

---

**RESOLUTION T**

**SYSTEM DESIGNER REFERENCE MANUAL**

**Copyright 2005 Trimble Navigation, Inc.**

**[www.trimble.com](http://www.trimble.com)  
[customerservice@trimble.com](mailto:customerservice@trimble.com)**

---

## **Corporate Office**

Trimble Navigation Limited  
Software and Component Technologies  
749 North Mary Avenue  
Post Office Box 3642  
Sunnyvale, CA 94088-3642  
U.S.A.  
Phone: 1-800-767-4822  
Fax:+1-408-481-7744  
www.trimble.com

## **Support Offices**

Trimble Navigation Limited  
Software and Component Technologies  
749 North Mary Avenue  
Post Office Box 3642  
Sunnyvale, CA 94088-3642  
U.S.A.  
Phone: 1-800-767-4822  
Fax:+1-408-481-7744

Trimble Navigation Europe Limited  
Trimble House, Meridian Office Park  
Osborn Way, Hook  
Hampshire RG27 9HX  
ENGLAND  
+44-1256-760-150  
Fax: +44-1256-760-148

## **Copyright and Trademarks**

© 2005 Trimble Navigation Limited. All rights reserved. No part of this manual may be copied, reproduced, translate, or reduced to any electronic medium or machine-readable form for any use other than with the Resolution T GPS timing receiver.

Printed in the United States of America. Printed on recycled paper.

The Globe & Triangle logo, Trimble, Colossus, FirstGPS, and Lassen are trademarks of Trimble Navigation Limited.

The Sextant logo with Trimble and ACE UTC GPS, ACE III, ACE II GPS, SVeeSix, SVeeSix-CM3, Lassen-SK8, Acutis, Acutime, Acutime II, and TSIP are trademarks of Trimble Navigation Limited, registered in the United States Patent and Trademark Office.

All other trademarks are the property of their respective owners.

---

## **Release Notice**

This is the January 2005 release (Revision A) of the *Resolution T System Designer Reference Manual*, part number 54655-05. The following limited warranties give you specific legal rights. You may have others, which vary from state/jurisdiction to state/jurisdiction.

## **Waste Electrical and Electronic Equipment (WEEE) Notice:**

This Trimble product is furnished on an OEM basis. By incorporating this Trimble product with your finished goods product(s) you shall be deemed the “producer” of all such products under any laws, regulations or other statutory scheme providing for the marking, collection, recycling and/or disposal of electrical and electronic equipment (collectively, “WEEE Regulations”) in any jurisdiction whatsoever, (such as for example national laws implementing EC Directive 2002/96 on waste electrical and electronic equipment, as amended), and shall be solely responsible for complying with all such applicable WEEE Regulations.

## **Hardware Limited Warranty**

Trimble warrants that this Trimble hardware product (the “Product”) shall be free from defects in materials and workmanship and will substantially conform to Trimble’s applicable published specifications for the Product for a period of one (1) year, starting from the date of delivery. The warranty set forth in this paragraph shall not apply to software/firmware products.

## **Software and Firmware License, Limited Warranty**

This Trimble software and/or firmware product (the “Software”) is licensed and not sold. Its use is governed by the provisions of the applicable End User License Agreement (“EULA”), if any, included with the Software. In the absence of a separate EULA included with the Software providing different limited warranty terms, exclusions, and limitations, the following terms and conditions shall apply. Trimble warrants that this Trimble Software product will substantially conform to Trimble’s applicable published specifications for the Software for a period of ninety (90) days, starting from the date of delivery.

## **Warranty Remedies**

Trimble’s sole liability and your exclusive remedy under the warranties set forth above shall be, at Trimble’s option, to repair or replace any Product or Software that fails to conform to such warranty (“Nonconforming Product”), or refund the purchase price paid by you for any such Nonconforming Product, upon your return of any Nonconforming Product to Trimble in accordance with Trimble’s standard return material authorization procedures.

---

## **Warranty Exclusions and Disclaimer**

These warranties shall be applied only in the event and to the extent that: (i) the Products and Software are properly and correctly installed, configured, interfaced, maintained, stored, and operated in accordance with Trimble's relevant operator's manual and specifications, and; (ii) the Products and Software are not modified or misused. The preceding warranties shall not apply to, and Trimble shall not be responsible for defects or performance problems resulting from (i) the combination or utilization of the Product or Software with products, information, data, systems or devices not made, supplied or specified by Trimble; (ii) the operation of the Product or Software under any specification other than, or in addition to, Trimble's standard specifications for its products; (iii) the unauthorized modification or use of the Product or Software; (iv) damage caused by accident, lightning or other electrical discharge, fresh or salt water immersion or spray; or (v) normal wear and tear on consumable parts (e.g., batteries).

THE WARRANTIES ABOVE STATE TRIMBLE'S ENTIRE LIABILITY, AND YOUR EXCLUSIVE REMEDIES, RELATING TO PERFORMANCE OF THE PRODUCTS AND SOFTWARE. EXCEPT AS OTHERWISE EXPRESSLY PROVIDED HEREIN, THE PRODUCTS, SOFTWARE, AND ACCOMPANYING DOCUMENTATION AND MATERIALS ARE PROVIDED "AS-IS" AND WITHOUT EXPRESS OR IMPLIED WARRANTY OF ANY KIND BY EITHER TRIMBLE NAVIGATION LIMITED OR ANYONE WHO HAS BEEN INVOLVED IN ITS CREATION, PRODUCTION, INSTALLATION, OR DISTRIBUTION, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, TITLE, AND NONINFRINGEMENT. THE STATED EXPRESS WARRANTIES ARE IN LIEU OF ALL OBLIGATIONS OR LIABILITIES ON THE PART OF TRIMBLE ARISING OUT OF, OR IN CONNECTION WITH, ANY PRODUCTS OR SOFTWARE. SOME STATES AND JURISDICTIONS DO NOT ALLOW LIMITATIONS ON DURATION OR THE EXCLUSION OF AN IMPLIED WARRANTY, SO THE ABOVE LIMITATION MAY NOT APPLY TO YOU. Trimble navigation limited is not responsible for the operation or failure of operation of gps satellites or the availability of gps satellite signals.

## **Limitation of Liability**

Trimble's entire liability under any provision herein shall be limited to the greater of the amount paid by you for the product or software license or u.s.\$25.00. to the maximum extent permitted by applicable law, in no event shall trimble or its suppliers be liable for any indirect, special, incidental, or consequential damages whatsoever under any circumstance or legal theory relating in any way to the products, software, and accompanying documentation and materials, (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or any other pecuniary loss), regardless of whether trimble has been advised of the possibility of any such loss and regardless of the course of dealing which develops or has developed between you and trimble. because some states and jurisdictions do not allow the exclusion or limitation of liability for consequential or incidental damages, the above limitation may not apply to you.

---

# TABLE OF CONTENTS

ABOUT THIS MANUAL .....	9
Technical Assistance .....	9
<b>STARTER KIT.....</b>	<b>10</b>
PRODUCT OVERVIEW.....	11
Timing Features .....	11
Basic Operation.....	11
Starter Kit.....	12
REMOVING THE RESOLUTION T MODULE.....	13
TIMING RECEIVER PERFORMANCE .....	14
INTERFACE PROTOCOLS.....	15
TSIP .....	15
NMEA.....	15
ORDERING STARTER KIT COMPONENTS .....	16
STARTER KIT INTERFACE UNIT .....	17
Serial Port Interface .....	19
Pulse-Per-Second (PPS).....	20
POWER.....	21
DC Power Cable.....	21
AC/DC Power Converter .....	22
HARDWARE SETUP .....	23
SOFTWARE TOOLKIT.....	25
<b>HARDWARE INTEGRATION.....</b>	<b>26</b>
GENERAL DESCRIPTION .....	27
CONNECTORS .....	28
RF Connector.....	29
Antenna Options .....	29
Digital IO/Power Connector Pin-out.....	29
POWER REQUIREMENTS.....	30
SERIAL INTERFACE.....	31
PULSE-PER-SECOND (PPS) .....	32
MOUNTING.....	33
GPS ANTENNA.....	34

---

<b>SOFTWARE INTERFACE.....</b>	<b>35</b>
START-UP .....	36
COMMUNICATING WITH THE RECEIVER .....	37
Software Tools .....	37
Port Protocol and Data Output Options .....	39
<b>SYSTEM OPERATION .....</b>	<b>41</b>
OPERATION.....	42
Start-Up.....	42
Automatic Operation.....	42
Satellite Masks .....	43
Tracking Modes .....	44
PPS QUANTIZATION ERROR .....	46
SERIAL DATA COMMUNICATION .....	48
SERIAL DATA COMMUNICATION .....	49
GPS Timing.....	49
Timing Operation .....	51
USING RESOLUTION T IN MOBILE APPLICATIONS.....	52
CUSTOMIZING OPERATIONS .....	53
Configuration Parameters.....	53
SYSTEM ARCHITECTURE.....	54
<b>NMEA 0183 .....</b>	<b>55</b>
INTRODUCTION.....	56
THE NMEA 0183 COMMUNICATION INTERFACE.....	57
NMEA 0183 MESSAGE FORMAT .....	58
FIELD DEFINITIONS.....	59
NMEA 0183 MESSAGE OPTIONS .....	61
NMEA 0183 MESSAGE FORMATS.....	62
GGA-GPS Fix Data .....	62
GLL - Geographic Position - Latitude/Longitude.....	63
GSA - GPS DOP and Active Satellites .....	64
GSV - GPS Satellites in View.....	65
RMC - Recommended Minimum Specific GPS/Transit Data.....	66
VTG - Track Made Good and Ground Speed .....	67
ZDA - Time & Date .....	68
EXCEPTION BEHAVIOR.....	69
Interruption of GPS Signal.....	69

---

## TRIMBLE STANDARD INTERFACE PROTOCOL (TSIP)..... 70

INTRODUCTION.....	71
Interface Scope.....	72
Automatic Output Packets.....	73
Customizing Operations Parameters.....	74
Packets Output at Power-Up.....	77
Report Packets: Resolution T to User.....	77
Command Packets: User to Resolution T.....	79
Packet Structure.....	80
Packet Descriptions.....	81
Command Packet 0x1E: Clear RAM then Reset.....	81
Command Packet 0x1F: Request Software Version.....	81
Command Packet 0x24: Request GPS Satellite Selection.....	81
Command Packet 0x25: Initiate Hot Reset & Self Test.....	81
Command Packet 0x27: Request Signal Levels.....	82
Command Packet 0x31: Accurate Initial Position (XYZ Cartesian ECEF).....	82
Command Packet 0x32: Accurate Initial Position (Latitude, Longitude, Altitude).....	83
Command Packet 0x34: Satellite Select For One-Satellite Mode.....	84
Command Packet 0x35: Set or Request I/O Options.....	84
Command Packet 0x37: Request Status and Values of Last Position.....	86
Command Packet 0x38: Request Satellite System Data.....	86
Command Packet 0x39: Set or Request SV Disable and Health Use.....	87
Command Packet 0x3A: Request last raw Measurement.....	88
Command Packet 0x3C: Request Current Satellite Tracking Status.....	88
Command Packet 0x7A: Set or Request NMEA Interval and Message Mask.....	89
Report Packet 0x7B: Set NMEA Message Output.....	90
Report Packet 0x42: Single-precision Position Fix.....	90
Report Packet 0x43: Velocity Fix, XYZ ECEF.....	90
Report Packet 0x45: Software Version Information.....	91
Report Packet 0x47: Signal Level for All Satellites Tracked.....	92
Report Packet 0x4A: Single Precision LLA Position Fix.....	93
Report Packet 0x55: I/O Options.....	94
Report Packet 0x56: Velocity Fix, East-North-Up (ENU).....	95
Report Packet 0x58: GPS System Data/Acknowledge from Receiver.....	97
Report Packet 0x59: Status of Satellite Disable or Ignore Health.....	102
Report Packet 0x5A: Raw Data Measurement Data.....	102
Report Packet 0x5C: Satellite Tracking Status.....	103
Report Packet 0x6D: All-in-View Satellite Selection.....	105
Report Packet 0x83: Double Precision XYZ.....	106
Report Packet 0x84: Double Precision LLA Position Fix and Bias Information.....	107
Command Packet 0xBB: Set Primary Configuration.....	108
Command Packet 0xBC: Set Port Configuration.....	109
TSIP Superpackets.....	111
Command Packet 0x8E-15: Request current Datum values.....	111
Command Packet 0x8E-26: Write Receiver Configuration to Flash ROM.....	111
Command Packet 0x8E-41: Request Manufacturing Parameters.....	111
Command Packet 0x8E-42: Stored Production Parameters.....	111
Command Packet 0x8E-4A: Set PPS Characteristics.....	112
Command Packet 0x8E-4E: Set PPS output option.....	113
Command Packet 0x8E-A2: UTC/GPS Timing.....	114
Command Packet 0x8E-A4: Test Modes.....	114
Test Mode 0 Data Fields:.....	114
Test Mode 1 Data Fields:.....	115
Test Mode 3 Data Fields:.....	115
Command Packet 0x8E-A5: Packet Broadcast Mask.....	117
Command Packet 0x8E-A6: Self-Survey Command.....	118

---

Command Packet 0x8E-A9:Self-Survey Parameters .....	118
Report Packet 0x8F-15 Current Datum Values .....	120
Report Packet 0x8F-41: Stored Manufacturing Operating Parameters.....	121
Report Packet 0x8F-42: Stored Production Parameters.....	122
Report Packet 0x8F-4A: Set PPS Characteristics.....	123
Report Packet 0x8F-4E: PPS Output .....	123
Report Packet 0x8F-A2: UTC/GPS Timing .....	123
Report Packet 0x8F-A5: Packet Broadcast Mask.....	123
Report Packet 0x8F-A9: Self-Survey Parameters .....	123
Report Packet 0x8F-AB: Primary Timing Packet.....	124
Broadcast Control: Packet 0x8E/8F-A5, Mask 0, Bit 0 .....	126
Report Packet 0x8F-AC: Supplemental Timing Packet.....	127
Broadcast Control: Packe8E/8F-A5, Mask 0, Bit 2 .....	130

**SPECIFICATIONS ..... 133**



---

## **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](http://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.

# 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 Integrity
- 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, 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.

<b>Product</b>	<b>Part Number</b>
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**

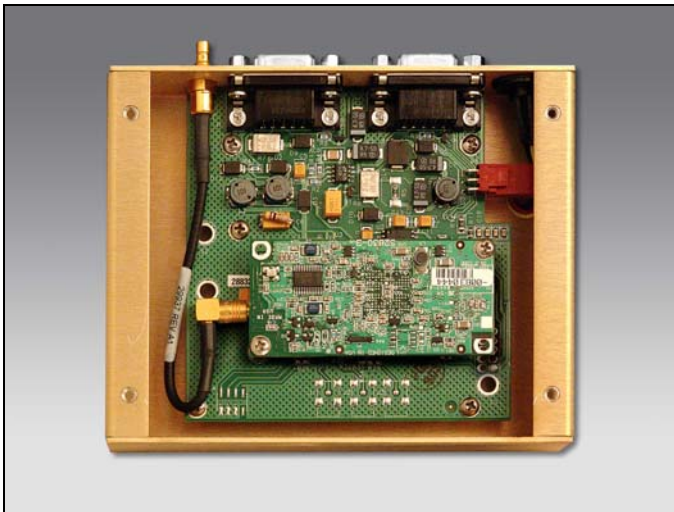
NOTE: Part numbers are subject to change. Confirm part numbers with your Trimble representative when placing your order. Other rooftop cables and antenna combinations are also available.



## 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 ( $1 \sigma$ ) 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 5 VDC 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—DC Power Cable**

**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.

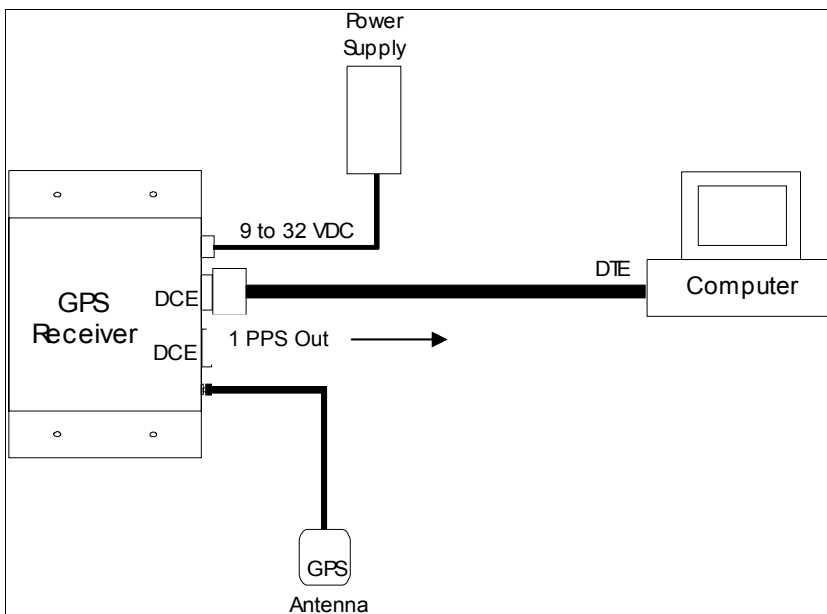


Figure 5—Starter Kit Interface Unit

- 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:
  - position
  - time
  - 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.

# 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.

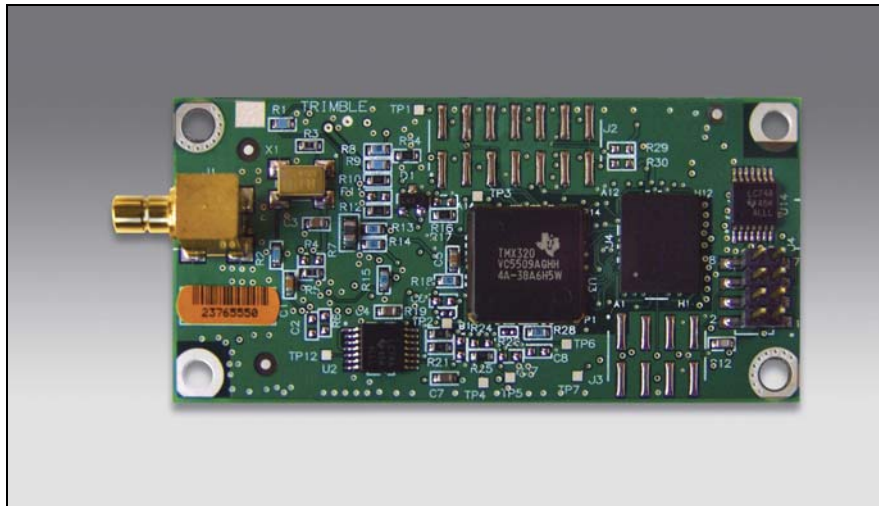


Figure 6—Resolution T Board

## 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 $\pm$ 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  $\pm$ 0.3 VDC at 110 mA, typical excluding the antenna. The on-board capacitance is approximately 65  $\mu$ F. An important design consideration for power is the receiver's internal clock frequency at 12.504 MHz  $\pm$  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 ( $1\sigma$ ) 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

# 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).

### 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

<b>TSIP Input</b>	<b>TSIP Output</b>
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 HyperTerminal 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.



# 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**

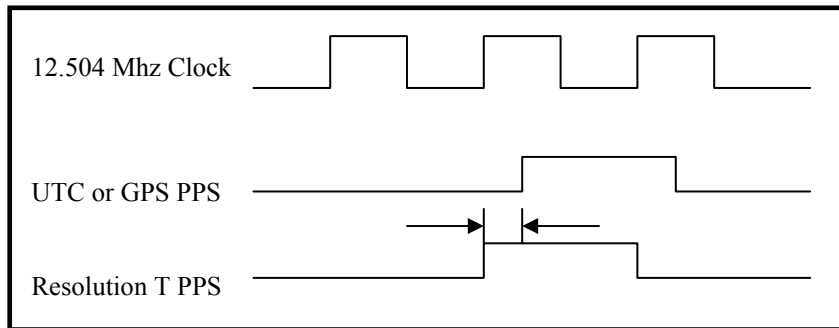
Overdetermined Clock Mode is used only in stationary timing applications. This is the default mode for the Resolution T once a surveyed (or user input) position is determined. After the receiver self-surveys its static reference position, it automatically switches to Overdetermined Clock Mode and determines 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  $\pm 20$ ns.

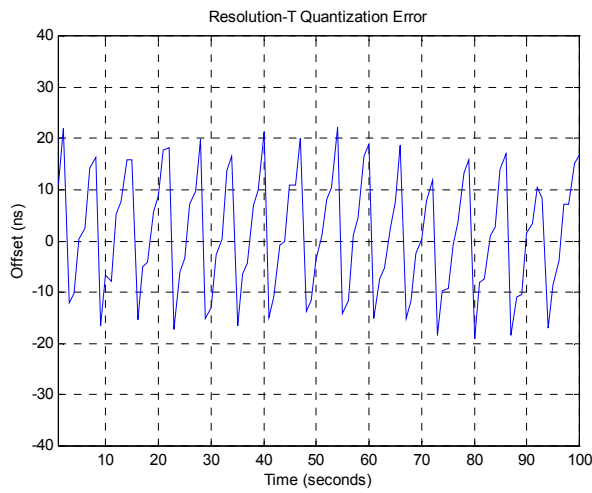
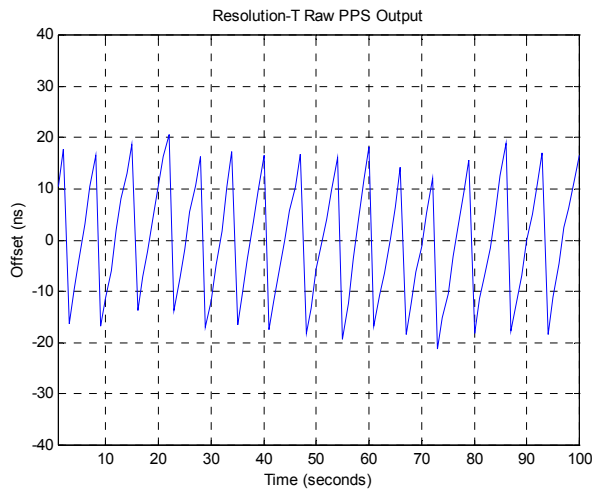
The quantization error is illustrated below. The top waveform represents the 12.504 MHz clock. The Resolution T output must be placed on one of the edges of this clock. The middle waveform represents the UTC/GPS on-time mark as determined by the receiver's electronics. The bottom waveform represents the Resolution T PPS output which is output on the clock edge closest to the actual UTC/GPS on-time mark.

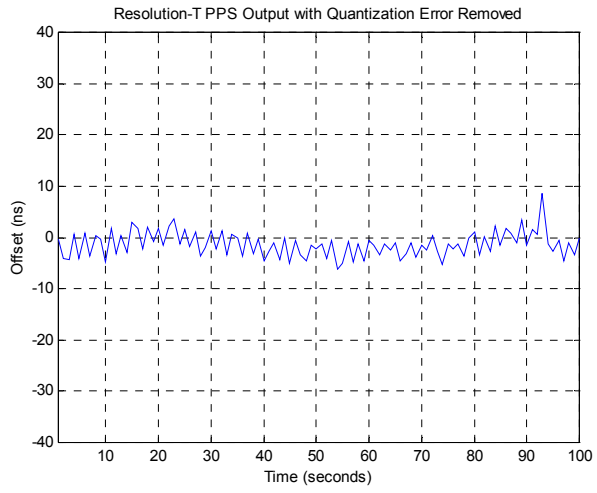


**Figure 9—PPS Quantization Error**

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.







## 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 ( $1\sigma$ ) 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 ( $\pm 20$  ns). Utilizing both the rising edge and falling edge of the pulse will enable a steering resolution of  $\pm 20$  ns. 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 ( $1\sigma$ ) 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-