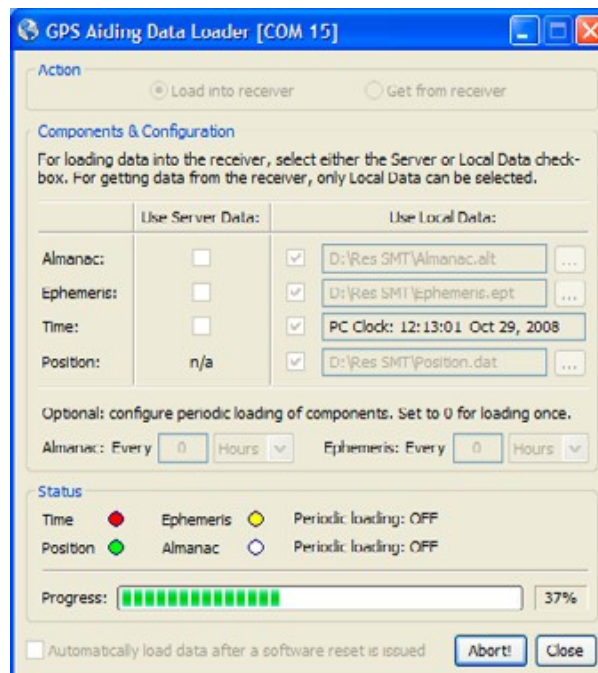
1. Attach the Resolution SMTx GPS interface unit to your computer.
2. Place the GPS antenna where there is a clear view of sky.
3. Allow the receiver to run and calculate fixes.
4. Start TGS and then connect to the receiver.
5. On the main monitor screen, wait for the almanac field to indicate “Complete”.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

*Note – It takes the Resolution SMTx 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 SMTx 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 SMTx GPS timing module is a complete GPS timing receiver designed to operate with the L1 frequency, standard position service, and Coarse Acquisition code. When connected to an external GPS antenna, the receiver contains all the circuitry necessary to automatically acquire GPS satellite signals, track up to 14 GPS 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 SMTx GPS 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 SMTx GPS timing module will not respond to commands sent within the 2 second window and will discard any associated command data

---

## Communicating with the receiver

The Resolution SMTx GPS 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 SMTx GPS 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 9600	Baud rate 9600
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 SMTx GPS 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 TGS or a user-written serial interface program.

### **Port B**

The industry standard port characteristics for NMEA are as follows

<b>NMEA Output</b>
Baud rate 4800
Data bits 8
Parity: None
Stop bits: 1
No Flow Control

*Note – The Resolution SMTx 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 GPS Studio (TGS) 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 TGS).

---

## **Port protocol and data output options**

### **Protocol configuration and interface**

The factory default protocol for the Resolution SMTx GPS timing module is the Trimble Standard Interface Protocol (TSIP), for both input and output. The serial port setting is 9600 bps 8-odd-1. The receiver protocol can be re-configured using TSIP command packet 0xBC, TGS, or a user-written serial interface program.

TGS, 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 SMTx GPS receiver, 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 SMTx GPS timing module including start-up, satellite acquisition, operating modes, serial data communication, and the timing pulse. The Resolution SMTx GPS 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 SMTx 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 SMTx GPS outputs periodic TSIP status messages. These status messages confirm that the receiver is working.

### Automatic operation

When the Resolution SMTx 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 SMTx 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 SMTx continuously tracks and uses up to 14 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 SMTx. 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 SMTx 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 SMTx 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 SMTx automatically switches to Over-determined (OD) Clock mode

### ***Self-survey mode***

At power-on, the Resolution SMTx 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 SMTx 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 SMTx 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.

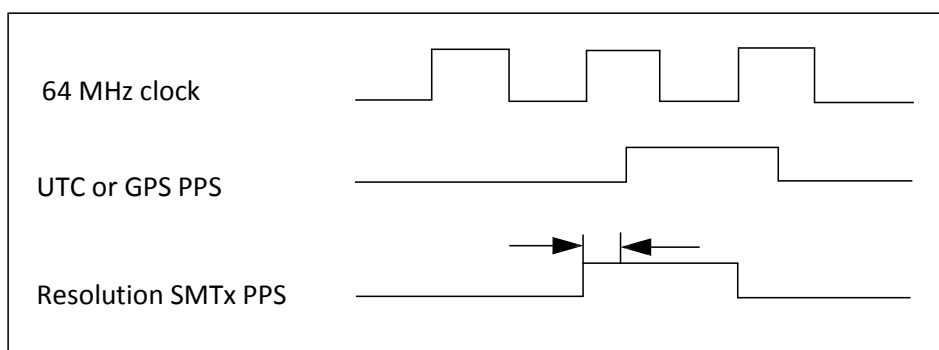
In this mode, the Resolution SMTx does not navigate or update positions and velocities, but maintains the PPS output, solving only for the receiver clock error (bias) and error rate (bias

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 SMTx timing module uses a high-precision, fixed frequency oscillator as the timing source to down-convert and decode the GPS signal and to generate the PPS output signal. Since a fixed-frequency oscillator is used, the Resolution SMTx must place the PPS output on the clock edge that it determines is closest to UTC or GPS 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  $\pm 15$  ns.

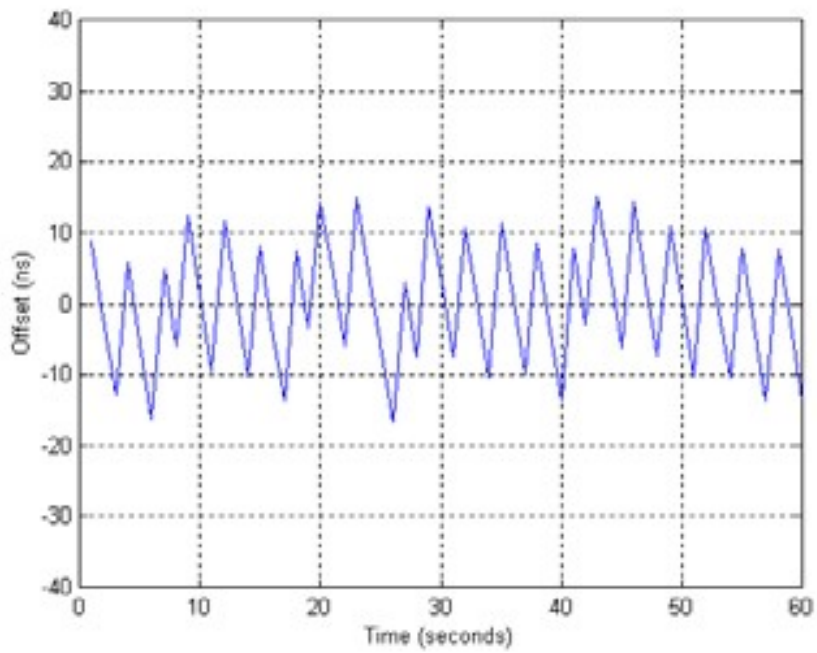
The quantization error is illustrated below. The top waveform represents the 64 MHz clock. The Resolution SMTx output must be placed on one of the edges of this clock. The middle waveform represents the UTC/GPS on-time mark as determined by the receiver's electronics. The bottom waveform represents the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



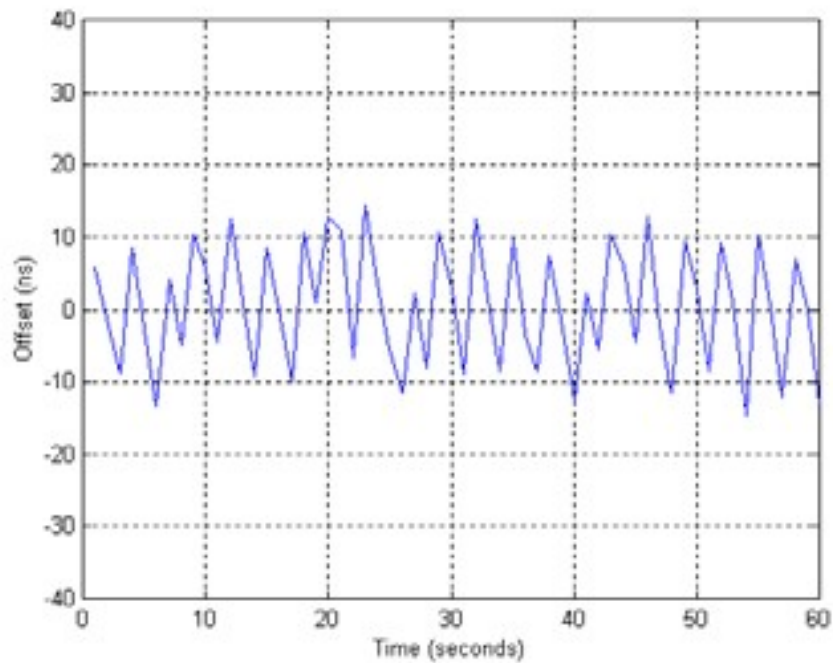
The amount of quantization error present on each PPS output pulse is reported in packet 0x8F-AC. This quantization error information can be used to reduce the effective amount of jitter on the PPS pulse.

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 SMTx in packet 0x8FAC. The bottom plot is the result of subtracting the quantization error from the PPS offset

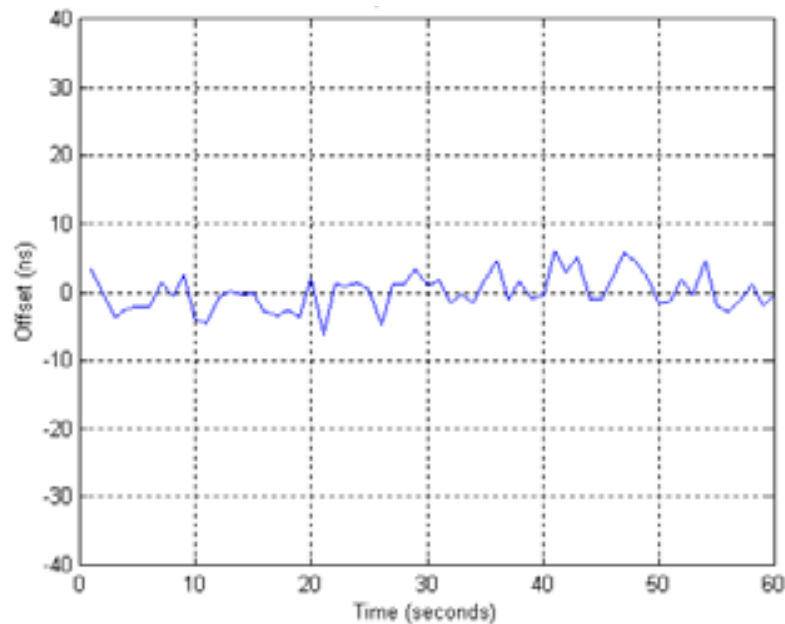
Resolution SMTx Raw PPS Output



Resolution SMTx Quantization Error



## Resolution SMTx with Quantization Error removed



### GPS timing

For many timing applications, such as time/frequency standards, site synchronization systems, and wireless voice and data networks, the Resolution SMTx 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 GPS 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 SMTx 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 SMTx, 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 GPS receiver's clocking rate and software affect PPS accuracy. Using software algorithms like an over-determined clock solution, the Resolution SMTx 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 SMTx 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 SMTx 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 SMTx 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 GPS 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 GPS 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 SMTx'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 SMTx receiver 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 SMTx 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 SMTx 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 SMTx GPS receiver 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 SMTx on a Carrier Board

### In this chapter:

Resolution SMTx carrier board

Connectors

Power requirements

Serial interface

Pulse-per-second (PPS)

Mounting

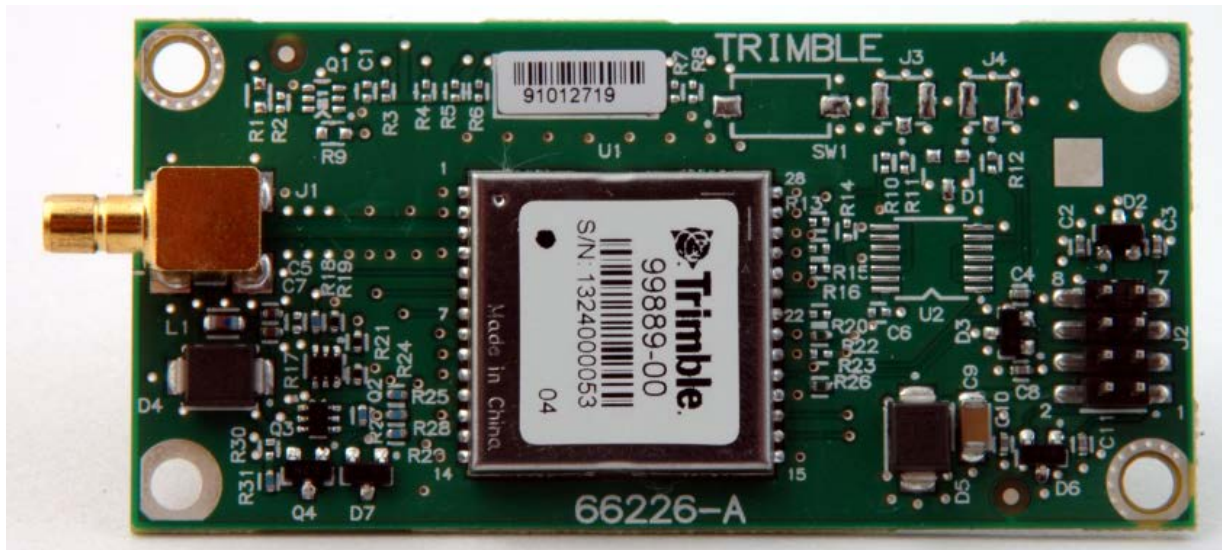
GPS antenna

Mechanical specification

The Trimble Resolution SMTx GPS timing receiver delivers accurate timing solutions for use in all applications where precision timing is needed.



## Resolution SMTx on a carrier board



### Connectors

#### Digital IO/Power connector

The Resolution SMTx on a carrier board GPS receiver 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 SMTx 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 SMTx GPS 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 SMTx GPS 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  $\mu$ 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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

## GPS antenna

Trimble offers the following two antenna options for use with the Resolution SMTx GPS timing module.

- A 3.3 VDC or 5.0 VDC Bullet III rooftop antenna

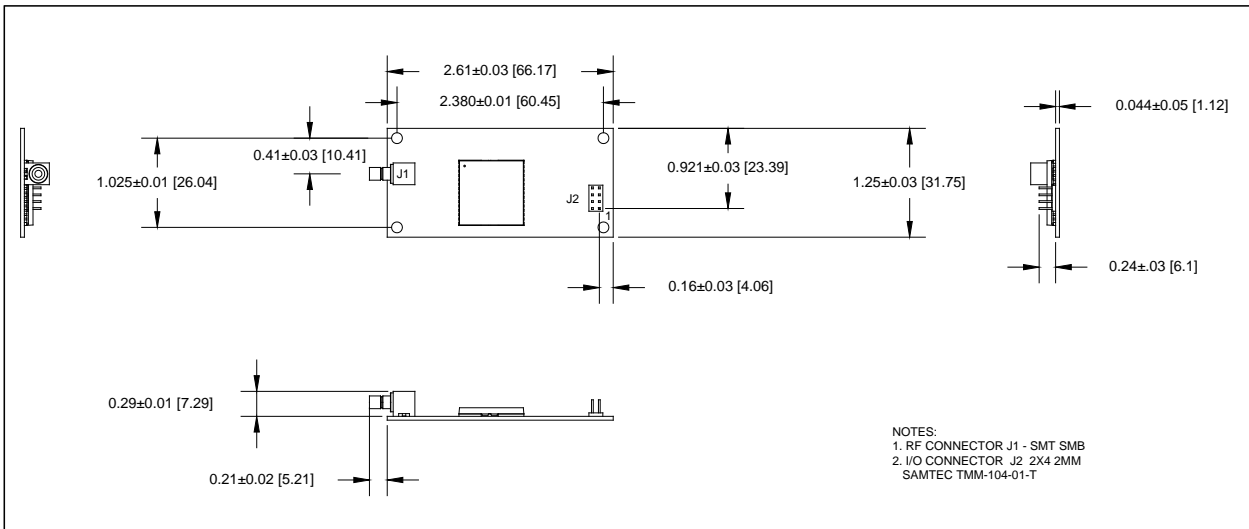


- A magnetic mount antenna



The antenna receives the GPS satellite signals and passes them to the receiver. The GPS signals are spread spectrum signals in the 1575 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 SMTx GPS timing module requires an active antenna. The received GPS 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 GPS signals before delivery to the receiver

## Mechanical specification



## Application Circuits

### In this chapter:

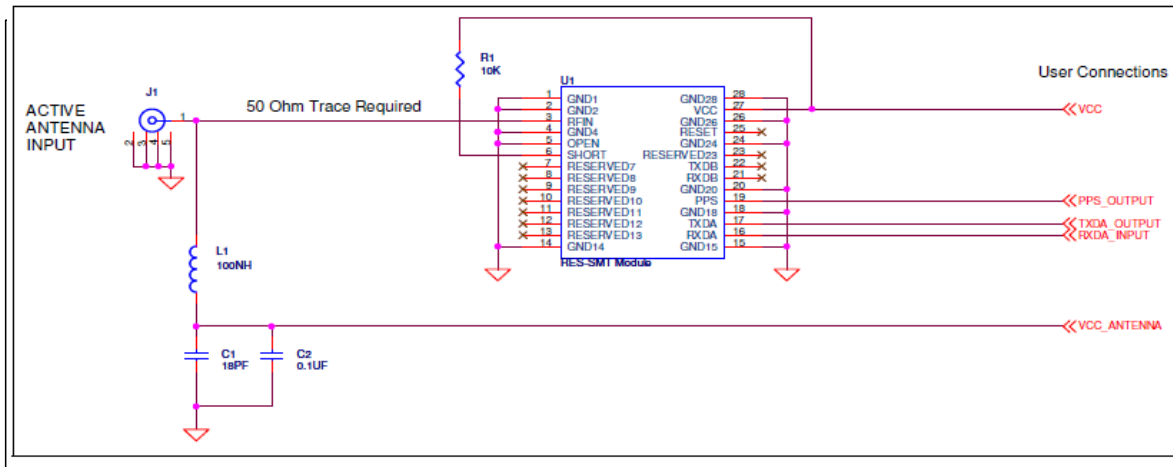
Active antenna – no antenna status

Active antenna – antenna short protection

Active antenna – antenna open and short protection

This chapter describes the Resolution SMTx GPS with active antenna connections.

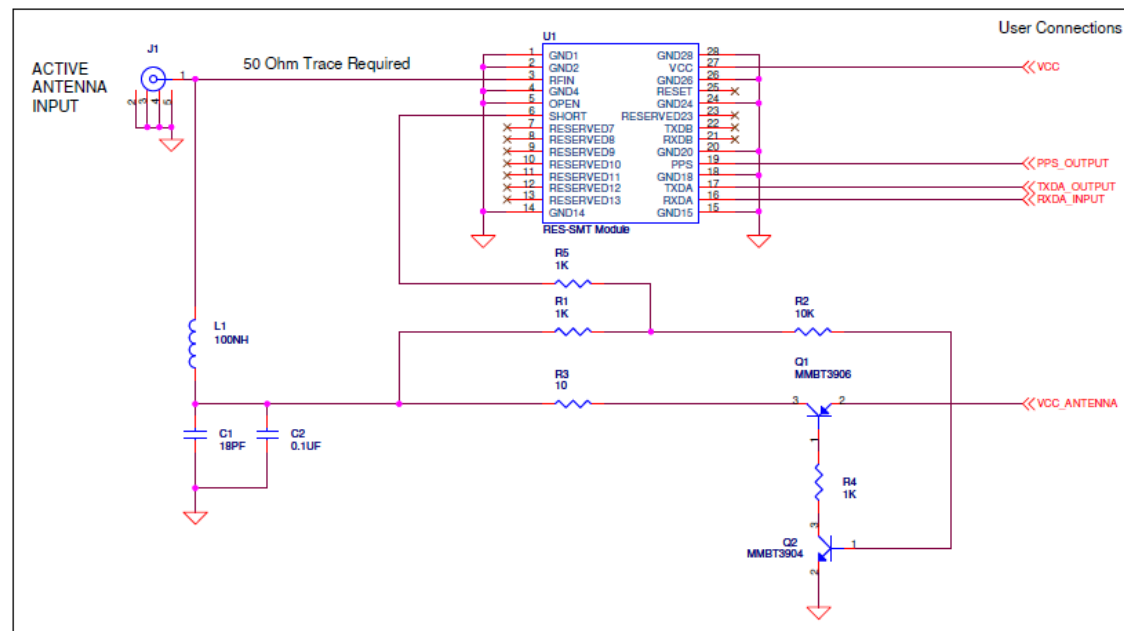
## Active antenna – no antenna status



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:

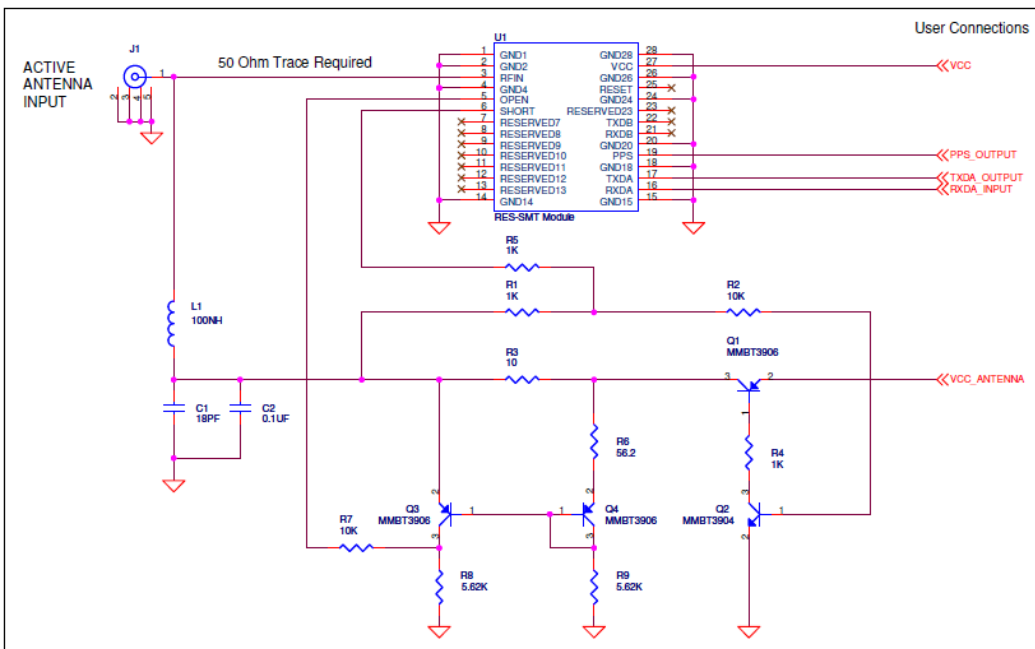
- An active antenna is used.

- 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 $\mu$ 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 Numer
C1	18 PF, 0402 capacitor	KEMET	C0402C180J5GAC
C2	0.1 $\mu$ 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 SMTx GPS timing module.

## General recommendations

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

The radio frequency (RF) input on the Resolution SMTx GPS module is 50  $\Omega$ , 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 GPS antenna at its input.

If the GPS antenna must be located any significant distance from the Resolution SMTx GPS timing module, the use of an LNA at the antenna location is necessary to overcome the transmission losses from the antenna to the Resolution SMTx GPS 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  $\Omega$ , unbalanced transmission system. This transmission system may take any form, such as microstrip, coaxial, stripline, or any other 50  $\Omega$  characteristic impedance unbalanced, low-loss system.

You must keep noise sources with frequencies at or near 1575 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 SMTx GPS module end. A simple series inductor (parallel resonant at 1575 MHz), and shunt capacitor (series resonant at 1575 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 SMTx GPS 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 SMTx GPS module and the board to which it is mounted, and that there is no

interference with features beneath the Resolution SMTx GPS 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 SMTx GPS 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 50 $\Omega$  system.

## Design considerations for RF track topologies

You must take the following into consideration when designing the RF layout for the Resolution SMTx GPS timing module:

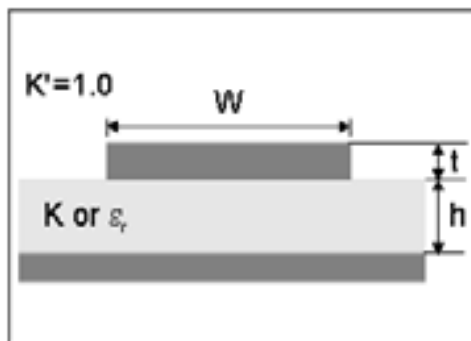
- The PCB track connection to the RF antenna input must:
  - Have a 50  $\Omega$  impedance.
  - Be as short as possible.
  - Be routed away from potential noise sources such as oscillators, transmitters, digital circuits, switching power supplies, and other sources of noise.
  - Transition from the 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



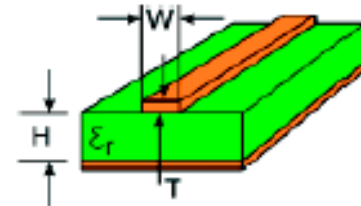
### *Ground plane design recommendation*

Use a complete ground plane immediately under the PCB layer on which the Resolution SMTx 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  $\Omega$  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 ( $\epsilon_r$ )
- PCB copper thickness (T) and proximity of same layer ground plane (to a lesser extent)



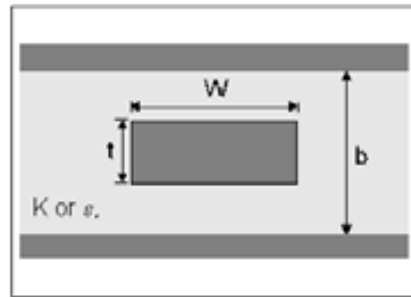
The following table shows typical track widths for an FR4 material PCB substrate (permittivity  $\epsilon_r$  of 4.6 at 1.5 GHz) and different PCB thickness. The thickness of the top layer is assumed as being one ounce copper. If using a multi-layer PCB, the thickness is the distance from the signal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

Substrate	Permittivity	Substrate thickness	Track width
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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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	Track width
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:

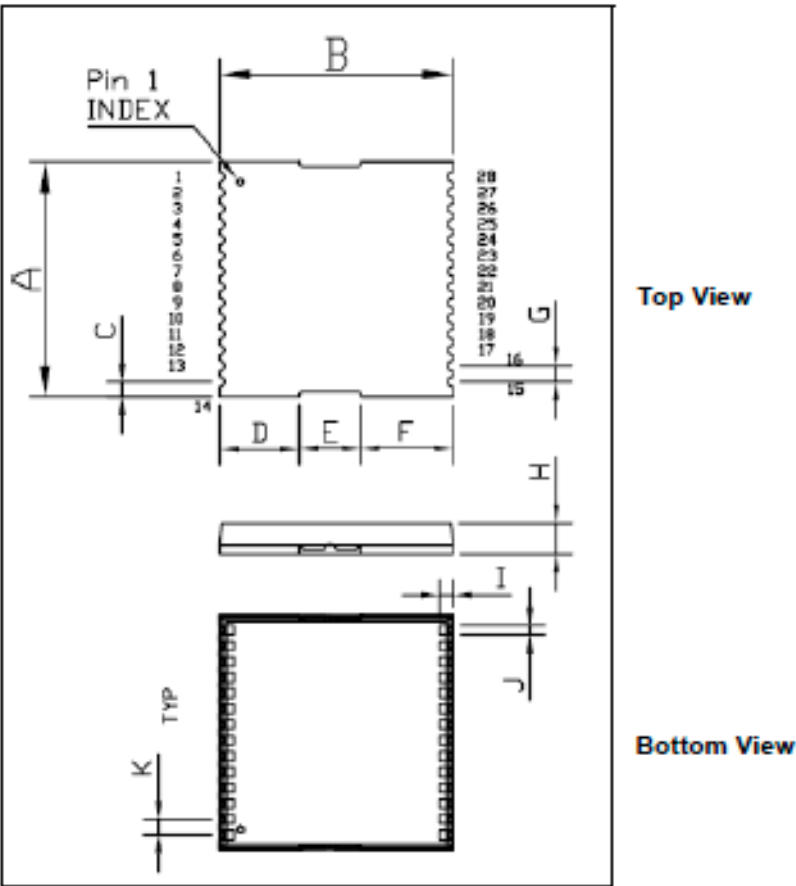
[Mechanical outline drawing](#)

[Soldering the Resolution SMTx GPS receiver to a printed circuit board](#)

This chapter provides product drawings and instructions for soldering the Resolution SMTx GPS timing module to a printed circuit board.

Mechanical outline drawing

Resolution SMTx GPS timing module, footprint



Outline Dimensions ( Inch $\pm 0.004$ )										
mm $\pm 0.10$										
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

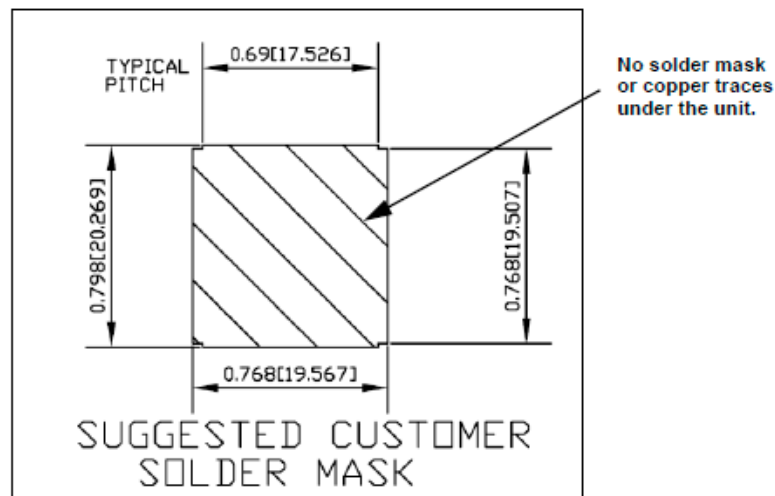
Soldering the Resolution SMTx to a printed circuit board

Note – All units shown are in millimeters.

Solder mask

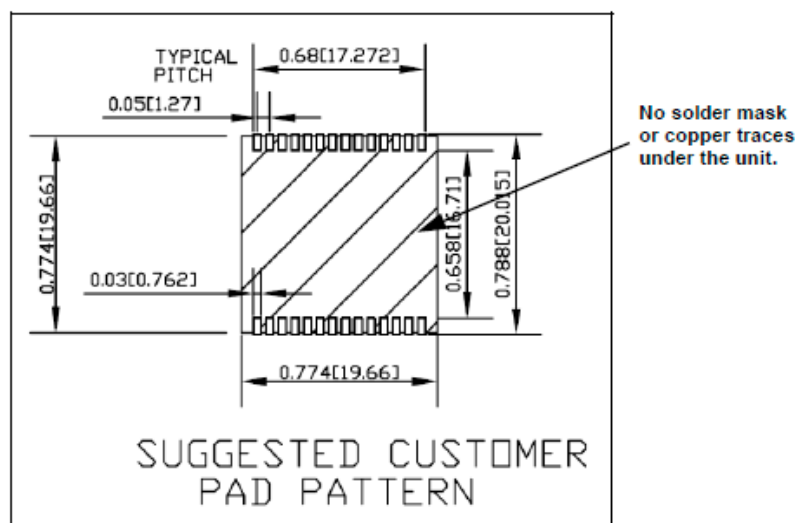
When soldering the Resolution SMTx GPS timing module to a PCB, keep an open cavity underneath the Resolution SMTx module (that is, do not place copper traces or solder mask underneath the module). The diagram below illustrates the required solder mask.





### 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  $5 \pm 1$  Mil stencil to deposit the solder paste, we recommend a 4 Mil toe extension on the stencil.

# Packaging

## In this chapter:

[Introduction](#)

[Reel](#)

[Weight](#)

[Tapes](#)

Follow the instructions in this chapter to ensure the integrity of the packaged and shipped Resolution SMTx GPS timing module modules.

## Introduction

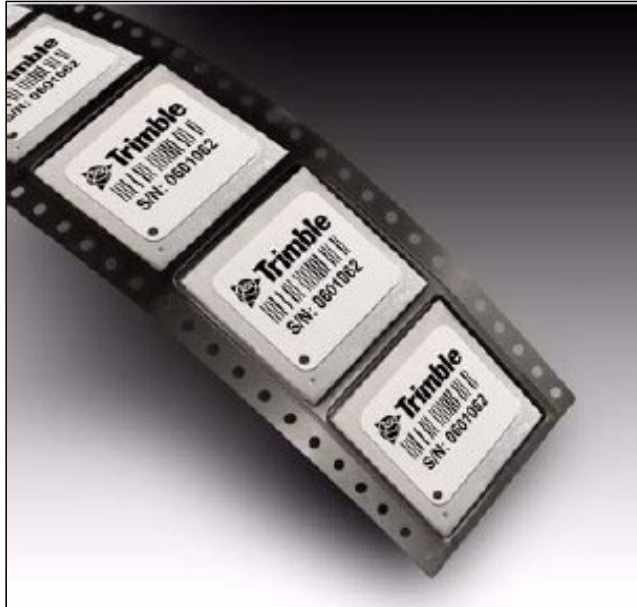
The Resolution SMTx GPS modules are packaged in tape and reel for mass production.

---

**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.

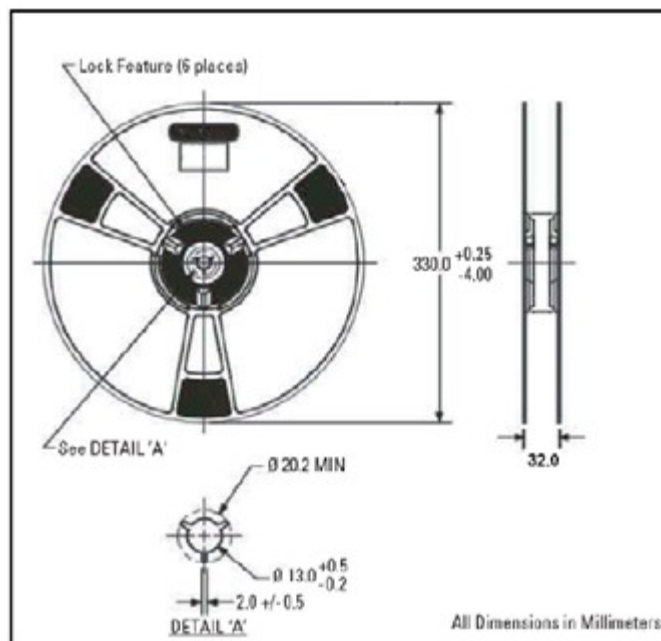
---

The Resolution SMTx GPS 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

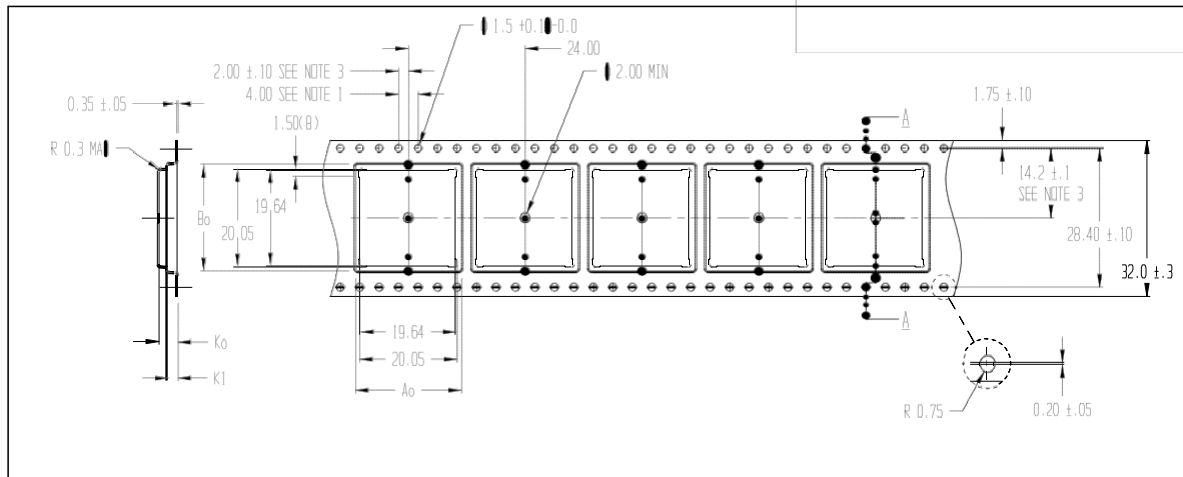


## Weight

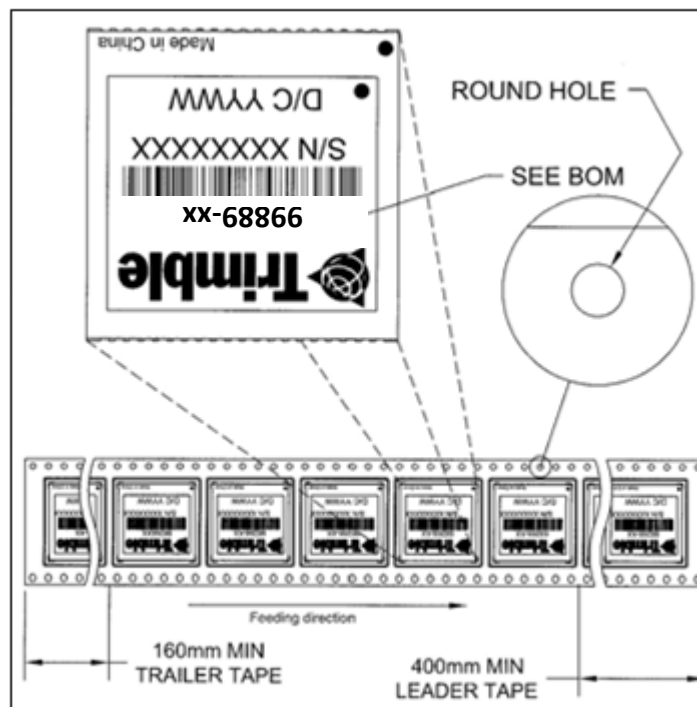
Unit description	Weight (approx.)
500 pieces with reel packaging, desiccant, and humidity indicator	1.47 Kg (3.52lb)
500 pieces with reel packaging, desiccant, humidity indicator & white	1.70 Kg (3.74lb)

## Tapes

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



The feeding direction is illustrated below



# 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 SMTx GPS receiver to ensure compliance with the product warranty.

## Shipping and handling guidelines

### Handling

The Resolution SMTx GPS 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 SMTx 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 SMTx GPS 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 SMTx GPS modules 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 SMTx GPS timing module is a lead-free component and is RoHS compliant. This unit is also plated with immersion gold that makes soldering easier..

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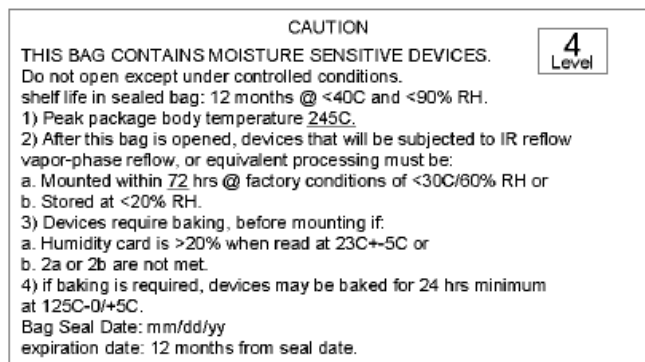
**CAUTION** – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. Ensure that no hand lotion or regular chlorinated faucet water comes in contact with the module before soldering.

---

## 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

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---

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

---

## Soldering paste

The Resolution SMTx GPS 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.

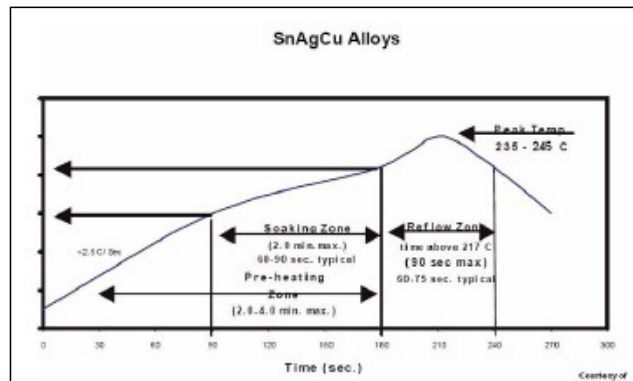
---

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

---

The size of this module is 916.9 mm<sup>3</sup>. 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS 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 SMTx GPS timing module is not allowed and will void the warranty

### **Grounding the metal shield**

The Resolution SMTx GPS 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.

# Trimble Standard Interface Protocol

## In this chapter:

[Introduction](#)

[Customizing operations parameters](#)

[Packets output at startup](#)

[Report packets: Resolution SMTx to User](#)

[Command Packets: User to Resolution SMTx](#)

[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 SMTx customization.

---

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

To customize the Resolution SMTx output for your application:

1. Set up the Resolution SMTx 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 SMTx 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 (9600 bps)	0xBC	0xBC	0xBC
Output baud	7 (9600 bps)			
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 SMTx 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 SMTx

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	0x45
0x1F	software version	0x45
0x24	request GPS satellite selection	0x6D
0x27	request signal levels	0x47
0x2B	initial position (LLA)	0x2B
0x2E	set GPS time	0x4E
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 (and other enabled packets)
0x38	load or request satellite system data	0x58
0x3A	request last raw measurement	0x5A
0x3C	request current satellite tracking status	0x5C
0x7A	NMEA Set/Request	0x7B
0xBB	set receiver configuration	0xBB
0xBC	set port configuration	0xBC
0x8E-4E	PPS output option	0x8F-4E
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-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

## Report packets: Resolution SMTx to User

The table below summarizes the packets output by the Resolution SMTx. 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
0x42	single precision XYZ ECEF position fix	0x35
0x43	velocity fix (XYZ ECEF)	0x37, auto
0x45	software version	0x1E,0x1F, power up
0x47	signal level for all satellites	0x27
0x4A	single precision LLA position	0x37, auto
0x4E	set GPS time	0x2E
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
0x5A	last raw measurement	0x3A
0x5C	current satellite tracking status	0x3C
0x6D	GPS satellite selection	0x24, auto
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-21	accuracy information	0x8E-21
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-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 SMTx 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<sup>-38</sup> to 1.7x10<sup>38</sup>) (24 bit precision)

Double - Float (8 bytes) (1.7x10<sup>-308</sup> to 3.4x10<sup>308</sup>) (53 bit precision)

---

*Note – Default settings are 9600-8-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 SMTx*. 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 SMTx at production.
- The hardware code for the Resolution SMTx is 3017.

- ID for Resolution SMTx timing module is Resolution SMTx.

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

### 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
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	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 SMTx to perform either a cold reset, or a factory reset:

- A cold reset will clear the GPS data (almanac, ephemeris, etc.) stored in RAM and is equivalent to a power cycle.
- A factory reset will additionally 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 SMTx. This packet contains no data. The GPS receiver returns packet 0x45.

### Command Packet 0x24: Request GPS Satellite Selection

This packet requests a list of satellites used for the current position/time fix. This packet contains no data. The GPS receiver returns packet 0x6D.

### Command Packet 0x27: Request Signal Levels

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

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

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

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

*This packet is ignored if the receiver is already calculating positions.* The 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 0x2E: Set GPS Time

This packet provides the approximate GPS time of week and the week number to the GPS receiver. The GPS 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 GPS 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 GPS week number	INT16	Weeks

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

This packet provides an accurate initial position to the GPS receiver in latitude, longitude, and altitude coordinates. Either the single precision or the double precision version of this packet may be used, however, we recommend using the double precision version for greatest accuracy. The GPS receiver returns report packet 0x32, which indicates if the position was accepted by the receiver. The GPS receiver uses this position for performing time-only fixes. If a survey is in progress when this command is issued, the survey is aborted, and this position data is used immediately. The coordinates entered must be in the WGS-84 datum. The Resolution SMTx 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	
1	velocity			1	double-precision position	
					reserved	
		5:7	0		reserved	
					reserved	
		0	0	0	ECEF off	0x43
				1	ECEF on	
2	timing	1	1	0	ENU off	0x56
				1	ENU on	
		2:7	0		reserved	0x42, 0x43, 0x4A, 0x83, 0x84, 0x56,
					reserved	
		0	0	0	GPS time reference	
				1	UTC time reference	

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	

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

### **Command Packet 0x37: Request Status and Values of Last Position**

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

### **Command Packet 0x38: Request/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 GPS receiver unit through a data logger or computer and then using that data to initialize a second GPS receiver unit). The GPS receiver returns packet 0x58.

*Note – The GPS 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

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**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.

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### Command Packet 0x3A: Request last raw Measurement

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

Byte	Item	Type	Value	Meaning
0	Satellite number	INT8	0	All satellites in current tracking set
			1-32	Specific desired satellite

### Command Packet 0x3C: Request Current Satellite Tracking Status

This packet requests the current satellite tracking status. The GPS 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 desired satellite

### 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	On
				1	Off
5	1-7	Reserved	Bit	0	
5	0	GGA	Bit	0	On
				1	Off
5	1	GGL	Bit	0	On

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

### 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 0x42: Single-precision Position Fix

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



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

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

Byte	Item	Type	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 SMTx. The GPS 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 GPS core layer of the firmware.*

### **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 0x4A: Single Precision LLA Position Fix**

The packet provides current GPS position fix in LLA (latitude, longitude, and altitude) coordinates. If the I/O position option is set to "LLA" and the I/O precision of position output is set to single precision, 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 time or UTC, depending on which I/O timing option is selected.

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

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

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### Report Packet 0x4E: Response to Set GPS Time

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

Value	Meaning
ASCII "Y"	The receiver accepts the time entered 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 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	double-precision position	0x83 / 84
		5:7	0		reserved	
1	UINT8 velocity	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 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 GPS data (almanac, ephemeris, and so on). The receiver sends this packet in response to Packet 0x38 (acknowledging the loading of data). The data format is shown below.

#### *Data Format*

Byte	Item	Type	Value	Definition
0	Operation	UINT8	1	Acknowledgement to a load command
			2	Acknowledgement to a request
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 to 32	Satellite PRN number
3	Length (n)	UINT8		Byte count
4 to n+3	Data	UINT8		Table 2.8

#### *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
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	$\alpha_0$	Single	Sec 20.3.3.5.1.9
16-19	$\alpha_1$	Single	Sec 20.3.3.5.1.9
20-23	$\alpha_2$	Single	Sec 20.3.3.5.1.9
24-27	$\alpha_3$	Single	Sec 20.3.3.5.1.9
28-31	$\beta_0$	Single	Sec 20.3.3.5.1.9
32-35	$\beta_1$	Single	Sec 20.3.3.5.1.9
36-39	$\beta_2$	Single	Sec 20.3.3.5.1.9
40-43	$\beta_3$	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	$\Delta t_{LS}$	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	$\Delta t_{LSf}$	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	$\Delta n$	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
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 0x5A: Raw Data Measurement Data

Packet 0x5A provides raw GPS 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 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	PRN
1	0:2	slot number	bit field	0 0 0	not used
1	3:7	channel number	bit field	0 0 0 0	channel 1
				0 0 0 1	channel 2
				0 0 1 0	channel 3
				0 0 1 1	channel 4
				0 1 0 0	channel 5
				0 1 0 1	channel 6
				0 1 1 0	channel 7
				0 1 1 1	channel 8
				1 0 0 0	channel 9
				1 0 0 1	channel 10
				1 0 1 0	channel 11
				1 0 1 1	channel 12
				1 1 0 0	channel 13
				1 1 0 1	channel 14
2		acquisition flag	UNIT8	0	never acquired
				1	acquired
				2	re-opened search
3		ephemeris flag	UNIT8	0	flag not set
				>0	good ephemeris
4-7		signal level	single		dBHz
8-11		time of last	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 0x6D: All-in-View Satellite Selection

This packet provides a list of satellites used for position or time only fixes by the GPS receiver. The packet also provides the PDOP, HDOP, and VDOP of that set and provides the current mode (automatic or manual, 3-D or 2-D, 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 GPS 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
	4:7	number of SVs in fix	bit field	0-14	count
1-4		PDOP	Single		PDOP
5-8		HDOP	Single		HDOP
9-12		VDOP	Single		VDOP
13-16		TDOP	Single		TDOP
17 - n		SV PRN	SINT8	±(1- 32)	PRN

### Report Packet 0x7B: Set NMEA Message Output

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

### Report Packet 0x83: Double Precision XYZ

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O "position" option is set to "XYZ ECEF" and the I/O double position option is selected, the receiver sends this packet each time a fix is computed. 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 time or UTC, as selected by the I/O "timing" option. Packet 0x42 provides a single-precision version of this information.*

### Report Packet 0x84: Double Precision LLA Position Fix and Bias Information

This packet provides current GPS position fix in LLA coordinates. If the I/O "position" option is set to "LLA" and the double position option is selected (see packet 0x35), the receiver sends this packet each time a fix is computed.

Byte	Item	Type	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 time or UTC time as selected by the I/O "timing" option.*

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

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### 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 GPS 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	Reserved	(automatic)
			3	Reserved	
			4	Reserved	
			5	Reserved	
			6	Reserved	
			7	Over Determined Clock	
2	reserved	UINT8	0xFF	do not alter	
3	reserved	UINT8	0xFF	do not alter	
4	reserved	UINT8	0xFF	do not alter	
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	Signal Level Mask	Single	0 - 55 dBHz	Minimum signal level for fixes. The signal level mask is used only when receiver is operating in the Over Determined Clock mode.	0
13-16	reserved	Single	-1	do not alter	
17-20	reserved	Single	-1	do not alter	
21	reserved	UINT8	0xFF	do not alter	
22	Anti-jamming mode	UINT8	0	Disabled	
			1	Enabled	1
23	reserved	UINT8	0xFF	do not alter	
24	reserved	UINT8	0xFF	do not alter	
25	reserved	UINT8	0xFF	do not alter	
26	reserved	UINT8	0xFF	do not alter	
27-39	reserved	UINT8	0xFF	do not alter	

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**CAUTION** – The operation of the Resolution SMTx 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 SMTx 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	0	None
			1	None
			2	None
			3	None
			4	None
			5	None
			6	4800 bps
			7	9600 bps
			8	19200 bps
			9	38400 bps
			10	57600 bps
			11	115200 bps
2	Output Baud Rate	UINT8	As above	As above
3	# Data Bits	UINT8	2	7 bits
			3	8 bits

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-21, 21 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-21: Request Accuracy Information

This packet requests accuracy information about the current position fix in a fixed length 11-byte packet. The reported accuracy information is for a GPS fix which is output only when the receiver mode is automatic (see packet 0xBB) and the packet broadcast mask has the "automatic outputs packets" bit set (see packet 0x8E-A5). When the receiver mode is over-determined clock, and the stored position is available, the timing accuracy information is available in packet 0x8F-AC.

This packet requests Packet 0x8F-21 or marks it for automatic output. If only the first byte (0) is sent, an 0x8F-21 report containing information about the current position 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. The 8Ex21 command can be issued with no data to request a one-time query of the super packet.

Byte	Item	Value	Type	Meaning
0	Subpacket ID	0x21	UINT8	
1	Packet control	0x00	UINT8	Auto report
		0x01		0 off

### 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.

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### 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 SMTx PPS characteristics. The Resolution SMTx responds to a query or set command with packet 8F-4A.

Byte	Item	Type	Value	Meaning
0	Subcode	UINT8	0x4A	
1	PPS driver switch	UINT8	0	off
			1	on
2	Reserved	UINT8		
3	PPS polarity	UINT8	0	positive
			1	negative
4-11	PPS offset or cable delay (see note)	Double		seconds
12-15	Reserved	Single	0	

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

### 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 SMTx 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
				PPS is output when at least one satellite is tracking. PPS is generated every even second
			131	PPS is output when at least three satellites are tracking
			132	PPS is generated every even second

### Command Packet 0x8E-A2: UTC/GPS Timing

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

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	UINT8	0xA2	
1	0 1	UTC/GPS time	bit field	0	GPS time/date in packet 0x8F-AB
			bit field	1	UTC time/date in packet 0x8F-AB
				0	PPS referenced to GPS time
				1	PPS referenced to UTC 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 SMTx 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 SMTx 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
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 GPS 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 SMTx 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 SMTx 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 SMTx 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 SMTx 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 second
			2	Send 0x8F-AB and 0x8F-AC on-time next second

The Request Type item determines how the Resolution SMTx 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-21: Request Accuracy Information

This packet returns accuracy information about the current position fix, in a fixed length 11-byte packet. The packet comes out every second. This accuracy information is for a GPS fix which is output only when the receiver mode is automatic (see packet

0xBB) and the packet broadcast mask has the "automatic outputs packets" bit set (see packet 0x8E-A5). When the receiver mode is over-determined clock, and the stored position is available, the timing accuracy information is available in packet 0x8F-AC.

Byte	Item	Type	Value	Range	Meaning
0	Subpacket ID	UINT8	0x21		Packet sub-code (always 0x21)
1	Foramt type	UINT8	0x01		
2-3	East uncertainty	INT16	Fixed point quantum = 0.01m	(0-320)m	0xFFFF = no uncertainty 0xFFFE = overflow
4-5	North	INT16	Fixed point quantum = 0.01m	(0-320)m	0xFFFF = no uncertainty 0xFFFE = overflow
6-7	Vertical	INT16	Fixed point quantum = 0.01m	(0-320)m	0xFFFF = no uncertainty 0xFFFE = overflow
8-9	Reserved	INT16	0		Reserved
10-11	Reserved	SINT16	0		Reserved
12	Reserved	UINT8	0		Reserved

### 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	
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. GPS week number, GPS 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 GPS time for the current GPS week. Time of week is often abbreviated as TOW.
- Week Number: This field represents the current GPS week number. GPS week number 0 started on January 6, 1980.
- UTC Offset: This field represents the current integer leap second offset between GPS and UTC according to the relationship:  $\text{Time (UTC)} = \text{Time (GPS)} - \text{UTC Offset}$ . The UTC offset information is reported to Resolution SMTx by the GPS system and can take up to 12.5 minutes to obtain. Before the Resolution SMTx 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. When 1, the Resolution SMTx is in a test mode and time is being generated by the test mode selected by the user.

See packet 8E-A4, Test Modes.

- 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	time from GPS
				1	time from user
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(for example 1998)

---

### 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 GPS receiver is currently configured for. The Resolution SMTx 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 SMTx 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 SMTx.

- 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 SMTx 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 GPS system has alerted the Resolution SMTx that a leap second transition is pending.
- Bit 8: When 1, indicates that the Resolution SMTx 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.
- 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.
- Temperature: This field shows the temperature (in Celsius) as reported by the Resolution SMTx's on-board temperature sensor.

- Latitude: This field carries the latitude of the position being shown. The units are in radians and vary from  $-\pi/2$  to  $+\pi/2$ . Negative values represent southern latitudes. Positive values represent northern latitudes.
- Longitude: This field carries the longitude of the position being shown. The units are in radians and vary from  $-\pi$  to  $+\pi$ . Negative values represent western longitudes. Positive values represent eastern longitudes.
- Altitude: This field carries the altitude of the position being shown. The units are in meters (WGS-84.)
- PPS Quantization Error: This field carries the PPS quantization error in units of seconds.

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0xAC	
1	Receiver Mode	UINT8	0	Automatic (2D/3D)
			7	Over-determined Clock
2	Reserved	UINT8	0	Reserved
3	Self-Survey Progress	UINT 8		0-100%
4-7	Reserved	UINT 32	0	Reserved
8-9	Reserved	UINT16	0	Reserved
10-11	Minor Alarms	UINT16	bit field	Bit 0: not used Bit 1: Antenna open Bit 2: Antenna shorted Bit 3: Not tracking satellites Bit 4: not used Bit 5: Survey-in progress Bit 6: no stored position Bit 7: Leap second pending Bit 8: In test mode Bit 9: Position is questionable Bit 10: not used Bit 11: Almanac not complete Bit 12: PPS was generated
12	GPS Decoding Status	UINT8	0	Doing fixes
			1	Don't have GPS time
			3	PDOP is too high
			8	No usable sats
			9	Only 1 usable sat

0x0A	Only 2 usable sats
0x0B	Only 3 usable sats
0x0C	The chosen sat is unusable

13	Reserved	UINT8	0	Reserved
14	Spare Status 1	UINT8	0	
15	Spare Status 2	UINT8	0	
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	Temperature	Single		degrees C
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

# 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 SMTx.

## 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 GPS receiver, NMEA 0183 is a popular choice since, in many cases, an NMEA 0183 software application code already exists. The Resolution SMTx 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	4800
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 SMTx. 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.
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
<b>Special Format Fields</b>		
Latitude	IIII.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.

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 SMTx can output any or all of the messages listed in the table below. In its default configuration (as shipped from the factory), the Resolution SMTx 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 SMTx GPS 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.
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 GPS receiver.

```
$GPGGA,hhmmss.sss,lll.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,lll.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 GPS receiver's operating mode and lists the satellites used for navigation and the DOP values of the position solution.

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

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 GPS satellites in view, including their PRN number, elevation, azimuth and SNR value. Each message contains data for four satellites. Second and third messages are sent when more than 4 satellites are in view. Fields #1 and #2 indicate the total number of messages being sent and the number of each message respectively.

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

Field	Description
1	Total number of GSV messages
2	Message number: 1 to 3
3	Total number of satellites in view
4	Satellite PRN number
5	Satellite elevation in degrees (90° Maximum)
6	Satellite azimuth in degrees true (000 to 359)
7	Satellite SNR (C/No), null when not tracking
8, 9, 10, 11	PRN, elevation, azimuth and SNR for second satellite
12, 13, 14, 15	PRN, elevation, azimuth and SNR for third satellite
16, 17, 18, 19	PRN, elevation, azimuth and SNR for fourth satellite
hh	checksum

### RMC - Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the GPS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed 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.sss,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
6	Unused
hh	Checksum

*Note – Fields #5 and #6 are null fields in the Resolution SMTx output. A GPS receiver cannot independently identify the local time zone offsets.*

---

**CAUTION** – If UTC offset is not available, time output will be in GPS time 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
hhhhhhhh	Satellite 1 - 4 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 5 - 8 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 9 - 12 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 13 - 16 health, one byte for each satellite, HEX data conforming to GPS ICD 200
hh	Checksum

### Message 2

\$PTNLaAH,2,hh,hhhhhhhh,hhhhhhhh,hhhhhhhh,hh\*hh<CR><LF>

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

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

## AL - Almanac Page

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

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

Field	Description
xx	Satellite ID

The set or response format is as follows:

```
$PTNLAL,xx,x.x,hh,hhhh,hh,hhhh,hhhh,hhhh,hhhh,hhhh,h,hhhh,h,h,h,h*  
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:

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

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

The corresponding response for the set is:

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

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

## BA - Antenna Status

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

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

The Response to query sentence format is:

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

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



## CR - Configure Receiver

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

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

Field	Description
a	Mode Q – Query S – Set R – Response
x.x	Signal level mask in dB-Hz (default = 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
A	Reserved

## EM - Enter Monitor Mode

This sentence is used to set the Resolution SMTx GPS 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

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

### **FS - Acquisition Sensitivity Mode**

This sentence sets or requests the current GPS Receiver Acquisition Sensitivity Mode. By default the Acquisition Sensitivity Mode is set to High.

\$PTNLaFS, a, x,\*hh<CR><LF>

Field	Description
a	Mode Q - Query S – Set R – Response
A	S = standard Mode, H -= High Mode
X	Reserved, always 0
hh	checksum

#### *Example set to high-sensitivity mode*

\$PTNLSFS,H,0\*38 # sent

\$PTNLRFS,A\*2C # received, A= Valid command, V= Invalid command

#### *Example set to Query mode*

\$PTNLQFS\*42 # sent \$PTNLRFS,H,0\*39 # received

## IO - Ionosphere

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

\$PTNLaiO, hh, hh, hh, hh, hh, hh, hh, hh\*hh, <CR><LF>

Field	Description
a	Mode Q – Query S – Set R – Response
hh	Alpha_0, HEX data conforming to GPS ICD 200.
hh	Alpha_1, HEX data conforming to GPS ICD 200.
hh	Alpha_2, HEX data conforming to GPS ICD 200.
hh	Alpha_3, HEX data conforming to GPS ICD 200.
hh	Beta_0, HEX data conforming to GPS ICD 200.
hh	Beta_1, HEX data conforming to GPS ICD 200.
hh	Beta_2, HEX data conforming to GPS ICD 200.
hh	Beta_3, HEX data conforming to GPS ICD 200

## KG - Set Initial Position

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

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

\$PTNLaKG,x.x,x.x,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
GGA, GLL and TF	0203

## **PS - PPS Configuration**

This sentence can query or set PPS configuration data.

\$PTNLaPS,b,x...x,6,x...x\*hh<CR><LF>

Field	Description
a	Mode Q – Query S – Set R – Response
b	PPS mode, default is 1 0 – PPS_OFF (Always Off) 1 – PPS_ON (Always On or Early PPS) 2 – Reserved 3 – Reserved

x...x	Reserved
c	Output pulse polarity, default is 1: 0 -output pulse is active low 1 -output pulse is active high
x...x	Antenna Cable Length Compensation. Default = 0, Units in nanoseconds. Can be positive or negative. Negative value will mean PPS comes out earlier, e.g. to compensate for cable delay
Field value range is -100000000...100000000 (±100 milliseconds)	

## PT - Serial Port Configuration

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

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

The Response to query or Set sentence format is:

```
$PTNLRPT,xxxxxx,b,b,b,h*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.

```
$PTNLrRT,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

## **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 GPS signal**

If the GPS 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.



#### **NORTH AMERICA**

Trimble Navigation Limited  
Corporate Headquarters  
935 Stewart Drive  
Sunnyvale, CA 94085  
+1-800-787-4225  
+1-408-481-7741

#### **EUROPE**

Trimble Navigation Europe  
Phone: +46-8-622-12-79

#### **KOREA**

Trimble Export Ltd, Korea  
Phone: +82-2-555-5361

#### **CHINA**

Trimble Navigation Ltd, China  
Phone: +86-10-8857-7575



[www.trimble.com](http://www.trimble.com)