RESOLUTION T

SYSTEM DESIGNER REFERENCE MANUAL

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About this Manual

This System Designer's Reference Manual describes how to integrate and operate the Resolution T® GPS timing receiver. The instructions in this manual assume that you know how to use the primary functions of Microsoft Windows.

If you are not familiar with GPS, visit Trimble's website, www.trimble.com, for an interactive look at Trimble and GPS.

Technical Assistance

If you cannot locate the information you need in this product documentation, contact the Trimble Technical Assistance Center at 800-767-4822.

CHAPTER

1

STARTER KIT

In this chapter:

- Product Overview
- Starter Kit
- Timing Receiver Performance
- Interface Protocols
- Ordering Starter Kit Components
- Starter Kit Interface Unit
- Power
- Hardware Setup
- Software Toolkit

PRODUCT OVERVIEW

The Trimble Resolution T embedded timing board, is a full featured, 12 channel, parallel tracking 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. It features an off-the-shelf, low cost, software programmable general purpose Digital Signal Processor (DSP) instead of a custom GPS ASIC.

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

Timing Features

The Resolution T timing features include:

- Automatic Self Survey
- Overdetermined Timing Mode
- Single Satellite Timing Mode
- Timing Super Packets
- TRAIM
- Position RAM
- Cable Delay Compensation
- Accuracy <15 ns (1 sigma).

Basic Operation

The Resolution T automatically initiates a self-survey upon acquisition of GPS satellites. When the survey is completed, the receiver switches into the Overdetermined 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 which allows the receiver to self determine a position change or to remove a satellite providing incorrect information from the timing solution.

NOTE: To offset the delay inherent in the RF cable 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.

Starter Kit

The Starter Kit makes it simple to evaluate the Resolution T receiver performance. The Starter Kit can be used as a platform for configuring the receiver software or as platform for troubleshooting your design. The Starter Kit includes the Resolution T timing module mounted on an interface motherboard in a durable metal enclosure. The motherboard accepts 9 - 32 VDC power and provides regulated +3.3V power to the Resolution T receiver. The motherboard also contains:

- 3.6V lithium battery that provides back-up power to the receiver.
- Circuitry to convert the CMOS output to RS-232, enabling the user to connect the RS-232 port in the Starter Kit to the PC COM port via an RS-232 cable connection.
  - 35 dB, 5.5 VDC Bullet III Rooftop GPS Antenna (F)
  - 50’ R59 antenna cable terminated with F connectors
  - 9-pin RS-232 interface cable.
  - AC/DC power supply adapter (input: 100-240VAC, output: 12 VDC).
  - SMB to F adapter cable.
  - CD containing software tools used to communicate with the receiver, the System Designer Reference Manual, C-programming source routines to be used as a template for communicating with the receiver, and the DSP Monitor Program.

REMOVING THE RESOLUTION T MODULE

The Resolution T GPS receiver is secured 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:

- Disconnect power to the enclosure.
- Remove base plate and unplug the RF cable from the receiver.
- Use a small Phillips headed screw driver to remove the securing hardware which holds the Resolution T GPS receiver to the motherboard.
- Gently rock the board loose from the motherboard I/O connector.

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 interface unit motherboard contains a 3.6 VDC lithium battery.

The Resolution T is designed for embedded applications. The digital I/O lines and power lines are not designed with additional ESD protection like a stand-alone receiver would be. Use standard CMOS ESD handling precautions when removing and installing the receiver module.

TIMING RECEIVER PERFORMANCE

The Resolution T GPS timing receiver is a complete 12-channel, parallel tracking, GPS receiver, designed to operate with the L1 frequency, Standard Position Service, Coarse Acquisition code. Using the Trimble Colossus RF Downconverter and Texas Instruments 5509 series General Purpose DSP, 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 T 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 Overdetermined Clock mode and no longer solve for position but only for clock error and clock bias using all of the available satellites. 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 or battery back-up power applied. The Resolution T receiver has a single configurable serial I/O communication port.

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

INTERFACE PROTOCOLS

The Resolution T receiver operates using one of two protocols—Trimble Standard Interface Protocol (TSIP) or NMEA 0183. The factory default setting for the I/O port is TSIP bi-directional. Protocol selection and port characteristics are user configurable.

TSIP

TSIP (Trimble Standard Interface Protocol) is a powerful binary packet protocol that allows the system designer maximum configuration control over the GPS receiver for optimum performance in timing applications. TSIP supports multiple commands and their associated response packets for use in configuring the Resolution T receiver to meet user requirements.

NMEA

NMEA 0183 (National Marine Electronics Association) is an industry standard protocol common to marine applications. NMEA provides direct compatibility with other NMEA-capable devices such as chart plotters, radar, etc. The Resolution T receiver supports the ZDA NMEA message for GPS timing. Other NMEA messages and output rates can be user selected as required.

ORDERING STARTER KIT COMPONENTS

The Resolution T GPS receiver 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:

- SMB to F, RG213 antenna transition cable.
- AC/DC power supply adapter.
- DC Power cable (3-wire).
- RS-232 interface cable DB9M/DB9F (pin to pin).
- 50' RG59 rooftop antenna cable (F to F).
- CD-ROM containing the Trimble Standard Interface Protocol (TSIP) for Resolution T, the System Designer Reference Manual, and the DSP_Monitor software.

The following table provides ordering information for the Resolution T GPS receiver and the associated antennas and cables.

Product	Part Number
Resolution T GPS timing receiver	52664-00
Resolution T GPS receiver Starter Kit	53188-00
Antenna transition cable RG213 SMB-F	22806
Bullet III 5.5 VDC rooftop Antenna (F type)	41556-00
50' RG59 Rooftop antenna cable	23420
RS-232 interface cable DB9M/DB9F	19309-00
Power cable	20260

Table 1: Ordering Products

NOTE: Part numbers are subject to change. Confirm part numbers with your Trimble representative when placing your order. Other rooftop cables and antenna combinations are also available.

STARTER KIT INTERFACE UNIT

The Starter Kit interface unit consists of a Resolution T GPS receiver attached to an interface motherboard, housed in a sturdy metal enclosure. This packaging simplifies evaluation and software development with the receiver by providing an RS-232 serial interface which is compatible with most PC communication ports. Power (9-32 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 volts required by the receiver and the 5 volts required by the antenna. The DB9 connector allows for an easy connection to a PC serial port using the serial 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 T GPS receiver, installed in the Starter Kit interface unit, is a single port receiver. 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 3.3VDC antenna can also be supported) On the Resolution T GPS receiver, an 8-pin (2x4), 2 mm header (J4) supports the serial interface (CMOS level), the pulse-per-second (PPS) signal (CMOS level), and the input power (+3.3 VDC). Figure 1 illustrates the receiver in the metal enclosure.

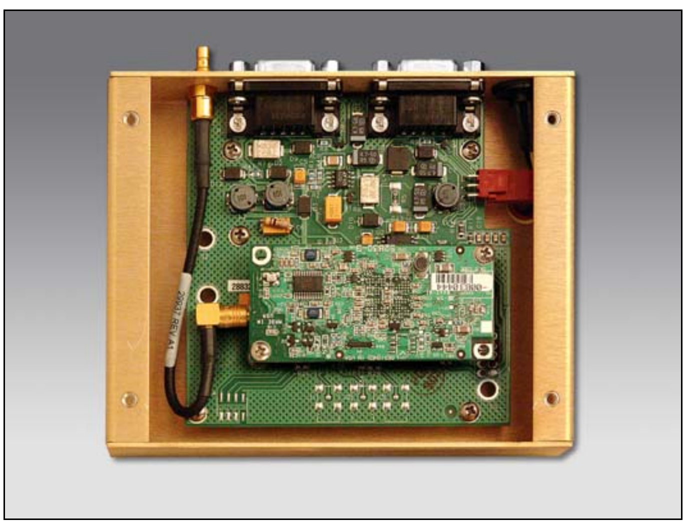


Figure 1—GPS Receiver in Enclosure

The interface motherboard includes a 9 to 32 VDC switching power supply which provides regulated +3.3 VDC power to the receiver, regulated +5 VDC power to the antenna, and contains circuitry which provides an RS-232 interface to a computer. The CMOS level PPS is brought directly out to Pin 9 of the Port 2 DB9 connector on the front of the interface unit.

The Starter Kit includes an AC/DC converter for powering the module from an AC wall socket. The metal enclosure (see Figure 2) provides 2 DB9 interface port connectors, an antenna connector, and a power connector. Port 1 on the metal enclosure is for serial I/O; port 2 is for PPS only.

Figure 2—Starter Kit Interface Unit

The mounting plate is secured to the metal enclosure with four screws. The eight pin I/O header on the receiver module connects directly to the motherboard. Figure 2 illustrates the Starter Kit interface unit.

Serial Port Interface

The Starter Kit interface unit is a DCE (Data Communication Equipment) device. To connect to a host computer, or DTE (Data Terminal Equipment) device, use a straight through cable. To connect a Differential Radio (DCE device) to the receiver (DCE Device) use a cross over cable or null modem cable

Pin	Description
1	NC
2	TX
3	RX
4	NC
5	GND
6	NC
7	NC
8	NC
9	NC

Table 2: Port 1 Pinouts

Pin	Description
1	NC
2	NC
3	NC
4	NC
5	GND
6	NC
7	NC
8	NC
9	PPS Out

Table 3: Port 2 Pinouts

Pulse-Per-Second (PPS)

The receiver provides a 1.0 millisecond wide, CMOS compatible Pulse-Per-Second (PPS). The PPS is a positive pulse available on pin 9 of the port 2 DB9 connector of the interface unit (see Table 3). The rising edge of the pulse is synchronized to GPS. The timing accuracy is <15 nanoseconds (1 σ) when operating in the Overdetermined Timing Mode. The rising edge of the pulse is less than 20 nanoseconds. The PPS is capable of driving a load up to 5mA without damaging the receiver.

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

POWER

The Resolution T GPS receiver 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 9 to 32 VDC input to the regulated 3.3 VDC required by the receiver and the regulated 5VDC required by the antenna. Power can be applied to the interface unit using one of two options: the DC power cable, or the AC/DC power converter.

DC Power Cable

The DC power cable is ideal for bench-top testing environments. The power cable is terminated at one end with a 3-pin plastic connector which mates with the power connector on the metal enclosure. The un-terminated end of the cable provides easy connection to a DC power supply. Connect the red power lead to a source of DC positive +9 to +32 VDC, and connect the black power lead to ground. This connection supplies power to both the receiver and the antenna. The yellow wire of the DC power cable is not used. Battery back-up power is provided by a factory installed 3.6V lithium battery on the motherboard.

Figure 3—AC/DC Power Converter

NOTE: To ensure compliance with CE conducted emissions requirements when using the DC power cable, the Starter Kit interface unit must be bonded to a ground plane.

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 12 VDC compatible with the interface unit. The AC/DC power converter output cable is terminated with a 3-pin connector compatible with the power connector on the metal enclosure. The AC power cable is not provided in the kit, since this cable can be country-specific. The input connector is a standard 3-prong connector used on many desktop PCs.

Figure 4—DC Power Converter

HARDWARE SETUP

The Resolution T GPS receiver supports the TSIP or NMEA protocols. A single port supports either the input/output of TSIP messages or the output of NMEA messages. Follow the steps below to setup the Starter Kit interface unit. Figure 5 illustrates the setup.

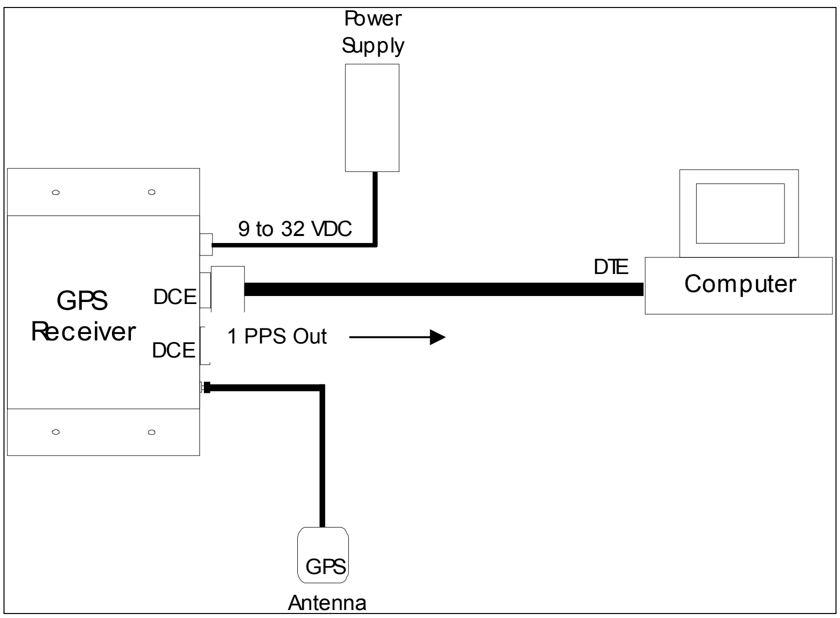


Figure 5—Starter Kit Interface Unit

- When using the TSIP protocol, connect one end of the 9-pin serial interface cable to Port 1 of the interface unit. Connect the other end of the cable to COM1 or COM2 on a PC. A 9-pin-to-25-pin adapter may be required for the serial interface connection to a PC, if your PC has a 25-pin communication port.
- Connect the antenna cable to the interface unit. This connection is made by attaching the antenna cable connector onto the SMB connector on the module. Place the antenna so that it has a clear (180) view of the sky. A reduced number of satellites will be available if this direct view is obstructed.
- Using either the DC power cable or an AC/DC power converter, connect to the 3-pin power connector on the interface unit.
  - DC Power Cable — Connect the terminated end of the power cable to the power connector on the interface unit. Connect the red lead to DC positive voltage (+9 to +32 VDC) and black power lead to DC ground. The yellow wire is not used. Switch on the DC power source.
  - AC/DC Power Converter — Connect the output cable of the converter to the 3-pin power connector on the interface unit. Using the appropriate 3-prong AC power cable (not provided), connect the converter to an AC wall socket (110 VAC or 220 VAC). The AC power cable is not provided in the Starter Kit.

SOFTWARE TOOLKIT

The CD provided in the Starter Kit contains the DSP Monitor program used to monitor GPS performance and to assist system integrators in developing a software interface for the GPS module. DSP Monitor runs on the Windows 95/98/2000/XP platforms.

Following are quick start instructions for using the DSP Monitor application to monitor the receiver's performance.

- Connect one end of the serial interface cable to Port 1 of the interface unit. Connect the other end of the cable to the COM port of your PC.
- Turn on the DC power source or plug in the AC/DC converter.
- Insert the CD in the computer's CD-ROM drive.
- The Monitor program, DSPMon.exe, must be copied onto your computer's hard drive.
- Right-click in the bottom right of the DSP monitor screen to specify the communications port and protocol.
- When the DSP_Monitor screen appears, the TX and RX indicators appear in the lower left corner of the status bar. A blinking TX indicates that the PC is transmitting commands to the receiver; a blinking RX indicates that the PC is receiving reports from the receiver. If either of these indicators stop blinking, there is no activity. The PC COM port settings appear in the lower right corner of this same status bar.
- After a GPS antenna is connected to the receiver, the self survey is complete, and the receiver has achieved a position fix, the following information will display:
  - transmitted position reports
  - time
  - velocity
  - satellites tracked
  - GPS receiver status

NOTES: The receiver also sends a health report every few seconds, even if satellites are not being tracked.

If the DSP Monitor program displays a question mark (?) in a data field, the receiver has not reported a status for this field. If a (?) remains in the data field, the GPS module may not be communicating with the computer. Re-check the interface cable connections and verify the serial port selection and settings. If the communication failure, please call the Trimble Technical Assistance Center (TAC) at 1 (800) 767-4822.

CHAPTER

2

HARDWARE INTEGRATION

In this chapter:

- General Description
- Connectors
- Power Requirements
- Serial Interface
- Pulse-Per-Second
- Mounting
- GPS Antenna

GENERAL DESCRIPTION

Trimble's new Resolution T GPS timing receiver delivers accurate timing solutions for use in all applications where precision timing is needed.

The Resolution T GPS timing receiver is packaged in a small form factor. It typically requires 350 mW of power (at 3.3 VDC). The receiver includes flash memory for field upgrades and for storing the user configuration.

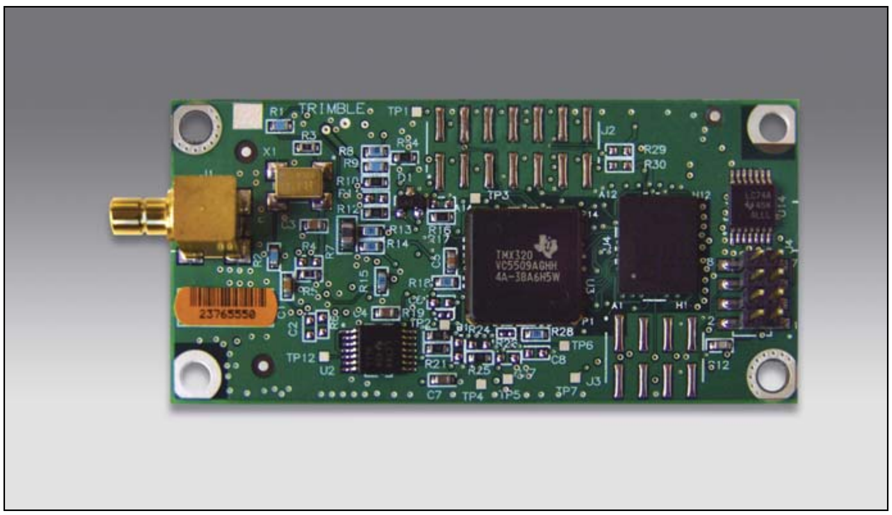


Figure 6—Resolution T Board

CONNECTORS

Digital IO/Power Connector

The Resolution T 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 0.126 inch (3.2 mm) high pins on 0.079 inch (2 mm) spacing. The manufacturer of this connector is Samtec, part number TMM-104-01-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 T receiver is a right angle SMB.

Antenna Options

Trimble offers either a 3.3 VDC or a 5.0 VDC rooftop antenna and cable for use with the Resolution T GPS receiver.

Digital IO/Power Connector Pin-out

The Digital IO/Power connector pin-out information is provided in the table below.

Pin Number	Function	Description
1	Antenna Power Input	3.0VDC to 5.5VDC, 55mA max
2	Prime Power Input	+3.3VDC ±0.3VDC
3	TXD A	Port A transmit, CMOS
4	Backup Power Input	Reserved
5	RXD A	Port A receive, CMOS
6	1 PPS	One Pulse-Per-Second, CMOS
7	No Connect	Not used
8	GND	Ground, Power and Signal

Table 4: J4 I/O Connector Signals

POWER REQUIREMENTS

The Resolution T GPS receiver requires +3.3 VDC ±0.3 VDC at 110 mA, typical excluding the antenna. The on-board capacitance is approximately 65 µF. An important design consideration for power is the receiver's internal clock frequency at 12.504 MHz ± 3 KHz. Interference spurs on prime power in this narrow frequency band should be kept to less than 1mV.

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 Table 5 for the power specifications.

Warning: The Resolution T GPS receiver is ready to accept TSIP commands approximately 2.1 seconds after power -up. If a command is sent to the receiver within this 2.1 second window, the receiver will ignore the command. The Resolution T GPS receiver will not respond to commands sent within the 2.1 second window and will discard any associated command data.

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

Table 5: Power Requirements

SERIAL INTERFACE

The Resolution T GPS receiver 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 T GPS receiver. 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.

NOTE: The serial I/O signals on J4 are CMOS level. They are not inverted or driven to RS-232 levels.

PULSE-PER-SECOND (PPS)

The Resolution T GPS timing receiver provides a one millisecond 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 of the PPS pulse is synchronized with respect to UTC. The timing accuracy is within 15 nanoseconds (1σ) to UTC when valid position fixes are being reported in the Overdetermined Mode.

The rising edge of the pulse is typically less than 20 nanoseconds. The distributed impedance of the attached signal line and input circuit can affect the pulse shape and rise time. The PPS can drive a load up to 5mA without damaging the receiver.

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 a 3.3 VDC or 5.0 VDC Bullet III rooftop antenna for use with the Resolution T GPS receiver . 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 T GPS receiver 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.

Figure 7—Bullet III Antenna

CHAPTER

3

SOFTWARE INTERFACE

In this chapter:

- Start-up
- Communicating with the Receiver
- Port Protocol and Data Output Options

START-UP

The Resolution T GPS timing receiver is a complete 12-channel parallel tracking GPS timing receiver designed to operate with the L1 frequency, standard position service, 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 12 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 overdetermined 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 within the first 46 seconds, 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).

Warning: The Resolution T GPS receiver is ready to accept TSIP commands approximately 2.1 seconds after power -up. If a command is sent to the receiver within this 2.1 second window, the receiver will ignore the command. The Resolution T GPS receiver will not respond to commands sent within the 2.1 second window and will discard any associated command data.

COMMUNICATING WITH THE RECEIVER

The Resolution T GPS receiver 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 Starter Kit CD-ROM includes a user friendly Windows application to facilitate communication with the receiver, via the Trimble Standard Interface Protocol (TSIP). Sample TSIP routines are provided in Appendix A.

Port Configuration

The Resolution T GPS receiver has a single I/O port. Table 6 provides the default protocol and port configuration for the receiver, as delivered from the factory. TSIP IN/OUT is the default protocol

TSIP Input	TSIP Output
Baud Rate: 9600 Data Bits: 8 Parity: Odd Stop Bits: 1 No Flow Control	Baud Rate: 9600 Data Bits: 8 Parity: Odd Stop Bits: 1 No Flow Control

Table 6: Default Protocol and Port Configuration

The Resolution T GPS receiver can also be configured to output NMEA messages. The industry standard port characteristics for NMEA are:

- Baud Rate: 4800
- Data Bits: 8
- Parity: None
- Stop Bits:1
- No Flow Control

Any standard serial communications program, such as Windows Hyper-Terminal or PROCOMM, 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 or PROCOMM. To view the output of the TSIP protocol in text format, use the DSP Monitor program (see the CD-ROM provided in the Starter Kit).

Warning:	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 TSIPCHAT).

Port Protocol and Data Output Options

Protocol Configuration and Interface

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

DSP Monitor (DSPMon.exe), 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.

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

The protocol settings and options are stored in Random-Access-Memory (RAM). They can be saved into the non-volatile memory (Flash), if desired, 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. The Resolution T GPS receiver also adheres to the NMEA 0183, Version 3.0 specification.

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 T GPS receiver, NMEA is an output only protocol.

The receiver is shipped from the factory with the TSIP protocol configured on Port 1. The receiver can be reconfigured using TSIP command packet 0xBC, in conjunction with TSIPCHAT, DSP Monitor, or a user written serial interface program.

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

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.

CHAPTER

4

SYSTEM OPERATION

In this chapter:

- Operation
- PPS Output Options
- Customizing Operations

OPERATION

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

Start-Up

At power-up, the Resolution T 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 T GPS outputs periodic TSIP status messages. These status messages confirm that the receiver is working.

Automatic Operation

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

Satellite Masks

The Resolution T continuously tracks and uses up to twelve satellites in an overdetermined clock solution. The satellites must pass the mask criteria to be included in the solution.

Table 4.1 lists the default satellite masks used by the Resolution T. 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.

Mask	Setting	Notes
Elevation	10°	SV elevation above horizon
SNR (AMUs)	4	Signal strength
PDOP	12	Self-survey only

Table 7: Mask Settings

Elevation Mask

Satellites below 10° elevation are not used in the solution. Generally, signals from low-elevation satellites are of poorer quality than signals from higher elevation satellites. These signals travel farther through the ionospheric and tropospheric layers and undergo distortion due to these atmospheric conditions.

SNR Mask

Although the Resolution T is capable of tracking signals with SNRs as low as 2, the default SNR mask is set to 4 to eliminate poor quality signals from the fix computation. Low SNR values can result from low-elevation satellites, partially obscured signals (for example, dense foliage), 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. Setting the SNR mask to 4 or higher minimizes the impact of multi-reflected signals.

PDOP Mask

Position Dilution of Position (PDOP) is a measure of the error caused by the geometric relationship of the satellites used in the position solution. Satellite sets that are tightly clustered or aligned in the sky have a high PDOP and contribute to lower position accuracy. For timing applications, a PDOP mask of 12 offers a satisfactory trade-off between accuracy and GPS coverage. With worldwide GPS coverage, the PDOP mask can be lowered even more for many applications without sacrificing coverage.

NOTE: PDOP is only applicable during self-survey or whenever the receiver is performing position fixes.

Tracking Modes

The Resolution T operates in one of two main fix modes:

- Self-Survey (Position fix mode)
- Overdetermined Clock mode

After establishing a reference position in Self-Survey mode, the Resolution T automatically switches to Overdetermined (OD) Clock mode.

Self-Survey Mode

At power-on, the Resolution T performs a self-survey by averaging 600 position fixes. The number of position fixes until survey completion is configurable using the 8E-A9 command.

The default mode during self-survey is 3-D manual, where the receiver must obtain a 3-D solution with a PDOP below the PDOP mask. The PDOP mask criteria can be set and queried using a TSIP packet. If fewer than four conforming satellites are visible, the Resolution T suspends the self survey.

The highest accuracy fix mode is 3-D manual, where altitude is always calculated along with the latitude, longitude, and time. Obtaining a position requires four satellites with a PDOP below the PDOP mask. Depending on how the PDOP mask is set, 3-D mode can be restrictive when the receiver is subjected to frequent obscuration or when the geometry is poor due to an incomplete constellation.

Overdetermined Clock Mode

Overdetermined Clock Mode is used only in stationary timing applications. This is the default mode for the Resolution T once a surveyed (or user input) position is determined. After the receiver self-surveys its static reference position, it automatically switches to Overdetermined Clock Mode and determines the clock solution. The timing solution is qualified by a TRAIM algorithm, which automatically detects and rejects faulty satellites from the solution.

In this mode, the Resolution T 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).

PPS QUANTIZATION ERROR

The Resolution T 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 T must place the PPS output on the clock edge that it determines is closest to UTC or GPS. This situation results in a quantization error on the placement of the PPS whose magnitude is equal to one-half the period of the fixed frequency oscillator. The oscillator frequency is 12.504 MHz which is equivalent to a period just under 80 nanoseconds. Since both clock edges are used, the quantization error on the PPS output is between ±20ns.

The quantization error is illustrated below. The top waveform represents the 12.504 MHz clock. The Resolution T 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 T PPS output which is output on the clock edge closest to the actual UTC/GPS on-time mark.

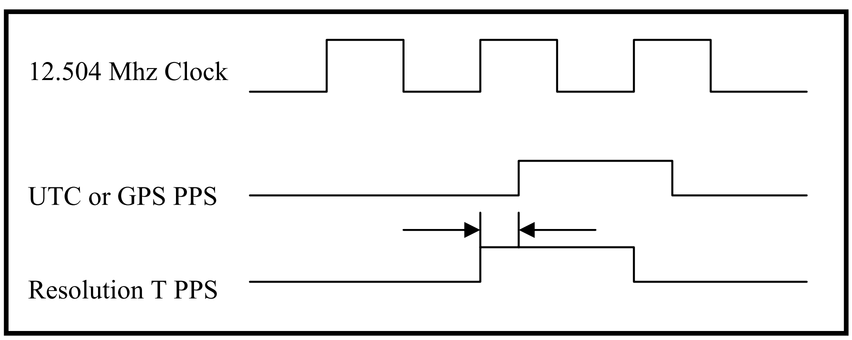
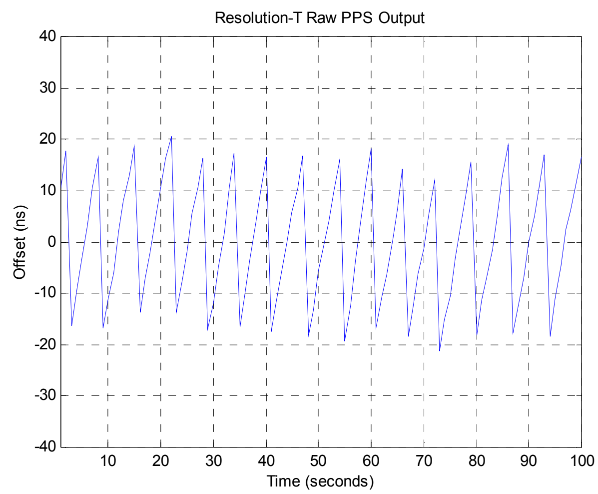
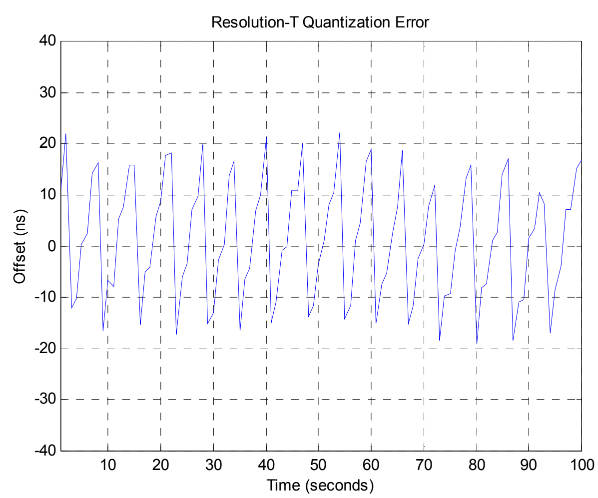


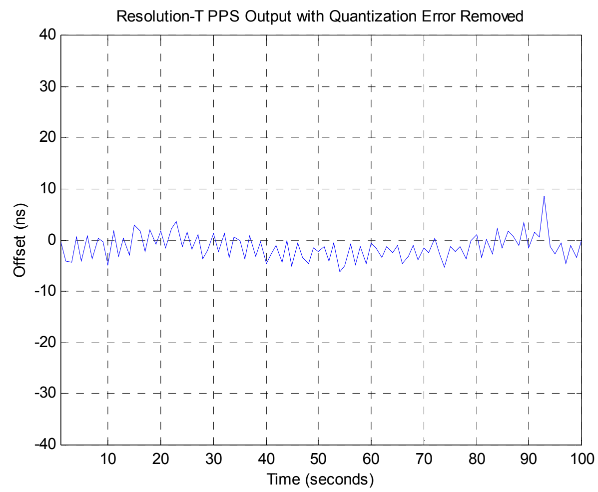
Figure 9—PPS Quantization Error

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 T in packet 0x8F-AC. The bottom plot is the result of subtracting the quantization error from the PPS offset.






Resolution-T PPS Output with Quantization Error Removed
Offset (ns)
Time (seconds)
40
30
20
10
0
-10
-20
-30
-40
10
20
30
40
50
60
70
80
90
100

SERIAL DATA COMMUNICATION

The Resolution T outputs TSIP super packets or NMEA messages, Immediately following power-on, the Resolution T outputs packets 8F-AB, 8F-AC, and PPS. Use packet 8E-A5 to enable or disable timing packets and automatic output packets. These packets are described in Appendix A.

The factory default port setting is 9600 baud in/out, 8 data bits, odd parity, 1 stop bit. The serial port setting can be changed and stored in FLASH MEMORY using a TSIP command. This port can be configured to transmit timing packets, using packet 8E-A5.

GPS Timing

For many timing applications, such as time/frequency standards, site synchronization systems, and wireless voice and data networks, the Resolution T can be used to steer a local reference oscillator. The steering algorithm combines the short-term stability of the oscillator with the long-term stability of the GPS PPS. An accurate GPS PPS allows the use of cost-effective crystal oscillators, which have less stability than expensive, high-quality oscillators, such as OCXO's (Oven Controlled Crystal Oscillator).

The GPS constellation consists of at least 24 orbiting satellites. Unlike most telecommunications satellites, GPS satellites are not geostationary, so satellites in view are constantly changing. Each GPS satellite contains four highly-stable atomic clocks, which are continuously monitored and corrected by the GPS control segment. Consequently, the GPS constellation can be considered a set of 24 orbiting "clocks" with worldwide 24-hour coverage.

A Trimble GPS receiver uses the signals from 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 T 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 T, this timing pulse is synchronized to GPS/UTC time within 15 nanoseconds (1σ) after survey is complete.

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

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. The Resolution T has a clocking rate of 12.504 MHz which enables a steering resolution of 40 ns (±20 ns). Utilizing both the rising edge and falling edge of the pulse will enable a steering resolution of ±20ns. Using software algorithms like an overdetermined clock solution, the Resolution T mitigates the effects of clock error to achieve a PPS accuracy within 15 ns (1σ) to GPS/UTC after survey is complete.

Timing Operation

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

The Resolution T'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 (1.25 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 1.25 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 1970, which, on 31 December 1998, was increased from 12 to 13 seconds. Historically, the offset increases by one second approximately every 18 months, usually just before midnight on 30 June or 31 December. **System designers should note whether the output time is UTC or GPS time**.

USING RESOLUTION T IN MOBILE APPLICATIONS

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

To prepare the Resolution T receiver for mobile applications, complete the following steps.

- Confirm that there is no stored position in the flash ROM by using command packet 8E-A6 to delete the stored position (if one exists).
- Disable the self-survey mechanism using command packet 8E-A9. If not disabled, the self-survey mechanism will automatically survey the antenna's position and then set the receiver to operate in a static, time-only mode.
- Set the desired position fix mode using command packet BB.
- Optionally, use packet 8E-A5 to enable the automatic output packets such as position and velocity.
- Use packet 8E-26 to save this new configuration to Flash storage and to retain these settings during power cycles and resets.

After these steps are completed, the Resolution T receiver is ready to operate properly in mobile applications. While operating in a mobile application, the receiver can continue to output a PPS pulse as well as timing packets.

NOTE: The accuracy of the PPS output pulse will be degraded by a factor of about 3 when the unit is operated in a mobile application.

CUSTOMIZING OPERATIONS

The Resolution T receiver provides a number of user configurable parameters that allow you to customize the operation of the unit. These parameters are stored in flash ROM chip 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 the flash ROM. You can change the values of these parameters to achieve the desired operations using a variety of TSIP packets. The Resolution T configures itself based on the new parameter immediately, but the new parameter value is not automatically saved to the flash ROM. You must direct the receiver to save the parameters to the flash ROM.

To change the parameter values stored in flash ROM, send packet 0x8E-26 to direct the Resolution T to save the current parameter values to the flash ROM. 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 T 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 non-volatile memory (flash ROM.)
- If the position was not automatically saved during the self survey or if it was manually entered, the position can be saved to Flash using TSIP packet 8E-A6.

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

Configuration Parameters

The following tables list the user configurable parameters. Each table lists the parameter name, its factory default value, and the TSIP packet that sets or reads the parameter value (typically, one TSIP packet sets or reads several related parameters.)

SYSTEM ARCHITECTURE

The Resolution T is a software GPS timing receiver. It is a complete all-in-view, 12 channel, parallel tracking GPS receiver designed to operate with the L1 frequency, standard position service, Coarse Acquisition code. Included are a saw filter, Colossus RF ASIC, a 12.504 TCXO, Texas Instruments 5509 DSP, real time clock (RTC is inside the 5509 DSP), 4Mbits external RAM, and 16Mbits Flash ROM.

The Resolution T receives the amplified GPS satellite signals through the antenna feed line connector and passes them to the RF down converter. A highly stable crystal reference oscillator operating at 12.504 MHz is used by the down converter to produce the signals used by the General Purpose DSP. The General Purpose DSP tracks the GPS satellite signals and extracts the carrier code information as well as the navigation data at 50 bits per second.

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

APPENDIX

A

NMEA 0183

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

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. The latest release of NMEA 0183 is Version 3.0 (July 1, 2000). Trimble Navigation supports both version 2.1 and version 3.0. The primary change in release 3.0 is the addition of the mode indicators in the GLL, RMC, and VTG messages.

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 T 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
PO Box 3435
New Bern, NC 28564-3435
U.S.A.
Telephone: +1-919-638-2626
Fax: +1-919-638-4885

THE 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

Table 8: NMEA 0183 Characteristics

NMEA 0183 MESSAGE FORMAT

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 T. The NMEA message structure is described below.

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

"$" The "$" 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 date fields are of variable length, and the user should always use the comma delineators to parse the NMEA message date field. Table\ specifies the definitions of all field types in the NMEA messages supported by Trimble

Type	Symbol	Definition
Status	A	Single character field: A=Yes, data valid, warning flag clear V=No, data invalid, warning flag set
Special Format Fields		
Latitude	llll.lll	Fixed/variable length field: Degreesminutes.decimal-2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading 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

Table 9: Field Type Summary

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

Warning: 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

Table 10: NMEA Messages

NMEA 0183 MESSAGE FORMATS

GGA-GPS Fix Data

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

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

Field #	Description
1	UTC of Position
2, 3	Latitude, N (North) or S (South)
4, 5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0 = No GPS, 1 = GPS, 2 = DGPS
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 between the WGS-84 earth ellipsoid and mean-sea-level.
13	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update
14	Differential Reference Station ID (0000 to 1023)
hh	Checksum

Table 11: GGA Message

GLL - Geographic Position - Latitude/Longitude

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

```
$GPGLL,llll.lll,a,yyyyy.yyy,a,hhmmss.ss,A,i*hh
<CR> <LF>
```

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

Table 12: GLL Message

GSA - GPS DOP and Active Satellites

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

```
$GPGSA,a,x,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,xx,
xx,x.x,x.x,x.x*hh<CR><LF>
```

Field #	Description
1	Mode: M = Manual, A = Automatic. In manual mode, the receiver is forced to operate in either 2D or 3D mode. In automatic mode, the receiver is allowed to switch between 2D and 3D modes subject to the PDOP and satellite masks.
2	Current Mode: 1 = fix not available, 2 = 2D, 3 = 3D
3 - 14	PRN numbers of the satellites used in the position solution. When less than 12 satellites are used, the unused fields are null
15	Position dilution of precision (PDOP)
16	Horizontal dilution of precision (HDOP)
17	Vertical dilution of precision (VDOP)
hh	Checksum

Table 13: GSA Message

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,x,x,xx,xx,xx,xxx,xx,xx,xx,xxx,xx,xx,xx,

xxx,xx,xx,xx,xxx,xx*hh<CR><LF>
```

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

Table 14: GSV Message

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.ss,A,llll.ll,a,yyyyy.yy,a,x.x,x.
x,xxxxxx,x.x,a,i*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
	Track made good in degrees true.
	Date: dd/mm/yy
	Magnetic variation in degrees, E = East / W= West
	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)

Table 15: RMC Message

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,x.x,T,x.x,M,x.x,N,x.x,K,i*hh<CR><LF>

Field #	Description
1	Track made good in degrees true.
2	Track made good in degrees magnetic.
3, 4	Speed over the ground (SOG) in knots.
5, 6	Speed over the ground (SOG) in kilometer per hour.
7	Mode Indicator: A=Autonomous Mode, D=Differential Mode, E=Estimated (dead reckoning) Mode, M=Manual Input Mode, S=Simulated Mode, N-Data Not Valid
hh	Checksum

Table 16: VTG Message

ZDA - Time & Date

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

`$GPZDA,hhmmss.ss,xx,xx,xxxx,,*hh<CR><LF>`

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

Table 17: ZDA Message

NOTE: Fields #5 and #6 are null fields in the Resolution T output. A GPS receiver cannot independently identify the local time zone offsets.

WARNING: 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.

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.

APPENDIX

B

Trimble Standard Interface Protocol (TSIP)

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 T customization.

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.

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.

Interface Scope

The Resolution T GPS 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 EPROM.)

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 T GPS embedded timing board 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.

Broadcast Packet ID	Description	Masking Packet ID	Request Packet ID	When Sent
0x42	Position XYZ (ECEF), single precision	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 updated
0x83	Position XYZ (ECEF),double precision	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

Table 18: Broadcast Output Packets

Customizing Operations Parameters

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

NOTE: Whenever configuration data is saved to the Flash EPROM (using 0x8E-26 or other packets) the Resolution T will automatically perform a reset.

To customize the Resolution T output for your application:

- Set up the Resolution T using TSIP commands until the desired operation is achieved.
- Use command 0x8E-26 to store the settings in non-volatile memory.

These settings will control Resolution T 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.

Parameter	**Factory Default**	**Set**	**Request**	**Report**
Receiver mode	4 (Full Position 3D)	0xBB	0xBB	0xBB
Dynamics code	1 (land)			
elevation mask	0.175 radians (10 deg)			
signal level mask	4(AMU)			
PDOP mask	12			
PDOP switch	6			
foliage mode	1sometimes			

Table 19: Factory Default Settings

Parameter	Factory Default	Set	Request	Report
Packet broadcast mask mask 0 mask 1	 0x05 0x00	0x8E-A5	0x8E-A5	0x8F-A5
Packet 0x35 data position (byte 0) velocity (byte 1) timing (byte 2) auxiliary (byte 3)	 0x12 0x02 0x00 0x00	0x35	0x35	0x35
Datum	0 WGS-84	0x8E-15	0x8E-15	0x8F-15

Table 20: Packet I/O Control

Parameter	Factory Default	Set	Request	Report
Input baud rate	7 (9600 baud)	0xBC	0xBC	0xBC
Output baud rate	7 (9600 baud)			
Data bits	8			
Parity	1 (odd)			
Stop bits	1			
Input protocol	2 (TSIP)			
Output protocol	2 (TSIP)			

Table 21: Serial Port Configuration

Parameter	Factory Default	Set	Request	Report
PPS enable	1 (enabled)	0x8E-4A	0x8E-4A	0X8F-4A
PPS sense	1 (rising edge)			
PPS offset	0.0 (seconds)			
Bias Uncertainty Threshold	300.0(Meters)	0x8E-4A	0x8E-4A	0x8F-4A
PPS Output Qualifier	2 (always on)	0x8E-4E	0x8E-4E	0x8F-4E
UTC/GPS Date/Time	0 (GPS)	0x8E-A2	0x8E-A2	0x8F-A2
UTC/GPS PPS Alignment	0 (GPS)	0x8E-A2	0x8E-A2	0x8F-A2

Table 22: Timing Outputs

Parameter	Factory Default	Set	Request	Report
Position	No stored position	0x31, 0x32, self-survey	0x8E-AC	0x8F-AC

Table 23: Accurate Position

Self-Survey	Factory Default	Set	Request	Report
Self-survey enable	1 (enabled)	0x8E-A9	0x8E-A9	0x8F-A9
Position save flag	1 (save)			
Self-survey count	600 (fixes)			

Table 24: Self-Survey

Packets Output at Power-Up

After completing its self-diagnostics, the Resolution T automatically outputs the following packets.

Output ID	Description	Notes
0x45	Software version	

Table 25: Packet Power-up Output Messages

Report Packets: Resolution T to User

The table below summarizes the packets output by the Resolution T. 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
0x42	single-precision XYZ position	0x37, auto
0x43	velocity fix (XYZ ECEF)	0x37, auto
0x45	software version information	0x1E, 0x1F, power-up
0x47	signal level for all satellites	0x27
0x4A	single-precision LLA position	0x37, auto
0x55	I/O options	0x35
0x56	velocity fix (ENU)	0x37, auto
0x57	information about last computed fix	0x37
0x58	GPS system data/acknowledge	0x38
0x59	sat enable/disable & health flag	0x39
0x5A	raw measurement data	0x3A
0x5C	satellite tracking status	0x3C
0x6D	all-in-view satellite selection	0x24, auto
0x83	double-precision XYZ	0x37, auto
0x84	double-precision LLA	0x37, auto
0xBB	primary configuration	0xBB
0xBC	port configuration	0xBC
0x8F-15	current datum values	0x8E-15
0x8F-41	stored manufacturing operating parameters	0x8E-41
0x8F-42	stored production parameters	0x8E-42

Output ID	Packet Description	Input ID
0x8F-4A	set PPS characteristics	0x8E-4A
0x8F-A2	UTC/GPS timing	0x8E-A2
0x8F-A4	test modes	0x8E-A4
0x8F-4E	PPS output option	0x8E-4E
0x8F-A5	packet broadcast mask	0x8E-A5
0x8F-A6	Self survey command	0x8E-A6
0x8F-A9	Self survey parameters	0x8E-A9
0x8F-AB	primary timing packet	auto
0x8F-AC	supplemental timing packet	auto

Table 26: Report Packets

Command Packets: User to Resolution T

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
0x1E	Initiate cold reset or factory reset	0x45
0x1F	software version	0x45
0x24	request GPS satellite selection	0x6D
0x25	initiate soft reset & self-test	0x45
0x27	request signal levels	0x47
0x31	set accurate initial position (XYZ ECEF)	--
0x32	set accurate initial position (lat, long, Alt)	--
0x34	satellite selection for one-satellite mode	--
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
0x39	set/request satellite disable or ignore health	0x59
0x3A	request last raw measurement	0x5A
0x3C	request current satellite tracking status	0x5C
0x7A	NMEA Set/Request	
0x7B	NMEA Output Interval	
0xBB	set receiver configuration	0xBB
0xBC	set port configuration	0xBB
0x8E-4E	PPS output option	0x8F-4E
0x8E-15	set/request current datum	0x8F-15
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-A4	test modes	0x8F-A4
0x8E-A5	packet broadcast mask	0x8F-A5
0x8E-A6	self-survey commands	0x8F-A6
0x8E-A9	self-survey parameters	0x8F-A9

Table 27: Command Packets

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

Multiple-byte numbers (integer, float, and double) follow the ANSI / IEEE Std. 754 IEEE Standard for binary Floating-Point Arithmetic. They are sent most-significant byte first. ***Note that switching the byte order will be required in Intel-based machines***. The data types used in the Resolution T TSIP are defined below.

- UINT8 - 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 - A 16 bit signed number (-32,768 to 32,767).
- UINT32 - A 32 bit unsigned number (0 to 4,294,967,295)
- SINT32 - A 32 bit signed number (-2,147,483,648 to 2,147,483,647).
  - Single — Float (4 bytes) (3.4x10-38 to 1.7x1038) (24 bit precision)
  - Double — Float (8 bytes) (1.7x10-308 to 3.4x10308) (53 bit precision)

Note: Default serial port settings are 9600-8-odd-1.

Packet Descriptions

Command Packet 0x1E: Clear RAM then Reset

This packet commands the Resolution T 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. A warm reset clears ephemeris and oscillator uncertainty but retains the last position, time and almanac. This packet contains one data byte. The data format is shown below.

Byte	Item	Type	Value	Meaning
0	Reset	UINT8	0x4B 0x0E 0x46	Cold reset Warm reset Factory reset

Table 28: Command Packet 0x1E Data Format

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 T. 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 0x25: Initiate Hot Reset & Self Test

This packet commands the GPS receiver to perform a software (hot) reset. This is **not** equivalent to cycling the power; RAM is not cleared. The GPS receiver performs a self-test as part of the reset operation. This packet contains no data. Following completion of the reset, the receiver will output the start-up messages. The GPS receiver sends packet 0x45 on power-up reset, and on request; thus, if packet 0x45 appears unrequested, then either the GPS receiver power was cycled or the GPS receiver was reset.

Command Packet 0x27: Request Signal Levels

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

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

This packet provides an accurate initial position to the GPS receiver in XYZ coordinates. Either the single precision or the double precision version of this packet may be used, however, we recommend using the double precision version for greatest accuracy. The GPS receiver uses this position for performing time-only fixes. If a survey is in progress when this command is sent, the survey is aborted, and this position data is used immediately. The Resulution T will automatically switch to the overdetermined 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.

Byte	Item	Type	Units
0-3	X-axis	Single	Meters
4-7	Y-axis	Single	Meters
8-11	Z-axis	Single	Meters

Table 29: Command Packet 0x31 Data Format (single precision)

Byte	Item	Type	Units
0-7	X-axis	Double	Meters
8-15	Y-axis	Double	Meters
16-23	Z-axis	Double	Meters

Table 30: Command Packet 0x31 Data Format (double precision)

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 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 Resulution T will automatically switch to the overdetermined 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 degreees to radians use the following value for PI.

3.1415926535898

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

Table 31: Command Packet 0 x 32 Data Format (single precision)

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

Table 32: Command Packet 0 x 32 Data Format (double precision)

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

This packet allows the user to control the choice of the satellite to be used for the one-satellite time-only fix mode. This packet contains one byte. If the byte value is 0, the GPS receiver automatically chooses the best. This automatic selection of the best satellite is the default action, and the GPS receiver does this unless it receives this packet. If the byte value is from 1 to 32, the packet specifies the PRN number of the satellite to be used.

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 (mean sea level), and UTC (universal coordinated time).

Byte	Data Type	Bit	Default	Value	Meaning	Associated Packet
0	Position	0	1	0 1	ECEF off ECEF on	0x42 or 0x83
		1	0	0 1	LLA off LLA on	0x4A or 0x84
		2	0	0 1	HAE (datum) MSL geoid	0x4A or 0x84
		3	0	0	reserved	
		4	0	0 1	single-precision position double-precision position	0x42/4A 0x83/84
		5:7	0		reserved	
1	velocity	0	1	0 1	ECEF off ECEF on	0x43
		1	0	0 1	ENU off ENU on	0x56
		2:7	0		reserved	
2	timing	0	0	0 1	GPS time reference UTC time reference	0x42, 0x43, 0x4A, 0x83, 0x84, 0x56,
3	auxiliary	0	0	0 1	packet 5A off packet 5A on	0x5A
		1	0	0	reserved	
		2			reserved	
		3	0	0 1	output AMU output dB/ Hz	0x5A, 0x5C, 0x47
		4:7	reserved	0	0	

Table 33: Command Packet 0 x 35 Data Format

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

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

Command Packet 0x38: Request Satellite System Data

This packet requests current satellite data.The GPS receiver returns packet 0x58.

Byte	Item	Type	Value	Meaning
0	Operation	UINT8	1	Must always be '1'
1	Type of data	UINT8	2 3 4 5 6	Almanac Health page, toa, WNa Ionosphere UTC Ephemeris
2	Sat PRN#	UINT8	0 1 - 32	Data not satellite ID specific satellite PRN number

Table 34: Command Packet 0 x 38 Data Format

Command Packet 0x39: Set or Request SV Disable and Health Use

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) which satisfy all mask values. This packet allows overriding the internal logic and forces the receiver to either unconditionally disable a particular satellite or to ignore a bad health flag. The GPS receiver returns packet 0x59 if operation 3 or 6 is requested; otherwise there is no reply.

It should be noted that when viewing the satellite disables list, the satellites are not numbered but are in numerical order. The disabled satellites are signified by a "1" and enabled satellites are signified by a "0".

Byte	Item	Type	Value	Meaning
0	Operation	UINT8	1 2 3 4 5 6	Enable satellite (default) Disable satellite Request enable/disable status of all 32 satellites Heed health (default) Ignore health Request heed - or - ignore health on all 32 satellites
1	Satellite #	UINT8	0 1 - 32	All 32 satellites Any one satellite PRN number

Table 35: Command Packet 0 x 39 Data Format

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

Caution: Improperly ignoring health can cause the GPS receiver software to lock up, as an unhealthy satellite may contain defective data. Use extreme caution in ignoring satellite health.

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 1-32	all satellites in current tracking set specific desired satellite

Table 36: Command Packet 0 x 3A Data Format

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 1-32	all satellites in current tracking set specific desired satellites

Table 37: Command Packet 0 x 3C Data Format

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 in Table A-21. 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 1	On Off
5	1-7	Reserved	Bit	0	
5	0	GGA	Bit	0 1	On Off
5	1	GGL	Bit	0 1	On Off
5	2	VTG	Bit	0 1	On Off
5	3	GSV	Bit	0 1	On Off
5	4	GSA	Bit	0 1	On Off
5	5	ZDA	Bit	0 1	On Off
5	6-7	Reserved	Bit	0	

Table 38: Command Packet 0 x 7A Data Format

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 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

Table 39: Report Packet 0 x 42 Data Format

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

Table 40: Report Packet 0 x 43 Data Format

Report Packet 0x45: Software Version Information

This packet provides information about the version of software in the Resolution T. 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 1900	UINT8
5	Major revision number of GPS core	UINT8
6	Minor revision number	UINT8
7	Month	UINT8
8	Day	UINT8
9	Year number minus 1900	UINT8

Table 41: Report Packet 0 x 45 Data Format

Note: Bytes 0 though 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 12 satellite number/signal level pairs may be sent, indicated by the count field. Signal level is normally positive. If it is zero then that satellite has not yet been acquired. If it is negative then that satellite is not currently in lock. The absolute value of 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.)

Table 42: Report Packet 0 x 47 Data Format

Note: The signal level provided in this packet is a linear measure of the signal strength after correlation or de-spreading. Units, either AMU or dB/Hz, are controlled by packet 0x35.

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

Table 43: Report Packet 0 x 4A Single Precision LLA Position Fix

The LLA conversion is done according to the datum selected using packet 8E-15. 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.

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

CAUTION: The MSL option is only valid with the WGS-84 datum. When using other datums, only the HAE option is valid.

Report Packet 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), and UTC (coordinated universal time).

Byte	Data Type	Bit	Default	Value	Meaning	Associated Packet
0	UINT8 Position	0	1	0 1	ECEF on ECEF off	0x42 or 0x83
		1	0	0 1	LLA off LLA on	0x4A or 0x84
		2	0	0 1	HAE (datum) MSL geoid	0x4A or 0x84
		3	0	0	reserved	
		4	0	0 1	single-precision position double-precision position	0x42/4A 0x83/84
		5:7	0		reserved	
1	UINT8 velocity	0	1	0 1	ECEF off ECEF on	0x43
		1	0	0 1	ENU off ENU on	0x56
		2:7	0		reserved	
2	UINT8 timing	0	0	0 1	GPS time reference UTC time reference	0x42, 0x43, 0x4A, 0x83, 0x84, 0x56,
3	UINT8 auxiliary	0	0	0 1	packet 5A off packet 5A on	0x5A
		1	0	0 1	raw PR's in 5A filtered PR's in 5A	0x5A
		2	reserved			
		3	0	0 1	output AMU output dB/ √Hz	0x5A, 0x5C, 0x47
		4:7	reserved	0	0	

Table 44: Report Packet 0 x 55 Data Format

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

Table 45: Report Packet 0 x 56 Data Format

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 1 2 4 5 6 8	none regular fix initialization diagnostic initialization diagnostic entered by 0x23 or 0x2B entered by 0x31 or 0x32 default after BBRAM fail
1	Tracking mode	UINT8	0 1 2 3 4 5 6	No previous fix Time only 1-SV 2D clock hold 2D 3D overdetermined clock DGPS reference
2-5	time of last fix	Single		seconds GPS time
6-7	week of last fix	UINT16		weeks

Table 46: Report Packet 0 x 57 Data Format

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

This packet provides GPS data (almanac, ephemeris, etc.). The receiver sends this packet in response to packet 0x38. The data format is shown below. The table and section numbers refered to in the “Meaning” column reference the “Global Positioning System Standard Positioning Service Signal Specification” document.

Byte	Item	Type	Value	Meaning
0	operation	UINT8	2 3	data out no data on SV
1	Type of data	UINT8	234 5 6	Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN #	UINT8	0 1 to 32	Data that is not satellite ID-specific Satellite PRN number
3	Length (n)	UINT8		byte count
4 to n+3	Data			

Table 47: Report Packet 0 x 58 Data Format

Note: If data is not available, byte 3 is set to 0 and “no” data is sent.

Byte	Item	Type	Value	Meaning (see note)
4	T_{oa} (raw)	UINT8		Table 2.8
5	SV_HEALTH	UINT8		
6-9	e	Single		
10-13	t_{oa}	Single		
14-17	i_o	Single		
18-21	OMEGADOT	Single		
22-25	sqrt(A)	Single		
26-29	$(OMEGA)_0$	Single		
30-33	(OMEGA)	Single		
34-37	M_0	Single		
38-41	a_{f0}	Single		
42-45	a_{f1}	Single		
46-49	Axis	Single		
50-53	n	Single		
54-57	OMEGA_n	Single		Derived
58-61	ODOT_n	Single		Derived
62-65	t_{zc}	Single		time of collection (set to –1.0 if there is no data available)
66-67	week number	UINT16		GPS week number
68-69	WN_a	UINT16		Sec 2.4.5.2.3

Table 48: Report Packet 0 x 58 Almanac Data Type 2

Note: All angles are in radians.

Byte	Item	Type	Meaning
4	week number for health	UINT8	Sec 2.4.5.3
5-36	SV health	UINT8	Sec 2.4.5.3
37	t_{oa} for health	UINT8	Sec 2.4.5.2.3
38	current t_{oa}	UINT8	time of collection
39-40	current week number	UINT16	time of collection

Table 49: Report Packet 0 x 58 Almanac Health Data Type 3

Byte	Item	Type	Meaning
4-11	not used		
12-15	α_0	Single	Sec 2.4.5.6
16-19	α_1	Single	
20-23	α_2	Single	
24-27	α_3	Single	
28-31	β_0	Single	
32-35	β_1	Single	
36-39	β_2	Single	
40-43	β_3	Single	

Table 50: Report Packet 0 x 58 Ionosphere Data Type 4

Byte	Item	Type	Meaning
4-16	not used		
17-24	A_0	Double	Sec 2.4.5.5
25-28	A_1	Single	
29-30	Δt_{LS}	SINT16	
31-34	t_{ot}	Single	
35-36	WN_t	UINT16	
37-38	WN_{LSF}	UINT16	
39-40	DN	UINT16	
41-42	Δt_{LSf}	SINT16	

Table 51: Report Packet 0 x 58 UTC Data Type 5

Byte	Item	Type	Meaning
4	SV number	UINT8	SV PRN number
5-8	t_ephem	Single	time of collection (seconds)
9-10	week number	UINT16	GPS week number 0 thru 1023
11	retired		
12	retired		
13	SV accuracy raw	UINT8	URA index of SV (0 thru 15)
14	SV health	UINT8	6 bit health code
15-16	IODC	UINT16	Issue of data clock
17-20	t_{GD}	Single	L1-L2 correction term
21-24	t_{oc}	Single	Sec 20.4.3.5
25-28	a_{f2}	Single	Sec 2.4.3.6
29-32	a_{f1}	Single	
33-36	a_{fo}	Single	
37-40	SV accuracy	Single	URA of SV
41	IODE	UINT8	issue of data

Byte	Item	Type	Meaning
			ephemeris
42	retired		
43-46	C_{rs}	Single	
47-50	Δn	Single	
51-58	M_0	Double	
59-62	C_{uc}	Single	
63-70	e	Double	
71-74	C_{US}	Single	
75-82	sqrt(A)	Double	
83-86	t_{oe}	Single	Table 2-5
87-90	C_{ic}	Single	
91-98	$(OMEGA)_0$	Double	
99-102	C_{is}	Single	
103-110	i_o	Double	
111-114	C_{rc}	Single	
115-122	(OMEGA)	Double	
123-126	OMEGADOT	Single	
127-130	IDOT	Single	
131-138	Axis	Double	
139-146	n	Double	
147-154	r1me2	Double	= $\mathrm{sqrt}(1.0\text{-}e^2)$
155-162	OMEGA_n	Double	derived from OMEGA_0, OMEGADOT
163-170	ODOT_n	Double	derived from OMEGADOT

Table 52: Report Packet 0 x 58 Ephemeris Data Type 5

Note: All angles are in radians. Reference numbers refer to “Global Positioning System Standard Positioning Service Signal Specification.” As of this writing, it is available in Adobe Acrobat format at http://www.navcen.uscg.gov/pubs/gps/sigspec/

Report Packet 0x59: Status of Satellite Disable or Ignore Health

This packet is sent in response to command packet 0x39.

Byte	Item	Type	Value	Meaning
0	Operation	UINT8	3	The remaining bytes tell whether receiver is allowed to select each satellite.
			6	The remaining bytes tell whether the receiver heeds or ignores each satellite's health as a criterion for selection.
1 to 32	Satellite #	UINT8 (1 per SV)	0	Enable satellite selection or heed satellite's health. Default value.
			1	Disable satellite selection or ignore satellite's health.

Table 53: Report Packet 0 x 59 Data Format

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	AMU or dB/Hz
9-12	code phase	single	1/16th chip
13-16	doppler	single	Hertz @ L1
17-24	time of measurement	double	seconds

Table 54: Report Packet 0 x 5A Data Format

Notes: The sample length is the number of milliseconds over which the sample was averaged.

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 0 0 0 1 0 0 1 0 0 0 1 1 0 1 0 0 0 1 0 1 0 1 1 0 0 1 1 1 1 0 0 0 1 0 0 1 1 0 1 0 1 0 1 1	channel 1 channel 2 channel 3 channel 4 channel 5 channel 6 channel 7 channel 8 channel 9 channel 10 channel 11 channel 12
2		acquisition flag	UNIT8	0 1 2	never acquired acquired re-opened search
3		ephemeris flag	UNIT8	0 >0	flag not set good ephemeris
4-7		signal level	Single		AMU or dB/Hz
8-11		time of last measurement	Single	secs	GPS time of week
12-15		elevation angle	single		radians
16-		azimuth angle	single		radians

Byte	Bit	Item	Type	Value	Meaning
19					
20		old measurement flag	UINT8	0 >0	flag not set measurement old
21		integer msec flag	UINT8	0 1 2 3 4	don't know msec known from subframe verified by bit crossing verified by good fix suspect msec error
22		bad data flag	UINT8	0 1 2	flag not set bad parity bad ephemeris health
23		data collection flag	UINT8	0 >0	flag not set collection in progress

Table 55: Report Packet 0 x 5C Data Format

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, overdetermined, clock, etc.). This packet has variable length equal to 17+nsvs where “nsvs” is the number of satellites used in the solution. If an SV is rejected for use by the T-RAIM algoritm then the SV PRN value will be negative.

The GPS receiver sends this packet in response to packet 0x24 when the selection list is updated. If enabled with packet 8E-A5, the reeiver 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	1 3 4 5	1D clock fix 2D fix 3D fix OD clock fix
	3	fix mode	bit field	0 1	auto manual
	4:7	number of sv’s in fix	bit field	0-12	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

Table 56: Report Packet 0 x 6D Data Format

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

Table 57: Report Packet 0 x 83 Data Format

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

Table 58: Report Packet 0 x 84 Data Format

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

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

Command Packet 0xBB Set Primary Configuration

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

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

Table 59: Command Packet 0 x BB Data Format (Query Only)

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

Byte	Item	Type	Value	Meaning	Default
0	Subcode	UINT8	0xFF	Primary receiver configuration block	
1	receiver mode	UINT8	0 1 3 4 5 6 7	automatic single satellite (1 SV) Horizontal (2D) Full position (3D) DGPS reference 2D clock hold over-determined clock	4 (3D)
2	reserved	UINT8	0	**do not alter**	
3	Dynamics Code	UINT8	1 2 3 4	Land Sea Air Stationary	Land
4	reserved	UINT8	0xFF	**do not alter**	
5-8	Elevation Mask	Single	0-π/2	Lowest satellite elevation for fixes (radians)	10 degrees
9-12	AMU Mask	Single		Minimum signal level for fixes	4
13-16	PDOP Mask	Single		Maximum DOP for fixes	12
17-20	PDOP Switch	Single		Switches 2D/3D mode	6
21	reserved	UINT8	0xFF	**do not alter**	
22	Foliage Mode	UINT8	0 1 2	Never Sometimes Always	sometimes
23	reserved	UINT8		**do not alter**	
24	reserved	UINT8		**do not alter**	
25	reserved	UINT8		**do not alter**	
26	reserved	UINT8		**do not alter**	
27-39	reserved	UINT8		**do not alter**	

Table 60: Report Packet 0 x BB Data Format

CAUTION: The operation of the Resolution T 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” send a value of 0xFF. The Resolution T will ignore this value.

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.

Byte	Item	Type	Value	Meaning
0	Port Number	UINT8	0 1 FF	Port 1 (standard) Port 2 (not available) Current port

Table 61: Command Packet 0 x BC Data Format (Query Mode)

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 1 0xFF	Port 1 (standard) Port 2 (factory only) Current port
1	Input Baud Rate	UINT8	0 1 2 3 4 5 6 7 8 9 10 11	None None 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud
2	Output Baud Rate	UINT8	As above	As above
3	# Data Bits	UINT8	2 3	7 bits 8 bits
4	Parity	UINT8	0 1 2	None Odd Even
5	# Stop Bits	UINT8	0 1	1 bit 2 bits
6	Flow Control	UINT8	0	none
7	Input Protocols	UINT8	0 2	none TSIP
8	Output Protocols	UINT8	0 2 4	none TSIP NMEA
9	Reserved	UINT8	0	

Table 62: Command and Report Packet 0 x BC Field Data Format

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-15, 15 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-15 Request current Datum values

This packet contains only the subpacket ID, 0x15. The response to this packet is 8F-15

Command Packet 0x8E-26: Write Receiver Configuration to Flash ROM

This command packet causes the current configuration settings to be written to the flash ROM. This packet contains only a single byte: the sub-packet ID. Note that the unit will reset itself following the execution of this command.

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 T PPS characteristics. The Resolution T 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 1	off on
2	reserved	UINT8		
3	PPS polarity	UINT8	0 1	positive negative
4-11	PPS offset or cable delay (see note)	Double		seconds
12-15	Bias uncertainty threshold	Single		meters

Table 63: Command and Report Packet 0 x 8E-4A Data Format

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.

Driver switch values 3 and 4 only make sence in Overdetermined Timing mode. In any position fix mode the effective choicds are always on or during fixes which you get if you set the driver switch to 3 or 4.

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

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

Table 64: Command Packet 0 x 8E-4E Data Format

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 T output PPS. Send packet 8E-A2 with no data to request the current settings. The Resolution T replies with response packet 8F-A2.

Byte	Bit	Item	Type	Value	Meaning
0		Subcode	UINT8	0xA2	
1	0	UTC/GPS time	bit field	0 1	GPS time/date in packet 0x8F-AB UTC time/date in packet 0x8F-AB
	1		bit field	0 1	PPS referenced to GPS time PPS referenced to UTC time

Table 65: Command Packet 0 x 8E-A2 Data Format

Command Packet 0x8E-A4 Test Modes

The Resolution T provides a test mode of operation that allows the user to set the time and UTC parameters. Packet 0x8F-AC provides a status bit (minor alarm bit 8) to warn the user that the Resolution T is operating in a test mode. There is no response to this packet.

Note that test mode 3 does not actually cause the Resolution T to enter a test mode, but instead provides a means for the user to send UTC parameters to the Resolution T that will be used in test mode 1.

Test Mode 0 Data Fields:

Test Mode: Set this field to 0 to exit test mode and return the Resolution T to normal operations. A reset or power cycle will also cause the Resolution T to exit test mode.

Test Mode 1 Data Fields:

Test Mode: Setting this field to 1 tells the Resolution T to enter the user time test mode. The Resolution T will set the time to the week number and TOW sent with this packet. The Resolution T will then increment this time once per second. The time in packets 8F-AB and 8F-A7 will show the user test time, but all other packets that have time fields will be unaffected.

Week Number: This field contains the week number for the user time test mode.

Time-of-Week: This field contains the TOW for the user time test mode.

Test Mode 3 Data Fields:

Note: For a more detailed description of UTC parameters GPS SPS Signal Specification

Test Mode: Setting this field to 3 tells the Resolution T that the following fields contain the user UTC parameters that are to be used while in test mode 1.

A_0: This field is the fractional second offset of GPS from UTC at the reference time in seconds.

A_1: This field is the rate of change of fractional second offset of GPS from UTC in seconds/second.

delta_t_LS: Current integer leap seconds

t_ot: This field is the reference time-of-week for the A_0/A_1 parameters.

WN_t: This field is the reference week number for the A_0/A_1 parameters.

WN_LSF: This field is the week number of a future leap second event

DN: This field is the day number of a future leap second event.

delta_t_LSF: This field is the integer number of future leap seconds.

Byte	Item	Type	Description
0	Subcode	UINT8	0xA4
1	Test Mode	UINT8	0 = Exit test mode

Table 66: Command Packet 0 x 8E-A4 Test Mode 0 Data Format

Byte	Item	Type	Description
0	Subcode	UINT8	0xA4
1	Test Mode	UINT8	1 = Set absolute time, ignore GPS time
2-3	Week Number	UINT16	Week number (0-1023)
4-7	Time of Week	UINT32	Seconds (0-604799)

Table 67: Command Packet 0 x 8E-A4 Test 1 Mode 1Data Format

Byte	Item	Type	Description
0	Subcode	UINT8	0xA4
1	Test Mode	UINT8	3 = Send user UTC parameter
2-5	A_0	Single	Seconds
6-9	A_1	Single	Seconds/second
10-11	delta_t_LS	SINT16	Seconds
12-15	t_ot	UINT32	Seconds
16-17	WN_t	UINT16	Week number
18-19	WN_LSF	UINT16	Week number
20-21	DN	UINT16	Day number (1-7)
22-23	delta_t_LSF	SINT16	Seconds

Table 68: Command Packet 0 x 8E-A4 Test Mode 3 Data Format

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 T 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 T 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 1 2 3 4 5 6	Mask 0	bit field	8F-AB, Primary Timing Information Reserved 8F-AC, Supplemental Timing Information Reserved ReservedReserved Automatic Output Packets
3-4		Mask 2	bit field	reserved

Table 69: Command and Report Packet 0 x 8E-A5 Data Format

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. There is no response to this packet.

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

Table 70: Command and Report Packet 0 x 8E-A6 Data Format

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 T replies to requests with response packet 8F-A9.

Data Fields

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

- 0: Disable the self-survey mechanism
- 1: Enable the self-survey mechanism

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

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

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

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

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0xA9	
1	Self-Survey Enable	UINT8	0 1	Disabled enabled
2	Position Save Flag	UINT8	0 1	don't save position save self-surveyed position at the end of the survey
3-6	Self-Survey Length	UINT32	see above	Number of fixes
7-10	Reserved	UINT32	0	0

Table 71: Command Packet 8E-A9 Data Format

Report Packet 0x8F-15 Current Datum Values

This packet contains 43 data bytes with the values for the datum currently in use and is sent in response to packet 8E-15. If a built-in datum is being used, both the datum index and the five double-precision values for that index are returned. If the receiver is operating on a custom user-entered datum, the datum index is set to –1 and the five values are displayed. These five values describe an elipsoid to convert ECEF XYZ coordinate system into LLA.

Byte	Type	Value	Description
0	Super Packet ID	14	
1-2	Datum index (-1 for custom)	Datum Index	
3-10	DOUBLE	DX	meters
11-18	DOUBLE	DY	meters
19-26	DOUBLE	DZ	meters
27-34	DOUBLE	A-axis	meters
35-42	DOUBLE	Eccentricity squared	none

Table 72: Datums

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	

Table 73: Stored Manufacturing Operating Parameters

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	

Table 74: Stored Production Parameter

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-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. If enabled, this packet will begin transmission within 20 ms after the PPS pulse to which it refers.

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: Time (UTC) = Time (GPS) - UTC Offset. The UTC offset information is reported to Resolution T by the GPS system and can take up to 12.5 minutes to obtain. Before the Resolution T 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 net 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 T 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 0x8E/8F-A5, 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 1 2 3 4	timing Flag	bit field	0 1 0 1 0 1 0 1 0 1	GPS time UTC time GPS PPS UTC PPS time is set time is not set have UTC info no UTC info time from GPS 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 (e.g. 1998)

Table 75: Report Packet 0x8F-AB

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 T spends most of its time in the Overdetermined 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 T 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 T.
- 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. On-board protection circuitry prevents any damage to the Resolution T when its antenna input is shorted to ground. This condition tends to indicates 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 T that a leap second transition is pending.
- Bit 8: When 1, indicates that the Resolution T 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 Resolution T'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.

Broadcast Control: Packe8E/8F-A5, Mask 0, Bit 2

Byte	Item	Type	Value	Description
0	Subcode	UINT8	0xAC	
1	Receiver Mode	UINT8	0 1 3 4 5 6 7	Automatic (2D/3D) Single Satellite (Time) Horizontal (2D) Full Position (3D) DGPR Reference Clock Hold (2D) Overdetermined Clock
2	Reserved	UINT8	0 1 2 3 4 5 6	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 1 3 8 9 0x0A 0x0B 0x0C 0x10	Doing fixes Don't have GPS time PDOP is too high No usable sats Only 1 usable sat Only 2 usable sats Only 3 usable sats the chosen sat is unusable TRAIM rejected the fix
13	Reserved	UINT8	0	Reserved
14	Spare Status 1	UINT8	0	
15	Spare Status 2	UINT8	0	
16-19	Local clock bias	Single		ns

Byte	Item	Type	Value	Description
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		seconds
64-67	Spare			Future expansion

Table 76: Report Packet 0x8F-AC

APPENDIX

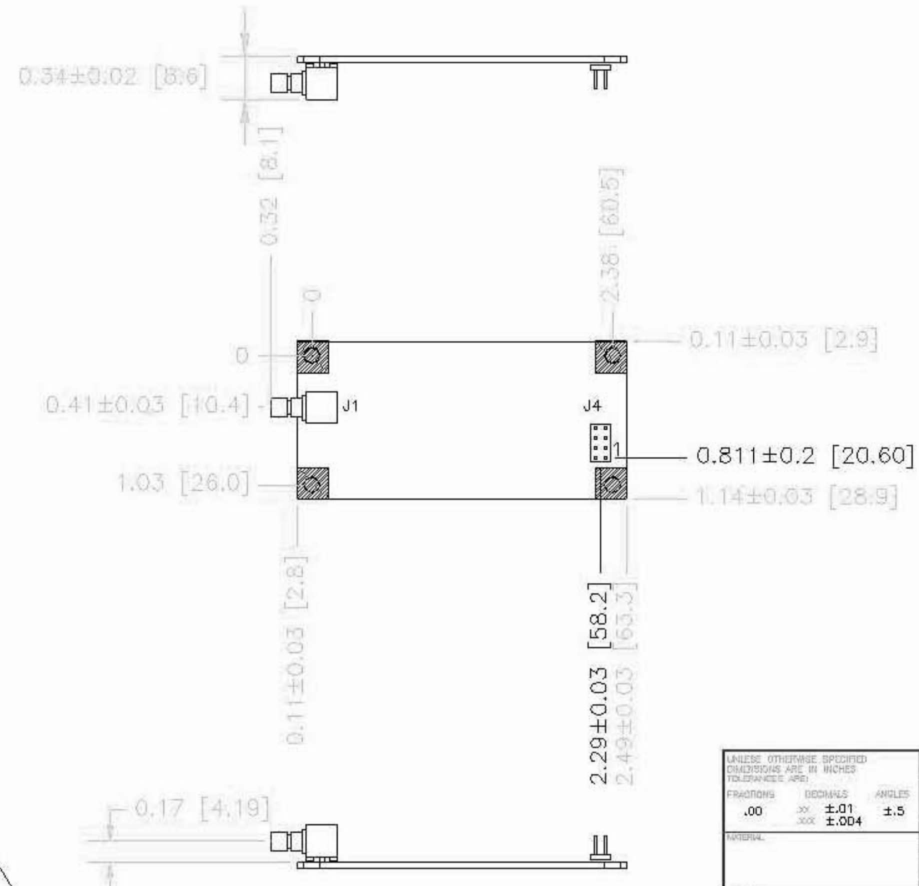
C

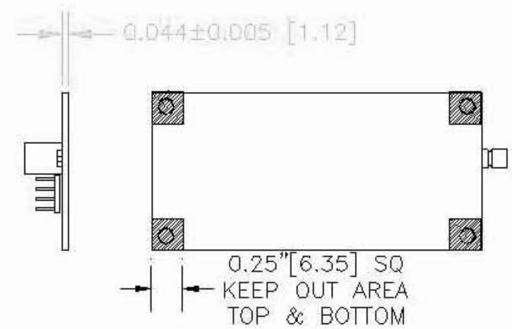
SPECIFICATIONS

The Resolution T is designed for a variety of embedded timing applications. This appendix includes the system specifications and mechanical drawings for the Resolution T and the available GPS antenna.

REVISIONS

ECN	REV	DESCRIPTION	DATE	APPROVED
	A	ENGINEERING RELEASE	4/20/04	D.C.





NOTES:
1. RF CONNECTOR: SMB
   J4 8 PIN I/O CONNECTOR
   2X4 2mm
   Samtec TMM-104-01-T-D-SM

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE:

FRACTIONS	DECIMALS	ANGLES
.00	.XX ±.01 .XXX ±.004	±.5

MATERIAL

FINISH

DO NOT SCALE DRAWING

CONTRACT NO.

CRITICAL DIMENSION

APPROVALS		DATE
DRAWN	4/20/04	4/20/04
CHECKED		
ISSUED		

Trimble

MECHANICAL SPEC. - DSP

SIZE	FSCM NO.	DWG NO.	REV
B		52830-XX-MS	A
SCALE 2X		SHEET 1 OF 1	

FILE: 52830-XX-MS

DWG NO. 52830-XX-MS SHT. REV. A