Palisade NTP Synchronization Kit

User Guide

Part Number 39139-00

Revision A

June 1999

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

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- Increase the separation between the equipment and the receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

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6. Lightning or other electrical discharge
7. Normal wear and tear on consumable parts (for example, batteries)

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About This Manual

Welcome to the *Palisade NTP Synchronization Kit User Guide*. This manual describes how to integrate the Palisade smart antenna with Network Time Protocol and your host system to create a precision time server.

Scope and Audience

The following sections provide you with a guide to this manual, as well as to other documentation that you may have received with this product.

Organization

This manual contains the following:

- Chapter 1, Introduction, describes the Palisade NTP Synchronization Kit.
- Chapter 2, Getting Started, describes how to quickly install, connect and operate the Palisade smart antenna.
- Chapter 3, Palisade Installation, covers general installation guidelines.
- Chapter 4, Palisade Connections, provides detailed interfacing guidelines for connecting the Palisade smart antenna to the host system.
- Chapter 5, System Operation, describes the operating characteristics of the Palisade from power-up through the output of GPS information. GPS timing applications are also described.
- Chapter 6, NTP Software Installation and Configuration, describes Network Time Protocol and provides instructions for installing and configuring the NTP software, including separate sections for Windows NT and Unix installations.
- Appendix A, Trimble Standard Interface Protocol, defines the TSIP protocol and the structure of all message packets.
- Appendix B, TSIP Utilities, describes the TSIP interface programs included with the GPS Tool Kit program disk.

Note – The GPS Tool Kit program disk is included with the Palisade NTP Synchronization Kit.

- Appendix C, NMEA 0183, provides a brief description of the NMEA 0183 protocol and defines the structure of the NMEA message output by the Palisade.

- Appendix D, Specifications, includes the specifications and mechanical drawings for the Palisade smart antenna interface cables.
- Appendix E, NTP Diagnostics and Debugging, presents common reports and failure conditions and options for troubleshooting, including instructions for running NTP in Debug mode.
- Appendix F, Theory of Operation, gives a more detailed technical description of many of the Palisade smart antenna's operating characteristics. A brief overview of the system architecture is also presented.

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Thank you for purchasing this product. We would appreciate feedback about the documentation. Contributors of particularly helpful evaluations will receive a thank-you gift.

To forward your feedback, do one of the following:

- send an email to ReaderFeedback@trimble.com
- complete and fax or mail the reader comment form at the back of this manual. (If the reader comment form is not available, send comments and suggestions to the address in the front of this manual.)

All comments and suggestions become the property of Trimble Navigation Limited.

Related Information

The following sections discuss other sources of information that introduce, extend, or update this manual.

Update Notes

If any changes are made to the firmware, update notes are posted to the Trimble web site.

Other Information

This section lists sources that provide other useful information.

World Wide Web (WWW) Site

For additonal information and updates, visit the Trimble site on the World Wide Web (www.trimble.com/oem/ntp).

File Transfer Protocol (FTP) Site

Use the Trimble FTP site to send files or to receive files such as software patches, utilities, and answers to Frequently Asked Questions (FAQs). The address is ftp://ftp.trimble.com/pub/ntp.

You can also access the FTP site from the Trimble World Wide Web site (www.trimble.com/support/support.htm).

Technical Assistance

If you have a problem and cannot find the information you need in the product documentation, ***contact your sales representative***.

Abbreviations

In this manual, the following abbreviations are used:

- Kit - Palisade NTP Synchronization Kit
- TSIP - Trimble Standard Interface Protocol
- host system or host - the device or instrument connected to the Palisade smart antenna

  The host system can be a PC, network equipment, or timing system, depending on the application.

Document Conventions

Italics identify software menus, menu commands, dialog boxes, and the dialog box fields.

SMALL CAPITALS identify user commands, directories, filenames, and filename extensions.

Helvetica represents messages printed on the screen.

`Courier Bold` represents information that you must type in a software screen or window.

Helvetica Bold identifies a software command button.

[Ctrl] is an example of a hardware function key that you must press on a personal computer (PC). If you must press more than one of these at the same time, this is represented by a plus sign, for example, [Ctrl] + [C].

Cautions, Notes, and Tips

Cautions, notes, and tips draw attention to important information and indicate its nature and purpose.

Caution – Cautions describe operating procedures and practices required for correct operation and alert you to situations that could cause hardware damage or malfunction or software error.

Note – Notes give additional significant information about the subject to increase your knowledge, or guide your actions.

1 Introduction

Palisade is the latest in the Trimble Navigation family of smart antennas. The smart antenna allows OEMs and systems integrators to add GPS capability to their product lines quickly and easily, without becoming GPS experts. Trimble's Palisade smart antenna encompasses the experience of four product lines: Acutis, Acutime, AcutimeII and Palisade.

Palisade, based on Sierra™ GPS technology, is designed for wireless voice and data network synchronization. It offers precise PPS output, event input, and also supports long cable runs.

The Palisade is composed of a set of matched subsystems. This ensures optimal GPS performance, long-term reliability, ease of operation, and easy integration.

The Palisade houses the GPS receiver, antenna, power supply, interface and other support circuitry in a single enclosure that mounts like an antenna. As a sealed, shielded, self-contained unit with a digital interface, the Palisade eliminates most of the difficulties associated with integrating GPS. Once power is applied, the Palisade self-initializes, acquires satellite signals, and computes position, course, speed and time, automatically outputting this data to the host system.

To integrate the Palisade, the OEM only needs to add an interface port on the host system and develop a software interface. Standard interface protocols, such as NMEA 0183, and software interface tools, such as the GPS Tool Kit and Palisade Monitor, simplify this task, minimizing the engineering costs associated with integrating the Palisade.

1.1 Palisade Smart Antenna Overview

The Palisade has many features common to previous products in the Trimble family of smart antennas. These include:

- A 9 to 32-volt DC power supply with protection against reverse polarity.
- Trimble's advanced multi-channel GPS receiver architecture including the reference oscillator, the synthesizer and IF circuits, the digital signal processing hardware, a microprocessor, and the serial interface circuitry.
- A cross-dipole GPS antenna with a 35 dB pre-amplifier and multiple band-pass filters. The antenna element provides excellent low-horizon performance and the filters improve the system's immunity to jamming signals.
- A sealed, waterproof connector supporting both the power and interface connections.
- A waterproof, UV-resistant, plastic enclosure with a proven epoxy seal. The Palisade smart antenna is illustrated in Figure 1-1.

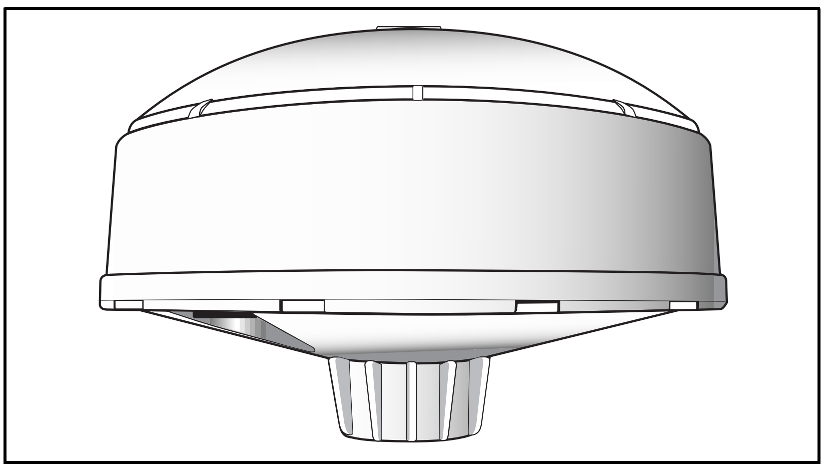


Figure 1-1 Palisade Smart Antenna

Palisade generates a PPS synchronized to UTC within ± 100 nanoseconds. This level of precision is obtained using an overdetermined time solution, a 40-nanosecond pulse steering resolution and a T-RAIM (Time - Receiver Autonomous Integrity Monitor) algorithm. Palisade's PPS conforms to RS-422, which supports long cable runs. Palisade outputs a comprehensive time packet synchronized with the PPS on a dedicated serial port. It also features an automatic operating mode that requires no user or host intervention. Palisade accepts an event input and reports time stamps in response to an external event mark.

Table 1-1 Palisade

Product Description	Part Number
Palisade with RS-422 Interface and Timing Pulse, version 7.12	38158-00

1.1.1 Palisade NTP Synchronization Kit

The Palisade NTP Synchronization Kit (38078-00) includes the components required to interface the Palisade with Network Time Protocol. The Kit includes the components listed in the table below.

Table 1-2 Palisade NTP Synchronization Kit Components

Component	Part Number
Palisade Smart Antenna with RS-422 Interface	38158-00
Synchronization Interface Module (SIM)	37071-00
Power supply (24 V, 100-250 VAC)	38076
AC power cord	39532
100’ Interface cable	37653
Serial Interface cable (RS-232, DB-9)	19309-00
GPS Toolkit Program disk	39650-01
Palisade Monitor disk	39571-01

2 Getting Started

The Palisade NTP Synchronization Kit includes all the components required to get started (see Table 1-2). The Kit allows you to connect the Palisade to a computer and communicate with the unit using the TSIPCHAT or Palisade Monitor interface programs.

The Synchronization Interface Module (SIM) supplies DC power to the Palisade and converts the serial communication signals from RS-422 to RS-232. This module enables the following interfaces:

- Port B supports bidirectional control/status communication with Palisade.
- Port A outputs the synchronous time packets and supports the precise timing event input.
- The PPS is converted from a differential signal to a 5V TTL active-high signal accessible through the BNC connector.

You will also need the following items:

- An IBM-compatible PC running DOS, Windows 95/98 or Windows NT.
- An appropriate power cord.

Note – A three-prong US AC power cord is provided in the starter kit. If your local AC power does not conform to U.S. standards, obtain a cord that conforms to the local AC power connector standard.

2.1 Connecting the Smart Antenna

Note – For permanent installations, see the instructions in Chapter 3.

For instructions on installing the smart antenna and routing the interface cable to the location of the PC, see Chapter 3, Palisade Installation.

The Palisade can be placed anywhere with clear view of the sky.

Note – If the Palisade is placed indoors, make sure that at least half the sky is visible and the view is not obscured by wire mesh or reflective window coatings.

Connect the interface cable to the smart antenna. The connector on the interface connector has a locking ring for securing the connection.

2.2 Connecting the Computer and Power Source

1. Connect the DB-25 connector on the Palisade interface cable to the Synchronization Interface Module as shown in Figure 2-1.
2. Connect port B to the computer’s serial port using the RS-232 serial interface cable.

   The SIM should be located as close as possible to the host computer, in order to minimize the length of RS-232 cable runs.
3. After the computer is powered up, apply power to the Palisade and SIM.

   The green Power LED lights up.

The green PPS LED on the SIM begins blinking after the receiver has acquired GPS time, driven by the automatic PPS timing packet on port A. This indicates proper function of the GPS receiver.

Note – The connection instructions provided in these instructions assume the Trimble interface cable included in the Kit. If you are using your own cable, modify the instructions accordingly.

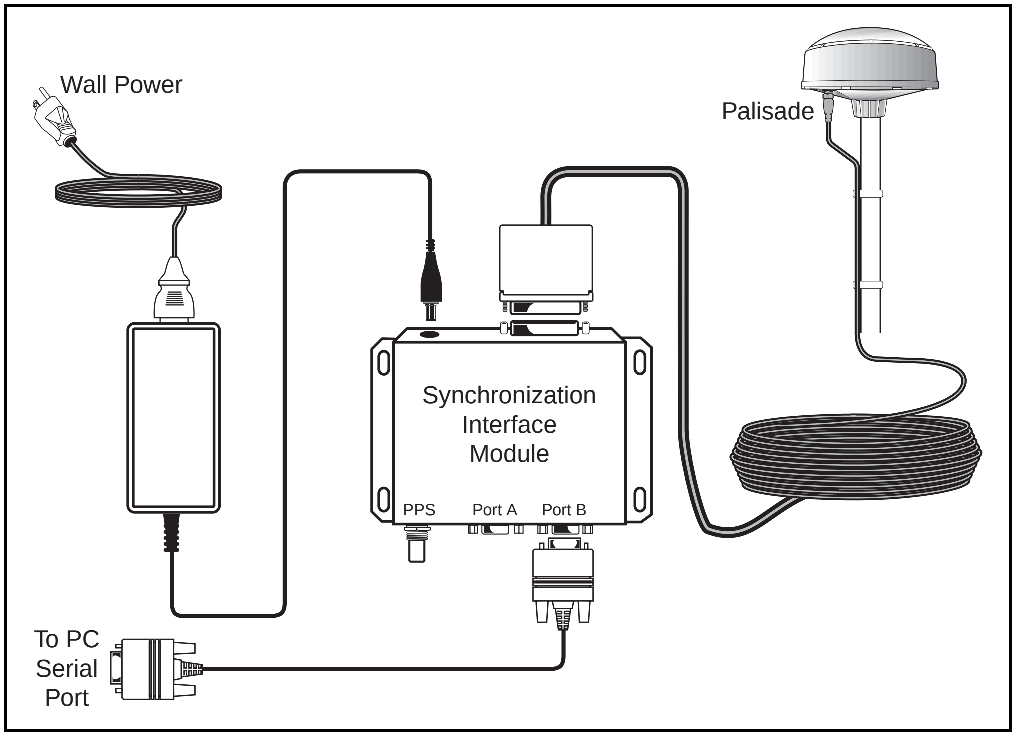


Figure 2-1 Connection Diagram

2.3 Time Transfer Connections

Connector A on the Synchronization Interface Module outputs time packet 8FxAD by default. To monitor the time packet output, attach a serial cable to connector A. Port A does not allow the user to send commands to Palisade.

2.4 Communicating with the Palisade

When power is applied, the Palisade acquires a valid set of satellites and automatically transmits position and time messages. During the satellite acquisition process, the Palisade outputs periodic status messages.

The Kit includes a disk containing TSIP interface programs that run on PC-DOS and Windows platforms. These programs aid system integrators in developing the software interface for the smart antenna. The TSIP programs are described in detail in Appendix B, TSIP Utilities.

To begin communicating with the Palisade, start the Palisade Monitor program. Data fields in the Palisade Monitor program fill up as the data becomes available. For details, see Appendix B.

3 Palisade Installation

This chapter provides installation guidelines for the Palisade smart antenna. Installation of the Palisade requires four steps:

1. Choose a location.
2. Mount the smart antenna.
3. Route and secure the interface cable.
4. Connect the host system.

Each of these installation steps is described in detail on the following pages.

3.1 Choosing a Location

Select an outdoor location for the antenna (such as the roof of your building) that has a relatively unobstructed view of the horizon. Consider the length of the cable run and the length of the interface cable when selecting a location. The Palisade smart antenna is designed for a pole mount. The mounting pole is not included with the Palisade. Pole mounting is illustrated in Figure 3-1.

The antenna can receive satellite signals through glass, canvas, and thin fiberglass, but dense wood, concrete and metal structures shield the antenna from satellite signals.

The Palisade smart antenna is an active-head antenna. For optimal performance, place the Palisade as far as possible from transmitting antennas, including radars, satellite communication equipment and cellular transmitters. When locating the antenna near a radar installation, ensure that the antenna is positioned outside of the radar's cone of transmission. Follow the same guideline when installing the antenna near satellite communication equipment. For best results, mount the antenna below and at least ten feet away from satellite communication equipment.

Note – For installations exposed to shock and/or vibration exceeding the limits specified in Appendix D, Specifications and Drawings, use a mounting scheme that isolates the Palisade from the excessive shock and/or vibration.

3.2 Mounting the Smart Antenna

The smart antenna is designed for a pole mount as illustrated in Figure 3-1. The threaded socket in the base of the antenna accepts either a 1"-14 straight thread (a common marine antenna mount) or a 3/4" pipe thread. A wide variety of 1"-14 pole mounts are available from marine hardware suppliers.

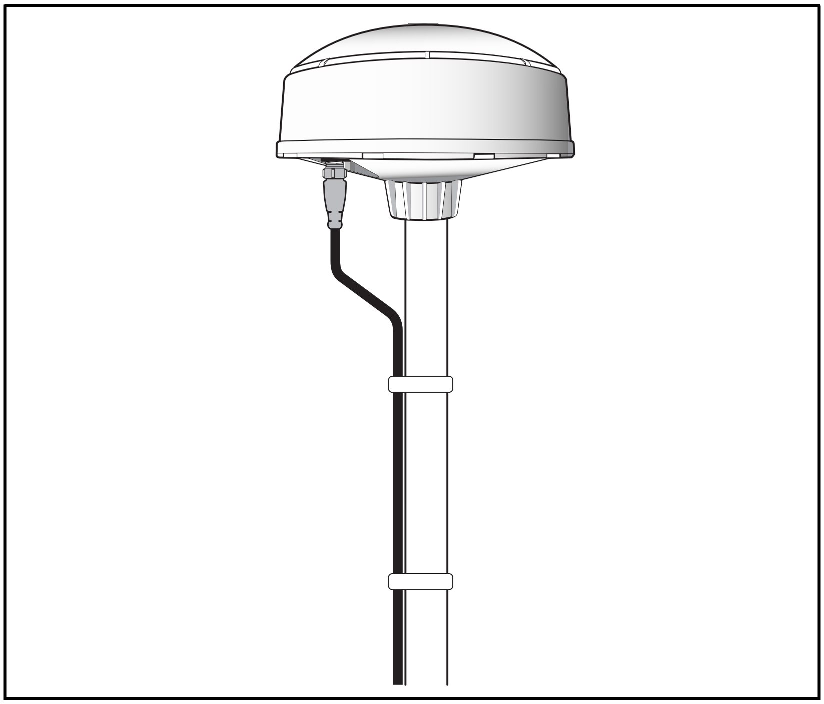


Figure 3-1 Pole Mount

After obtaining an appropriate mounting pole, follow these three simple steps to install the Palisade smart antenna.

1. Secure the mounting pole to a solid structure so that it is oriented vertically.
2. Thread the smart antenna onto the pole or pipe and hand-tighten until snug.

Caution – Do not over-tighten the smart antenna on the pole or use a tool—this could damage the threaded socket in the base of the antenna. Also, do not use a thread-locking compound because it can corrode plastic.

3. Connect the interface cable to the smart antenna.

   The connector on the interface connector has a locking ring for securing the connection.

Caution – Over-tightening the locking ring can strip the connector.

3.3 Routing and Securing the Interface Cable

After the smart antenna is mounted:

1. Route the interface cable from the smart antenna to the host location.

   The interface cable is a digital cable, so it can be spliced and extended, if necessary.

   Choose the most direct path to the host system, while avoiding the following hazards:

   - sharp bends or kinks in the cable
   - hot surfaces (exhaust manifolds or stacks)
   - rotating or reciprocating equipment
   - sharp or abrasive surfaces
   - door and window jambs
   - corrosive fluids or gases

2. When you have established the ideal cable routing, secure the cable along the routing using tie-wraps.

   When securing the cable, start at the antenna and work towards the host system. To provide strain relief for the interface cable connections, ensure that the cable is secured at points close to the smart antenna and the host system.

   Additional protection (for example, heat-shrink tubing) may be required to protect the cable jacket at points where the cable enters or exits bulkheads, especially if the opening is rough or sharp.

3. Once the cable is secured, the host end of the cable can be cut to an appropriate length (if necessary).

   Leave enough slack to allow easy connection to the host and normal movement (for example, rack, gimbal or swivel mounts).

3.4 Connecting the Host System

The final step, if applicable, is the installation of the connector on the host end of the cable. The connector installation instructions depend on the type of connector required by the host system.

For information on pin-outs, see Chapter 4, Palisade Connections.

4 Palisade Connections

This chapter provides instructions on connecting the Palisade to the host system and power source.

4.1 Interface and Power Connections

The black plastic connector located in the base of the Palisade supports both the interface and power connections. The location of the connector is illustrated in Figure 4.1. The Palisade uses a 12-pin connector. The pin arrangement for this connector is illustrated in Figure 4.2.

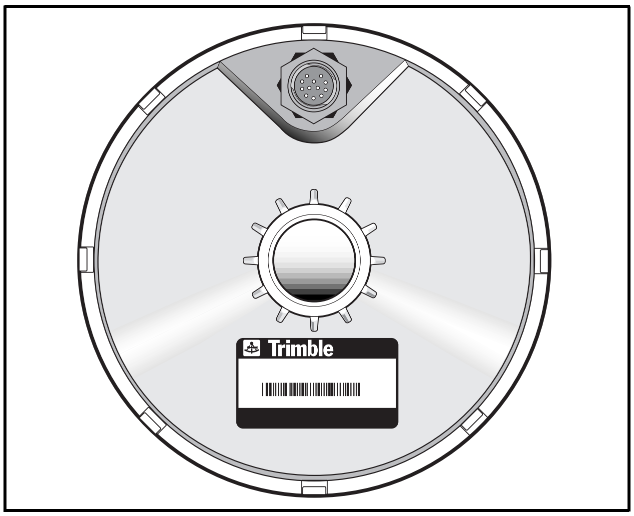


Figure 4-1 Palisade Interface Connector

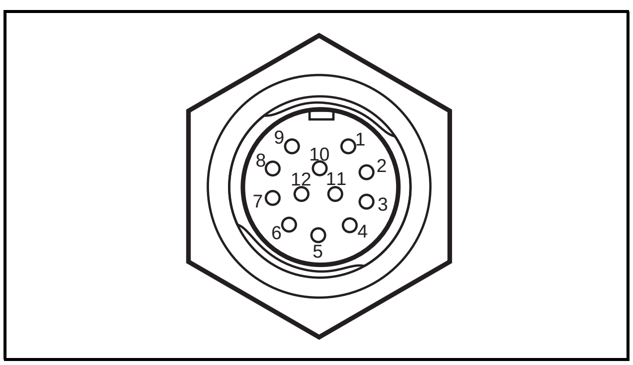


Figure 4-2 Palisade 12-pin Connector format

4.2 Interface Cables and Connectors

Trimble offers interface cables for the Palisade in various lengths.

The Palisade NTP Synchronization Kit cables are provided with a DB-25 connector compatible with the Palisade NTP Synchronization Interface Module.

Table 4-1 Starter Kit Interface Cables

Product Description	Part Number
100’ (30-meter) Kit Interface Cable	37653
200’ (60-meter) Kit Interface Cable	39227

Note – The standard interface cables offered by Trimble are not terminated on the host end, so the appropriate connector must be installed before connecting the cable to the host system.

Table 4-2 Standard Interface Cables

Product Description	Part Number
50' (15-meter) Interface Cable	23098
100' (30-meter) Interface Cable	23099
200' (60-meter) Interface Cable	24017
400' (120-meter) Interface Cable	24260
Contact Trimble for custom cables up to 500 m in length	

For OEMs and integrators who want to produce their own interface cables, Table 4-3 specifies the source and part number of the mating cable connectors for the 12-pin connector.

Table 4-3 Mating Connectors

Antenna Connector	Mating Connector	Manufacturer	Description
MMP Series #68001-2212P1	MMP Series #26C-2212S1	Deutsch Commercial Products 5733 W. Whittier Avenue Hemet, California 92545 Phone: (909) 765-2200 Fax: (909) 922-1544	Connector body (requires a molded backshell)

4.2.1 Pin-Outs

The pin-out descriptions and color codes for the Palisade NTP Synchronization Kit and standard interface cables are listed in Table 4-4.

The interface cable supplied with the Palisade NTP Kit is provided with a DB-25 connector conforming to the Synchronization Interface Module, as detailed in the following specification.

Non-terminated cables conform to the same signal, wire color and Palisade connector specifications. Select the appropriate connector for your host system. Using the pin-out information for both the smart antenna and the host system, install the connector on the standard interface cable.

Table 4-4 Palisade NTP Synchronization Kit Cable Pin-Out

Signal Description	Wire Color	Protocol	Palisade Connector	NTP DB25 Interface
DC Power (+9 to +32 Volts DC)	Red	+9 to 32 V	Pin 1	Pin 1
Port B: RS-422 / Receive -	Violet	TSIP RS422	Pin 2	Pin 25
Port B: RS-422 / Receive +	Orange	TSIP RS422	Pin 3	Pin 13
Port B: RS-422 / Transmit -	Brown	TSIP RS422	Pin 4	Pin 11
Port B: RS-422 / Transmit +	Yellow	TSIP RS422	Pin 5	Pin 23
Port A: RS-422 / Receive -	White	Event Input RS422	Pin 6	Pin 24
Port A: RS-422 / Receive +	Gray	Event Input RS422	Pin 7	Pin 12
Port A: RS-422 / Transmit -	Green	NMEA / TSIP RS422	Pin 8	Pin 10
DC Ground	Black	Ground	Pin 9	Pin 7
Port A: RS-422 / Transmit +	Blue	NMEA / TSIP RS422	Pin 10	Pin 22
One PPS: Transmit +	Orange w/ White stripe	RS422	Pin 11	Pin 21
One PPS: Transmit -	Black w/ White stripe	RS422	Pin 12	Pin 9

Note – The cable color codes listed in this table apply only if you are using the Trimble interface cable.

Note – Receive and Transmit are with respect to the Palisade smart antenna. The host Transmit should be connected to the Palisade's Receive, and vice versa.

Note – Hardware flow control (RTS/CTS) is not supported by the Synchronization Interface Module.

4.3 Connection Instructions

This section provides detailed information for connecting the Palisade's power, timing pulse and data packet lines.

4.3.1 Power Connection (Red and Black Wires)

The red wire (Palisade pin #1) and black wire (Palisade pin #9) in the interface cable support the power and ground connections, respectively. The Palisade features a switching DC power supply, which accepts from 9 to 32 volts. The Palisade is protected against reverse polarity and brief over-voltage conditions, but sustained over-voltage conditions can cause permanent damage.

Caution – Voltages exceeding 32 volts can cause permanent damage to the Palisade's power supply.

The typical power consumption of the Palisade at an input voltage of 12 volts is 250 milliAmps, or 3 Watts.

Note – The Palisade requires a minimum of 9 volts at the interface connector. When specifying the supply voltage, line losses in the interface cable must be considered. To account for line loss, the supply voltage may need to exceed 9 volts to satisfy the minimum voltage at the Palisade.

4.3.2 Timing Pulse Connections

Palisade outputs a timing pulse for use in timing and synchronization applications. The timing pulse is generated using an RS-422 line driver circuit (pins #11 and #12). The leading edge of the PPS output pulse is synchronized to UTC. The width of the pulse's leading edge is 20 nanoseconds or less. The exact width and shape of the pulse depends on the distributed capacitance in the interface cable.

For more information on using the timing pulse, see Chapter 5, System Operation.

4.3.3 Timing Packet Serial Connection

Palisade transmits a time packet on Port A within a few milliseconds after the PPS. This time packet can be either the NMEA ZDA packet or the comprehensive TSIP time packets (8Fx0B or 8FxAD). These time packets are synchronized to the PPS output, which simplifies identification of each time pulse.

4.3.4 Event Input

Palisade accepts an external event input in the form of an RS-422 pulse. The external event pulse input is supported on Port A (pins #6 and #7). Palisade transmits a time packet (NMEA, 8Fx0B or 8FxAD) in response to the event input and increments the event count field for each event received.

The event input is connected to the RTS signal line on Port A of the Synchronization Interface Module.

The event time stamp is generated within 40 nanoseconds of arrival at the Palisade’s interface connector. The precision of the time stamp is subject to Selective Availability and has specifications identical to those of the PPS.

Note – For precise synchronization, the host system must correct for cable delay.

5 System Operation

This chapter describes the operating characteristics of the Palisade, including start-up, satellite acquisition, operating modes, serial data communication, and the timing pulse. The Palisade acquires satellites and computes position and time solutions. Palisade outputs data in the TSIP protocol through its serial ports.

For more technical information on system operation, see Appendix F, Theory of Operation.

5.1 Start-up

At power-up, the Palisade automatically begins to acquire and track GPS satellite signals. Due to its 8-channel, 32-correlator design, Palisade typically obtains its first fix in under two minutes.

During the satellite acquisition process, the Palisade outputs periodic TSIP status messages on Port B. These status messages confirm that the receiver is working.

Note – Palisade has no provision for external backup power and always begins operation from a cold start unless a warm start is forced by uploading almanac data and time.

5.2 Automatic Operation

When the Palisade 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, lasting approximately 40 minutes, the self-survey is complete. At that time, Palisade automatically switches to a time-only mode and periodic outputs of navigation information cease.

5.2.1 Satellite Masks

Palisade continuously tracks and uses up to eight satellites in an overdetermined solution. The satellites must pass the mask criteria to be included in the solution.

The default satellite masks used by the Palisade are listed in Table 5-1. These masks serve as the screening criteria for satellites used in fix computations and ensure that solutions meet a minimum level of accuracy. The receiver suspends PPS output unless all satellite mask criteria are satisfied. The satellite masks can be adjusted using the TSIP protocol described in Appendix A.

Table 5-1 Default Satellite Mask Settings

Mask	Setting	Notes
Elevation	10°	SV elevation above horizon
SNR	5	Signal strength
DOP	8	Self-survey only

Elevation Mask

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

SNR Mask

Although the Palisade is capable of tracking signals with SNRs as low as 2, the default SNR mask is set to 5 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)
- multi-reflected signals (multipath)

Multi-reflected signals, also known as multipath, can degrade the position 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 a lower position accuracy. For most applications, a PDOP mask of 8 offers a satisfactory trade-off between accuracy and GPS coverage time. 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.

5.2.2 Tracking Modes

Palisade operates in one of two main fix modes:

- Self-Survey
- Overdetermined Clock Timing

After establishing a reference position in Self-Survey mode, Palisade automatically switches to Overdetermined (OD) Timing mode.

Self-Survey Mode

At power-on, Palisade performs a self-survey by averaging 2000 position fixes using up to eight satellites. The number of position fixes until survey completion is configurable using the 8E-4B command.

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

The highest accuracy fix mode is 3-D manual, where altitude is always calculated along with the latitude, longitude, and time. Four satellites with a PDOP below the PDOP mask are required in order to obtain a position. 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.

If the user wants only a 2-D solution, or if the exact altitude is known, 2-D manual should be requested. In this case, the receiver uses either the last altitude obtained in a 3-D fix, or the altitude supplied by the user. Any error in the assumed altitude affects the accuracy of the latitude and longitude solution.

Note – Altitude and the fix mode are stored in non-volatile memory.

OD Timing Mode

OD Timing mode is used only in stationary timing applications. This is Palisade's default mode. After Palisade self-surveys its static reference position, it automatically switches to OD Timing mode and determines the clock solution using up to eight satellites. The timing solution is qualified by a T-RAIM algorithm, which automatically detects and rejects faulty satellites from the solution.

In this mode, Palisade 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).

5.3 Serial Data Communication

When the Palisade has acquired a set of satellites that conforms to the mask and mode settings and collected a valid ephemeris for each satellite, it automatically commences periodic outputs of GPS data and generates a timing pulse (PPS).

5.3.1 Port B

The Palisade outputs periodic TSIP health, mode, and time messages on Port B. These status messages confirm that the receiver is working. These packets are described in Appendix A, Trimble Standard Interface Protocol.

The factory default port setting is 9600 baud in/out, 8-odd-1. The serial port setting can be changed and stored in serial EEPROM using a TSIP command.

5.3.2 Port A (Timing)

Palisade has a dedicated serial port for outputting comprehensive time packets. Messages are output synchronous with the PPS and after external events. This message can consist of either binary TSIP super packets or the ASCII NMEA ZDA message, or both. The factory default setting is TSIP, 9600, 8-odd-1, output only.

The host system receives both the PPS and the time packet identifying each pulse.

Palisade generates a packet in response to the external event input. The event count field in packet 8Fx0B increments for each event received. This field resets after a power cycle and rolls over at 65535. The event tag messages are interleaved with the PPS messages. PPS tags are distinguished by a zero (0) in the event count field. Palisade accepts external events up to a 5 Hz rate.

5.4 GPS Timing

In many timing applications, such as time/frequency standards, site synchronization systems, wireless voice and data networks and event measurement systems, GPS receivers are 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 cost-effective use of crystal oscillators, which have poorer stability than expensive high-quality oscillators, such as atomic cells.

The GPS constellation consists of 32 orbiting satellites. Unlike most telecommunications satellites, GPS satellites are not geosynchronous, so satellites in view are constantly changing. Each GPS satellite contains a highly-stable atomic (cesium) clock, which is continuously monitored and corrected by the GPS control segment. Consequently, the GPS constellation can be considered a set of 32 orbiting clocks with worldwide 24-hour coverage.

Trimble GPS receivers use the signals from these GPS "clocks" to correct their own internal clocks, which are not as stable or accurate as the GPS atomic clocks. GPS receivers like the Palisade output a highly accurate timing pulse (PPS) generated by their internal clocks, which is constantly corrected using the GPS clocks. In the case of the Palisade, this timing pulse is synchronized to UTC within 100 nanoseconds (nominal) after survey is complete.

In addition to serving as highly-accurate stand-alone time sources, GPS 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.

GPS time accuracy is bounded by the same major source of error that affects position accuracy: Selective Availability (S/A). The position and time errors are related by the speed of light. Therefore, a position error of 100 meters corresponds to a time error of approximately 333 nanoseconds. The GPS receiver's clocking rate and software affect PPS accuracy. Palisade's 25 MHz clocking rate enables a steering resolution of 40 ns (±20 ns). Using software algorithms like an overdetermined clock solution, Palisade mitigates the effects of S/A to achieve a PPS accuracy of ±100 ns after survey is complete.

5.4.1 Timing Operation

Palisade automatically outputs a PPS and time tag. With an accurate reference position, Palisade automatically switches to an overdetermined timing mode, activates its T-RAIM algorithm and outputs a precise PPS. The overdetermined clock solution mitigates the effects of S/A. Using a simple voting scheme based on pseudo-range residuals, Palisade's integrity algorithm automatically removes the worst satellite with the highest residual from the solution set.

Palisade's default configuration provides optimal timing accuracy. The only item under user or host control that can affect the Palisade’s absolute PPS accuracy is the delay introduced by the interface cable. For long cable runs, this delay can be significant (1.25 nanoseconds per foot). The Palisade's default configuration assumes a 100-ft interface cable. 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. The cable delay is 1.25 nanoseconds per foot of cable. For cables longer than 100 feet, increase the delay. For cables shorter than 100 feet, decrease the delay.

Timing Pulse Output (PPS)

A pulse-per-second (PPS), 1.25 microsecond-wide pulse is available on the Palisade's interface connector. The pulse is sent once per second and the leading edge of the pulse is synchronized to UTC. The pulse shape is affected by the distributed capacitance of the attached cabling and input circuit. The leading edge is typically less than 20 nanoseconds wide. The pulse's trailing edge should never be used for timing applications. An accurate timing pulse is available only when the Palisade is operating in the static Overdetermined Timing mode. Palisade stops generating the PPS output when no satellites are available for time transfer.

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.

Note – The event time reported in 8F-0B and 8-AD is corrected for the fractional UTC offset if UTC PPS (default) is selected.

6 NTP Software Installation and Configuration

6.1 Network Time Protocol

The Network Time Protocol (NTP) is a family of programs that are used to adjust the system clock on your computer and keep it synchronized with external sources of time. NTP was developed by Dr. David Mills at the University of Delaware. Information is available at the official NTP web site:

www.eecis.udel.edu/~ntp

The Network Time Protocol is designed to function as a background task on the host operating system, so that its operation is transparent to the user and system tasks. Time data is transferred from external time sources to clients within your domain. NTP achieves accuracy in the sub-microsecond to low-millisecond range with hardware currently available.

This section describes installation of the NTP software on a designated network computer for use with the Palisade Smart Antenna as primary reference clock.

6.1.1 NTP Time Servers

A primary network time server is a networked computer connected to an accurate external source of reference time. The time server synchronizes its clock to the reference clock's time, and provides accurate time of day information to clients on the network. The network computer is also referred to as the host, because it provides a serial interface for the Palisade and processing facilities for time transfer.

NTP Time Server Requirements

The Palisade NTP Synchronization Kit can be used on any Windows NT or UNIX system with an available serial port. The NTP software used must include support for the Palisade Smart Antenna.

- Windows NT 4.0 or UNIX System with RS-232 Port
- NTP Version 4 Executable with Palisade NTP reference clock support

As many as four Palisade receivers can be connected to a single time server.

Optional Equipment:

DOS/Windows 95/98/NT System for monitoring GPS operation through Palisade Port B.

6.2 Software Sources and Compatibility

The list of systems supporting the Palisade NTP reference clock is continuously growing. For updated information, see the Trimble web site at **www.trimble.com/oem/ntp**.

For the latest documentation for the Palisade driver, or if Palisade NTP reference clocks are not supported by the version of NTP shipped with your operating system, see the Trimble FTP site at **ftp://ftp.trimble.com/pub/ntp**. You may also be able to obtain binaries supporting Palisade NTP through your operating system vendor's support channel.

You can also download and compile a late release of the NTP distribution yourself. For more information, see Compiling the NTP Distribution, page E-17.

6.2.1 Installation Support

Trimble is attempting to provide the best possible support for customers who use the Palisade NTP Synchronization Kit to transfer time to NTP hosts. Due to the wide variety of systems, peripherals, and associated configurations, Trimble is not able to provide assistance installing and testing NTP. Technical support for installation and configuration of NTP servers is limited to NTP documentation and software available on the Trimble Navigation NTP Web site at **www.trimble.com/oem/ntp**.

Please consult with a qualified systems administrator to verify I/O connections between the Palisade NTP reference clock and your host system.

For more information, consult the Internet news group **news://comp.protocols.time.ntp**.

If you suspect a problem with the Palisade GPS receiver, please see Chapter 2, Getting Started, before calling Trimble technical support.

6.3 Pre-Installation Check List

Before beginning installation and configuration of NTP, complete the following tasks:

6.3.1 GPS Preparation

- Perform the checkout, installation and connection instructions in chapters 1–4.

Note – Temporary installations, as described in Chapter 2, can be used to establish functionality of NTP, but reliable performance cannot be achieved until the Palisade smart antenna is properly installed with clear view of the sky.

- The Palisade and Synchronization Interface Module should be powered up.
- PPS indicator LED should be flashing once per second, indicating the output of data packets.
- A valid UTC almanac has been acquired by the Palisade Smart Antenna. This should be confirmed using the Palisade Monitor or TSIPCHAT applications.

Note – NTP will not accept time stamps from the Palisade NTP reference clock until a valid UTC almanac has been obtained. The UTC information is stored in non volatile memory and only erased during a factory reset operation.

6.3.2 Host System Preparation

- Installation of NTP must be performed by a user with administrative or super-user privileges.
- Network Time Protocol can not coexist with other clock synchronization utilities, such as the TimeServ utility available in the Microsoft Windows NT Resource Kit. Any other time synchronization utility running on the host system must be stopped, disabled or de-installed.
- The host system clock should be set manually to the correct time. If your network already has a time server, use the NTPDATE utility to reset the system clock is recommended. For more information on using NTPDATE, see Appendix E, NTP Diagnostics and Debugging. In absence of existing time servers, use the operating system date/time facilities to reset the clock to the approximate local time.

6.3.3 Operating System Specific Information

This documentation is applicable to Windows NT and UNIX Installation. Separate instructions for the different operating systems are provided where required.

6.4 Time Transfer Cable Connection

The serial port of the host computer serves as a precision synchronization interface between NTP and the Palisade smart antenna.

Connect Port A on the Palisade Synchronization Interface Module, to the NTP time server's serial port, as shown in Figure 6-1. Trimble provides a standard DB-9 serial cable with the Palisade NTP Synchronization Kit.

Note – If your network host's serial port is not a standard DB-9 serial connector, you need an appropriate converter. Ensure that proper Ground, Request To Send, Data Transmit and Data Receive connections are supported by the converter.

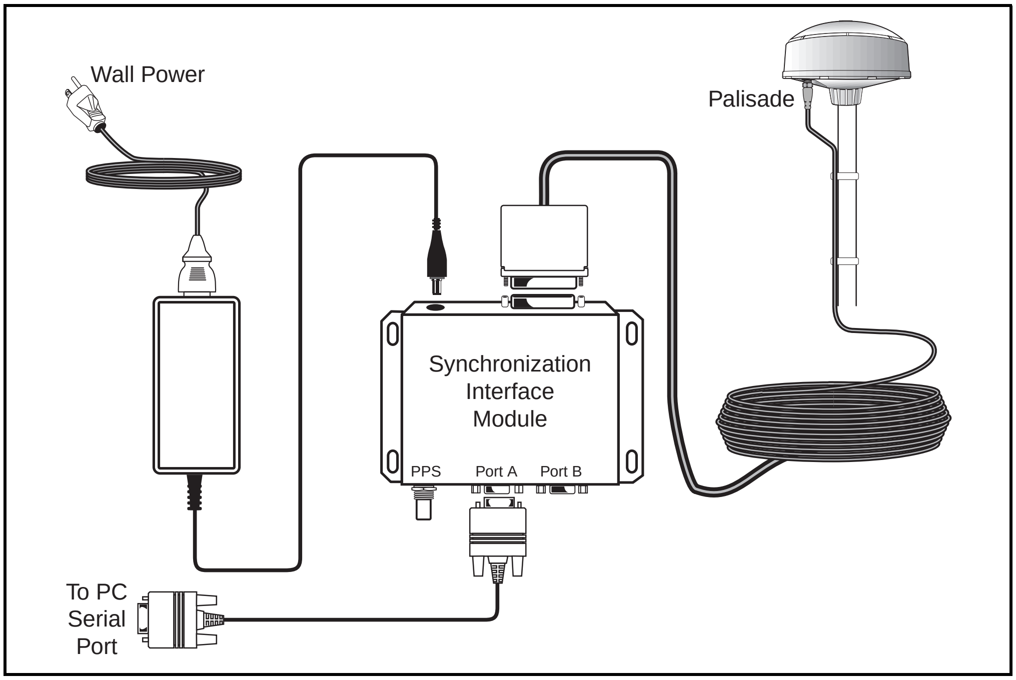


Figure 6-1 Time Transfer Connection Diagram

6.4.1 Optional Connections

Port B and the PPS output of the Synchronization Interface Module are not currently used by the Palisade NTP reference clock driver, and do not require connection. They are available for other applications, such as backup timing interfaces on the time server.

6.5 NTP Software Installation

NTP software installation consists of copying the NTP program and utilities to the host system's fixed disk, and configuring the system to start NTP after booting.

The same NTP software can be used on servers and client workstations. This versatility allows efficient reconfiguration of time servers to function with the Palisade NTP reference clock if necessary.

6.5.1 NTP Configuration File

The NTP configuration file, NTP.CONF, is a human readable text file which contains information about security settings, time servers and reference clocks. NTP reads the information in this file at startup, and initializes itself according to the configuration entries.

The order of the line items in the configuration file is arbitrary. You must edit the configuration file for the serial port connection on your system. You should also include any available time servers on your network.

Note – The configuration file is a security sensitive file. It should be protected from accidental or intentional modification by users, and should only be modified by a qualified systems administrator.

Create a NTP configuration file similar to the one shown in Figure 6-2.

```
#-------------------------------------------------------
# Simple NTP Configuration File for Palisade NTP
#
# Trimble Palisade Smart Antenna GPS (Stratum 1).
server 127.127.29.1
#
# A network time server
server terrapin.trimble.com
#-------------------------------------------------------
```

Figure 6-2 NTP Configuration File

Note – If your system already has a configuration file, you may want to review the entries or make a backup file before modifying the existing configuration.

6.5.2 Palisade Configuration

The following line must be found in the NTP configuration file to declare an external Palisade NTP reference clock:

`server 127.127.29.x`

The prefix 127.127.29 uniquely identifies the Palisade NTP reference clock.

The last number, represented by **`x`**, represents the reference clock unit number.

Unit Number

The unit number identifies the physical serial port to which Palisade is connected. Selection of the unit number, location of the NTP configuration file and installation of the software are different for Windows NT and UNIX. Follow the appropriate instructions to select the correct unit number for your Palisade Reference Clock.

6.5.3 Network Server Selection

To complete the configuration file, you need to define additional sources of time for the server. Each time server on the network should have at least three independent clock references to function optimally.

In large organizations there may already be network time servers in operation. Consult your system administrators for their names or IP numbers. If you have Internet Access, look at the list of public time servers and choose geographically close sites for your sources.

You should choose a minimum of one time server, and it is a good idea to choose three or more for redundancy. An example of a time server entry is provided in the sample configuration file. Create one server line item with the name or IP number for each available time server.

6.5.4 Additional Configuration Information

This documentation provides only minimal required configuration information. For complete information about available configuration options, please refer to documentation provided with your NTP distribution.

6.6 Windows NT Installation

The following instructions are specific to installing the port of NTP for Windows NT distributed by Trimble Navigation at **ftp://ftp.timble.com/pub/ntp/binaries/winnt**.

Note – To install NTP, you must log into the Windows NT system as a user with administrator privileges.

Note – Other third-party distributions of NTP for Windows NT may not support the Palisade NTP reference clock.

Note – Not all features documented in the UNIX Version of NTP are supported in the Windows NT port. Trimble makes every effort to maintain the Windows NT port at the highest performance levels, but cannot maintain complete compatibility with UNIX versions, or provide technical support on the NTP port beyond the online documentation.

6.6.1 Automatic Installation

The automatic installation program for Windows NT performs all the steps required to install and configure the Network Time Protocol Service for Windows NT, with minimal input from the user.

For detailed installation instructions, please refer to the documentation accompanying the NTP installation program. The installation program creates the NTP configuration file after allowing the user to input the names or IP numbers of Network Time Servers, and information about the Palisade NTP reference clock.

6.6.2 Manual Installation

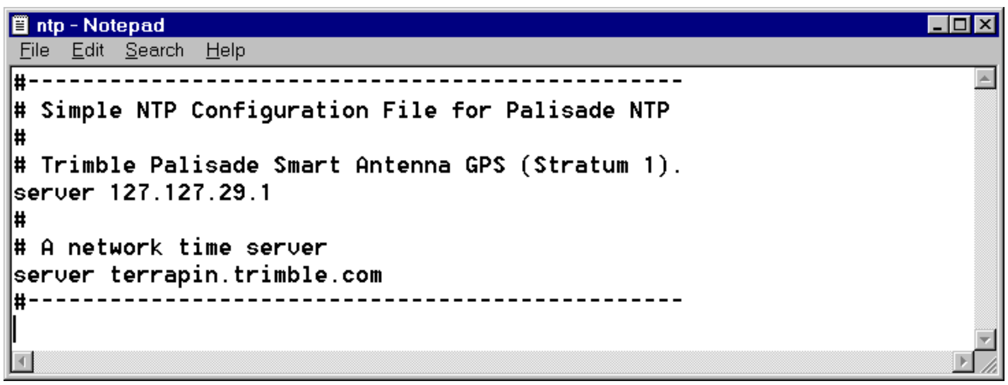
Manual installation requires the user to create the configuration file, copy the NTP executable to the appropriate location on disk, and then install, configure and start the NTP service.

The manual installation procedures for the NTP software are below.

Create the Configuration File

The NTP configuration file, NTP.CONF, should be created in the \WINNT\ directory.

The lines preceded by # symbols are comments and are ignored by NTP.



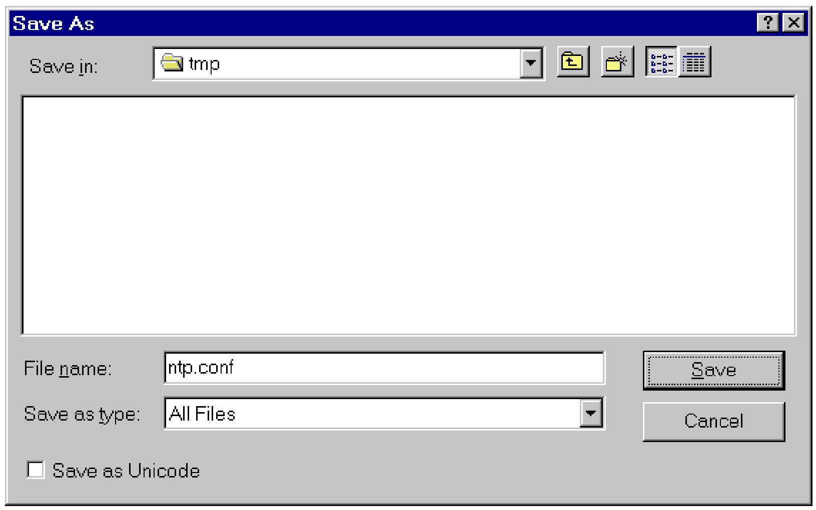

```
#-----------------------------------------------
# Simple NTP Configuration File for Palisade NTP
#
# Trimble Palisade Smart Antenna GPS (Stratum 1).
server 127.127.29.1
#
# A network time server
server terrapin.trimble.com
#-----------------------------------------------
```

Valid unit numbers on Windows NT are 1–255. The unit number identifies the number of the serial port on the Windows NT host. For example, if the Palisade NTP reference clock is connected to COM2, the entry line should read:

```
server 127.127.29.2
```

1. Copy the sample configuration file above.
2. Change the Palisade unit number to the correct number corresponding to the COM port you are using.
3. Add SERVER lines for available NTP servers on your network. You must add one line for each NTP server with which you want your time server to communicate.
4. NTP clients should not be included in the SERVER configuration entries in the configuration file.

Note – If you are using NOTEPAD to create the configuration file, make sure that you select *All files* in the *Save as type* drop-down menu (this avoids creating a file named NTP.CONF.TXT, which NTP will not recognize).



Copying Executable Files

The NTP service requires the NTP service executable, NTPD.EXE, to be available at system boot. In this example, the NTP executable is located in the \WINNT\SYSTEM32 directory.

1. Verify that all required files are present. The file sizes and dates may vary, but all files must be present for successful installation.

```
Command Prompt

C:\ntp>dir
 Volume in drive C has no label.
 Volume Serial Number is D845-2F2F

 Directory of C:\ntp

05/09/99  02:46p        <DIR>          .
05/09/99  02:46p        <DIR>          ..
05/04/99  01:52p                36,864 Instsrv.exe
05/04/99  02:22p                98,304 ntpq.exe
05/04/99  02:21p                65,536 ntpdate.exe
05/04/99  02:22p               102,400 ntpdc.exe
05/04/99  02:22p                57,344 ntptrace.exe
05/04/99  02:21p               167,936 ntpd.exe
05/09/99  03:18p        <DIR>          debug
               9 File(s)        528,384 bytes
                              9,601,024 bytes free

C:\ntp>
```

The debug directory contains a debug version of NTP, which can be used to obtain more information about system operation or to diagnose problems. For more information on using the debug version of NTP, refer to Appendix E, NTP Diagnostics and Debugging.

2. Copy NTPQ.EXE, NTPDATE.EXE, NTPDC.EXE, NTPTRACE.EXE and NTPD.EXE to the \WINNT\SYSTEM32 directory.

```
Command Prompt
 Volume Serial Number is D845-2F2F

 Directory of C:\ntp

05/09/99  02:46p        <DIR>          .
05/09/99  02:46p        <DIR>          ..
05/04/99  01:52p                36,864 Instsrv.exe
05/04/99  02:22p                98,304 ntpq.exe
05/04/99  02:21p                65,536 ntpdate.exe
05/04/99  02:22p               102,400 ntpdc.exe
05/04/99  02:22p                57,344 ntptrace.exe
05/04/99  02:21p               167,936 ntpd.exe
05/09/99  03:18p        <DIR>          debug
               9 File(s)        528,384 bytes
                              9,601,024 bytes free

C:\ntp>copy ntp*.exe c:\winnt\system32\
ntpq.exe
ntpdate.exe
ntpdc.exe
ntptrace.exe
ntpd.exe
        5 file(s) copied.

C:\ntp>
```

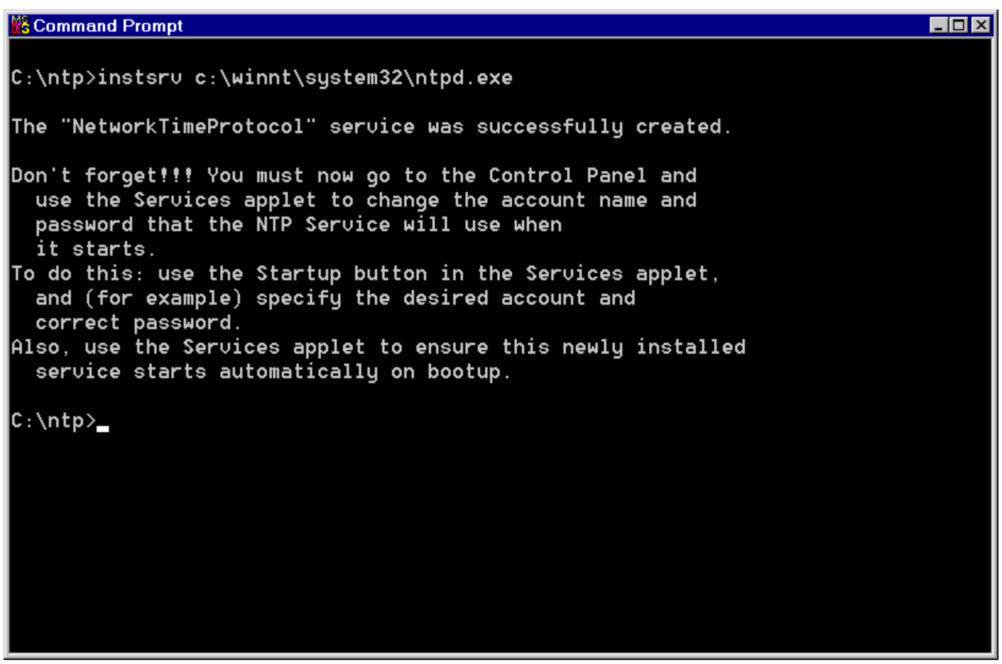
This operation ensures the NTP service files are available to Windows NT when the system starts.

Installing the Service

The NTP service must be registered with the Windows NT Service Control Manager and configured to start at system boot.

To register the service, use the command line utility, INSTSRV.EXE, provided with NTP. The INSTSRV.EXE utility requires a single parameter representing the complete path to the location of the NTPD.EXE executable. This example assumes Windows NT is installed in: C:\WINNT. If your system directory is different, modify the path to the NTP executable accordingly.

1. Start a *command prompt* window, and change to the directory containing the INSTSRV.EXE utility.
2. Type **`instsrv c:\winnt\system32\ntpd.exe`**.



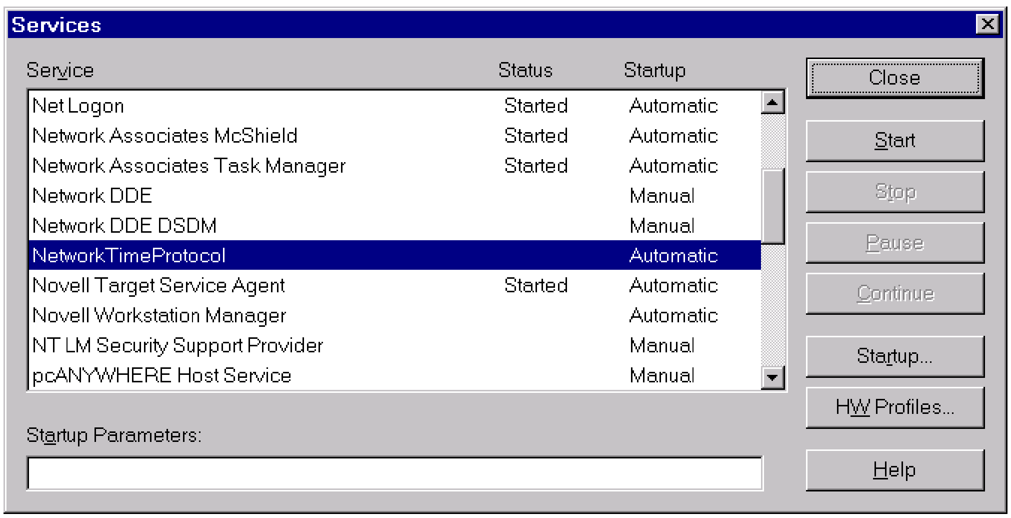
Note – Make sure to also type the ***.exe*** extension of the file name.

The program has registered the NTP service with the operating system. A message is printed informing the user to change the account name and password for NTP. This is not necessary in later versions of the Windows NT port.

6.6.3 Starting the Service

The last steps are performed using the Services Applet in the Windows NT Control panel.

1. Open the Control Panel Services Applet.
2. Scroll to Network Time Protocol.
3. Make sure Startup is set to Automatic**.**
4. Click **Start.**



NTP starts and the Network Time Protocol service status changes to Started. Close the Services Applet.

Manual NTP configuration is complete. NTP will start each time the system is booted. To verify the correct operation of NTP and the Palisade NTP reference clock, follow the instructions in Monitoring NTP, page 6-25.

6.7 UNIX Installation

Unix installation must be performed by a user with root (or super-user) privileges on the system.

The host system is usually configured to start NTP when the system boots, so that re-synchronization can be established quickly in case of a power or network failure.

Consult your UNIX system documentation to determine what start-up scripts must be modified to load NTP at system boot time. Many late Unix distributions contain administration tools that perform automatic installation and configuration of startup system tasks such as NTP.

6.7.1 Create the Configuration File

The NTP configuration file, NTP.CONF, should be located in the /ETC directory.

The window below shows a simple configuration file declaring a Palisade NTP reference clock and a network time server in the Trimble.COM domain. The Palisade NTP reference clock is declared as unit #1.

A maximum of four Palisade NTP reference clocks can be connected to any UNIX host. Valid unit numbers on UNIX systems are 0–3. The next section examines the use of the unit number in mapping to physical serial ports on the host system.

xterm

```
lucky_first# cat /etc/ntp.conf
#-------------------------------------------------------------
# UNIX Configuration for Palisade NTP refclock #1
server 127.127.29.1
#
# a Network Time Server
server terrapin.trimble.com
#
#-------------------------------------------------------------
lucky_first# 
```

The /ETC/DRIFT file is used to record information about the onboard system's intrinsic frequency error. For more information on this feature, please refer to NTP documentation .

6.7.2 Set Up Device Links

NTP attempts to open the I/O file /DEV/PALISADEX, to communicate with the Palisade NTP reference clock. The **x** represents the unit number of the reference clock in the configuration file.

A symbolic link /DEV/PALISADEX must be set up to point to the correct host serial port. This is typically performed by a sequence of shell commands similar to:

```
cd /dev
ln -s ttyS0 /dev/palisade0
```

Creation of a symbolic link for Palisade NTP reference clock unit #1 connected to the second serial port, **ttyb**, is shown below for a Solaris system. The link for unit 0 has already been established and remains unused in this configuration.

```
xterm
lucky_first#
lucky_first# cd /dev
lucky_first#
lucky_first# ls -l palisade*
lrwxrwxrwx   1 root     other          4 Nov  3  1998 palisade0 -> ttya
lucky_first#
lucky_first# ls -l tty?
lrwxrwxrwx   1 root     root           6 Feb  2  1995 ttya -> term/a
lrwxrwxrwx   1 root     root           6 Feb  2  1995 ttyb -> term/b
lucky_first#
lucky_first# ln -s ttyb /dev/palisade1
lucky_first#
lucky_first# ls -l palisade*
lrwxrwxrwx   1 root     other          4 Nov  3  1998 palisade0 -> ttya
lrwxrwxrwx   1 root     other          4 May 10 00:17 palisade1 -> ttyb
lucky_first#
lucky_first# cat /etc/motd
Sun Microsystems Inc.   SunOS 5.5       Generic November 1995
lucky_first#
```

1. Replace the string **`ttyb`** in the **`ln`** command with the appropriate serial port designator for your system.
2. Replace the number 1 in the string **`/dev/palisade1`** with the unit number in your NTP configuration file.

Serial port designators on UNIX systems are usually designated by `/dev/cua`***u*** or `/dev/tty`***u***, where ***u*** may be composed of one or more alphanumeric characters.

The following table may assist you in locating the appropriate serial port and symbolic link names for your system. Verify presence of the actual device files and validity of all links in the /DEV directory before using a serial device.

Table 6-1 System Serial Ports and Symbolic Link Names

Operating system	Port Name / Enumeration	Serial Port	Sample Link
Linux	ttyS / 0, 1, 2, ...	/dev/ttyS0	/dev/palisade0
HPUX	cua / 0, 1, 2, ...	/dev/cua1	/dev/palisade1
SUN OS / Solaris	tty / a, b, c, ...	/dev/ttyc	/dev/palisade2

6.7.3 Hardware Configuration

You may want to use a system configuration tool to enable and configure system serial ports to function with Palisade. Turn off any login service or modem server that may be attempting to use the port.

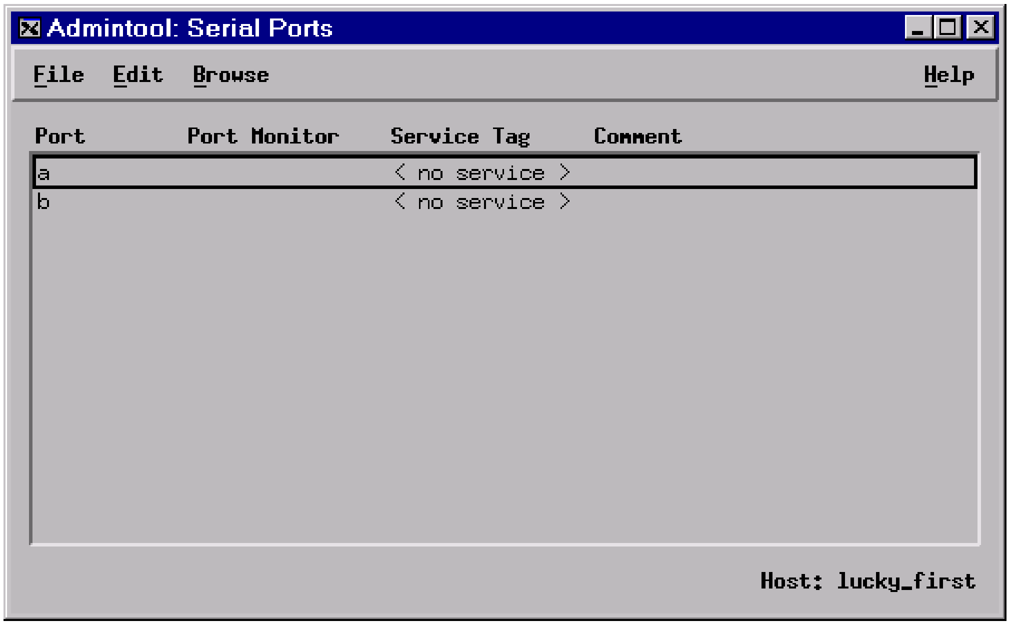


Figure 6-3 Disabling Serial Port Services Using an Administrative Tool

Palisade NTP uses the following serial port configuration:

- 9600 baud, 8-bits, 1-stop bit, odd parity.
- No DSR signal is generated.
- No DTR signal is required.
- Flow control protocols are not acknowledged.

If your UNIX system requires initialization of serial devices, use a configuration corresponding to these parameters.

6.7.4 Copying Executable Files

If you obtained binary executable versions of the NTP daemon and its utilities, you will have to unpack the archive and manually move the files to the desired storage directory. NTP is commonly located in /USR/LOCAL/BIN.

You must also edit your startup scripts to point to the location of the NTP executable you choose.

6.7.5 System Initialization

Some systems may require additional initialization before NTP can run. Sun OS and Solaris may require running the TICKADJ utility to turn off synchronization with the onboard real-time clock.

xterm

```
lucky_first#
lucky_first#
lucky_first# cat /etc/motd
Sun Microsystems Inc.   SunOS 5.5       Generic November 1995
lucky_first#
lucky_first#
lucky_first# tickadj -s
KERNEL nsec_per_tick = 10000000 nsec
KERNEL tick = 10000 usec (from nsec_per_tick kernel variable)
PRESET tick = 10000 usec
PRESET tickadj = 5 usec
dosynctodr is off
kernel level printf's: on
KERNEL hz = 100
calculated hz = 100.00 Hz
zeroing dosynctodr: done!
lucky_first#
lucky_first#
lucky_first#
```

6.7.6 Start NTP

Execute NTP from the command line by typing the path and name of the ntp executable:

```
/usr/local/bin/ntpd
```

Installation of NTP is complete. You still need to modify startup scripts to ensure NTP is loaded when the system reboots.

To verify the correct operation of NTP and the Palisade NTP reference clock, follow the instructions in the next section, Monitoring NTP. To diagnose possible problems communicating with the Palisade, see Appendix E, NTP Diagnostics and Debugging.

6.8 Monitoring NTP

This section briefly describes the tools and operating system facilities used when monitoring NTP for correct operation. For more information of the capabilities of these tools, please refer to your Operating System and NTP documentation.

NTP provides a network accessible management interface that allows the NTP utilities included in the distribution to communicate with different servers. The NTP utilities are virtually identical on both UNIX and Windows platforms.

NTP query is a utility to quickly check the status of NTP servers or clients. The use of the NTP Query utility, NTPQ.EXE, is outlined on page 6-28.

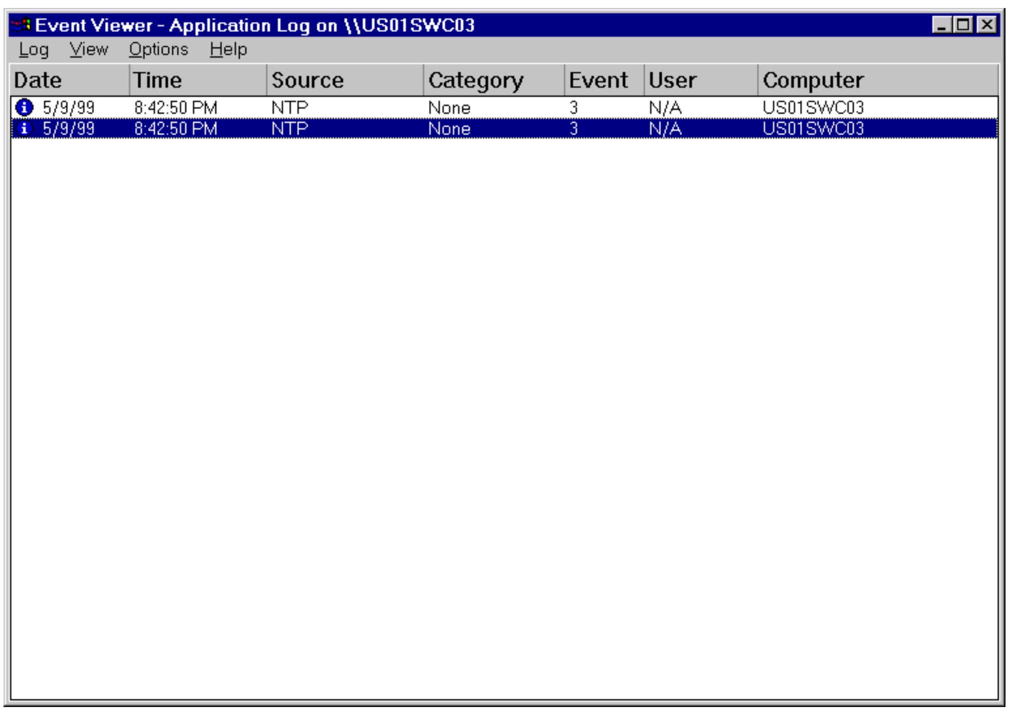
NTP start-up and synchronization events are written into the Operating System Log files. The same messages are generated for UNIX and Windows NT, although the log interface is different for the two system classes.

6.8.1 NTP Events on Windows NT

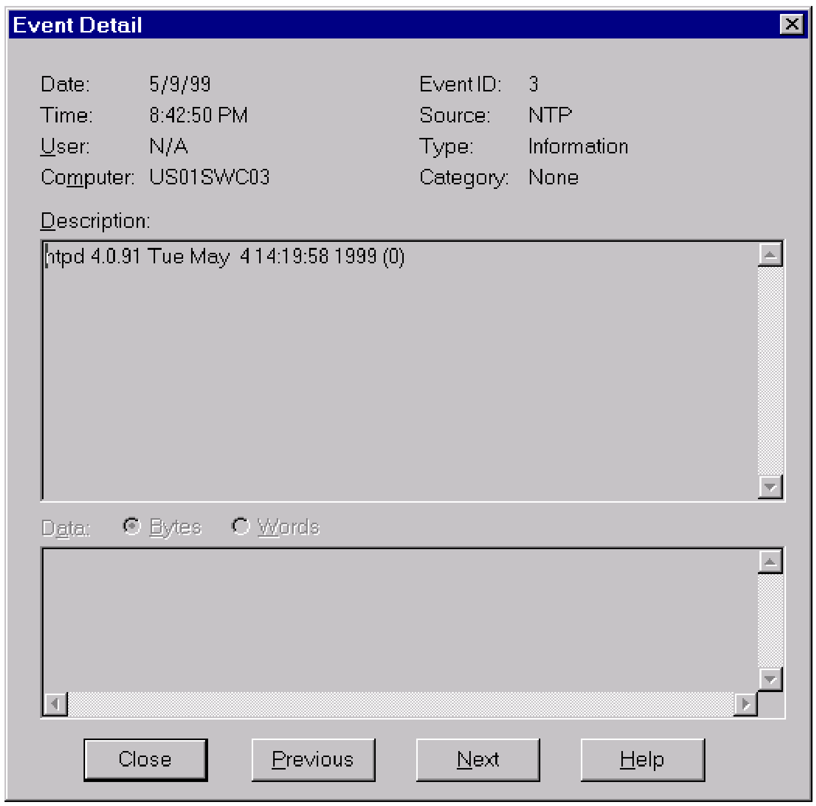
On Windows NT, the Application Event Log is used to record NTP events.

Event Log Entries

Check the Application Event Log for status messages from the NTP task. Event log entries generated by the NTP service appear in the event log as shown. When reviewing events in the event log, begin with the first event, and move upwards reviewing events in chronological order.



The first entry in the Application log is the NTP startup message, reporting the NTP Version and build date. This entry indicates that NTP has started. For more information on system log entries generated by NTP, see Appendix E, NTP Diagnostics and Debugging.



6.8.2 UNIX System Log Files

In its native UNIX environment, NTP uses the host system's system log facilities to send reports to the operating system log files. Refer to your specific system's documentation to learn how to check the system log reports.

Monitor the host's system message log for status messages from the NTP task. A sample sequence of log entries generated by the NTPD daemon at startup are shown below:

```
May  3 17:42:27 terrapin ntpd[4032]: ntpd 4.0.92h Mon
May  3 14:28:00 PDT 1999
May  3 17:42:28 terrapin ntpd[4032]: precision = 25 usec
May  3 17:42:28 terrapin ntpd[4032]: using kernel phase-
lock loop 0041
May  3 17:42:28 terrapin ntpd[4032]: Palisade(0) fd: 8
dev: /dev/palisade0
```

Figure 6-4 Sample UNIX Log Entries

6.8.3 NTPQ – The NTP Query Utility

NTP includes a network-enabled monitoring utility called NTP QUERY. This utility has a number of features that enable the user to monitor the performance of all time servers from a single console. To learn more about NTPQ, please refer to NTP documentation.

When NTPQ is first started, it presents a prompt:

```
ntpq>
```

The user enters **pe** to request the Peer Status List from the local server:

```
ntpq> pe
```

A table similar to the following one is generated. Each entry in the table provides information about a reference clock that NTP is attempting to synchronize with.

NTP is Communicating with the Palisade NTP Reference Clock

```
C:\WINNT\System32\ntpq.exe
ntpq>
ntpq>
ntpq> pe
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
-US01SWC02       homer.Trimble.C  3 u  205 1024  377    2.449    2.496   1.058
+ra.Trimble.COM  spring.ENG.Trim  3 u   98  128  377    3.587    0.784   0.359
+terrapin.Trimbl spring.ENG.Trim  3 u   87  128  377    2.679   -0.486   0.158
 spring.ENG.Trim 0.0.0.0         16 u    - 1024    0    0.000    0.000 4000.00
x155.63.38.190   .GPS.            1 u   27   64  373    4.032   97.775  48.526
*GPS_PALISADE(1) .GPS.            0 -   61  128  377    0.000   -0.017   0.002
ntpq>
ntpq>
ntpq>
ntpq>
ntpq> rv
status=04f4 leap_none, sync_uhf_clock, 15 events, event_peer/strat_chg,
processor="i586", system="Linux2.0.30", leap=00, stratum=1,
precision=-17, rootdelay=0.000, rootdispersion=2.935, peer=48057,
refid=GPS, reftime=bae0f470.1e077036  Sun, May  9 1999 23:00:16.117,
poll=7, clock=bae0f4b6.ac232096  Sun, May  9 1999 23:01:26.672, state=4,
phase=0.000, frequency=8.632, jitter=0.002, stability=0.001
ntpq>
ntpq>
ntpq> _
```

The Palisade NTP reference clock is identified in the list as GPS_PALISADE. The data indicates that the Palisade GPS is selected as reference clock, that it was last polled 61 seconds ago, and that it has responded to each of the last 11 polls. The offset between the system clock and UTC is 17 microseconds, with a jitter of 2 microseconds.

The use of the **rv** command is also shown above. It reveals more information about the reference clock source in use by NTP.

NTP is not Running

If NTP is not running on the machine, you will see a timeout message:

```
ntpq> pe
hostname.trimble.com: timed out, nothing
received
***Request timed out
ntpq>
```

Problems with NTP and the Palisade NTP reference clock can be observed using NTPQ by monitoring the ***when*** and ***reach*** fields of the GPS_PALISADE line item.

No Response from the Palisade NTP Reference Clock

If the Palisade is not responding to NTP poll requests, the debug output appears as follows:

```
C:\WINNT\System32\ntpq.exe
ntpq>
ntpq>
ntpq>
ntpq> pe
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
 ra.Trimble.COM  155.63.38.190    2 u   81  256  377    3.805  -619.49   0.000
+terrapin.Trimbl iq.Trimble.COM   2 u   24   64  377    2.215  -589.47  23.508
xspring.ENG.Trim LOCAL(0)         4 u   24  256  377    2.626  7579.85   0.000
x155.63.38.190   .GPS.            1 u   25   64  377    3.439  -889.22  29.290
 GPS_PALISADE(2) .GPS.            0 u    -   16    0    0.000    0.000 4000.00
*homer.Trimble.C iq.Trimble.COM   2 u    5   64  377   -4.628  -579.42  23.760
ntpq>
ntpq>
ntpq> rv
status=06a4 leap_none, sync_ntp, 10 events, event_peer/strat_chg,
processor="unknown", system="WINDOWS/NT", leap=00, stratum=3,
precision=-20, rootdelay=6.917, rootdispersion=95.273, peer=35601,
refid=homer.Trimble.COM,
reftime=bae2553d.5b0f27bb  Tue, May 11 1999  0:05:33.355, poll=6,
clock=bae25559.a0cd5304  Tue, May 11 1999  0:06:01.628, state=1,
phase=-583.564, frequency=-58.680, jitter=85.053, stability=75.934
ntpq>
ntpq>
ntpq>
```

The reach count for GPS_PALISADE is 0, which indicates a clock or communication failure.

Observe also that the `status` reports `sync_ntp`, and that `refid` is no longer `GPS`, indicating the server has fallen back to an available network time source.

For more information on correcting this condition, see Appendix E.

A Trimble Standard Interface Protocol

The Trimble Standard Interface Protocol (TSIP) provides commands that the system designer may use to configure a GPS receiver for optimum performance in a variety of applications. TSIP enables the system designer to customize the configuration of a GPS module to meet the requirements of a specific application.

TSIP is a simple bidirectional, binary packet protocol used in a wide variety of Trimble GPS receivers. TSIP offers a broad range of command packets and report packets that provide the GPS user with maximum control over the Palisade. Palisade TSIP data packets are always less than 256 bytes in length.

This appendix provides the information needed to make judicious use of the powerful TSIP features, to greatly enhance overall system performance, and to reduce the total development time. The reference tables beginning on page A-3 will help you determine which packets apply to your application. For those applications requiring customization, see Table A-12 for a detailed description of the key setup parameters. Application guidelines are provided for each TSIP command packet, beginning on page A-7.

A.1 Interface Scope

The Trimble Standard Interface Protocol is used in a large number of Trimble GPS modules and navigation receivers. The Palisade receiver features a primary bidirectional port and one output-only port, which may be configured to generate one or more comprehensive time packets. Palisade's primary port supports bidirectional TSIP communication.

The TSIP protocol is based on the transmission of packets of information between the user equipment and the GPS sensor. Each packet includes an identification code (1 byte, representing 2 hexadecimal digits) that identifies the meaning and format of the data that follows. Each packet begins and ends with control characters.

This document describes in detail the format of the transmitted data, the packet identification codes, and all available information over the output channel to allow the user to choose the data required for his particular application. The receiver transmits some of the information (position and velocity solutions, etc.) automatically when it is available, while other information is transmitted only on request. Additional packets may be defined for particular products and these will be covered in the specifications for those products as necessary.

A.2 Packets Output at Power-Up

The following table lists the messages output by the receiver at power-up. After completing its self-diagnostics, the receiver automatically outputs a series of packets, which indicate the initial operating condition of the receiver. Messages are output in the following order. Upon output of packet 82, the sequence is complete and the receiver is ready to accept commands.

Table A-1 Packets Output at Power-Up

Output ID	Description	Notes
46	Receiver health	--
4B	Machine code/status	--
45	Software version	--
42	single precision XYZ position	If double precision is selected, packet 83 is output instead.
4A	single precision LLA position	If double precision is selected, packet 84 is output instead.
41	GPS time	
82	DGPS position fix mode	--

A.3 Receiver Warm Start

You can warm start the receiver by sending each of the following commands after the receiver has completed its internal initialization and has output packet 82.

Table A-2 Receiver Warm Start Commands

Input ID	Description
2B	initial position (LLA)
2E	initial time
38 (type 2)	almanac (for each SV)
38 (type 3)	almanac health
38 (type 4)	ionosphere page
38 (type 5)	UTC correction

A.4 Background Packets

The receiver automatically outputs a set of packets that the user may want to monitor for changes in receiver operations including receiver health, time, almanac pages, and ephemeris updates. These messages are output at the rates indicated in the table below.

Table A-3 Background Packets

Output ID	Description	Notes
40	almanac data	Almanac data is output as new pages are received.
41	GPS time	If the receiver's GPS clock is set and the receiver is not outputting positions, time is output approximately every 16 seconds. Output approximately every 2.5 minutes if the receiver is doing position fixes.
46	receiver health	Output approximately every 16 seconds, if the receiver is not outputting positions. Output approximately every 30 seconds if the receiver is doing position fixes. Whenever any bit in the health message changes, receiver health is automatically output.
6D	mode packet	Output approximately every 30 seconds or when a constellation change occurs.

Note – The background packets listed in this table are automatically output. It is possible to turn off background packets. For more information on this option, see Command Packet 8E-4D – Automatic Packet Output Mask, page A-90.

A.5 Automatic Position and Velocity Reports

The receiver automatically outputs position and velocity reports at set intervals. Report intervals are controlled by packet 35.

Table A-4 Automatic position and Velocity Reports

Output ID	Description
42	single precision XYZ position
83	double-precision XYZ position
4A	single-precision LLA position
84	double-precision LLA position
43	velocity fix (XYZ ECEF)
54	See Note
56	velocity fix (ENU)

Note – When the receiver is in the Manual or Overdetermined Timing mode, it outputs packet 54 to provide the computed clock-only solution.

A.6 Timing Packets

If you are using the GPS receiver as a primary timing system, you may wish to implement the following TSIP control commands.

Table A-5 Timing Packets

Input ID	Description	Output ID
21	get the current GPS time	41
22	set up Overdetermined Timing mode if desired	
2C	set up static mode if desired	4C
2F	request UTC parameters	4F
34	choose the satellite for 1 SV timing mode	
BB	set static mode; set OD timing mode	BB
8E-4A	set PPS characteristics	8F-4A

Palisade is capable of outputting combinations of the following packets on Port A.

Table A-6 Port A Timing Packets

Input ID	Description	Output ID
Auto	Comprehensive time	8F-0B
Auto	Primary UTC Time	8F-AD
Auto	NMEA	ZDA

A.7 Satellite Data Packets

The following packets request data transmitted by the GPS satellites and satellite tracking information.

Table A-7 Satellite Data Packets

Input ID	Description	Output ID
20	request almanac	40
27	request signal levels	47
28	request GPS system message	48
29	request almanac health page	49
2F	request UTC parameters	4F
38	request/load satellite system data	58
39	set/request satellite disable or ignore health	59
3A	request last raw measurement	5A
3B	request satellite ephemeris status	5B
3C	request tracking status	5C

A.8 Customizing Receiver Operations

To customize the receiver output for your application, consider the following packets. For a review of the key setup parameters, see page A-17.

Table A-8 Customizing Receiver Operations

Input ID	Description	Output ID
21	request current time	41
22	position fix mode select (2-D, 3-D, auto)	
23	initial position (XYZ ECEF)	
24	request receiver position fix mode	6D
26	request receiver health	46 and 4B
27	request satellite signal levels	47
2A	altitude for 2-D mode	4A
2B	initial position (LLA)	
2C	request receiver operating parameters	4C
2E	GPS time	4E
35	set input/output options	55
37	status and values of last position and velocity	57 (Note 1)
3D	Configure channel A	3D
BB	set/request receiver configuration	BB
BC	set/request port configuration	BC
8E-14	set datum value	
8E-15	request datum values	8F-15
8E-4A	set PPS characteristics	8F-4A

Note 1: Output is determined by packet 35 settings (see Table A-3).

A.9 Advanced Packets

The following packets are recommended for sophisticated users who wish to customize receiver operations.

Table A-9 Advanced Packets

Input ID	Description	Output ID
1D	clear oscillator offset	--
1E	clear memory, reset	(Note 1)
25	soft reset and self test	(Note 1)
2D	oscillator offset	4D
37	information about last computed fix	57 (Note 3)
39	satellite disable or ignore health	59 (Note 2)
3A	last raw measurement	5A
3B	satellite ephemeris status	5B
3C	tracking status	5C
BB	set receiver configuration parameters	BB
8E-4A	set PPS characteristics	8F-4A
8E-20	Fixed Point Superpacket	8F-20

Note 1: Output is determined by packet 35 settings. See Table A-1 to determine which messages are output at power-up.

Note 2: Not all modes of packet 39 cause a reply (see the packet 39 description, later in this appendix).

Note 3: Output is determined by packet 35 settings.

A.10 Command Packets Sent to the Receiver

The table below summarizes the command packets sent to the receiver. In some cases, the response packets depend on user-selected options. Table A-10 includes a short description of each packet, and the associated output packet. These selections are covered in the packet descriptions beginning on page A-25.

Table A-10 Command Packets Sent to the Receiver

Input	Packet Description	Output ID
1D	Clear oscillator offset	
1E	Clear memory/reset	(note 1)
1F	Software version	45
20	Almanac	40
21	Current time	41
22	Fix Mode select (2-D, 3-D, auto)	6D (note 2)
23	Initial position (XYZ ECEF)	
24	Receiver position fix mode	6D
25	Soft reset and self-test	(note 1)
26	Receiver health	46, 4B
27	Signal levels	47
28	GPS system message	48
29	Almanac health page	49
2A	Altitude for 2-D mode	4A
2B	Initial position (LLA)	
2C	Operating parameters	4C
2D	Oscillator offset	4D
2E	Set GPS time	4E
2F	UTC parameters	4F
31	Accurate initial position (XYZ Cartesian ECEF)	
32	Accurate initial position (LLA)	
34	Satellite # for 1-sat mode	
35	I/O options	55
37	Status and values of last position and velocity	57 (note 1)

Table A-10 Command Packets Sent to the Receiver (Continued)

38	Load satellite system data	58
39	Satellite disable	59 (note 3)
3A	last raw measurement	5A
3B	Satellite ephemeris status	5B
3C	Tracking status	5C
3D	Main port configuration	3D
BB	Set receiver configuration	BB
BC	Set port configuration	BC
8E-14	Set new datum	
8E-15	Current datum values	8F-15
8E-20	last fix (fixed point)	8F-20
8E-41	Manufacturing parameters	8F-41
8E-42	Production parameters	8F-42
8E-45	Revert to default settings	8F-45
8E-4A	Set PPS characteristics	8F-4A
8E-4B	Survey limit	8F-4B
8E-4D	Packet Output Mask	8F-4D
8E-0B	8F-0B output configuration	8F-A5/8F-0B
8E-AD	8F-AD output configuration	8F-A5/8F-AD

Note 1: Output is determined by packet 35 settings.

Note 2: Entering 1SV mode initiates automatic output of packet 54.

Note 3: Not all packet 39 operations have a response. See packet 39 description.

A.11 Report Packets Sent by the GPS Receiver to the User

The table below summarizes the packets output by the receiver. 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. These selections are covered in the packet descriptions beginning on page A-25.

Table A-11 Report Packets Sent by GPS Receiver to User

Output ID	Packet Description	Input
3D	main port configuration	3D
40	almanac data for sat	20
41	GPS time	21
42	single-precision XYZ ECEF position	37
43	velocity fix (XYZ ECEF)	37
45	software version information	1F
46	health of receiver	26
47	signal level for all satellites	27
48	GPS system message	28
49	almanac health for all sats	29
4A	single-precision LLA position	37
4B	machine code/status	26
4C	report operating parameters	2C
4D	oscillator offset	2D
4E	response to set GPS time	2E
4F	UTC parameters	2F
54	one-satellite bias and bias rate	22
55	I/O options	35
56	velocity fix (ENU)	37
57	information about last computed fix	37
58	GPS system data/acknowledge	38
59	sat enable/disable and health heed	39

Table A-11 Report Packets Sent by GPS Receiver to User (Continued)

5A	raw measurement data	3A
5B	satellite ephemeris status	3B
5C	satellite tracking status	3C
6D	all-in-view satellite selection	24
83	double-precision XYZ	37
84	double-precision LLA	37
BB	set receiver configuration	BB
BC	set port configuration	BC
8F-20	last fix with extra information (fixed point)	8E-20
8F-41	manufacturing parameters	8E-41
8F-42	production parameters	8E-42
8F-45	Revert to default settings	8E-45
8F-4A	PPS characteristics	8E-4A
8F-4B	Survey limit	8F-48
8F-AD	UTC Event Time	Event/Auto
8F-0B	comprehensive time	Auto/Event

A.12 Key Setup Parameters

Selecting the correct operating parameters has significant impact on receiver performance. Five packets control the key setup parameters:

- Packet 22 (set fix mode)
- Packet 2C (set operating parameters)
- Packet 35 (set I/O options)
- Packet BB (set receiver configuration)

The default values in Table A-12 enable the receiver to operate well under the most varied and demanding conditions. A user can choose to optimize the receiver for a particular application if the receiver is required to perform in a specific or limited environment, and if dynamics and expected level of obscuration are understood. The user should be warned that when the receiver is exposed to operating conditions different from the conditions described by the user setup, the specifically tuned receiver's performance may be degraded when compared to a receiver with the default options.

Table A-12 lists suggested parameter selections as a function of obscuration and whether accuracy or fix density is important. In this table, NA indicates that the operating parameter is not applicable; DC (don't care) indicates that the user may choose the operating parameter.

Table A-12 Key Setup parameters

Packet	Parameter	Accuracy	Fixes
22	Fix mode	Man 3D	AUTO
2C	Elevation mask	10	5
2C	Signal mask	6.0	0.0
2C	PDOP mask	6.0	12.0
2C	PDOP switch	NA	8.0
35	Fix time	ASAP	DC
35	Output time	When computed	DC
35	Sync meas.	OFF	OFF
35	Min. projection	ON	DC

For a complete examination of the four key configuration parameter packets, see the descriptions of packet 22, packet 2C, packet 35 and packet BB.

A.13 Packet Structure

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

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

<DLE> is the byte 0x10, <ETX> is the byte 0x03, and <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 ('unstuffed') 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 as illustrated below. They are sent most-significant byte first. This may involve switching the order of the bytes as they are normally stored in Intel based machines. Only the fractional part of the mantissa for real numbers, SINGLE and DOUBLE, is reported because the leading bit on the mantissa is always 1. Specifically:

INTEGER is a 16 bit unsigned number sent in two's complement format.

SINGLE (float, or 4 byte REAL) is sent as a series of four bytes; it has a precision of 24 significant bits, roughly 6.5 digits.

DOUBLE (8 byte REAL) is sent as a series of eight bytes (a, b, c, d, e, f, g, h); it has a precision of 52 significant bits, a little better than 15 digits.

A.14 Packet Descriptions

A.14.1 Command Packet 1D – Clear Oscillator Offset

This packet commands the GPS receiver to set or clear the oscillator offset in non-volatile memory. This is normally used for servicing the unit.

Table A-13 Command Packet 1D - Clear Oscillator Offset

Byte	Item	Type	Value	Response
0	Operation	Byte	"C," 43 hex	clear the oscillator offset

To set the oscillator offset, four data bytes are sent: the oscillator offset in Hertz relative to L1 as a SINGLE real value. The oscillator offset is automatically updated when the receiver is doing fixes.

Table A-14 Command Packet 1D - Set Oscillator Offset

Byte	Item	Type	Value	Response
0-3	Offset	Single	Offset in Hertz	None

A.14.2 Command Packet 1E – Clear Memory, then Reset

This packet commands the GPS receiver to clear all data and to perform a software reset. This packet contains one data byte, an ASCII letter corresponding to the requested function:

Table A-15 Cold Start

Byte	Item	Type	Value	Response
0	Operation	Byte	"K," 4B hex	receiver performs a cold start

Table A-16 Factory Re-Start

Byte	Item	Type	Value	Response
0	Operation	Byte	"F," 46 hex	receiver re-initializes factory defaults, and then cold starts

Table A-17 Compatibility Re-Start

Byte	Item	Type	Value	Response
0	Operation	Byte	"C," 43 hex	receiver re-initializes defaults to be compatible with firmware version 7.02, and then cold starts

Caution – All almanac, ephemeris, current position, mode, and communication port setup information is lost by the execution of this command. In normal use this packet should not be sent. It is very helpful to keep a fresh copy of the current almanac, which is stored in the file GPSALM.DAT collected by the TSIPCHAT command "!". This allows near-instantaneous recuperation by the receiver in case of power loss by using the TSIPCHAT command "@" to load it back into the receiver memory.

A.14.3 Command Packet 1F – Request Software Versions

This packet requests information about the version of software running in the Navigation and Signal Processors. This packet contains no data bytes. The GPS receiver returns packet 45 hex.

A.14.4 Command Packet 20 – Request Almanac

This packet requests almanac data for one satellite from the GPS receiver. This packet contains one data byte specifying the satellite PRN number. The GPS receiver returns packet 40 hex.

A.14.5 Command Packet 21 – Request Current Time

This packet requests current GPS time. This packet contains no data. The GPS receiver returns packet 41 hex.

A.14.6 Command Packet 22 – Position Fix Mode Select

This packet commands the GPS receiver to operate in a specific position fix mode. This packet contains one data byte indicating the mode, as follows.

Table A-18 Command Packet 22

Data Byte Value	Mode
0	2D/ 3D Automatic
1	1D Time only
3	Horizontal only (2-D)
4	3-D only
5	n/a
6	n/a
10	Over-Determined Time (default)

For a detailed discussion of each position fix mode, see Chapter 5, System Operation.

Selecting any non-timing mode with this packet cancels the self survey and forces the receiver into that navigation mode indefinitely.

Selecting a timing mode using packet 22 immediately sets the receiver to use the last calculated position for timing.

In overdetermined mode the GPS receiver computes no positions, instead the receiver sends packet 54 hex with the clock bias and bias rate. This can be used for time transfer applications and to enable the GPS receiver to maintain the accuracy of the PPS (Pulse Per Second) output even if a full position fix cannot be done. Any position error will propagate to the correctness of the time solution.

A.14.7 Command Packet 23 – Initial Position (XYZ Cartesian ECEF)

This packet provides the GPS receiver with an approximate initial position in XYZ coordinates. This packet is useful if the user has moved more than about 1,000 miles after the previous fix. (Note that the GPS receiver can initialize itself without any data from the user; this packet merely reduces the time required for initialization.) This packet is ignored if the receiver is already calculating positions.

The X-axis points toward the intersection of the equator and the Greenwich meridian, the Y-axis points toward the intersection of the equator and the 90^{o} meridian, and the Z-axis points toward the North Pole. The cold start default LLA position is 0, 0, 0.

The data format is shown below.

Table A-19 Command Packet 23

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

A.14.8 Command Packet 24 – Request GPS Receiver Position Fix Mode

This packet requests the current position fix mode of the GPS receiver. This packet contains no data. The GPS receiver returns packet 6D.

A.14.9 Command Packet 25 – Initiate Soft Reset & Self Test

This packet commands the GPS receiver to perform a software reset. 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 startup messages (see Table A-1). The GPS receiver sends packet 45 hex only on power-up and reset (or on request). If packet 45 appears unrequested, either the GPS receiver power was cycled or the GPS receiver was reset.

A.14.10 Command Packet 26 – Request Health

This packet requests health and status information from the GPS receiver. This packet contains no data. The GPS receiver returns packet 46 hex and 4B hex.

A.14.11 Command Packet 27 – Request Signal Levels

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. The GPS receiver returns packet 47 hex.

A.14.12 Command Packet 28 – Request GPS System Message

This packet requests the GPS system ASCII message sent with the navigation data by each satellite. This packet contains no data. The GPS receiver returns packet 48 hex.

A.14.13 Command Packet 29 – Request Almanac Health Page

This packet requests the GPS receiver to send the health page from the almanac. This packet contains no data. The GPS receiver returns packet 49 hex.

A.14.14 Command Packet 2A – Altitude for 2-D Mode

This packet provides the altitude to be used for Manual 2-dimensional navigation mode. This altitude is also used for Auto 2-D mode when the dynamics code is set to SEA. This packet contains one SINGLE number (4 bytes) specifying the altitude in meters, using the WGS-84 model of the earth or MSL geoid altitude depending on I/O options (set by packet 35).

If a set altitude is not provided, the receiver will use the altitude of the previous 3-D fix (altitude-hold mode). Sending packet 2A with one data byte equal to 0xFF will cancel altitude-set mode and return the reference altitude to 0. The altitude setting is stored in non-volatile memory.

The receiver must be configured to Manual 2-D navigation mode using packet 0xBB in order to use the fixed altitude survey mode. The reference altitude will be used in 2-D survey from both warm and cold start.

Note – If the receiver altitude is set above 18,000 m, the receiver will be forced to reset each time it acquires satellites. This is implemented to conform with the COCOM industry standard.

A.14.15 Command Packet 2B – Initial Position (Latitude, Longitude, Altitude)

This packet provides the GPS receiver with an approximate initial position in latitude and longitude coordinates (WGS-84). This packet is useful if the user has moved more than about 1,000 miles after the previous fix. (Note that the GPS receiver can initialize itself without any data from the user; this packet merely reduces the time required for initialization.) This packet is ignored if the receiver is already calculating positions. See the description for packet 23. The cold start default LLA position is 0, 0, 0.

The data format is shown below.

Table A-20 Command packet 2B

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

A.14.16 Command Packet 2C – Set/Request Operating Parameters

This packet optionally sets the operating parameters of the GPS receiver or requests the current values. The four parameters are described below and in Table A-21.

Dynamics Code

The default is LAND mode, where the receiver assumes a moderate dynamic environment. In this case, the satellite search and re-acquisition routines are optimized for vehicle-type environments. In SEA mode, the search and re-acquisition routines assume a low acceleration environment and reverts to user entered altitude in 2-D auto. In AIR mode, the search and re-acquisition routines are optimized for high acceleration conditions.

Elevation Mask

This is the minimum elevation angle for satellites to be used in a solution output by the receiver. Satellites which are near the horizon are typically more difficult to track due to signal attenuation, and are also generally less accurate due to higher variability in the ionospheric and tropospheric corruption of the signal. When there are no obstructions, the receiver can generally track a satellite down to near the horizon. However, when this mask is set too low, the receiver may experience frequent constellation switching due to low elevation satellites being obscured.

Frequent constellation switching is undesirable because position jumps may be experienced when Selective Availability is present and DGPS is not available to remove these effects. The benefit of a low elevation mask is that more satellites are available for use in a solution and a better PDOP may be yielded. The current mask is set to 10° and provides a reasonable trade-off of the benefits and drawbacks.

Signal Level Mask

This mask defines the minimum signal strength for a satellite used in a solution. There is some internal hysteresis on this threshold which allows brief excursions below the threshold if lock is maintained and the signal was previously above the mask. This mask should only be lowered with caution since it is also used to minimize the effects of jammers and reflected signals on the receiver. Users who require high accuracy can use a slightly higher mask of 6.0-8.0, since weaker measurements may be noisier and are often caused by reflected signals, which provide erroneous ranges.

Make sure that the elevation and SNR masks are not set too low. The satellite geometry is sometimes improved considerably by selecting low elevation satellites. These satellites are, however, subject to significant signal degradation by the greater ionospheric and tropospheric attenuation that occurs. They are also subject to more obscuration by the passing scenery when the receiver is in a moving vehicle. The code phase data from those satellites is more difficult to decode and therefore has more noise.

PDOP Mask and Switch

The PDOP mask is the maximum PDOP limit for which any 2-D or 3-D position solution will be made. The PDOP switch is the level at which the receiver stops attempting a 3-D solution, and tries for a 2-D solution when in automatic 2-D, 3-D mode. The switch level has no effect on either manual mode. Raising the PDOP mask generally increases the fix density during obscuration, but the fixes with the higher PDOP are less accurate (especially with Selective Availability present). Lowering the mask improves the average accuracy at the risk of lowering the fix density.

The data format is shown in Table A-21. The GPS receiver returns packet 4C hex.

Table A-21 Command Packet 2C

Byte	Item	Type/Units	Default	Byte 0 Value/Ve
0	Dynamics	BYTE/---	1-Land	(0) value left unchanged (1) land/<120 knots (2) sea/<50 knots (3) air/<800 knots (4) static/stationary
1-4	Elevation angle mask	SINGLE/ radians	0.1745 or 10	
5-8	Signal level mask	SINGLE/---	0	
9-12	PDOP mask	SINGLE/---	8	
13-16	PDOP switch (3-D or 2-D)	SINGLE/---	6	

A negative value in a SINGLE field leaves that current setting unchanged.

Selection of mode 4 informs the GPS receiver that it is stationary. Any position fix computed or provided through the data channels is assumed to be accurate indefinitely. When the dynamics code is set to static (byte value = 4) and the fix mode is automatic (set by packet 22 hex), the GPS receiver enters 1-satellite mode when a position fix cannot be performed but there is at least one usable satellite. In this mode, no positions or velocities are computed. Instead, the GPS receiver sends packet 54 hex with the clock bias and bias rate. As long as the GPS receiver is truly stationary, this mode can be used for time transfer applications and to enable the GPS receiver to maintain the accuracy of the 1 PPS (Pulse Per Second) output even if a full position fix cannot be accomplished.

Packet 2C defines the extreme conditions under which the receiver will operate, and the set of usable satellites based on the satellite geometry at the user's position.

Note – A level of hysteresis in the signal level mask is allowed in the core operating software. The hysteresis allows the receiver to continue using satellite signals which fall slightly below the mask and prevents the receiver from incorporating a new signal until the signal level slightly exceeds the mask. This feature minimizes constellation changes caused by temporary fluctuations in signal levels.

A.14.17 Command Packet 2D – Request Oscillator Offset

This packet requests the calculated offset of the GPS receiver master oscillator. This packet contains no data. The GPS receiver returns packet 4D hex. This packet is used mainly for service. The permissible oscillator offset varies with the particular GPS receiver.

A.14.18 Command Packet 2E – Set GPS Time

This packet provides the approximate GPS time of week and the week number to the GPS receiver. The GPS receiver returns packet 4E hex. The data format is shown below. The GPS week number reference is Week # 0 starting January 6, 1980. The seconds count begins at the midnight which begins each Sunday morning.

Table A-22 Command Packet 2E

Byte	Item	Type	Units
0-3	GPS time of week	Single	seconds
4-5	GPS week number	Integer	weeks

This packet is ignored if the receiver has already calculated the time from tracking a GPS satellite.

A.14.19 Command Packet 2F – Request UTC Parameters

This packet requests the current UTC-GPS time offset (leap seconds). The packet has no data. The receiver returns packet 4F.

A.14.20 Command Packet 31 – Accurate Initial Position (XYZ Cartesian ECEF)

This packet is identical in content to packet 23 hex. This packet provides an initial position to the GPS receiver in XYZ coordinates. However, the GPS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the GPS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters.

A.14.21 Command Packet 32 – Accurate Initial Position (Latitude, Longitude, Altitude)

This packet is identical in content to packet 2B hex. This packet provides the GPS receiver with an initial position in latitude, longitude, and altitude coordinates. However, the GPS receiver assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the GPS receiver in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters.

A.14.22 Command Packet 34 – Satellite Number For One-Satellite Mode

This packet allows the user to control the choice of the satellite to be used for the 1D Timing mode. This packet contains one byte. If the byte value is 0, the GPS receiver automatically chooses the usable satellite with the highest elevation above the horizon. This automatic selection of the highest 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. A subsequent value of 0 will return the receiver to automatic 1-SV mode.

A.14.23 Command Packet 35 – Set/Request I/O Options

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

To request the option states without changing them, the user sends the packet with no data bytes included. To change any option states, the user includes 4 data bytes with the values indicated below in the packet. The I/O options, their default states, and the byte values for all possible states are shown below. These option states are held in non-volatile memory. The GPS receiver returns packet 55 hex.

These abbreviations apply:

ALT - Altitude

ECEF - Earth-centered, Earth-fixed

XYZ - Cartesian coordinates

LLA - latitude, longitude, altitude

HAE - height above ellipsoid

WGS-84 - Earth model (ellipsoid)

MSL geoid - Earth mean sea level mode

UTC - coordinated universal time.

Table A-23 Command Packet 35

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packets
0	position	0 (LSB)	0	XYZ ECEF Output 0: off 1: on	42 or 83
		1	1	LLA Output 0: off 1: on	4A or 84
		2	0	LLA ALT Output 0: HAE (current datum) 1: MSL geoid WGS-84	4A or 84
		3	0	ALT input 0: HAE (current datum) 1: MSL geoid WGS-84	2A
		4	1	Precision-of-position output 0: single-precision packet 42 and/or 4A. 1: double-precision packet 83 and/or 84	
		5	0	0: output no Super Packets 1: output all enabled Super Packets	
		6-7	0	unused	
1	velocity	0	0	XYZ ECEF Output 0: off 1: on	43
		1	1	ENU output 0: off 1: on	56
		2-7	0	unused	
2	Timing	0	1	time type 0: GPS time 1: UTC	
		1	0	Fix computation time 0: ASAP 1: next integer sec	
		2	0	Fix output time 0: when computed 1: only on request	37

Table A-23 Command Packet 35 (Continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packets
2	Timing	3	0	Synchronized measurements 0: off 1: on	N/A
		4	0	Minimize Projection 0: off 1: on	N/A
		5-7	0	unused	
3	Auxiliary	0	0	raw measurements 0: off 1: on	5A
		1	1	Doppler smoothed codephase 0: raw 1: smoothed	5A
		2-7		unused	

Packet 35 is used to control the format and timing of the position and velocity output.

Bytes 0-1

Bytes 0 and 1 control the message output format.

Byte 2

Byte 2 contains the five time parameters described below:

- Time Type - This bit defines whether the time tags associated with a position fix are in GPS time or UTC time. The default is UTC time.
- Fix Computation Time - This bit controls the time and frequency of position fixes. The default is ASAP.

Alternatively, in the integer second mode, the most recent measurements are projected to next integer second, and the solution is then valid at this time. The benefit of this mode is the standard fix time and a 1 Hz output rate. The drawbacks are that some measurement projection is performed and that the fix may be slightly older than with the default option. This mode also matches to the output rate of NMEA.

- Output Time - This bit defines whether fixes are automatically output when computed or only sent in response to a packet 37 request. The default is automatic output.
- Synchronized Measurements - This bit controls whether all satellite range measurements are required to have the same time tag. The default is OFF. Slightly older measurements are tolerated (on the order of 3-5 seconds) to provide solutions when obscurations make it impossible to obtain exactly concurrent measurements from each satellite.

  When this bit is ON, all measurements are required to have the same time tag. This only applies to a six-channel receiver, where selected satellites are tracked continuously on their own channel. This mode is used only when the user application requires all satellite measurements to be identical to the position time tag. If a satellite is lost which is in the selected set for the solution, then no fix will be made until a new selection is made.

  The Synchronized measurement mode combined with the minimized projection timing mode (see next paragraph) allows absolutely no measurement projection. However, obscurations may reduce the fix density when there are limited satellites. Use this mode cautiously.

- Minimized Projection - This bit controls the time of the position fix relative to the time of the satellite range measurements. The default mode is OFF. In this mode, the time of solution is the time at which the GPS position fix is computed. Thus, all measurements are projected by an interval which is roughly the amount of time it takes to compute the solution. This approach minimizes the latency between the time tag of the computed solution and the solution output. The drawback is that the measurement projection (which is only about 100 ms) may induce some error during high accelerations.

  Alternatively, when minimized projection is ON, the time of the solution is the time of the most recent measurements. Thus, if all measurements are taken at exactly the same time, there is no measurement projection. If a selected satellite's measurement time lags the most recent measurement, then it is projected to this time. The difference is that the fix will have more latency than a fix provided with the above timing option. This is the best choice for users performing non real-time error analysis, or non real-time DGPS solution-space corrections. This is also the preferable mode for users integrating GPS with other sensors, where communication lags are the dominant latencies, and thus the time lag between the applicability and availability of the fix is small. This option is only available in version 1.14 and higher.

Byte 3

Byte 3, the auxiliary byte, controls the output of additional fix data. It contains two control bits:

- Bit 0 controls the output of raw measurements (Packet 5A).
- Bit 1 controls whether the raw measurements output in packet 5A are doppler smoothed.

A.14.24 Command Packet 37 – Request Status and Values of Last Position and Velocity

This packet requests information regarding the last position fix and is only used when the receiver is not automatically outputting positions. The GPS receiver returns packet 57 and the appropriate position packet 42 or 4A, or 83 or 84, and the appropriate velocity packet 43 or 56, based on the I/O options in effect.

A.14.25 Command Packet 38 – Request/Load Satellite System Data

This packet requests current satellite data (almanac, ephemeris, etc.) or permits loading initialization data from an external source (for example, by extracting initialization data from an operating GPS receiver unit via a data logger or computer and then using that data to initialize a second GPS receiver unit). The GPS receiver returns packet 58.

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

To request data without loading data, use only bytes 0 through 2; to load data, use all bytes. Before loading data, read the caution below.

Caution – Proper structure of satellite data is critical to receiver operation. Requesting data is not hazardous; loading data improperly is hazardous. Use this packet only with extreme caution. The data should not be modified in any way. It should only be retrieved and stored for later reload.

Table A-24 Command Packet 38

Byte	Item	Type	Value	Meaning
0	Operation	Byte	1 2	Request data from receiver Load data into receiver
1	Type of data	Byte	1 2 3 4 5 6	not used Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN#	Byte	0 1-32	data that is not satellite-ID specific satellite PRN number
3	length (n)	Byte		number of bytes of data to be loaded
4 to n+3	data		n Bytes	

A.14.26 Command Packet 39 – Set/Request Satellite Disable or Ignore Health

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) that satisfy all mask values for use in the position solution. This packet allows you to override the internal logic and force the receiver to either unconditionally disable a particular satellite or to ignore a bad health flag. The GPS receiver returns packet 59 for operation modes 3 and 6 only.

Table A-25 Command Packet 39

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

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

Caution – Ignoring health can cause the GPS receiver software to fail, as an unhealthy satellite may contain defective data. Use extreme caution in ignoring satellite health.

A.14.27 Command Packet 3A – Request Last Raw Measurement

This packet requests the most recent raw measurement data for one specified satellite. The GPS receiver returns packet 5A hex if data is available.

Table A-26 Command Packet 3A

Byte	Item	Type	Value	Meaning
1	Satellite #	Byte	0 1-32	All satellites in the current tracking set Desired satellite

A.14.28 Command Packet 3B – Request Current Status Of Satellite Ephemeris Data

This packet requests the current status of satellite ephemeris data. The GPS receiver returns packet 5B hex if data is available.

Table A-27 Command Packet 3B

Byte	Item	Type	Value	Meaning
1	Satellite #	Byte	0 1-32	All satellites in the current tracking set Desired satellite

A.14.29 Command Packet 3C – Request Current Satellite Tracking Status

This packet requests the current satellite tracking status. The GPS receiver returns packet 5C hex if data is available.

Table A-28 Command Packet 3C

Byte	Item	Type	Value	Meaning
1	Satellite #	Byte	0 1-32	All satellites in the current tracking set Desired satellite

A.14.30 Command Packet 3D – Request or Set Timing Port Configuration

This packet requests and optionally sets the timing port (port A) configuration. This configuration includes the baud rate, number of bits, parity, number of stop bits, and also the language mode. When this packet is used only to request the configuration, the packet contains no data bytes. When this packet is used to set the configuration, the packet contains the 5 data bytes shown below.

Packet 3D is both an input and an output packet. A 3D input packet, with or without data, is responded to with a 3D output packet. The language mode is defined as follows. For transmission, the language mode specifies whether TSIP packets or NMEA are output on the timing port. For reception, the language mode specifies whether packets or RTCM data are received on the primary port.

Note – The timing port can be used for input only. This port will not accept input of TSIP packets.

The baud rate for the transmitter and the receiver can be set independently; but the number of bits, parity, and number of stop bits are common between them. The default mode is packets for both transmission and reception at 9,600 baud with 8 data bits, odd parity, and one stop bit.

Table A-29 Command Packet 3D

Byte	Item	Type	Units	
0	XMT Baud Rate code	Byte	0: 50 baud 1: 110 4: 300 5: 600	6: 1200 8: 2400 9: 4800 11: 9600
1	RCV Baud Rate code	Byte	0: 50 1: 110 4: 300 5:600	6: 1200 8: 2400 9: 4800 11: 9600

2	Parity and # bits/char code: Xxxpppbb
	X = Don't care
		Byte	ppp:
			
			bb:
				0: even parity
				1: odd parity
				4: no parity
				2: 7
				3: 8

3	Stop bits code	Byte	7: 1 stop bit 15: 2 stop bits	
4	Language mode for Transmission	Byte	0: Packets 1: off 5: NMEA	
5	Language mode for Reception	Byte	0: Packets	

This information is held in non-volatile memory.

A.14.31 Report Packet 40 – Almanac Data Page

This packet provides almanac data for a single satellite. The GPS receiver sends this packet on request (packet 20 hex) and optionally, when the data is received from a satellite. The data format is shown below.

Table A-30 Report Packet 40

Byte	Item	Type	Units
0	satellite	BYTE	(identification number)
1-4	T_zc	SINGLE	seconds
5-6	week number	INTEGER	weeks
7-10	eccentricity	SINGLE	(dimensionless)
11-14	T_oa	SINGLE	seconds
15-18	i_o	SINGLE	radians
19-22	OMEGA_dot	SINGLE	radians/second
23-26	square root A	SINGLE	$(\text{meters})^{1/2}$
27-30	OMEGA 0	SINGLE	radians
31-34	omega	SINGLE	radians
35-38	M o	SINGLE	radians

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

A.14.32 Report Packet 41 – GPS Time

This packet provides the current GPS time of week and the week number. The GPS receiver sends this packet in response to packet 21 hex and during an update cycle. Update cycles occur approximately every 15 seconds when not doing fixes and occur approximately every 150 seconds when doing fixes. The data format is shown below.

Table A-31 Report Packet 41

Byte	Item	Type	Units
0-3	GPS time of week	SINGLE	seconds
4-5	GPS week number	INTEGER	weeks
6-9	GPS/UTC offset	SINGLE	seconds

Note – GPS time differs from UTC by a variable integral number of seconds. UTC = (GPS time) - (GPS/UTC offset).

Caution – GPS week numbers run from 0 to 1023 and then cycles back to week #0. Week #0 began January 6, 1980. There will be another week #0 beginning August 22, 1999. The receiver automatically adds 1024 to the GPS week number after August 21, 1999, and reports the cumulative week number.

The seconds count begins with "0" each Sunday morning at midnight GPS time. A negative indicated time-of-week indicates that time is not yet known; in that case, the packet is sent only on request. The following table shows the relationship between the information in packet 41, and the packet 46 status code.

Table A-32 Relationship Between Packet 41 and Packet 46

Approximate Time Accuracy	Time Source	Sign (TOW)	Packet 46 Status Code
None	no time at all	-	01 hex
Unknown	approximate time from real-time clock or packet 2E	+	01 hex
20 to 50 msec + clock drift	time from satellite	+	not 01 hex
Full accuracy	time from GPS solution	+	00 hex

Note – Before using the GPS time, verify that the packet 46 status code is 00 hex ("Doing position fixes"). This ensures the most accurate GPS time.

A.14.33 Report Packet 42 – Single-precision Position Fix, XYZ ECEF

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. The data format is shown below.

Table A-33 Report Packet 42

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

The time-of-fix is in GPS time or UTC as selected by the I/O "timing" option. At start-up, this packet or packet 83 is also sent with a negative time-of-fix to report the current known position. Packet 83 provides a double-precision version of this information.

A.14.34 Report Packet 43 – Velocity Fix, XYZ ECEF

This packet provides current GPS velocity fix in XYZ ECEF coordinates. If the I/O "velocity" option is set to "XYZ ECEF, then the GPS receiver sends this packet each time a fix is computed if selected by the I/O "timing" option. The data format is shown below.

Table A-34 Report Packet 43

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

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

A.14.35 Report Packet 45 – Software Version Information

This packet provides information about the version of software in the Navigation and Signal Processors. The GPS receiver sends this packet after power-on and in response to packet 1F hex.

Table A-35 Report Packet 45

Byte	Item	Type
0	Major version number	BYTE
1	Minor version number	BYTE
2	Month	BYTE
3	Day	BYTE
4	Year number minus 1900	BYTE
5	Major revision number	BYTE
6	Minor revision number	BYTE
7	Month	BYTE
8	Day	BYTE
9	Year number minus 1900	BYTE

The first 5 bytes refer to the Navigation Processor and the second 5 bytes refer to the Signal Processor.

A.14.36 Report Packet 46 – Health of Receiver

This packet provides information about the satellite tracking status and the operational health of the Receiver. The receiver sends this packet after power-on or software-initiated resets, in response to packet 26 hex, during an update cycle, when a new satellite selection is attempted, and when the receiver detects a change in its health. Packet 4B hex is always sent with this packet. The data format is given in the following table.

Table A-36 Report Packet 46

Byte	Item	Type	Value	Meaning
0	Status code	Byte		
			00 hex	Doing position fixes
			01 hex	Don’t have GPS time yet
			02 hex	Not used
			03 hex	PSOP is too high
			08 hex	No usable satellites
			09 hex	Only 1 usable satellite
			0A hex	Only 2 usable satellite
			0B hex	Only 3 usable satellite
			0C hex	The chosen satellite is unusable
1	Error codes	Byte		

The error codes in Byte 1 of packet 46 are encoded into individual bits within the byte. The bit positions and their meanings are shown below.

Table A-37 Report Packet 46 - Error Code Bit Positions

Error Code Bit Position	Meaning if bit value = 1
0 (LSB)	Battery back-up failed (note 3)
1	Signal Processor error (note 1)
2	Alignment error, channel or chip 1 (note 1)
3	Alignment error, channel or chip 2 (note 1)
4	Antenna feed line fault (Open or Short)
5	Excessive ref freq. error (note 2)
6	(Unused)
7 (MSB)	(Unused)

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

Note 2: This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance. (Packet 2D requests the oscillator offset and packet 4D returns the oscillator offset to the user.)

Note 3: This bit is always set; Palisade does not have battery backup.

A.14.37 Report Packet 47 – Signal Levels for all Satellites

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (that is, above the elevation mask and healthy according to the almanac). The receiver sends this packet only in response to packet 27 hex. The data format is shown below.

Table A-38 Report Packet 47

Byte	Item	Type
0	Count	BYTE
1	Satellite number 1	BYTE
2-5	Signal level 1	SINGLE
6	Satellite number 2	BYTE
7-10	Signal level 2	SINGLE
(etc.)	(etc.)	(etc.)

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.

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

A.14.38 Report Packet 48 – GPS System Message

This packet provides the 22-byte ASCII message carried in the GPS satellite navigation message. The receiver sends this packet in response to packet 28 hex and when this data is received from a satellite.

The message effectively is a bulletin board from the Air Force to GPS users. The format is free-form ASCII. The message may be blank.

A.14.39 Report Packet 49 – Almanac Health Page

This packet provides health information on 32 satellites. Packet data consists of 32 bytes each containing the 6-bit health from almanac page 25. First byte is for satellite #1, and so on. The receiver sends this packet in response to packet 29 hex and when this data is received from a satellite.

Table A-39 Report Packet 49

Byte	Item
0	health of satellite #1
1	health of satellite #2
- - -	- - -
- - -	- - -
- - -	- - -
31	health of satellite #32

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

A.14.40 Report Packet 4A – Reference Altitude

This packet is returned in response to a set or request reference altitude packet 0x2A.

Table A-40 Report Packet 4A - Reference Altitude

Byte	Item	Type	Units
0-3	Altitude	SINGLE	Meters above WGS-84 or MSL
4-7	Reserved	SINGLE	Reserved
8	Flag	BYTE	Reserved

A.14.41 Report Packet 4A – Single-Precision LLA Position Fix

This 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.

Table A-41 Report Packet 4A - Single-Precision LLA Position Fix

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
6-19	Time-of-Fix	SINGLE	Seconds

The LLA conversion is done according to the datum selected using packet 8E-14. The default is WGS-84. Altitude is referred to the WGS-84 ellipsoid or the MSL Geoid, depending on which I/O "LLA altitude" option is selected. The time-of-fix is in GPS time or UTC, depending on which I/O "timing" option is selected.

This packet also is sent at start-up with a negative time-of-fix to report the current known position. Packet 84 provides a double-precision version of this information.

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

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

A.14.42 Report Packet 4B – Machine/Code ID and Additional Status

The receiver transmits this packet in response to packets 25 and 26 and following a change in state. In conjunction with packet 46, "health of receiver," this packet identifies the receiver and may present error messages. The machine ID can be used by equipment communicating with the receiver to determine the type of receiver to which the equipment is connected. Then the interpretation and use of packets can be adjusted accordingly.

Table A-42 Report Packet 4B

Byte	Item	Type/ Value	Status/Meaning
0	Machine ID	BYTE	6-channel receiver
1	Status 1	BYTE	The Status 1 error codes are encoded into individual bits within the byte
2	Status 2	BYTE	Super packets are supported.

The error codes are encoded into individual bits within the bytes. The bit positions and their meanings are shown below.

Table A-43 Report Packet 4B - Error Code Bit Positions

Status 1 Bit Position	Meaning if bit value = 1
0 (LSB)	Synthesizer Fault
1	Battery Powered Time Clock Fault
2	A-to-D Converter Fault (Not Used)
3	The Almanac stored in the receiver is not complete and current
4-7	Not used

A.14.43 Report Packet 4C – Report Operating Parameters

This packet provides several operating parameter values of the receiver. The receiver sends this packet in response to packet 2C hex. The data string is four SINGLE values. The dynamics code indicates the expected vehicle dynamics and is used to assist the initial solution. The elevation angle mask determines the lowest angle at which the receiver tries to track a satellite. The signal level mask sets the required signal level for a satellite to be used for position fixes.

The PDOP mask sets the maximum PDOP with which position fixes are calculated. The PDOP switch sets the threshold for automatic 3-D/2-D mode. If 4 or more satellites are available and the resulting PDOP is not greater than the PDOP mask value, then 3-dimensional fixes are calculated. This information is stored in non-volatile memory.

Table A-44 Report Packet 4C

Byte	Item	Type/Units	Default	Byte 0 Value/ Velocity
0	Dynamics code	BYTE	Land	(0) value left unchanged (1) land / <120 knots (2) sea / <50 knots (3) air / <800 knots (4) static/ stationary
1-4	Elevation angle mask	SINGLE/radians	0.1745 or 10°	

Table A-44 Report Packet 4C (Continued)

Byte	Item	Type/Units	Default	Byte 0 Value/ Velocity
5-8	Signal level mask	SINGLE/---	0	
9-12	PDOP mask	SINGLE/---	8	
13-16	PDOP switch (3-D or 2-D)	SINGLE/---	8	

A.14.44 Report Packet 4D – Oscillator Offset

This packet provides the current value of the receiver master oscillator offset in Hertz at carrier. This packet contains one SINGLE number (4 Bytes). The receiver sends this packet in response to packet 2D hex. The permissible offset varies with the receiver unit.

A.14.45 Report Packet 4E – Response to Set GPS Time

Indicates whether the receiver accepted the time given in a Set GPS time packet. The receiver sends this packet in response to packet 2E hex. This packet contains one byte.

Table A-45 Report Packet 4E

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

A.14.46 Report Packet 4F – UTC Parameters

This packet is sent in response to command packet 2F and contains 26 bytes. It reports the UTC information broadcast by the GPS system. For details on the meanings of the following parameters, consult ICD-200, Sections 20.3.3.5.2.4, 20.3.3.5.1.8, and Table 20-IX. On the simplest level, to get UTC time from GPS time, subtract ΔT_{LS} seconds. The other information contained in this packet indicates when the next leap second is scheduled to occur.

Table A-46 Report Packet 4F

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

A.14.47 Report Packet 54 – Bias and Bias Rate

The receiver sends this packet to provide the computed clock-only solution when the receiver is in the manual or automatic overdetermined timing mode.

Table A-47 Report Packet 54

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

The bias is the offset of the receiver internal time clock from GPS time. Bias is expressed as meters of apparent range from the satellites. It is used to correct the one PPS output. Bias rate is the frequency error of the receiver internal oscillator. It is expressed as apparent range rate.

Caution – For accurate interpretation of the propagation delay, the precise constant for the speed of light must be used. The ICD-200 value for the speed of light is 299,792,458 meters per second.

A.14.48 Report Packet 55 – I/O Options

This packet provides current I/O options in effect in response to packet 35 request. The data format is the same as for packet 35 hex and is repeated below for convenience.

In the table below, the following abbreviations apply: 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).

Table A-48 Report Packet 55

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated packet
0	position	0(LSB)	0	XYZ ECEF Output 0: off 1: on	42 or 83
		1	1	LLA Output 0: off 1: on	4A or 84
		2	0	LLA ALT Output 0: HAE 1: MSL geoid	4A or 84
		3	0	ALT input 0: HAE 1: MSL geoid	2A
		4	1	Precision-of-position output 0: single-precision packet 42 and/or 4A. 1: double-precision packet 83 and/or 84	
		5	0	Superpacket output 0: off 1: on	
		6	0	Superpacket format 0: binary 1: ASCII	
		7	0	unused	

Table A-48 Report Packet 55 (Continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated packet
1	velocity	0	0	XYZ ECEF Output 0: off 1: on	43
		1	1	ENU Output 0: off 1: on	56
		2-7	0	Unused	
2	Timing	0	1	Time type 0: GPS time 1: UTC	
		1	0	fix computation time 0: ASAP 1: next integer sec	
		2	0	Output time 0: when computed 1: only on request	37
		3	0	Synchronized measurements 0: off 1: on	
		4	0	Minimize projection 0: off 1: on	
		5-7	0	Unused	

Table A-48 Report Packet 55 (Continued)

Byte	Parameter Name	Bit Position	Default Bit Value	Option	Associated packet
3	auxiliary	0	0	Raw measurements 0: off 1: on	5A
		1	0	Doppler smoothed codephase 0: raw 1: smoothed	5A
		2-7		Unused	

A.14.49 Report Packet 56 – 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: (1) each time that a fix is computed; (2) in response to packet 37 hex (last known fix). The data format is shown below.

Table A-49 Report Packet 56

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

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

A.14.50 Report Packet 57 – 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 37 hex.

The data format is shown below.

Table A-50 Report Packet 57

Byte	Item	Type/Units	Byte 0 Value/Velocity
0	Source of information	BYTE/- - -	00/hex/none 01/regular fix
1	Mfg. diagnostic	BYTE/- - -	
2-5	Time of last fix	SINGLE/ seconds, GPS time	
6-7	Week of last fix	INTEGER/ weeks, GPS time	

A.14.51 Report Packet 58 – Satellite System Data/ Acknowledge from Receiver

This packet provides GPS data (almanac, ephemeris, etc.). The receiver sends this packet under the following conditions: (1) on request; (2) in response to packet 38 hex (acknowledges the loading of data). The data format is shown below.

Table A-51 Report Packet 58

Byte	Item	Type	Value	Meaning
0	Operation	BYTE	1 2	Acknowledge Data Out
1	Type of data	BYTE	1 2 3 4 5 6	not used Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN #	BYTE	0 1 to 32	Data that is not satellite ID-specific Satellite PRN number
3	length (n)	BYTE		Number of bytes of data to be loaded
4 to n+3	data	n BYTES		

The binary almanac, health page, and UTC data streams are similar to reports 40, 49, and 4F respectively, and those reports are preferred. To get ionosphere or ephemeris, this report must be used.

Table A-52 Packet 58 ALMANAC Data

Byte	Item	Type	
4	t_oa_raw	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.2)
5	SV_HEALTH	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.2)
6-9	e	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
10-13	t_oa	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
14-17	i_o	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
18-21	OMEGADOT	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
22-25	sqrt_A	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
26-29	OMEGA_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
30-33	omega	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
34-37	M_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
38-41	a_f0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
42-45	a_f1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
46-49	Axis	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
50-53	n	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
54-57	OMEGA_n	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
58-61	ODOT_n	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
62-65	t_zc	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.2)
66-67	weeknum	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.2)
68-69	wn_oa	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.2)

Note: All angles are in radians.

Table A-53 Packet 58 ALMANAC HEALTH Data

Byte	Item	Type	
4	week # for health	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.3)
5-36	SV_health	32 BYTES	(cf. ICD-200, Sec 20.3.3.5.1.3)
37	t_oa for health	BYTE	(cf. ICD-200, Sec 20.3.3.5.1.3)
38	current t_oa	BYTE	units = seconds/2048
39-40	current week #	INTEGER	

Table A-54 Packet 58 IONOSPHERE Data

Byte	Item	Type	
4-11	---	---	compact storage of the following info
12-15	alpha_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
16-19	alpha_1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
20-23	alpha_2	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
24-27	alpha_3	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
28-31	beta_0	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
32-35	beta_1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
36-39	beta_2	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)
40-43	beta_3	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.9)

Table A-55 Packet 58 UTC Data

Byte	Item	Type	
4-16	---	---	compact storage of the following info
17-24	A_0	DOUBLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
25-28	A_1	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
29-30	delta_t_LS	INTEGER	(cf. ICD-200, Sec 20.3.3.5.1.8)
31-34	t_ot	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
35-36	WN t	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
37-38	WN_LSF	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
39-40	DN	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)
41-42	delta_t_LSF	SINGLE	(cf. ICD-200, Sec 20.3.3.5.1.8)

Table A-56 Packet 58 EPHEMERIS Data

Byte	Item	Type	
4	sv_number	BYTE	SV PRN number
5-8	t_ephem	SINGLE	time of collection
9-10	weeknum	INTEGER	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
11	codeL2	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
12	L2Pdata	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
13	SVacc_raw	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
14	SV_health	BYTE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
15-16	IODC	INTEGER	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
17-20	T_GD	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
21-24	t_oc	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
25-28	a_f2	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
29-32	a_f1	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
33-36	a_f0	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
37-40	SVacc	SINGLE	(cf. ICD-200, Sec 20.3.3.3, Table 20-I)
41	IODE	BYTE	(cf. ICD-200, Sec 20.3.3.4)
42	fit_interval	BYTE	(cf. ICD-200, Sec 20.3.3.4)
43-46	C_rs	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
47-50	delta_n	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
51-58	M_0	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
59-62	C_uc	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
63-70	e	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
71-74	C_us	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
75-82	sqrt_A	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
83-86	t_oe	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
87-90	C_ic	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
91-98	OMEGA_0	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
99-102	C_is	SINGLE	(cf. ICD-200, Sec 20.3.3.4)

Table A-56 Packet 58 EPHEMERIS Data (Continued)

Byte	Item	Type	
103-110	i_o	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
111-114	C_rc	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
115-122	omega	DOUBLE	(cf. ICD-200, Sec 20.3.3.4)
123-126	OMEGADOT	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
127-130	IDOT	SINGLE	(cf. ICD-200, Sec 20.3.3.4)
131-138	Axis	DOUBLE	= $(sqrt\_A)^2$
139-146	n	DOUBLE	derived from delta_n
147-154	r1me2	DOUBLE	= $sqrt(1.0-e^2)$
155-162	OMEGA_n	DOUBLE	derived from OMEGA_0, OMEGADOT
163-170	ODOT_n	DOUBLE	derived from OMEGADOT

Note: All angles are in radians.

A.14.52 Report Packet 59 – Status of Satellite Disable or Ignore Health

Normally the GPS receiver selects only healthy satellites (based on transmitted values in the ephemeris and almanac) which satisfy all mask values, for use in the position solution. The data format is shown below.

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

Table A-57 Report Packet 59

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

A.14.53 Report Packet 5A – Raw Measurement Data

This packet provides raw GPS measurement data. If the I/O auxiliary option for "raw data" has been selected, the receiver also sends this packet in response to packet 3A hex. The data format is shown below.

Table A-58 Report Packet 5A

Byte	Item	Type	Units
0	Satellite PRN number	BYTE	----
1-4	reserved	SINGLE	
5-8	Signal level	SINGLE	
9-12	Code phase	SINGLE	1/16th chip
13-16	Doppler	SINGLE	Hertz
17-24	Time of Measurement	DOUBLE	seconds

APPLICATION NOTE:

Packet 5A provides the raw satellite signal measurement information used in computing a fix.

The *satellite PRN* (Byte 0) number is a unique identification for each of the 32 GPS satellites.

The *signal level* (Byte 5) is a linear approximation of C/N0 which is stated in antenna amplitude measurement units (AMUs), a Trimble devised unit. An approximate correlation of AMU levels to C/N0 follows:

Table A-59 Correlation of AMU levels to C/N0

AMU level	C/N0
5	-20 dB SNR
16	-10 dB SNR
26	-5 dB SNR

Note – SNR $_{(\pm 3)}$ = 20log((signal counts/noise counts)*(BW/2)) where: signal counts = 64 * AMU; noise counts = 90, and BW = 1000Hz.

The C/N0 is affected by five basic parameters:

- signal strength from the GPS satellite
- receiver/antenna gain
- pre-amplifier noise figure
- receiver noise bandwidth
- accumulator sample rate and statistics

The approximation is very accurate from 0 to 25 AMUs.

The *codephase* (Byte 9) 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. Thus, it includes all receiver, satellite, and propagation biases and errors. It is expressed in 1/16th of a C/A code chip.

The *Doppler* (Byte 13) value is apparent carrier frequency offset averaged over the sample interval. It is measured with respect to the nominal GPS L1 frequency of 1575.42 MHz, referenced to the receiver's internal oscillator. Thus, it includes all receiver and satellite clock frequency errors. It is expressed in Hertz at the L1 carrier.

The *time of measurement* (Byte 17) is the center of the sample interval adjusted by adding the receiver supplied codephase (modulo mS) to a user determined integer number of mS between user and satellite.

The receiver codephase resolution is 1/16th of a C/A code chip. This corresponds to:

1/16 x C/A code chip =	977.517ns/16 = 61.0948 ns
	61.0948 x speed of light (m/s)
	18.3158 meters

The integer millisecond portion of the pseudo-range must then be derived by utilizing the approximate user and satellite positions. Rough user position (within a few hundred kilometers) must be known; the satellite position can be found in its almanac / ephemeris data.

Each mS integer corresponds to:

C/A code epoch x speed of light =	1 ms x speed of light (m/s)
	300 km (approximate)
	299.792458 km (precise)

The satellite time-of-transmission for a measurement can be reconstructed using the code phase, the time of measurement, and the user-determined integer number of milliseconds. Note that the receiver occasionally adjusts its clock to maintain time accuracy within ±0.5 milliseconds, at which time the integer millisecond values for all satellites are adjusted upward or downward by one millisecond.

A.14.54 Report Packet 5B – Satellite Ephemeris Status

This packet is sent in response to packet 3B and optionally, when a new ephemeris (based on IODE) is received. It contains information on the status of the ephemeris in the receiver for a given satellite. The structure of packet 5B is as follows.

Table A-60 Report Packet 5B

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

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

A.14.55 Report Packet 5C – Satellite Tracking Status

This packet provides tracking status data for a specified satellite. Some of the information is very implementation-dependent and is provided mainly for diagnostic purposes. The receiver sends this packet in response to packet 3C hex. The data format is shown below.

Table A-61 Report Packet 5C

Byte/Item	Type/Units	Value/Meaning
Byte 0 / Satellite PRN number	BYTE/ number 1-32	
Byte 1 / Channel and slot code	BYTE	
		Bit position within byte 1 7(MSB) 3 (channel number beginning with 0) (MSB) 0 0 0 0 0 channel 1: used by all receivers 0 0 0 0 1 channel 2: 8-channel receivers 0 0 0 1 0 channel 3: 8-channel receivers 0 0 0 1 1 channel 4: 8-channel receivers 0 0 1 0 0 channel 5: 8-channel receivers 0 0 1 0 1 channel 6: 8-channel receivers 0 0 1 1 0 channel 7: 8-channel receivers 0 0 1 1 1 channel 8: 8-channel receivers
Byte 2 / Acquisition flag		0 never acquired 1 acquired 2 re-opened search
Byte 3 / Ephemeris flag		0 flag not set ≠0 good ephemeris for this satellite (<4 hours old, good health)
Byte 4-7 / Signal level	SINGLE	same as in packet 47 hex
Byte 8-11 / GPS time of last measurement	SINGLE/ seconds	<0 no measurements have been taken ≥0 center of the last measurement taken from this satellite

Table A-61 Report Packet 5C (Continued)

Byte/Item	Type/Units	Value/Meaning
Byte 12-15 / Elevation	SINGLE/ radians	Approximate elevation of this satellite above the horizon. Updated about every 15 seconds. Used for searching and computing measurement correction factors.
Byte 16-19 / Azimuth	SINGLE/ radians	Approximate azimuth from true north to this satellite. Usually updated about every 3 to 5 minutes. Used for computing measurement correction factors.
Byte 20 / old measurement flag	BYTE	N/A
Byte 21 / Integer msec flag	BYTE	N/A
Byte 22 / bad data flag	BYTE	N/A
Byte 23 / Data collection flag	BYTE	N/A

A.14.56 Report Packet 6D – All-In-View Satellite Selection

This packet provides a list of satellites used for position 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). This packet has variable length equal to 16+nsvs (minimum 4), where "nsvs" is the number of satellites used in the solution.

The GPS receiver sends this packet in response to packet 24 hex or whenever a new satellite selection is attempted. The GPS receiver attempts a new selection every 30 seconds and whenever satellite availability and tracking status change. The data format is shown below.

Table A-62 Report Packet 6D

Byte	Item	Type	Units
0	Mode	BYTE	<u>Bit</u> <u>Value</u> <u>Meaning</u> 0-2 3 2D 4 3D 3 0 Auto 1 manual 4-7 - - nsvs
1-4	PDOP	SINGLE	PDOP
5-8	HDOP	SINGLE	HDOP
9-12	VDOP	SINGLE	VDOP
13-16	TDOP	SINGLE	TDOP
(16+nsvs)	SV PRN	BYTE	

PDOP values of zero indicate that the GPS receiver is not doing fixes, usually because there are not enough healthy usable satellites for position fixes. In this case, the satellite number list contains up to four of the satellites which are usable. Empty satellite number-bytes contain zero. Negative PDOP values indicate that the PDOP is greater than the PDOP mask value and therefore the GPS receiver is not performing fixes.

A.14.57 Report Packet 82 – Differential Position Fix Mode

This packet provides the differential position fix mode of the receiver. This packet contains only one data byte to specify the mode.

This packet is sent in response to packet 62 and whenever a satellite selection is made and the mode is Auto GPS/GPD (modes 2 and 3).

Note – Palisade does not support Differential Position Fix Mode. This packet is provided for compatibility reasons only.

A.14.58 Report Packet 83 – Double-precision XYZ Position Fix And Bias Information

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-precision option is selected, the receiver sends this packet each time a fix is computed. The data format is shown below.

Table A-63 Report Packet 83

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

The time-of-fix is in GPS time or UTC, as selected by the I/O "timing" option. At start-up, if the I/O double-precision option is selected, this packet is also sent with a negative time-of-fix to report the current known position.

Packet 42 provides a single-precision version of this information.

A.14.59 Report Packet 84 – 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-precision option is selected, the receiver sends this packet each time a fix is computed. The data format is shown below.

Table A-64 Report Packet 84

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
32-35	time of fix	SINGLE	seconds

The time-of-fix is in GPS time or UTC, as selected by the I/O "timing" option. At start-up, this packet is also sent with a negative time-of-fix to report the current known position.

Packet 4A provides a single-precision version of this information.

Caution – When converting from radians to degrees, using an insufficiently precise approximation for the constant π (Pi) introduces significant and readily visible errors. The value of π as specified in ICD-GPS-200 is 3.1415926535898.

A.14.60 Command Packet BB – Set Primary Receiver Configuration

TSIP command packet BB contains the primary Palisade configuration parameters. To leave any parameter unchanged when issuing a set, enter command 0 x FF or -1.0 as the value. The table below lists the individual fields within the BB packet.

To query for the primary receiver configuration, send packet BB with subcode 0 as the only data byte. The table below lists the individual fields within the BB packet.

Note – The receiver may require an initial position fix before switching to some modes.

Table A-65 Command Packet BB

Byte #	Item	Type	Value	Meaning	Default
0	Subcode	BYTE	0	Primary receiver configuration block	
1	Operating Dimension	BYTE	0 1 3 4 5 6 7	Automatic Time only (1-SV) Horizontal (2D) Full position (3D) DGPS reference 2D clock hold Overdetermined clock	Full Position
2	DGPS Mode	BYTE	0 1 3	DGPS off DGPS only DGPS auto	DGPS Auto
3	Dynamics Code	BYTE	1 2 3 4	Land/<120 knots Sea/<50 knots Air/<800 knots static/stationary	Land

Table A-65 Command Packet BB (Continued)

Byte #	Item	Type	Value	Meaning	Default
4	Solution Mode	BYTE	1 2	Overdetermined fix Weighted Overdetermined fix	Weighted Over-determined fix
5-8	Elevation Mask	SINGLE	0-π/2	Lowest satellite elevation for fixes	10°
9-12	AMU Mask	SINGLE		Minimum signal level for fixes	0
13-16	PDOP Mask	SINGLE		Maximum GDOP for fixes	8
17-20	PDOP Switch	SINGLE		Selects 2D/3D mode	6
21	DGPS Age	BYTE		Maximum time to use a DGPS correction (seconds)	30 seconds
22	Foliage Mode	BYTE	0 1 2	Never Sometimes Always	Sometimes
23	Low Power Mode	BYTE	N/A	N/A	Disabled
24	Clock Hold Mode	BYTE	N/A	N/A	Off
25	Measurement Rate	BYTE	0 1 2	1 Hertz 5 Hertz 10 Hertz	1 Hz
26	Position Fix Rate	BYTE	0 1 2 3	1 Hertz 5 Hertz 10 Hertz Position at measurement rate	1 Hz
27-42	Reserved	BYTE	-1	Reserved for future use	

A.14.61 Report Packet BB – Report Receiver Configuration

TSIP report packet BB is used to report the GPS Processing options.

Table A-66 Report Packet BB

Byte #	Item	Type	Value	Meaning	Default
0	Subcode	BYTE	0	Primary receiver configuration block	
1	Operating Dimension	BYTE	0 1 3 4 5 6 7	Automatic Time only (1-SV) Horizontal (2D) Full position (3D) DGPS reference 2D clock hold Over-determined clock	Full Position
2	DGPS Mode	BYTE	0 1 3	DGPS off DGPS only DDGPS auto	DGPS auto
3	Dynamics Code	BYTE	1 2 3 4	Land/<120 knots Sea/<50 knots Air/<800 knots Static/Stationary	Land
4	Solution Mode	BYTE	1 2	Overdetermined fix Weighted O/D fix	
5-8	Elevation Mask	SINGLE	0-π/2	Lowest satellite elevation for fixes (radians)	
9-12	AMU Mask	SINGLE		Minimum signal level for fixes	
13-16	PDOP Mask	SINGLE		Maximum GDOP for fixes	8
17-20	PDOP Switch	SINGLE		Selects 2D/3D mode	6

Table A-66 Report Packet BB (Continued)

Byte #	Item	Type	Value	Meaning	Default
21	DGPS Age	BYTE		Maximum time to use a DGPS correction (seconds)	30 seconds
22	Foliage Mode	BYTE	0 1 2	Never Sometimes Always	Sometimes
23	Low Power Mode	BYTE	N/A	N/A	Disabled
24	Clock Hold Mode	BYTE	N/A	N/A	Off
25	Measurement Rate	BYTE	0 1 2	1 Hertz 5 Hertz 10 Hertz	1 Hz
26	Position Fix Rate	BYTE	0 1 2 3	1 Hertz 5 Hertz 10 Hertz Position at measurement rate	1 Hz
27-43	Reserved	BYTE	-1	Reserved for future use	

A.14.62 Command Packet BC – Set Port Configuration Parameters

TSIP command packet BC is used to set the communication parameters on Port A and Port B. The table below lists the individual fields within the BC packet.

Palisade supports only Ports 0 (A) and 1 (B) and the TSIP and NMEA protocols. Port B supports only the 8 bit TSIP protocol. Flow control is not supported.

Table A-67 Command Packet BC

Byte #	Item	Type	Value	Meaning	Default
0	Port Number	BYTE	0 1 0xFF	Port A Port B current port	
1	Input Baud Rate	BYTE	0 1 2 3 4 5 6 7 8 9	None 110 baud 300 baud 600 baud 1200 baud 2400 baud 4800 baud 9600 baud 19200 baud 38400 baud	9600
2	Output Baud Rate	BYTE	0 1-9	Same as input baud rate As above	9600
3	# Data Bits	BYTE	2 3	7 bits 8 bits	8 bits
4	Parity	BYTE	0 1 2	None Odd Even	Odd
5	# Stop Bits	BYTE	0 2	1 bit 2 bits	1 bit
6	reserved	BYTE	0-15	0 = none	0

Table A-67 Command Packet BC (Continued)

Byte #	Item	Type	Value	Meaning	Default
7	Input Protocols	BYTE	0 2	none TSIP	TSIP
8	Output Protocols	BYTE	0 2 4	none TSIP NMEA	TSIP
9	Reserved	BYTE	0	None	

A.14.63 Report Packet BC – Request Port Configuration Parameters

TSIP packet BC is used to request the communication parameters on Port A and Port B. To query a port's configuration parameters, send packet BC with the requested port number. Table A-68, above, lists the individual fields within the BC report packet.

A.15 Custom OEM Packets

Several packets have been added to the core TSIP protocol to provide additional capability for OEM receivers. In OEM packets 8E and their 8F responses, the first data byte is a subcode that indicates the superpacket type. For example, in packet 8E-14, 14 is the subcode that indicates the superpacket type. Therefore the ID code for OEM packets is 2 bytes long, followed by the data.

A.16 TSIP Superpackets

Superpackets describes packets that reduce the I/O traffic with the receiver and facilitate interpretation to a modem or data acquisition device with limited programming facilities.

A.16.1 Command Packet 8E-14 - Set New Datum

This packet allows the user to change the default datum from WG-84 to one of 180 selected datums or a user-entered custom datum. The datum is a set of 5 parameters which describe an ellipsoid to convert the GPS receiver's internal coordinate system of XYZ ECEF into Latitude, Longitude and Altitude (LLA). This will affect all calculations of LLA in packets 4A and 84. The receiver responds with packet 8F-14.

The user may want to change the datum to match coordinates with some other system (usually a map). Most maps are marked with the datum used and in the US the most popular datum for maps is NAD-27. The user may also want to use a datum that is more optimized for the local shape of the earth in that area. However, these optimized datums are truly "local" and will provide very different results when used outside of the area for which they were intended. WGS-84 is an excellent general ellipsoid valid around the world.

To change to one of the internally held datums the packet must contain exactly 2 bytes representing the integer value of the index of the datum desired:

Table A-68 Command Packet 8E-14

Byte #	Type	Value
0	Superpacket ID	0 x 14
1-2	INTEGER	Datum index

Alternatively, the unit will accept a 40 byte input packet containing 5 double precision floating point value representing the ellipse. The first 3 are DX, DY, and DZ, which represent an offset in meters from the ECEF origin for the ellipse. The fourth parameter is the semi-major axis of the ellipse (called the a-axis) and is also in meters. The fifth parameter is the eccentricity of the ellipse and is dimensionless.

Caution – The GPS receiver does not perform an integrity check on the datum values. If unusual inputs are used, the output will be equally unusual.

Table A-69 Command Packet 8E-14

Byte #	Type	Value	Units
0	Superpacket ID	0x14	
1-8	DOUBLE	DX	M
9-16	DOUBLE	DY	M
17-24	DOUBLE	DZ	M
25-32	DOUBLE	A-axis	M
33-40	DOUBLE	Eccentricity Squared	None

A.16.2 Command Packet 8E-15 – Request Current Datum Values

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

A.16.3 Command Packet 8E-20 – Request Last Fix with Extra Information

This packet requests packet 8F-20 or marks it for automatic output. If only the first byte (20) is sent, an 8F-20 report containing the last available fix will be sent immediately. If two bytes are sent, the packet is marked/unmarked for auto report according to the value of the second byte.

Table A-70 Command Packet 8E-20

Byte #	Item	Type	Meaning
0	Sub-packet ID	BYTE	ID for this sub-packet (always 0 x 20)
1	Mark for Auto-report (cf. bit 5 of packet 35)	BYTE	0 = do not auto-report 1 = auto-report

Note – Auto-report requires that superpacket output is enabled. Refer to command packet 35.

A.16.4 Command Packet 8E-41 – Manufacturing Operating Parameters

This packet is used to request the manufacturing parameters stored in nonvolatile memory. The packet contains only a single byte, the subpacket ID. The receiver returns packet 8F-41.

A.16.5 Command Packet 8E-42 – Production Parameters

This packet is used to request the production parameters stored in nonvolatile memory. This packet contains only a single byte, the subpacket ID. The receiver returns packet 8F-42.

A.16.6 Command Packet 8E-45 – Revert to Default Settings

This packet is used to clear the serial E^2 PROM segments or revert the stored parameters to their factory settings.

Table A-71 Command Packet 8E-45

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 45
1	Production options prefix	BYTE	3 CNFG 5 PORT 6 PPS 7 ACCU 8 DECORR 9 TIMING

Note – There are six nonvolatile memory segments that contain parameters that are programmable: CNFG, PORT, PPS, ACCU, DECORR and TIMING. The CNFG segment stores the receiver configuration parameters that are programmable with the command packets 0xBB and 0x2A. The PORT segment stores the port configuration parameters that are programmable with command packet 0xBC. The PPS segment stores the timing pulse characteristics defined by the command packet 0x8E-0x4A. The ACCU segment stores the accurate initial position supplied by the command packets 0x31 and 0x32. The DECORR segment stores the maximum number of position fix averages in the auto-survey before the switch to overdetermined clock mode (packet 8E-4B). The TIMING segment stores UTC offset information that is automatically collected by the receiver.

This packet generates an 8F-45 response.

A.16.7 Command Packet 8E-4A - Set PPS Characteristics

This packet allows the user to query and control Palisade's PPS characteristics. Palisade responds to a query or control command with packet 8F-4A. The packet contains 16 bytes in the following order:

Table A-72 Command Packet 8E-4A

Byte #	Item	Type	Meaning
0	Sub-packet ID	BYTE	Always 0 x 4A
1	PPS Driver Switch	BYTE	0 = off 1 = on
2	Time Base	BYTE	0: GPS 1: UTC (default)
3	PPS Polarity	BYTE	0: positive (default) 1: negative
4-11	PPS Offset or Cable Delay	DOUBLE	seconds 0.0
12-15	Bias Uncertainty Threshold	FLOAT	meters 300

Send a two byte 8E-4A packet without any parameters to request 8F-4A. Send the entire 16-byte message to update parameters.

The default setting for byte 3 is positive. This configures Palisade for the same pulse polarity as the AcutimeII smart antenna. Bytes 4 to 11 define the PPS cable delay offset. The default offset is 0, which corresponds to a 100-foot (30 meter) cable. These bytes allow the application to adjust the cable delay offset for longer or shorter cable lengths. Use a cable delay of ± 1.25 ns/foot to adjust PPS offset for cable lengths different than 100 feet. Palisade estimates the bias uncertainty as part of a PPS validity monitor. If the bias uncertainty exceeds the threshold, then Palisade disables the PPS output. The default bias uncertainty threshold is 300 meters, but this parameter may be programmed by the application. Palisade limits the threshold to $3x10^8$ meters. Each time the application adjusts the packet 8E-4A settings, the new settings are stored in nonvolatile memory.

A.16.8 Command Packet 8E-4B – Programming the Survey Limit

This packet allows the user to override the factory survey limit of 2000 position fix averages. Sending 8E-4B without parameters allows querying the current setting. The receiver returns packet 8F-4B.

Table A-73 Command Packet 8E-4B

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 4B
1-4	Auto-survey limit	LONG	Indicates the maximum number of position fixes to average in Auto 2D/3D before switching to over-determined timing mode

A.16.9 Command Packet 8E-4D – Automatic Packet Output Mask

Automatic output of packets on port B can be throttled using this command packet. The current mask can be requested by sending this packet with no data bytes except the subcode byte.

Table A-74 Command Packet 8E-4D - Current Mask

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 4D

The automatic packet output mask can be set by sending this packet with 4 data bytes. This mask only disables automatic packet output. Packets generated in response to TSIP set or query commands will always be output by the receiver.

Table A-75 Command Packet 8E-4D - Automatic Packet Output Mask

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 4D
1-4	Auto-output mask	LONG	32-bit packet enable bitmap

The bits are numbered in descending order of receipt, starting with bit 32 as the MSB of Byte 1, down to bit 0 as the LSB of Byte 4. The following table describes the packets affected by each bit.

Table A-76 Command Packet 8E-4D - Packets Affected By Bits

Bit #	Packets Output	Default	When Output	Meaning
0 (LSB)	40	0	After Decode	Almanac data collected from satellite.
1	58, 5B	0	After Decode	Ephemeris data collected from satellite.
2	4F	0	After Decode	UTC data collected from satellite.
3	58	0	After Decode	Ionospheric data collected from satellite.
4	48	0	After Decode	GPS Message.
5	49	0	After Decode	Almanac health page collected from satellite.
6		1		Reserved
7		1		Reserved
8	41	1	New Fix	Partial and full fix complete and packet output timer has expired.
9		1		Reserved
10		1		Reserved
11 (Note 1)	6D, 46, 4B, 82	1	Constellation Change, New Fix	New satellite selection
12		1	External Event	Reserved
13-29		1		Reserved
30	42, 43, 4A, 54, 56, 83, 84, 8F-20,	1	New Fix Update	Kinetic and Timing information. Output must be enabled using I/O options.
31	5A	1	New Fix	Output must be enabled using I/O options.

Note 1: A *1* in the bit mask turns on the associated packets and a *0* turns off the output of the associated packets.

A.16.10 Command Packet 8E-A5 – Super Packet Output Mask

This packet allows the user to query the enabled super packets. Selected super packets are output if they are enabled and the configured protocol is TSIP.

Table A-77 Command Packet 8E-A5

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x A5

The receiver returns the super packet enable mask, packet 8F-A5. Super packet output is configured using the output protocol options available in packet BC and 3D, and by sending the 8E-20, 8E-0B and 8E-AD auto-output configuration commands described in each packet’s respective section.

A.16.11 Command Packet 8E-AD – Request or Configure Super Packet Output

The 8E-AD packet is a dual-purpose packet. If the 8E-AD byte sequence is sent with no data, the receiver will generate an 8F-AD packet on port B. The time reported by the 8F-AD packet on port B is always the beginning of the current second.

Output of the 8F-AD Primary UTC timing packet on Port A is configured by sending a 3 byte message 8E-AD n, where n ranges from 0 to 3, as defined below. The receiver returns the 8F-A5 Super Packet Output Mask. The packet structure for the 8E-AD n configuration command is:

Table A-78 Command Packet 8E-AD

Byte #	Item	Type	Value	Default	Meaning
0	Subcode	Byte	AD	Required	Super-packet ID
1	Flag	Byte	0 1 2 3	3	disable packet output on port A output packet on port A only at PPS output packet on port A only at event input output at both event input and PPS

A.16.12 Command Packet 8E-0B – Request or Configure Super Packet Output

The 8E-0B packet is identical in function to the 8E-AD packet. If the 8E-0B byte sequence is sent with no data, the receiver will return an 8F-0B packet on port B. The time reported by the 8F-AD packet on port B is always the beginning of the current second.

Output of the 8F-0B Comprehensive timing packet on Port A is configured by sending a 3-byte message 8E-0B n, where n ranges from 0 to 3. The receiver returns the 8F-A5 Super Packet Output Mask. The packet structure for the 8E-0B n configuration command is:

Table A-79 Command Packet 8E-0B

Byte #	Item	Type	Value	Default	Meaning
0	Subcode	Byte	OB	Required	Super-packet ID
1	Flag	Byte	0 1 2 3	2	disable packet output on port A output packet on port A only at PPS output packet on port A only at event input output at both event input and PPS

A.16.13 Report Packet 8F-14 – Current Datum Values

This packet contains 41 data bytes with the values for the datum currently in use and is sent in response to packet 8E-14. These five values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA.

Table A-80 Report Packet 8F-14

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

A.16.14 Report Packet 8F-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 will be returned. If the receiver is operating on a custom user-entered datum, the datum index will be set to −1 and the five values will be displayed. These five values describe an ellipsoid to convert ECEF XYZ coordinate system into LLA.

Table A-81 Report Packet 8F-15

Byte #	Type	Value
0	BYTE	ID for this sub-packet (always 0 x 15)
1-2	INTEGER	Datum index (-1 for custom)
3-10	DOUBLE	DX
11-18	DOUBLE	DY
19-26	DOUBLE	DZ
27-34	DOUBLE	A-axis
35-42	DOUBLE	Eccentricity Squared

Note – A complete list of datums is provided at the end of this appendix.

A.16.15 Report Packet 8F-20 – Last Fix with Extra Information (binary fixed point)

This packet provides information concerning the time and origin of the previous position fix. This is the last-calculated fix; it could be quite old. The receiver sends this packet in response to Packet 8E-20; it also can replace automatic reporting of position and velocity packets. Automatic output of 8F-20 must also be enabled by setting bit 5 of byte 0 in command packet 0x35.

The data format is shown below.

Table A-82 Report Packet 8F-20

Byte #	Item/Type	Meaning
0	Subpacket ID / BYTE	ID for this subpacket (always 0 x 20)
1	KeyByte/BYTE	Reserved for Trimble DGPS postprocessing
2-3	east velocity / INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
4-5	north velocity / INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
6-7	up velocity /INTEGER	units 0.005 m/s or 0.020 m/s (see Byte 24). Overflow = 0 x 8000
8-11	Time of Week / UNSIGNED LONG	GPS Time in milliseconds
12-15	Latitude / LONG INTEGER	WGS-84 latitude, units = 2^{-31} semicircle. Range = -2^{30} to 2^{32}
16-19	Longitude / UNSIGNED LONG	WGS-84 longitude east of meridian, units = 2^{-31} semicircle. Range = 0 to 2^{32}
20-23	Altitude / LONG INTEGER	Altitude above WGS-84 ellipsoid, mm.
24	Velocity Scaling	When bit 0 is set to 1, velocities in Bytes 2-7 have been scaled by 4.
25	Reserved	0
26	Datum	Datum index + 1

Table A-82 Report Packet 8F-20 (Continued)

Byte #	Item/Type	Meaning
27	Fix Type / BYTE	Type of fix. This is a set of flags. 0 (LSB) 0: Fix was available 1: No fix available 1 0: Fix is autonomous 1: Fix was corrected with RTCM 2 0: 3D fix 1: 2D fix 3 0: 2D fix used last-circulated altitude 1: 2D fix used entered altitude 4 0: unfiltered 1: position or altitude filter on 5-7 unused (always 0)
28	NumSVs/BYTE	Number of satellites used for fix. Will be zero if no fix was available.
29	UTC Offset / BYTE	Number of leap seconds between UTC time and GPS time.
30-31	Week/INTEGER	GPS time of fix (weeks)
32-47	Fix SVs	Repeated groups of 2 bytes, one for each satellite. There will always be 8 of these groups. The bytes are 0 if group N/A. The following table describes the contents of each group.
48-55	Iono Param / 8 CHARS	The broadcast ionospheric parameters.

Table A-83 Report Packet 8F-20

Bytes 32-47	Item/Type	Meaning
0	PRNX/BYTE	Satellite number and IODC - IODE. PRN = the lower six bits of PRNX. IODC = (PRNX/64)∞256 + IODE
1	IODE/BYTE	

Thus the total length of data in packet is 41 + 2n bytes, where n is the number of satellites.

A.16.16 Report Packet 8F-41 – Manufacturing Operating Parameters

This packet provides information on the manufacturing parameters stored in nonvolatile memory.

Table A-84 Report Packet 8F-41

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 41
1-2	Board serial number prefix	INTEGER	
3-6	Board serial number	ULONG	
7	Year of build	BYTE	
8	Month of build	BYTE	
9	Day of build	BYTE	
10	Hour of build	BYTE	
11-14	Oscillator offset	SINGLE	
15-16	Test code identification number	INTEGER	

A.16.17 Report Packet 8F-42 - Production Parameters

This packet provides information on the production parameters stored in nonvolatile memory.

Table A-85 Report Packet 8F-42

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 42
1	Production options prefix	BYTE	
2	Production number extension	BYTE	
3-4	Case serial number prefix	INTEGER	
5-8	Case serial number	ULONG	
9-12	Production number	ULONG	
13-14	Reserved	INTEGER	
15-16	Machine identification number	INTEGER	
17-18	Reserved	INTEGER	

A.16.18 Report Packet 8F-45 – Revert to Default Settings

This packet is sent in response to packet 8E-45 and indicates that the E^2 PROM segment indicated in Byte 1 has been cleared back to factory settings successfully. If packet 45 appears unrequested, then either the GPS receiver power was cycled or the GPS receiver was reset.

Table A-86 Report Packet 8F-45

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x 45
1	Production options	BYTE	3 CNFG 5 PORT 6 PPS 7 ACCU 8 DECORR 9 TIMING

A.16.19 Report Packet 8F-4A – PPS Characteristics

This packet reports Palisade's PPS characteristics. This packet is sent in response to a query command with packet 8E-4A. The packet contains 16 bytes in the following order:

Table A-87 Report Packet 8F-4A

Byte #	Item	Type	Units
0	Subpacket ID	BYTE	Always 0 x 4A
1	PPS Driver Switch	BYTE	0: off 1: on
2	Time Base	BYTE	0: GPS 1: UTC (default)
3	PPS Polarity	BYTE	0: positive (default) 1: negative
4-11	PPS Offset or Cable Delay	DOUBLE	seconds
12-15	Bias Uncertainty Threshold	SINGLE	meters

A.16.20 Report Packet 8F-4B – Programming the Survey Limit

This packet provides information on user overrides of the factory survey limit of 2000 position fix averages. It is sent in response to a query or set command 8E-4B.

Table A-88 Report Packet 8F-4B

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 4B
1-4	Maximum	ULONG	Indicates the maximum number of position fixes to average in Auto 2D/3D before the switch to overdetermined clock (static mode)

A.16.21 Report Packet 8F-4D – Automatic Packet Output Mask

This packet provides information on the automatic packets that may be output by the receiver. Sent in response to 8E-4D query or set.

Table A-89 Report Packet 8F-4D

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this sub-packet is always 0 x 4D
1-4	Bit Mask	ULONG	Bits in the mask enable output packets

The following table describes the meaning and packets output by each set bit.

Table A-90 Report Packet 8F-4D

Bit #	Packets Output	When Output	Meaning
0(LSB)	40 Alm	After Decode	Almanac data collected from satellite
1	58, 5B	After Decode	Ephemeris data collected from satellite.
2	4F	After Decode	UTC data collected from satellite
3	58	After Decode	Ionospheric data collected from satellite
4	48	After Decode	GPS Message.
5	49	After Decode	Almanac health page collected from satellite.
6			Reserved
7			Reserved
8	41	New Fix	Partial and full fix complete and packet output timer has expired.
9			Reserved
10			Reserved
11	6D, 82	Constellation Change	New satellite selection
12		External Event	Reserved
13-29			Reserved
30	4A, 8F-20, 42, 43, 54, 56, 82, 83, 84	New Fix Update	Kinetic and Timing information. Output must be enabled with I/O options.
31 (Note 1)	5A	New Fix	Output must be enabled with I/O options.

Note 1: A *1* in the bit mask indicates that output for the associated packets is ON and a *0* indicates that the output is turned OFF.

A.16.22 Report Packet 8F-A5 – Super Packet Output Mask

This packet reports the 32-bit Super Packet Output Mask. Mask bits set to 1 indicate that output of the corresponding packet is enabled. Enabled super packets are output only if the configured port output protocol on port A is TSIP.

Table A-91 Report Packet 8F-A5

Byte #	Item	Type	Meaning
0	Subcode	BYTE	ID for this subpacket is always 0 x A5
1-4	Bit Mask	BYTES	bits in the mask enable super packets

The receiver bit mask is defined as follows: Bytes are numbered as above, and bit 0 is LSB within the byte.

Table A-92 Report Packet 8F-A5

Byte	Bit #	Item	Default	Meaning if set to 1
1	0	8F-0B	0	Synchronous 8F-0B (1 Hertz)
	1	8F-0B	1	Event output of 8F-0B
	2-3	Reserved	1	
	4	8F-AD	1	Synchronous 8F-AD (1 Hertz)
	5	8F-AD	1	Event output of 8F-AD
	6-7	Reserved	1	Future use
2	0	8F-20	1	Enable 8F-20 output
	1-7	Reserved	1	
3	0-7	Reserved	0	Always 0
4	0-7	Reserved	0	Always 0

A.16.23 Synchronous Packets Output on Port A

The following packets are output immediately after transition of the PPS pulse, to allow identification and qualification of the PPS pulse. These packets may also be requested on port B. See the associated 8E-AD and 8E-0B packets for more information.

Report Packet 8F-AD - Primary UTC Time

The output of the 8F-AD packet is synchronized with the PPS, and may also be generated in response to external events. This packet provides accurate time and date information for time stamping and time transfer. The leap flag provides complete UTC event information, allowing implementation of sophisticated distributed systems intended to operate synchronously with UTC time. This packet is always output first in a possible sequence of up to 3 synchronous packets available on port A. Output of this packet can be disabled and configured using the 8E-AD packet on port B.

Table A-93 Report Packet 8F-AD

Byte #	Item	Type	Meaning
0	Subpacket ID	BYTE	Subcode 0 x AD
1-2	Event Count	INTEGER	External event counter. Zero for PPS.
3-10	Fractional Second	DOUBLE	Time elapsed in current second (seconds)
11	Hour	BYTE	UTC Hour
12	Minute	BYTE	UTC Minute
13	Second	BYTE	Second (0-59; 60 = leap)
14	Day	BYTE	Date (1-31)
15	Month	BYTE	Month (1-12)
16-17	Year	INTEGER	Year (4 digit)
18	Receiver Status	BYTE	Tracking Status (see definition below)
19	UTC Flags	BYTE	Leap Second Flags (see definition below)
20	Reserved	BYTE	Contains 0 x FF
21	Reserved	BYTE	Contains 0 x FF

The tracking status flag allows precise monitoring of receiver tracking status and allows a host system to determine whether the time output by the receiver is valid. After self survey has completed, the receiver only needs to track one satellite to maintain precise synchronization with UTC.

Table A-94 Tracking Status Flag Definitions

Flag	Status	Meaning
0	DOING_FIXES	Receiver is navigating.
1	GOOD_1SV	Receiver is timing using one satellite
2	APPX_1SV	Approximate time
3	NEED_TIME	Start-up
4	NEED_INITALIZATION	Start-up
5	PDOP_HIGH	Dilution of Precision too High
6	BAD_1SV	Satellite is unusable
7	0SVs	No satellites usable
8	1SV	Only 1 satellite usable
9	2SVs	Only 2 satellites usable
10	3SVs	Only 3 satellites usable
11	NO_INTEGRITY	Invalid solution
12	DCORR_GEN	Differential corrections
13	OVERDET_CLK	Overfetermined fixes

Leap Second Flag

Leap seconds are inserted into the UTC timescale to counter the effect of gradual slowing of the earth's rotation due to friction. The 8F-AD packet provides extensive UTC leap second information to the user application. The **Leap Scheduled** bit is set by the receiver, when the leap second has been scheduled by the GPS control segment. The Control segment may schedule the leap second several weeks before the leap second takes place. The **Leap Pending** bit indicates that the leap second will be inserted at the end of the current day. The **GPS Leap Warning** bit is set while GPS is operating in the leap exception mode specified in ICD-200. The **Leap in Progress** bit is set to 1 at the beginning of the leap second, and cleared at the beginning of the second following the leap event. The date rollover is delayed by one second on the day the leap second is inserted. The date will not increment until the beginning of the first second following the leap second.

Table A-95 Leap Second Flag Definitions

Bit #	Name	Meaning if set to 1
0	UTC Flag	UTC Time is available
1-3	Reserved	N/A
4	Leap Scheduled	GPS Almanac's leap second date is not in the past.
5	Leap Pending	24-hour warning. Cleared before leap second.
6	GPS Leap Warning	Set +/- 6 hours before/after leap event.
7	Leap in Progress	Leap second is now being inserted.

Report Packet 8F-0B - Comprehensive Time

Palisade outputs this packet port A. The output of the packet is synchronized with the PPS, and may also be generated in response to external events. Report packet 8F-0B provides easy identification of each timing pulse and contains all the information required for most timing and synchronization applications. Output of this packet can be disabled and configured using the 8E-0B packet on port B. If output of the 8F-AD packet is also enabled, the 8F-0B packet will always be output after the 8F-AD packet. If the NMEA protocol is also enabled, 8F-0B will always be output before the NMEA ZDA packet. The packet contains 74 bytes in the following order:

Table A-96 Report Packet 8F-0B

Byte #	Item	Type	Meaning
0	Subpacket ID	BYTE	Subcode 0 x 0B
1-2	Event Count	INTEGER	External event counter. Zero for PPS.
3-10	UTC/GPS TOW	DOUBLE	UTC/GPS time of week (seconds)
11	Date	BYTE	Date of event or PPS
12	Month	BYTE	Month of event or PPS
13-14	Year	INTEGER	Year of event or PPS
15	Receiver Mode	BYTE	Receiver operating dimensions 0 Horizontal (2D) 1 Full position (3D) (Survey) 2 Single satellite (0D) 3 Automatic (2D/3D) 4 DGPS reference 4 Clock hold (2D) 6 Overdetermined clock (default)
16-17	UTC Offset	INTEGER	UTC offset value (seconds)
18-25	Oscillator Bias	DOUBLE	Oscillator bias (meters)
26-33	Oscillator Drift Rate	DOUBLE	Oscillator drift (meters/second)
34-37	Oscillator Bias Uncertainty	SINGLE	Oscillator bias uncertainty (meters)

Table A-96 Report Packet 8F-0B (Continued)

Byte #	Item	Type	Meaning
38-41	Oscillator Drift Uncertainty	SINGLE	Oscillator bias rate uncertainty (meters/second)
42-49	Latitude	DOUBLE	Latitude in radians
50-57	Longitude	DOUBLE	Longitude in radians
58-65	Altitude	DOUBLE	Altitude above mean sea level, meters
66-73	Satellite ID	8 BYTES	Identification numbers of tracking and usable satellites

Bytes 66 through 73 identify the tracking and usable satellites. A tracked satellite is distinguished from a usable satellite by a negative sign (–) appended to its PRN number.

In this superpacket, time is referenced to UTC to correspond to the default PPS timebase. To configure Palisade to output time relative to GPS, the PPS must be characterized accordingly. Command packet 8E-4A enables the PPS to be re-defined at run-time and stores the new settings in nonvolatile memory.

Note – Leap seconds can not be predicted in advance using only the 8F-0B packet. A leap second can be identified by observing that the date does not increment after 86400 seconds have elapsed in the current day. The date rollover is delayed for the duration of the leap second, and the day/month/year count reported does not increment to the next day until the beginning of the second following the leap event. Decoding of the 8F-AD packet provides complete leap status information.

The UTC offset is incremented at the beginning of the first second following the leap second.

A.17 Datums

The table on the following pages lists datums.

Table A-97 Datums

Index	DX	DY	DZ	A-axis	Eccentricity	Description
0	0	0	0	6378137.000	0.00669437999014	/*WGS-84*/
1	-128	481	664	637797.155	0.00667437311265	/*Tokyo from old J6 values*/
2	-8	160	176	6378206.400	0.0067865799761	/*NAD-27*/
3	-9	151	185	6378206.400	0.00676865799761	/*Alaska/Canada*/
4	-87	-98	-121	6378388.000	0.00672267002233	/*European*/
5	-133	-48	148	6378160.000	0.00669454185459	/*Australian*/
6	0	0	4	6378135.000	0.00669431777827	/*WGS-72*/
7	0	0	0	6378137.000	0.00669438002290	/*NAD-83*/
8	0	0	0	6378137.000	0.00669437999014	/*NAD-02*/
9	0	0	0	6378137.000	0.00669437999014	/*Mexican*/
10	0	0	0	6378137.000	0.00669437999014	/*Hawaiian*/
11	0	0	0	6378137.000	0.00669437999014	/*Astronomic*/
12	0	0	0	6378137.000	0.00669437999014	/*U S Navy*/
13	-87	-98	-121	6378388.000	0.00672267002233	/*European*/
14	-134	-48	149	6378160.000	0.00669454185459	/*Australian 1984*/
15	-166	-15	204	6378249.145	0.00680351128285	/*Adindan-Mean*/
16	-165	-11	206	6378249.145	0.00680351128285	/*Adindan-Ethiopia*/
17	-123	-20	220	6378249.145	0.00680351128285	/*Adindan-Mali*/
18	-128	-18	224	6378249.145	0.00680351128285	/*Adindan-Senegal*/
19	-161	-14	205	6378249.145	0.00680351128285	/*Adindan-Sudan*/
20	-43	-163	45	6378245.000	0.00669342162297	/*Afgooye-Somalia*/
21	-150	-250	-1	6378388.000	0.00672267002233	/*Ain El Abd-Bahrain*/
22	-491	-22	435	6378160.000	0.00669454185459	/*Anna 1 Astr 1965*/
23	-143	-90	-294	6378249.145	0.00680351128285	/*Arc 1950-Mean*/
24	-138	-105	-289	6378249.145	0.00680351128285	/*Arc 1950-Botswana*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
25	-125	-108	-295	6378249.145	0.00680351128285	/*Arc 1950-Lesotho*/
26	-161	-73	-317	6378249.145	0.00680351128285	/*Arc 1950-Malawi*/
27	-134	-105	-295	6378249.145	0.00680351128285	/*Arc 1950-Swaziland*/
28	-169	-19	-278	6378249.145	0.00680351128285	/*Arc 1950-Zaire*/
29	-147	-74	-283	6378249.145	0.00680351128285	/*Arc 1950-Zambia*/
30	-142	-96	-293	6378249.145	0.00680351128285	/*Arc 1950-Zimbabwe*/
31	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Mean*/
32	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Kenya*/
33	-160	-6	-302	6378249.145	0.00680351128285	/*Arc 1960-Tanzania*/
34	-205	107	53	6378388.000	0.00672267002233	/*Ascension Isl 1958*/
35	145	75	272	6378388.000	0.00672267002233	/*Astro Beacon E 1945*/
36	114	-116	-333	6378388.000	0.00672267002233	/*Astro B4 Sorol Atoll*/
37	-320	550	-494	6378388.000	0.00672267002233	/*Astro Dos 71/4*/
38	124	-234	-25	6378388.000	0.00672267002233	/*Astro Station 1952*/
39	-133	-48	148	6378160.000	0.00669454185459	/*Australian Geo 1966*/
40	-127	-769	472	6378388.000	0.00672267002233	/*Bellevue (IGN)*/
41	-73	213	296	6378206.400	0.00676865799761	/*Bermuda 1957*/
42	307	304	-318	6378388.000	0.00672267002233	/*Bogota Observatory*/
43	-148	136	90	6378388.000	0.00672267002233	/*Compo Inchauspe*/
44	298	-304	-375	6378388.000	0.00672267002233	/*Canton Island 1966*/
45	-136	-108	-292	6378249.145	0.00680351128285	/*Cape*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
46	-2	151	181	6378206.400	0.00676865799761	/*Cape Canaveral mean*/
47	-263	6	431	6378249.145	0.00680351128285	/*Carthage*/
48	175	-38	113	6378388.000	0.00672267002233	/*Chatham 1971*/
49	-134	229	-29	6378388.000	0.00672267002233	/*Chua Astro*/
50	-206	172	-6	6378388.000	0.00672267002233	/*Corrego Alegre*/
51	-377	681	-50	6377397.155	0.00667437223180	/*Djakarta (Batavia)*/
52	230	-199	-752	6378388.000	0.00672267002233	/*DOS 1968*/
53	211	147	111	6378388.000	0.00672267002233	/*Easter Island 1967*/
54	-87	-98	-121	6378388.000	0.00672267002233	/*Euro 1950-Mean*/
55	-104	-101	-140	6378388.000	0.00672267002233	/*Euro 1950-Cyprus*/
56	-130	-117	-151	6378388.000	0.00672267002233	/*Euro 1950-Egypt*/
57	-86	-96	-120	6378388.000	0.00672267002233	/*Euro 1950-Eng/ Scot*/
58	-86	-96	-120	6378388.000	0.00672267002233	/*Euro 1950-Eng/Ire*/
59	-84	-95	-130	6378388.000	0.00672267002233	/*Euro 1950-Greece*/
60	-117	-132	-164	6378388.000	0.00672267002233	/*Euro 1950-Iran*/
61	-97	-103	-120	6378388.000	0.00672267002233	/*Euro 1950-Sardinia*/
62	-97	-88	-135	6378388.000	0.00672267002233	/*Euro 1950-Sicily*/
63	-87	-95	-120	6378388.000	0.00672267002233	/*Euro 1950-Norway*/
64	-87	-107	-120	6378388.000	0.00672267002233	/*Euro 1950-Port/ Spain*/
65	-86	-98	-119	6378388.000	0.00672267002233	/*European 1979*/
66	-133	-321	50	6378388.000	0.00672267002233	/*Gandajika Base*/
67	84	-22	209	6378388.000	0.00672267002233	/*Geodetic Datum 1949*/
68	-100	-248	259	6378206.400	0.00676865799761	/*Guam 1963*/
69	252	-209	-751	6378388.000	0.00672267002233	/*GUX 1 Astro*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
70	-73	46	-86	6378388.000	0.00672267002233	/*Hjorsey 1955*/
71	-156	-271	-189	6378388.000	0.00672267002233	/*Hong Kong 1963*/
72	209	818	290	6377276.345	0.00663784663020	/*Indian-Thai/Viet*/
73	295	736	257	6377301.243	0.00663784663020	/*Indian-India/Nepal*/
74	506	-122	611	6377340.189	0.00667053999999	/*Ireland 1965*/
75	208	-435	-229	6378388.000	0.00672267002233	/*ISTS O73 Astro 1969
76	89	-79	-202	6378388.000	0.00672267002233	/*Johnston Island 1961*/
77	-97	787	86	6377276.345	0.00663784663020	/*Kandawala*/
78	145	-187	103	6378388.000	0.00672267002233	/*Kerguelen Island*/
79	-11	851	5	6377304.063	0.00663784663020	/*Kertau 1948*/
80	94	-948	-1262	6378388.000	0.00672267002233	/*La Reunion*/
81	42	124	147	6378206.400	0.00676865799761	/*L.C. 5 Astro*/
82	-90	40	88	6378249.145	0.00680351128285	/*Liberia 1964*/
83	-133	-77	-51	6378206.400	0.00676865799761	/*Luzon-Phillippines*/
84	-133	-79	-72	6378206.400	0.00676865799761	/*Luzon-Mindanao*/
85	41	-220	-134	6378249.145	0.00680351128285	/*Mahe 1971*/
86	-289	-124	60	6378388.000	0.00672267002233	/*Marco Astro*/
87	639	405	60	6377397.155	0.00667437223180	/*Massawa*/
88	31	146	47	6378249.145	0.00680351128285	/*Merchich*/
89	912	-58	1227	6378388.000	0.00672267002233	/*Midway Astro 1961*/
90	-92	-93	122	6378249.145	0.00680351128285	/*Minna*/
91	-247	-148	369	6378249.145	0.00680351128285	/*Nahrwan-Masirah*/
92	-249	-156	381	6378249.145	0.00680351128285	/*Nahrwan-UAE*/
93	-243	-192	477	6378249.145	0.00680351128285	/*Nahrwan-Saudia*/
94	616	97	-251	6377483.865	0.00667437223180	/*Namibia*/
95	-10	375	165	6378388.000	0.00672267002233	/*Naparima*/
96	-8	159	175	6378206.400	0.00676865799761	/*NAD 27-Western US*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
97	-9	161	179	6378206.400	0.00676865799761	/*NAD 27-Eastern US*/
98	-5	135	172	6378206.400	0.00676865799761	/*NAD 27-Alaska*/
99	-4	154	178	6378206.400	0.00676865799761	/*NAD 27-Bahamas*/
100	1	140	165	6378206.400	0.00676865799761	/*NAD 27-San Salvador*/
101	-10	158	187	6378206.400	0.00676865799761	/*NAD 27-Canada*/
102	-7	162	188	6378206.400	0.00676865799761	/*NAD 27-Alberta/ BC*/
103	-22	160	190	6378206.400	0.00676865799761	/*NAD 27-East Canada*/
104	-9	157	184	6378206.400	0.00676865799761	/*NAD 27-Manitoba/ Ont*/
105	4	159	188	6378206.400	0.00676865799761	/*NAD 27-NW Ter/ Sask*/
106	-7	139	181	6378206.400	0.00676865799761	/*NAD 27-Yukon*/
107	0	125	201	6378206.400	0.00676865799761	/*NAD 27-Canal Zone*/
108	-3	143	183	6378206.400	0.00676865799761	/*NAD 27-Caribbean*/
109	0	125	194	6378206.400	0.00676865799761	/*NAD 27-Central Amer*/
110	-9	152	178	6378206.400	0.00676865799761	/*NAD 27-Cuba*/
111	11	114	195	6378206.400	0.00676865799761	/*NAD 27-Greenland*/
112	-12	130	190	6378206.400	0.00676865799761	/*NAD 27-Mexico*/
113	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Alaska*/
114	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Canada*/
115	0	0	0	6378137.0	0.00669438002290	/*NAD 83-CONUS*/
116	0	0	0	6378137.0	0.00669438002290	/*NAD 83-Mex/Cent Am*/
117	-425	-169	81	6378388.0	0.00672267002233	/*Observatorio 1966*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
118	-130	110	-13	6378200.0	0.00669342162297	/*Old Egyptian 1907*/
119	61	-285	-181	6378206.400	0.00676865799761	/*Old Hawaiian-mean*/
120	89	-279	-183	6378206.400	0.00676865799761	/*Old Hawaiian-Hawaii*/
121	45	-290	-172	6378206.400	0.00676865799761	/*Old Hawaiian*/
122	65	-290	-190	6378206.400	0.00676865799761	/*Old Hawaiian*/
123	58	-283	-182	6378206.400	0.00676865799761	/*Old Hawaiian*/
124	-346	-1	224	6378249.15	0.00680351128285	/*Oman*/
125	375	-111	431	6377563.4	0.00667053999999	/*Ord Sur Brit '36-Mean*/
126	375	-111	431	6377563.4	0.00667053999999	/*OSB-England*/
127	375	-111	431	6377563.4	0.00667053999999	/*OSB-Isle of Man*/
128	375	-111	431	6377563.4	0.00667053999999	/*OSB-Scotland/ Shetland*/
129	375	-111	431	6377563.4	0.00667053999999	/*OSB-Wales*/
130	-307	-92	127	6378388.0	0.00672267002233	/*Pico De Las Nieves*/
131	-185	165	42	6378388.0	0.00672267002233	/*Pitcairn Astro 1967*/
132	16	196	93	6378388.0	0.00672267002233	/*Prov So Chilean1963*/
133	-288	175	-376	6378388.0	0.00672267002233	/*Prov S. American 1956-Mean*/
134	-270	188	-388	6378388.0	0.00672267002233	/*Prov S. American 1956-Bolivia*/
135	-270	183	-390	6378388.0	0.00672267002233	/*Prov S. American 1956-N Chile*/
136	-305	243	-442	6378388.0	0.00672267002233	/*Prov S. American 1956-S Chile*/
137	-282	169	-371	6378388.0	0.00672267002233	/*Prov S. American 1956-Colom*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
138	-278	171	-367	6378388.0	0.00672267002233	/*Prov S. American 1956-Equador*/
139	-298	159	-369	6378388.0	0.00672267002233	/*Prov S. American 1956-Guyana*/
140	-279	175	-379	6378388.0	0.00672267002233	/*Prov S. American 1956-Peru*/
141	-295	173	-371	6378388.0	0.00672267002233	/*Prov S. American 1956-Venez*/
142	11	72	-101	6378206.4	0.00676865799761	/*Puerto Rico*/
143	-128	-283	22	6378388.0	0.00672267002233	/*Quatar National*/
144	164	138	-189	6378388.0	0.00672267002233	/*Qornoq*/
145	-225	-65	9	6378388.0	0.00672267002233	/*Rome 1940*/
146	-203	141	53	6378388.0	0.00672267002233	/*Santa Braz*/
147	170	42	84	6378388.0	0.00672267002233	/*Santo (DOS)*/
148	-355	21	72	6378388.0	0.00672267002233	/*Sapper Hill 1943*/
149	-57	1	-41	6378160.0	0.00669454185459	/*S. American 1969-Mean*/
150	-62	-1	-37	6378160.0	0.00669454185459	/*S. American 1969-Argentina*/
151	-61	2	-48	6378160.0	0.00669454185459	/*S. American 1969-Bolivia*/
152	-60	-2	-41	6378160.0	0.00669454185459	/*S. American 1969-Brazil*/
153	-75	-1	-44	6378160.0	0.00669454185459	/*S. American 1969-Chile*/
154	-44	6	-36	6378160.0	0.00669454185459	/*S. American 1969-Colombia*/
155	-48	3	-44	6378160.0	0.00669454185459	/*S. American 1969-Ecuador*/
156	-53	3	-47	6378160.0	0.00669454185459	/*S. American 1969-Guyana*/
157	-61	2	-33	6378160.0	0.00669454185459	/*S. American 1969-Paraguay*/

Table A-97 Datums (Continued)

Index	DX	DY	DZ	A-axis	Eccentricity	Description
158	-58	0	-44	6378160.0	0.00669454185459	/*S. American 1969-Peru*/
159	-45	12	-33	6378160.0	0.00669454185459	/*S. American 1969-Trin/Tob*/
160	-45	8	-33	6378160.0	0.00669454185459	/*S. American 1969-Venezuela*/
161	7	-10	-26	6378155.0	0.00669342162297	/*South Asia*/
162	-499	-249	314	6378388.0	0.00672267002233	/*Southeast Base*/
163	-104	167	-38	6378388.0	0.00672267002233	/*Southwest Base*/
164	-689	691	-46	6377276.345	0.00663784663020	/*Timbalai 1948*/
165	-148	507	685	6377397.16	0.00667437223180	/*Tokyo-Mean*/
166	-146	507	687	6377397.16	0.00667437223180	/*Tokyo-Korea*/
167	-158	507	676	6377397.16	0.00667437223180	/*Tokyo-Okinawa*/
168	-632	438	-609	6378388.0	0.00672267002233	/*Tristan Astro 1968*/
169	51	391	-36	6378249.15	0.00680351128285	/*Viti Levu 1916*/
170	102	52	-38	6378270.0	0.00672267002233	/*Wake-Eniwetok*/
171	-265	120	-358	6378388.0	0.00672267002233	/*Zanderij*/
172	-384	664	-48	6377397.16	0.00667437223180	/*Bukit Rimpah*/
173	-104	-129	239	6378388.0	0.00672267002233	/*Camp Area Astro*/
174	-403	684	41	6377397.16	0.00667437223180	/*Gunung Segara*/
175	-333	-222	114	6378388.0	0.00672267002233	/*Herat North*/
176	-637	-549	-203	6378388.0	0.00672267002233	/*Hu-Tzu-Shan*/
177	-189	-242	-9	6378388.0	0.00672267002233	/*Tananarive Observ. 1925*/
178	-155	171	37	6378388.0	0.00672267002233	/*Yacare*/
179	-146.43	507.89	681.46	6377397.155	0.00667437223180	/*Tokyo GSI coords*/

A.18 Reference Documents

SS-GPS-300B
System Specification for the NAVSTAR Global Positioning System

ICD-GPS-200
NAVSTAR GPS Space Segment/Navigation User Interfaces

25334-10
Trimble Navigation Smart Antenna Developers Guide, Rev. B, June 1996

17035
Trimble Advanced Navigation Sensor Specification and User's Manual Rev. A October 1990

RTCM (SC-104)
RTCM Recommended Standards For Differential NAVSTAR GPS Service Version 2.0. RTCM Special Committee No. 104. Published by the Radio Technical Commission For Maritime Services Washington D.C. January 1 1990.

GPS - A Guide to the Next Utility
Trimble 1990 - an introduction to the GPS system in non-mathematical terms .

Proceedings - Institute of Navigation Washington DC
A series of three abstracts published between 1980 & 1986 of papers from the Journal of the Institute of Navigation. Essential source material for any system designer.

B TSIP Utilities

Software integration involves the creation and addition of software that allows the host system to communicate with the Palisade. The magnitude of the software integration effort varies with the protocol selected. For information on the available TSIP and NMEA 0183 protocols, see Appendix A and Appendix C.

B.1 GPS Tool Kit

The GPS Tool Kit program disk includes several TSIP interface programs designed to aid developers in evaluating and integrating a Trimble GPS receiver. These programs run on a PC-DOS platform and are intended as a base upon which to build application-specific software. The source code in ANSI C is included for many of these programs. The GPS Tool Kit program disk includes the following programs:

- TSIPCHAT.EXE reads TSIP reports and prints them to the screen. It also allows the user to exercise TSIP commands by translating keystroke codes into TSIP commands, which are output over the serial port. When data input is required, TSIPCHAT prompts the user for the information. It can also log TSIP reports in binary or ASCII formats, and can set time on a PC based on time information from the GPS module. Source code is provided.
- TSIPPRNT.EXE interprets a binary TSIP data stream, such as that logged by TSIPCHAT, and prints it to a file. Source code is provided.
- RTCM_MON.EXE monitors a serial port carrying RTCM differential corrections, translates the messages and prints them to the screen.
- TSIPLITE.EXE is a simplified version of TSIPCHAT. It provides a good working basis for GPS development. Source code is provided. The program is compatible with Microsoft Visual C and Borland C.

This section provides explicit instructions for each of the programs contained in the GPS Tool Kit, and guidelines for using the source code as a template for integrated systems applications.

B.1.1 TSIPCHAT

To monitor the TSIP output and communicate with the smart antenna using TSIPCHAT:

1. Power on the DC power supply.
2. Turn on your PC.
3. Insert the GPS Tool Kit disk in the disk drive.
4. Go to the directory where you want to establish the GPS tool kit subdirectory. In most cases, this will be the root directory on the C: drive.

Note – For detailed installation guidelines, view README.TXT.

5. At the DOS prompt, type **`A:\INSTALL`** to create a subdirectory called TOOLKIT and to install the tool kit files.
6. Type the appropriate path name to execute the TSIPCHAT program (for example, **`C:\TOOLKIT\TSIPCHAT`**). TSIPCHAT provides full access to the TSIP protocol. It converts binary TSIP packets into printable ASCII characters and vice versa. When TSIPCHAT is initiated, it configures the SPDRIVE serial port to the default TSIP settings (9600 baud, 8-Odd-1).
7. After the TSIPCHAT title screen appears, type **?**.

The primary TSIPCHAT screen shown in Figure B-1 is displayed.

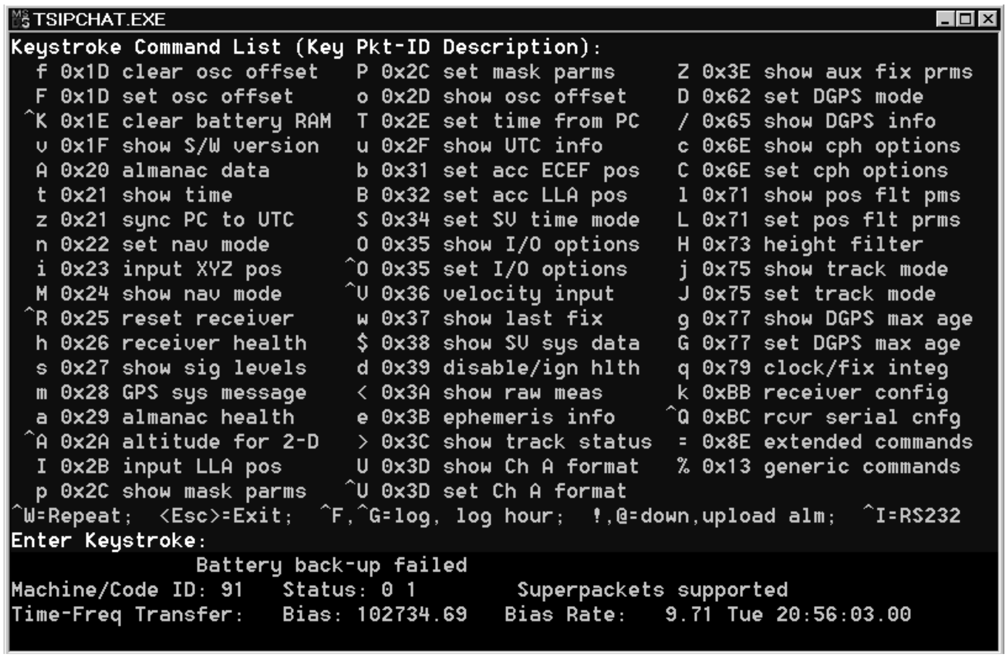


Figure B-1 TSIPCHAT Screen

Note – The TSIPCHAT screen shown above supports the full TSIP protocol. All packets may not be supported by Palisade. For more information, see Appendix A, Trimble Standard Interface Protocol.

The upper (shaded) portion of the screen is the command window and the lower portion of the screen is the automatic report window (auto window). The auto window displays a running account of the messages that are automatically output by the smart antenna in the lower half of the screen. The common automatic reports are the position and velocity reports. Other automatic reports include the almanac, ephemeris status and almanac health reports.

When the smart antenna has achieved a position fix and starts transmitting position reports, the position reports begin scrolling in the auto window. An automatic receiver health report is sent every 30 seconds, even when no satellites are being tracked.

If the auto window is not displaying messages, then the smart antenna may not be connected properly to your computer.

- To test the connection, type **v**.

  This message requests the firmware version numbers from the smart antenna. If connected and operating properly, the smart antenna responds with a software version report within one second. This report is displayed in the command window.

  If `waiting for reply` appears continuously in the command window, then the smart antenna is not communicating with your computer. If this occurs, re-check the interface cable connections and verify the serial port selection. If the communication failure still occurs after checking all connections and settings, then call the Trimble Technical Assistance Center (TAC) for assistance.

For more information about the TSIP protocol, see Appendix A, Trimble Standard Interface Protocol.

TSIPCHAT provides full visibility into the TSIP interface. Source code is provided. The source code (dual windows) requires a BORLAND C compiler.

Starting TSIPCHAT

1. To start the program, type **TSIPCHAT**.

   As TSIPCHAT starts, it displays a list of commands in the upper half of the console screen (command window) and a running account of automatic (unrequested) reports in the bottom half of the screen (auto window). It also sets the serial port to the default settings of 9600 baud, 8-Odd-1.

   If the receiver is alive and outputting positions, position reports scroll immediately in the auto window.

2. If the auto window is empty, type **v** to test if the receiver is connected properly to the computer.

   If the serial port is properly connected, the receiver responds within a second with the receiver software version numbers; otherwise `waiting for reply` remains on the screen. An auto-report of receiver health is sent every 30 seconds, even if satellites are not being tracked.

Report Packets

When a TSIP report packet is issued by the receiver, it is received by TSIPCHAT, translated into a printable form and put on the screen. If the report packet has been specifically requested by a command, it is put in the command (upper) window; otherwise, it is reported in the auto (lower) window.

The common automatic reports are the navigation reports: position, velocity, and health data. The **^O** command can change the content of these auto-reports or turn them on and off. Other automatic reports include almanac, ephemeris status, and almanac health page when decoded; and receiver health, machine code status, and satellite selection at regular intervals.

Command Packets

TSIPCHAT uses keystroke codes to send TSIP command packets to the receiver. For instance, type **v** to send the TSIP command packet 0x1F, requesting a TSIP report packet 0x45 listing the software versions. For a complete list of keystrokes and their associated TSIP commands, type **?**.

Many TSIP command packets require user-provided data or parameters. For instance, a request for a satellite almanac report packet requires the satellite identifier (SV PRN). In such cases, TSIPCHAT prompts the user for inputs. For any of the following three types of prompts, typing **^z** or pressing Esc aborts the whole command:

- prompt for number

  To enter a numerical value, type the value and press Enter. If no value is typed, the value entered will be 0.

- prompt for selection

  To select from a number of choices, cycle through the choices with the space bar and select with Enter. An index 0 - 9 associated with the choice is shown in parentheses; this index can be typed in for direct access of the choice.

- prompt for confirmation

  To confirm when asked, type **y** or **Y**. Any other keystroke will be 'negative', including Enter.

Serial Port Control

To control the serial port settings on the data channel (Channel A of the Palisade), use the **^U** command. Channel A is the serial port used for RTCM differential GPS correction input. A single port receiver may only have Channel A; when that is reset, control of the receiver can be lost. In such cases the receiver must be hard-reset.

To control the serial port settings on the computer, use the keystroke **^I**. This keystroke does not generate a TSIP packet. It prompts for the parameters for the buffered serial port. On start-up, the program automatically sets the port parameters to **9600 baud, 8-odd-1**. If the port parameters are changed from the default during the execution of TSIPCHAT, upon exit the program asks if the serial port is to be reset to the default.

File Storage

TSIPCHAT provides two options for file storage, a native binary TSIP stream and a translated ASCII stream mimicking the TAIP (Trimble ASCII Interface Protocol) Long Navigation (LN) message.

The native binary stream records the data coming off the serial port into a file. To turn data collection on and off, use the keystroke **^F**. The user has the option to append to a previously existing file. All report packet bytes are recorded into the file, whether translatable into packets or not. The exception is that using [Esc] to terminate the program exits gracefully; that is, not recording the partially received packet at the end of the file. Using **+** does not terminate gracefully and records all bytes at the end. The recorded binary data stream is translated into an ASCII file with the program TSIPPRNT.

The translated ASCII stream provides a simple data collection capability. To turn data collection on and off, use the keystroke **^L**. The user has the option to append to a previously existing file. Each sentence contains time, position (latitude, longitude in degrees, altitude in feet), velocity (horizontal speed in m.p.h., heading, vertical speed), satellites used in the position fix, and a source indicator (2D/3D, differential/stand-alone). The LN record format is documented in the TAIP manual. When the user opens the file, he has the option of declaring a field separator (TAIP records normally do not have field separators within the sentence.). If no separator is declared, the file is pure TAIP sentences, and the file can be read by the GPSSK.EXE program in the TAIP "tool kit."

Note – GPSSK is the software tool kit for TAIP.

For compatibility, use the extension .LTF for the collected file. If a separator is declared, the sentences have no TAIP framing, the decimal points are provided, and headers appear at the top of the columns. To support Excel for the graphic output, Tab can be declared as the separator by typing in **0** or some other digit.

To support output of TAIP LN messages, the receiver is set into a specific TAIP output mode: command packet 0x35, parameters 0x1E 02 00 00, with latitude-longitude double-precision outputs, WGS-84 altitude, and ENU velocity outputs. Data collection may be delayed a few seconds as the sentence accumulator (*taip_output()* in TSIP_IFC.C) waits for constellation information. If the output mode is changed by command packet 0x35 during the file collection to not include double-precision lat-lon-alt position and ENU velocity, the sentence accumulator will stop outputting sentences until it is changed back.

Quick-Start Almanac Get and Load

A stored almanac can allow the receiver to be "warm-started," reducing time to first fix. If the receiver is started 'cold', with no almanac data in memory, it performs a search for satellites in the sky, which can take a few minutes. If the receiver has a recent almanac of satellite orbits, fixes begin within a minute. The receiver responds most quickly if loaded with time, frequency offset, last position, and a recent almanac. There is a command sequence for getting an almanac from the receiver and storing in a file named GPSALM.DAT, and a reverse command sequence for reading a file named GPSALM.DAT on the computer and loading it into the receiver. These command sequences use the command packet 0x38 and the report packet 0x58.

The keystroke for the get-and-store sequence is `!`, and for the read-and-load sequence is `@`. It is useful to record a fresh almanac every few days. A new almanac is available after the receiver has been operating continuously for about fifteen minutes. Check the health message to see that `Almanac not complete and current` is no longer reported.

Setting PC Time from the Receiver

TSIPCHAT includes the capability to set the PC clock to UTC time from the GPS satellite signal. (GPS time differs from UTC time by leap seconds.) The keystroke **`z`** requests a time set (command packet 0x21, report packet 0x41). A special sequence is required the first time the request is made during execution of the program. The user is prompted for the local time zone offset and then requested to type **`z`** again, at which time the time set operation is completed. The user time zone offset is '0' for UTC/GMT; 5 for EST, 4 for EDT; 8 for PST, 7 for PDT; and negative numbers if ahead of (east of) GMT. Allowable range is 13 hours, plus or minus. The accuracy of this software method is approximately ±0.5 seconds.

Exiting TSIPCHAT

To exit the program, press Esc.

Source Code

Source code is provided with TSIPCHAT and TSIPPRNT and TSIPLITE. This source code is designed to provide a template for the user interface with the TSIP receiver. In particular, TSIP_IFC.C contains routines that define the interface with the TSIP receiver. These should be re-used in the system integrator's code.

TSIPCHAT is created by compiling under a Borland compiler with the macros PORT_INPUT, and BORLAND defined and with the include file TSIPINCL.H. The following routines must be compiled:

TSIPCHAT.C (main)

TSIP_UTIL.C

TSIP_CMD.C

TSIP_RPT.C

TSIP_ALM.C

TSIP_IFC.C

TSIP_SIO.C

Serial.C

TSIPCHAT Software Levels

TSIPCHAT is divided into five levels of software. The following pages show these levels in simplified form as they are used to issue a command packet 0x23 (set initial position) and receive a report packet 0x42 (position report). General routines contained in TSIP_IFC.C are identified by boldface type.

Level 1 Routine

```
typedef struct {
   unsigned char code;      /* TSIP id code */
   unsigned char buf[512]; /* report or command string */
   short int cnt;           /* size of buf */
} TSIPPKT;

main ()
{
   unsigned char kbch;
   for (;;)
   {
      kbch = read_rpts_wait_for_kbhit ();
      if (kbch == 0x1B /* ESCAPE */) break;
      do_command (kbch);
   }
}
```

Level 2 Routines

```
byte read_rpts_wait_for_kbhit (void)
{
   static TSIPPKT
      rpt;            /* structure for TSIP report  */
   int
      kbch_waiting = FALSE;
   byte
      kbch;

   /* continue looping until report packet is completely
   received and keystroke is detected */
   while (!kbch_waiting || rpt.cnt != 0) {

   /* if a keystroke is detected, save it until report
   packet is complete then exit */
   if (kbhit()) {
      kbch = getch();
      kbch_waiting = TRUE;

   }

   /* read serial port input, byte by byte */
   accumulate_rptbuf (&rpt);

   /* if end of packet received, process packet */
   if (end_of_rptbuf (&rpt)) {

      /* remove DLE stuffing, head and tail bytes *
      unstuff_rptbuf (&rpt);

      /* translate packet, print to screen */
      rpt_packet (&rpt);

      /* after packet is translated, zero rpt structure
to prepare for reading new packet */
      reset_rptbuf (&rpt);
   }

   return kbch;
}
```

```
void do_command (byte kbch)
{
   static TSIPPKT
      cmd;      /* structure for TSIP command */
   /* interpret keystroke as a command */
   interpret_keystroke (kch, &cmd.code);
   /* assemble command string */
   proc_kbd (kch, &cmd);
   /* send command string */
   send_cmd (&cmd);
}
```

Level 3 Routines

```
int interpret_keystroke (unsigned char kbch, unsigned
char *cmdcode)
{
    ...;
    {" i",  'i', 0x23, "input XYZ pos    "};
    ...;
}


void proc_kbd (unsigned char kbch, TSIPPKT *cmd)
{
    switch (cmd‘code) {
    case 0x1D:
        ...;
    case 0x23:
        set_initial_ECEF_position (cmd);
    case 0x24:
        ...;
    }
}


void rpt_packet (TSIPPKT *rpt)
{
    switch (rpt‘code) {
    case 0x3D:
        ...;
    case 0x42:
        rpt_float_ECEF_position (rpt);
    case 0x44:
        ...
    }
}
```

Level 4 Routines

```
/* 0x23 */
void set_initial_ECEF_position  (TSIPPKT *cmd)
{
   float pos_ECEF[3];
   pos_ECEF[0] = ask_dbl ("Enter ECEF x: ");
   pos_ECEF[1] = ask_dbl ("Enter ECEF y: ");
     pos_ECEF[2] = ask_dbl ("Enter ECEF z: ");
   cmd_0x23 (cmd, pos_ECEF);
   return;
}


/* 0x42 */
void rpt_float_ECEF_position (TSIPPKT *rpt)
{
   float ECEF_pos[3], time_of_fix;
   /* unload rptbuf */
   rpt_0x42 (rpt, ECEF_pos, &time_of_fix);
   xprintf
      ("Position: %f   %f   %f   %f",
          ECEF_pos[0],  ECEF_pos[1],  ECEF_pos[2],
time_of_fix);
}
```

Level 5 Routines

```
void cmd_0x23 (TSIPPKT *cmd, float pos_ECEF[3])
/* initial position in ECEF coordinates */
{
   bputfloat (pos_ECEF[0], &cmd‘buf[0]);
   bputfloat (pos_ECEF[1], &cmd‘buf[4]);
   bputfloat (pos_ECEF[2], &cmd‘buf[8]);
   cmd‘cnt = 12;
   cmd‘code = 0x23;
}
```

```
int rpt_0x42 (TSIPPKT *rpt, float pos_ECEF[3], float
*time_of_fix)
/* position in ECEF, single precision */
{
   unsigned char *buf;
   buf = rpt‘buf;
   if (rpt‘cnt != 16) return FALSE;
   pos_ECEF[0] = bgetfloat (buf);
   pos_ECEF[1]= bgetfloat (&buf[4]);
   pos_ECEF[2]= bgetfloat (&buf[8]);
   *time_of_fix = bgetfloat (&buf[12]);
   return TRUE;
}
```

B.1.2 TSIPPRNT

TSIPPRNT translates TSIP report packet byte streams into readable reports. It uses the same report interface routines as TSIPCHAT, but uses 'printf' rather than 'cprintf' so that output can be redirected to a file.

The command line for console output is:

```
TSIPPRNT tsip_filename
```

where tsip_filename is the name of a stream of TSIP report packets collected directly from the receiver output port or from TSIPCHAT. The command line for re-directing output to a file is:

```
TSIPPRNT tsip_filename > ascii_filename
```

Full source code is provided. TSIPPRNT is created by compiling under any C compiler with the macro FILE_INPUT defined (BORLAND and PORT_INPUT *not* defined) and with the include file TSIPINCL.H. The following routines must be compiled:

TSIPPRNT.C (main)

TSIP_RPT.C

TSIP_IFC.C

TSIPPRNT code can be easily modified by the user to supply any ASCII output file format that is required by adjusting the report interpreter routines in TSIP_RPT.C, provided the necessary information is contained in the binary input file. Software flow follows that of TSIPCHAT, except with no user-interactive and command features.

B.1.3 RTCM_MON

RTCM_MON translates RTCM SC-104 Version 2.0 (Differential GPS correction) byte streams off a serial port. It is designed to be configured to the same port parameters as the TSIP receiver. RTCM streams can best be tested by using the TSIP receiver itself as a decoder, using TSIPCHAT and the **/** command (packet 0x65), which returns packet 0x85 listing all differential RTCM messages decoded. RTCM_MON is provided in case the user prefers to use a direct connection to a computer serial port to decode an RTCM stream.

The RTCM_MON command line has no arguments. When listening to the serial port, characters will be printed on the screen. RTCM 6-of-8 bytes are identified by the first two bits and all other bytes are reported as non-RTCM bytes. Once the program locks onto the RTCM preamble and framing, it begins to report differential correction messages for each of the satellites.

To exit the program, press Esc.

Bit-Slipping

Even though the RTCM bytes are 6 bits of data and fit neatly into a 8-bit byte once the lead bits '01' are attached, some reference receivers do not align the RTCM data onto 8-bit boundaries for the serial link ("bit-slipping"). RTCM_MON automatically searches for bit-slipping.

Serial Port Parameters

The default at start-up is 9600 baud, 8-odd-1. The serial port parameters on the computer can be adjusted by typing **^I**. The program will prompt for new serial port parameters.

B.1.4 TSIPLITE

TSIPLITE is a simplified version of TSIPCHAT that provides a good basis for GPS software development.

The command line syntax is:

```
TSIPLITE -c[port number] <optional file name>
```

where <optional file name> is the file where bytes received directly from the receiver will be collected.

Full source code is provided. Unlike TSIPCHAT, TSIPLITE can be compiled under both Microsoft and Borland Compilers. It uses the same source code modules as TSIPCHAT. TSIPLITE is composed of the following modules:

TSIPLITE.C (main)

TSIP_RPT.C

TSIP_IFC.C

SERIAL.C

Software flow follows the same as TSIPCHAT, except that the display and user interface has been greatly simplified. It is recommended that software developers become familiar with TSIPLITE before studying the source code to TSIPCHAT.

B.2 Palisade Monitor

The Palisade Monitor program disk is included in the Palisade NTP Synchronization Kit.

B.2.1 Start-up

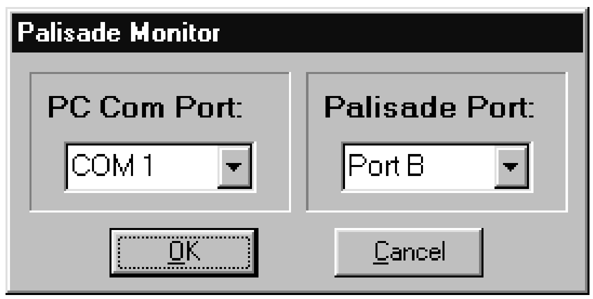


Figure B-2 Start-up Screen

This screen appears at the start of the program. It allows you to choose which Palisade port you want to use and which PC com port the selected Palisade port is connected to. Palisade Monitor is capable of talking to both Palisade ports at the same time, but you must choose one port to start with.

On start-up, the Palisade Monitor determines which com ports are available to the PC and only displays those in the PC com port list. There are two ways to choose a port that is not shown:

- Start the program using the parameter **`-c*`**, with **`*`** being the com port you want to select.

  This will add the selected port to the com port list.

- Type **`COM*`**, with **`*`** being the com port you want to select, into the PC com port box. Click **OK**.

B.2.2 Port B

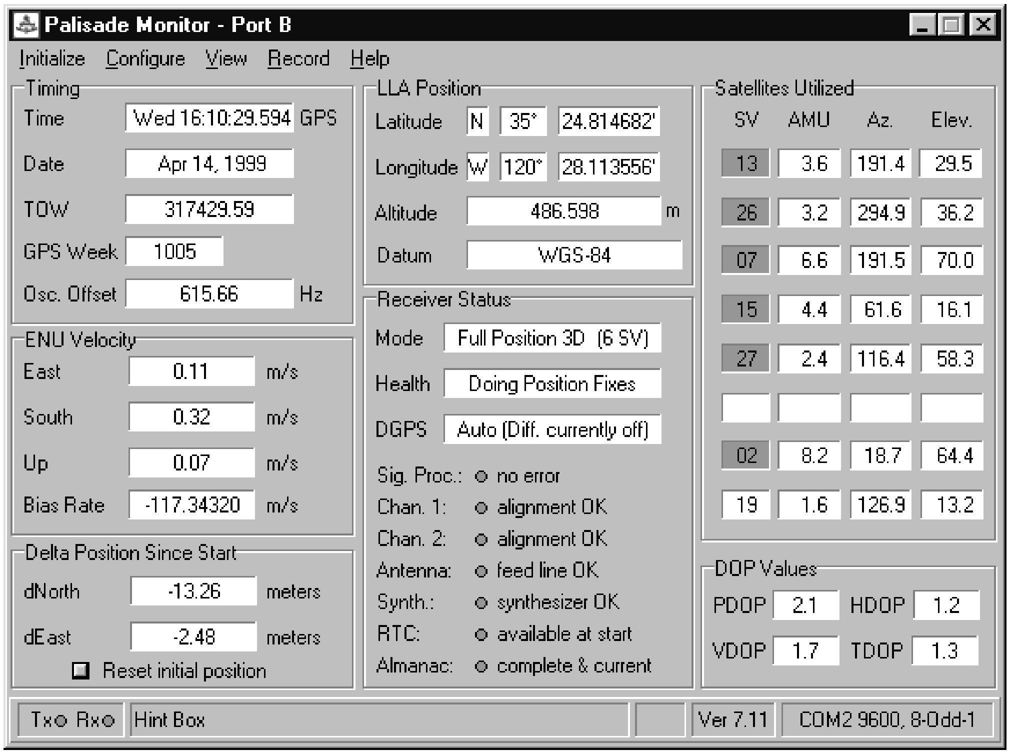


Figure B-3 Port B - Main Screen

This is the main screen for Palisade Port B. It displays time, position, velocity, SV selection and data, and receiver health. The status bar displays Tx and Rx activity, program hints, recording status, firmware version, and com settings. The menu provides other options that let you send data to the receiver or request additional data from the receiver.

Initialize Menu

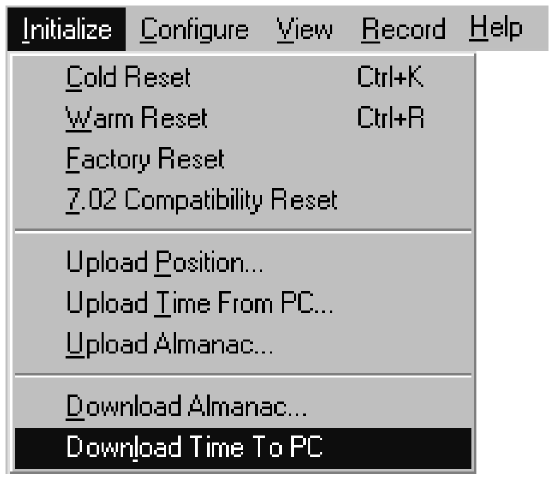


Figure B-4 Initialize Menu

The Initialize menu has three basic functions. You can:

- send four different reset commands to the receiver.
- initialize the receiver with almanac, position, and time data.
- download time or an almanac to the PC.

Configure Menu

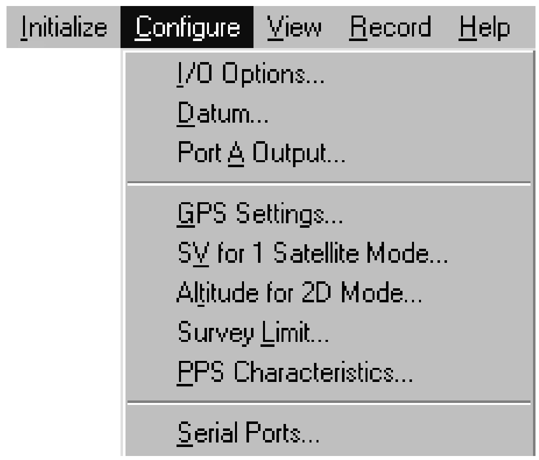


Figure B-5 Configure Menu

This menu lets you configure the operation of the receiver. See the TSIP appendix for a more detailed list of which aspects of the receiver are configurable.

View Menu

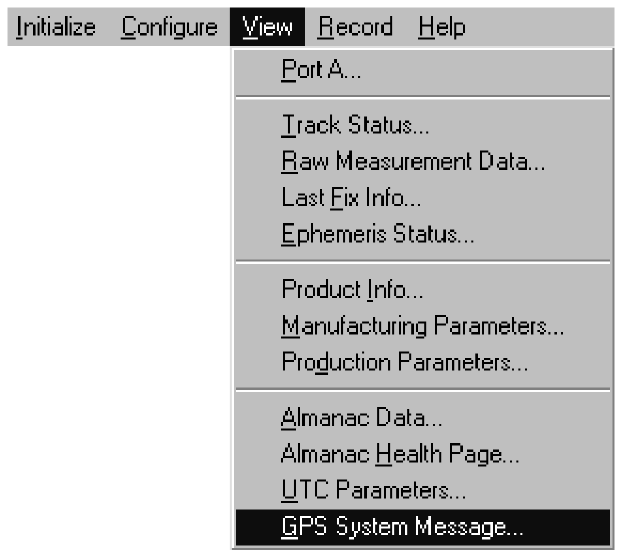


Figure B-6 View Menu

The View menu lets you initiate communications with Port A, as well as view other data not shown on the main screen.

Help

Figure B-7 Help Menu

The Help menu lets you view the *Palisade Monitor About* page.

B.2.3 Port A

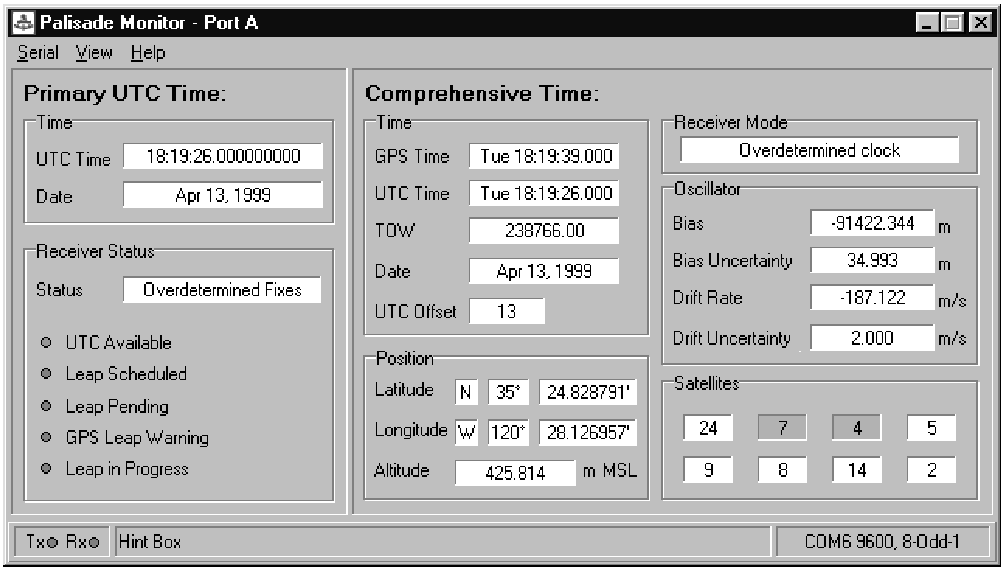


Figure B-8 Port A - Main Screen

This is the main screen for Palisade Port A. It displays the Primary UTC Time packet and the Comprehensive Time packet. The status bar displays Tx and Rx activity, program hints, and COM settings. In default mode the Palisade only outputs the Primary UTC Time packet, in which case the Comprehensive Time portion of the screen remains blank.

Note – You cannot configure or request information from the receiver using Port A. To make any changes to the Port A output, use receiver Port B and Palisade Monitor Port B.

Serial Menu

Figure B-9 Serial Menu

The Serial menu lets you change the serial port settings for the PC. To change the serial settings for the receiver, use Palisade Monitor Port B.

View Menu

Figure B-10 View Menu

The View menu lets you initiate communications with Port B, view the trigger screen, or view the diagnostics screen. The diagnostics screen contains four LEDs and an update button. The LEDs correspond to different packets sent by the receiver. The update button clears the LEDs and triggers an event. Upon receipt of the packets, the corresponding LEDs turn green.

Help Menu

Figure B-11 Help Menu

This menu is the same as the help menu for Port B.

Event Trigger

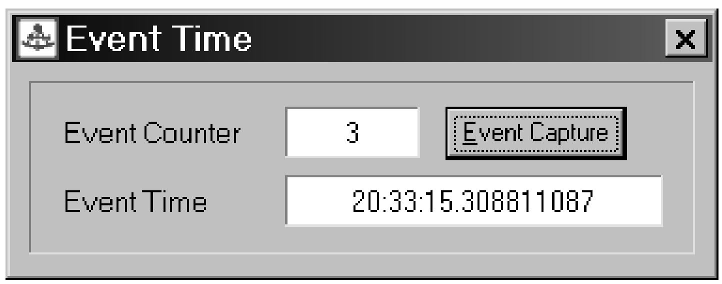


Figure B-12 Event Trigger

The event trigger sends an event to Palisade Port A. The receiver responds with the event time and number.

Note – The event trigger does not work when Palisade Monitor is run on a PC using Windows 95 version A.

C NMEA 0183

NMEA 0183 is an interface protocol created by the National Marine Electronics Association. The latest release of NMEA 0183 is Version 2.00. This protocol was originally established to allow marine navigation equipment to share information. NMEA 0183 is a simple, yet comprehensive ASCII protocol that defines both the communication interface and the data format. Since it is a well-established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics.

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

National Marine Electronics Association
Executive Director
PO Box 50040
Mobile, Alabama 36605

C.1 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 characteristics of the NMEA 0183 data transmissions.

Table C-1 NMEA 0183 Characteristics

Signal Characteristics	NMEA Standard
Baud Rate	4800
Data Bits	8 (d7=0)
Parity	None (Disabled)
Stop Bits	1

Note – Palisade uses a default Baud Rate of 9600 and odd parity.

C.2 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 sensor like the Palisade. 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 that describes the source of the navigation information. The GP identification signifies a GPS source.
MSG	The message identification is a three-letter mnemonic that 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. Checksums and checksum delimiters are optional for most NMEA 0183 messages.
CS	The checksum field is optional for most NMEA 0183 messages. It 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.

C.3 NMEA 0183 Message Option for the Palisade

The standard version of Palisade can output one message: ZDA. This message is configurable and is output at 1 Hz, synchronous with the PPS.

Table C-2 Palisade NMEA Messages

Standard	Message	Description
X	ZDA	Time and Date

The format for the ZDA message is described in more detail in the next section.

Note – In all NMEA position messages, latitude and longitude are formatted in degrees, minutes and decimal minutes.

C.4 Palisade NMEA 0183 Message Format

C.4.1 ZDA - Time & Date

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

```
ZDA,hhmmss.ss,xx,xx,xxxx,xx,xx
```

Field #	Description
1	UTC
2	Day (01 to 31)
3	Month (01 to 12)
4	Year
5	Local Zone Description Hours (±13 hours). Local zone description is the number of whole hours added to local time to obtain UTC. The zone description is always negative for eastern longitudes.
6	Local Zone Description Minutes. Local zone description minutes using the same sign convention as local zone hours.

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

D Specifications and Drawings

This appendix contains the Palisade NTP Interface Cable specification and diagram.

Note – The interface cable specifications provided in this appendix are for the 100-foot (30-meter) versions of the cables. Longer versions of these cables are available. The specifications for the longer cables are identical to that of the 100-foot version.

The specifications for the Palisade smart antenna and the Palisade NTP Synchronization Kit Interface Module are available on the Trimble web site.

D.1 Palisade NTP Interface Cable Specification

Smart Antenna Interface Cable:

12-Conductor Shielded Cable

D.2 Palisade NTP Interface Cable Diagram

See Figure D-1 on the following page.

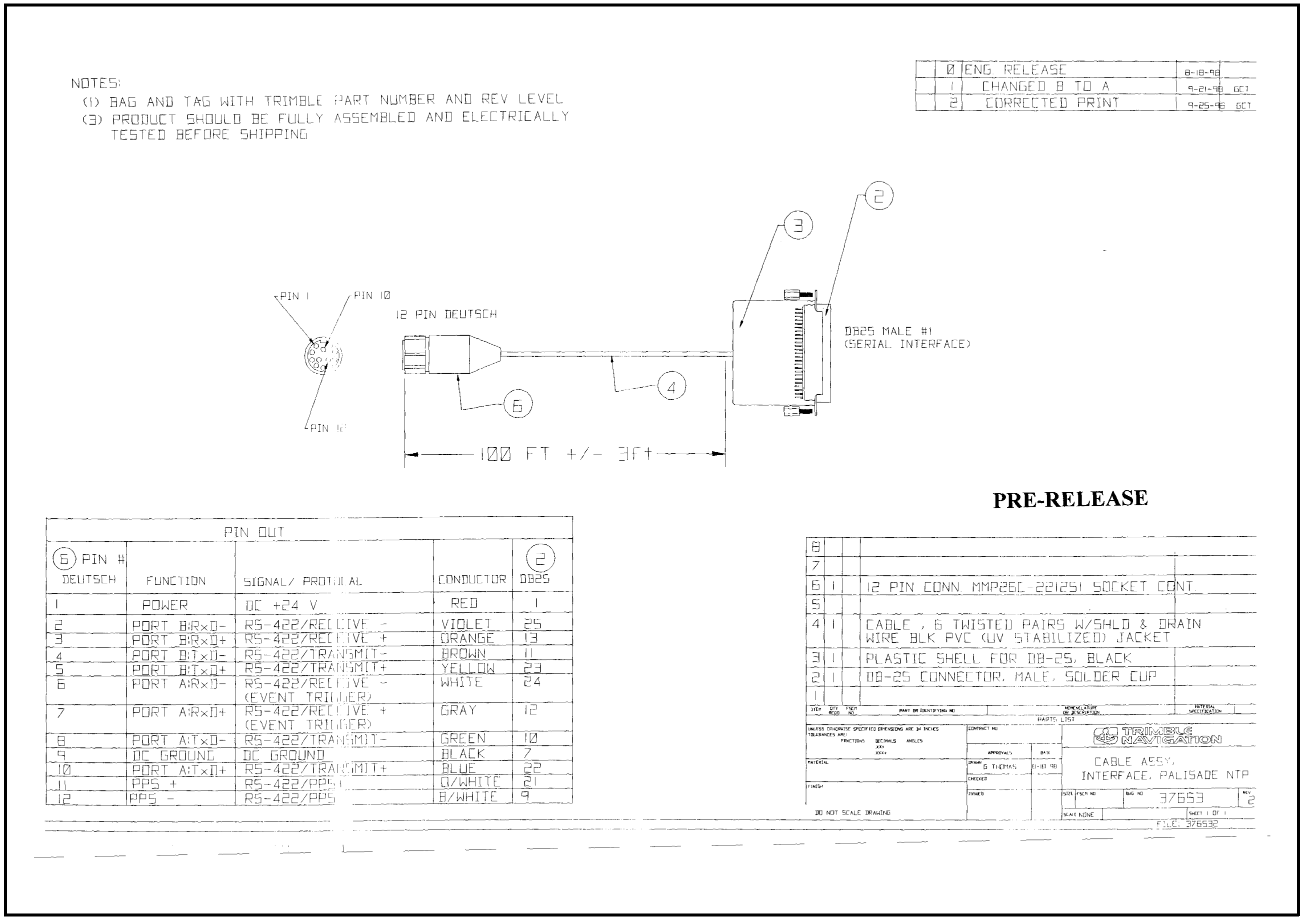


Figure D-1 Palisade NTP Interface Cable Diagram

E NTP Diagnostics and Debugging

E.1 Diagnostics and Debugging

This section presents common reports and failure conditions that may occur on Windows NT and UNIX systems, and provides suggestions for their possible sources.

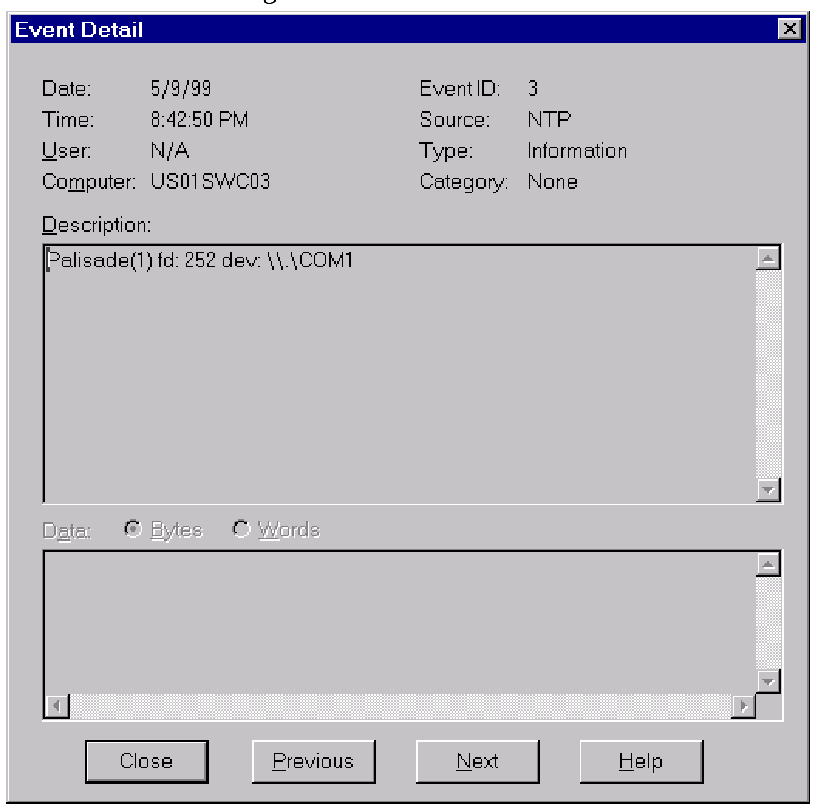
Note – Administrators should check the system's log files periodically. Failures usually do not occur unexpectedly, and can be averted in many cases.

E.1.1 System Log Entries

The system log entries are shown here in a Windows NT context. The text contained in the *Description* field of the *Event Detail* dialog is the same that would be found in the System Log of a UNIX system. Separate descriptions are provided where the log messages differ.

Serial Port Acces Report

The configuration of the Palisade NTP reference clock is acknowledged by a report of the COM port used by the driver. Verify that the correct port is being used by NTP. If this message does not appear, there has been a failure. Refresh the system log to observe additional error messages.



The UNIX version of the message reports the serial port device used in a message similar to:

```
May 3 17:42:28 terrapin ntpd[4032]:
Palisade(0) fd: 8 dev: /dev/palisade0
```

For more information on UNIX device names, see Set Up Device Links, page 6-21.

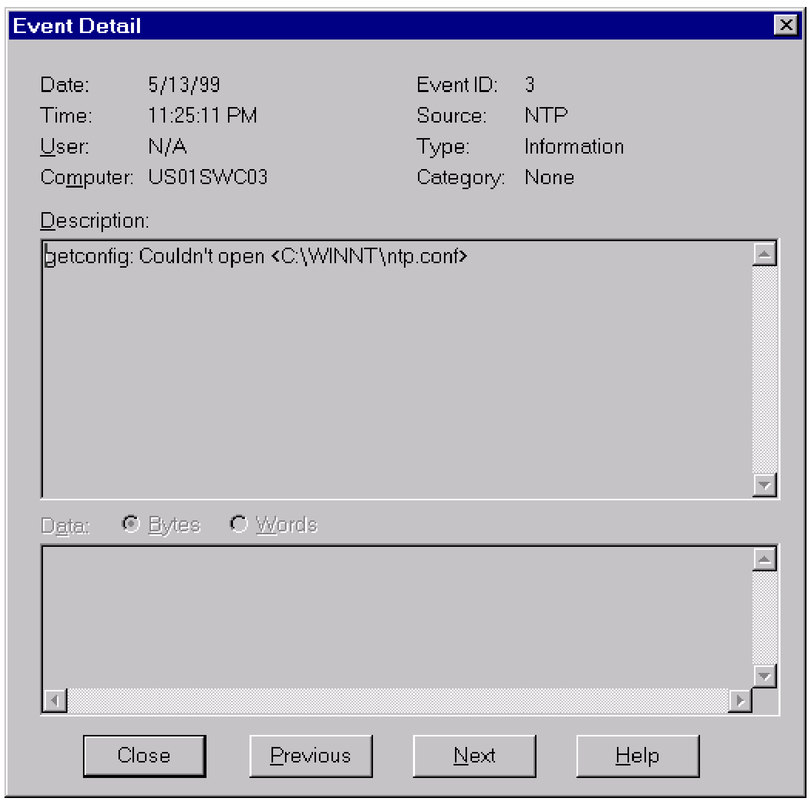
E.1.2 Error Log Entries

The following entries show NTP errors that degrade system operation. These failures should be corrected immediately.

Configuration File Not Found

If the Configuration File is not found, the following event log entry will be generated:

On a UNIX system, the message will report the file name </ETC/NTP.CONF>.



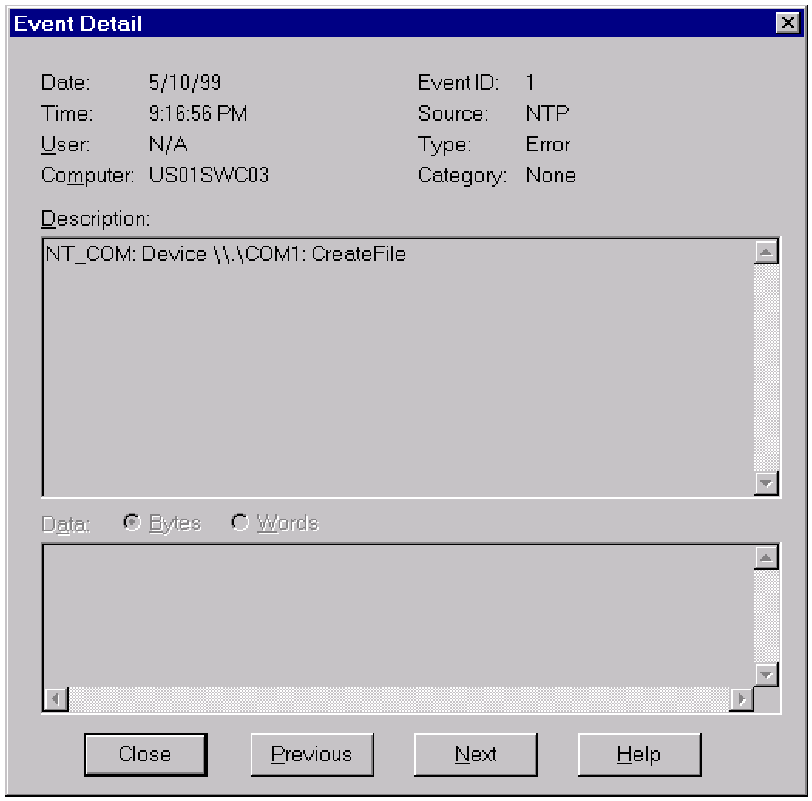
Note – If you are using Windows NT, please review Create the Configuration File, page 6-12 to ensure the configuration file is named correctly.

Warning – NTP does not stop because of this error. Provide a valid configuration file, and stop and re-start NTP.

For more information on correcting this error, see NTP Configuration File, page 6-8.

Palisade Configuration Failure

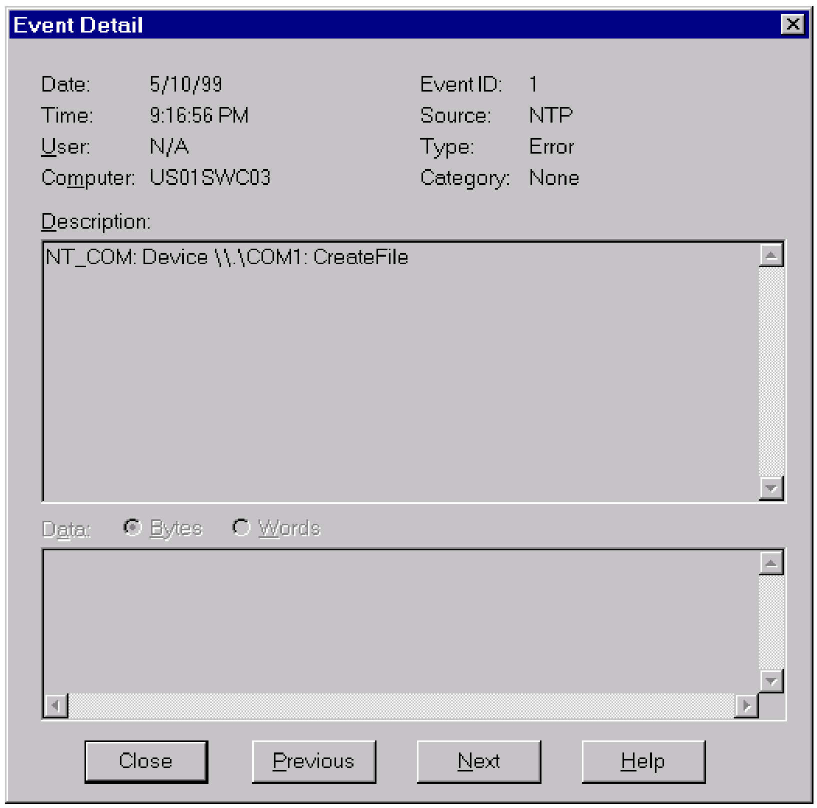
An Event Log message that indicates a problem configuring the Palisade NTP reference clock is shown below:



This message is accompanied by additional messages indicating the source of the failure.

COM Port Unavailable

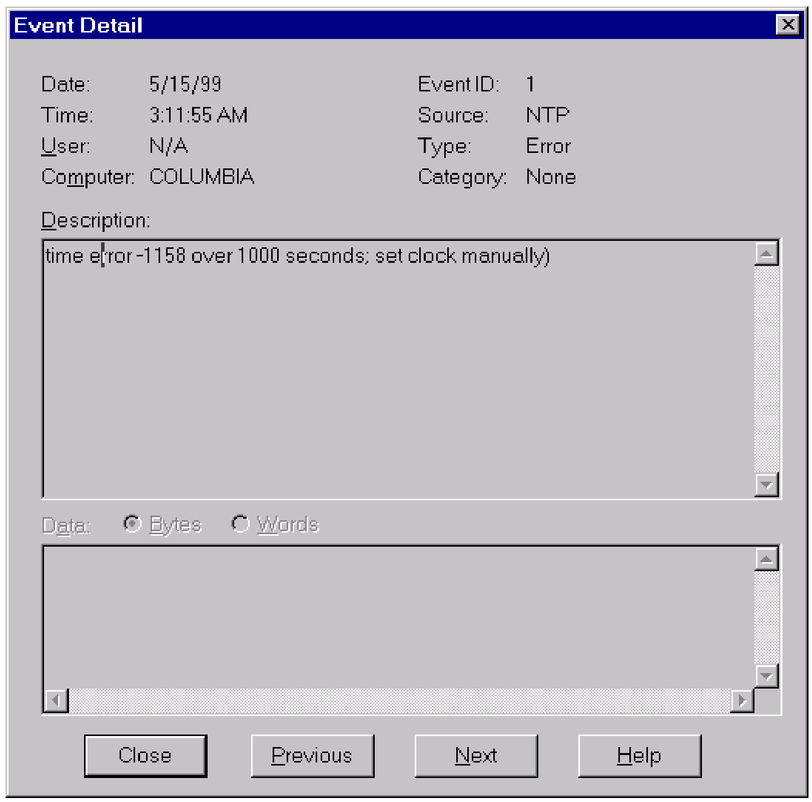
If the COM port defined in the NTP configuration file is not found, or is locked by another application, the following Application Event Message is generated:



This message is unique to Windows NT, but the solution is based on general guidelines. For more information on resolving device unavailablility, see page E-16.

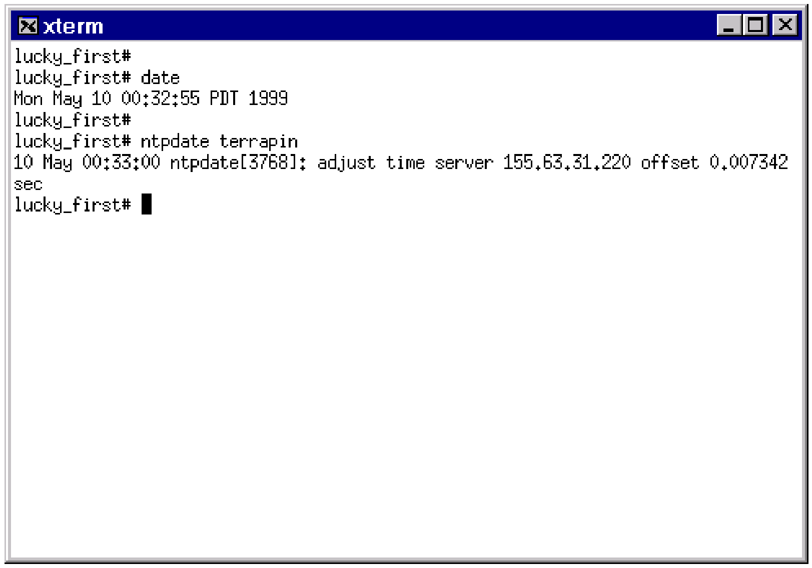
System Clock Not Set

The system clock must be set close to the correct local time. If NTP finds the system clock too far offset, it will stop and report the following error:



Solution:

The sample screen below demonstrates using NTPDATE to reset UNIX system time to another NTP server. The utility requires an additional **–b** parameter behind the server name when run on Windows NT. If you cannot use NTPDATE, use your system's native clock function to reset the system clock.



E.2 Running NTP in Debug Mode

NTP can be run in debug mode as a foreground command line application. In this mode, messages reporting system events are printed to the screen, which reveal more information about errors and problems encountered by the program.

In order to be able to quickly diagnose communication problems with the Palisade, it is helpful to have a debug version of NTP available. The debug version allows starting NTP from the command line, and observing text debug messages reporting events and failures.

If the normal operating exectable is not debug enabled, you may need to consult your system documentation or obtain a debug-enabled executable for your system using the software sources listed on page 6-3. This file should be stored in a dignostic tools folder on the system.

NTP is run in debug mode by a command such as: NTPD –D

E.2.1 Debug Mode Not Available

If NTP is not compiled in debug mode, it will report:

```
ntpd not compiled with -DDEBUG option - no
DEBUG supportusage: ...
```

E.2.2 NTP Startup and Palisade Poll

The startup of NTP debug output from start to the Palisade NTP reference clock's first poll response is shown below:

xterm

```
lucky_first# ntpd -d
create_sockets(123)
bind() fd 5, family 2, port 123, addr 0.0.0.0, flags=1
bind() fd 6, family 2, port 123, addr 127.0.0.1, flags=0
bind() fd 7, family 2, port 123, addr 155.63.33.57, flags=1
init_io: maxactivefd 7
refclock_open: fd 9 modem status 6
refclock_ioctl: fd 9 flags 20
peer_config: 127.127.29.0 mode 3 vers 4 min 5 max 10 flags 0x00a1 ttl 0 key 0
resolving terrapin.trimble.com
resolving iq.trimble.com
loop_config: state 2 freq -40.642
report_event: system event 'event_restart' (0x01) status 'sync_alarm, sync_unspe
c, 1 event, event_unspec' (0xc010)
auth_agekeys: at 1 keys 1 expired 0
key_expire_all: at 1 private f9bcd099
peer_config: 155.63.31.220 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
peer_config: 155.63.32.173 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
refclock_transmit: at 18 127.127.29.0
palisade_poll: unit 0: polling event
palisade_receive: unit 0: 1999 131 06:25:36.981446
palisade_receive: unit 0: bae24be0.fc549b62  Mon, May 10 1999 23:25:36.985
refclock_receive: at 18 127.127.29.0
peer GPS_PALISADE(0) event 'event_reach' (0x84) status 'unreach, conf, 1 event,
event_reach' (0x8014)
refclock_sample: offset -0.004220 disp 0.000000 std 0.000000
clock_filter: offset -0.004220 delay 0.000000 disp 7.937502 std 0.003947, age 0
transmit: at 19 to 155.63.31.220 mode 3
transmit: at 19 to 155.63.32.173 mode 3
receive: at 19 from 155.63.31.220 mode 4
pkt_mode 4 action 1
peer 155.63.31.220 event 'event_reach' (0x84) status 'unreach, conf, 1 event, ev
ent_reach' (0x8014)
clock_filter: offset -0.006652 delay 0.002852 disp 7.937510 std 0.006222, age 0
receive: at 19 from 155.63.32.173 mode 4
pkt_mode 4 action 1
peer 155.63.32.173 event 'event_reach' (0x84) status 'unreach, conf, 1 event, ev
ent_reach' (0x8014)
clock_filter: offset -0.005882 delay 0.002414 disp 7.937506 std 0.005502, age 0
```

The Palisade NTP reference clock driver reports requests and receipt of the time stamp data. Typical Palisade NTP time transfer debug output appears as four lines in the debug output, as shown here.

```
palisade_poll: unit 0: polling event
palisade_receive: unit 0: 1999 131 06:25:36.981446
palisade_receive: unit 0: bae24be0.fc549b62  Mon, May 10
1999 23:25:36.985
refclock_receive: at 18 127.127.29.0
```

The Palisade driver reports the GPS time stamp in the first `palisade_receive` line. The second line reports the local NTP and system time associated with the time transfer event. The third line discloses the source identifier prefix and unit number of the time source.

Note – The `palisade_poll` message may not be immediately succeeded by a `palisade_receive` event.

E.2.3 Palisade is not Responding

If the Palisade smart antenna is not responding to polls, the following output is generated in the debug stream:

```
xterm
lucky_first# ntpd -d
create_sockets(123)
bind() fd 5, family 2, port 123, addr 0.0.0.0, flags=1
bind() fd 6, family 2, port 123, addr 127.0.0.1, flags=0
bind() fd 7, family 2, port 123, addr 155.63.33.57, flags=1
init_io: maxactivefd 7
refclock_open: fd 9 modem status 6
refclock_ioctl: fd 9 flags 20
peer_config: 127.127.29.1 mode 3 vers 4 min 5 max 10 flags 0x0021 ttl 0 key 0
resolving terrapin.trimble.com
resolving iq.trimble.com
loop_config: state 2 freq -40.642
report_event: system event 'event_restart' (0x01) status 'sync_alarm, sync_unspe
c, 1 event, event_unspec' (0xc010)
auth_agekeys: at 1 keys 1 expired 0
key_expire_all: at 1 private 3b9d1599
peer_config: 155.63.31.220 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
peer_config: 155.63.32.173 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
receive: at 9 from 155.63.31.220 mode 3
pkt_mode 3 action 0
pkt_mode 3 action 2
transmit: at 9 to 155.63.31.220 mode 4
refclock_transmit: at 18 127.127.29.1
palisade_poll: unit 1: polling event
transmit: at 19 to 155.63.31.220 mode 3
transmit: at 19 to 155.63.32.173 mode 3
receive: at 19 from 155.63.31.220 mode 4
pkt_mode 4 action 1
peer 155.63.31.220 event 'event_reach' (0x84) status 'unreach, conf, 1 event, ev
ent_reach' (0x8014)
clock_filter: offset -0.004226 delay 0.002572 disp 7.937510 std 0.003953, age 0
receive: at 19 from 155.63.32.173 mode 4
pkt_mode 4 action 1
peer 155.63.32.173 event 'event_reach' (0x84) status 'unreach, conf, 1 event, ev
ent_reach' (0x8014)
clock_filter: offset -0.003626 delay 0.002129 disp 7.937506 std 0.003391, age 0
refclock_transmit: at 50 127.127.29.1
clock GPS_PALISADE(1) event 'clk_noreply' (0x01)
palisade_poll: unit 1: polling event
```

The last two lines of output on this screen show the Palisade NTP driver reporting failure to receive a time stamp from the GPS. These messages indicate that NTP is not receiving data from the reference clock.

Table E-1 shows troubleshooting options.

Table E-1 Troubleshooting: Palisade is Not Responding

Possible Problem	Solution
Cabling or connectors have become detached.	Connect and secure loose or disconnected cables and connectors.
System does not support event polling.	Configure fallback to synchronous polling mode. Update NTP software.
No activity of Power or PPS indicators on the Palisade Synchronization Interface Module.	Confirm availability of wall power. Use a monitoring utility on Port B to check GPS status.
GPS is not tracking satellites. (The Palisade NTP driver will not accept time stamps from the GPS receiver if it is not tracking satellites.)	Receiver may be jammed or obscured. Use a TSIP monitoring utility on Port B to check GPS health and status. Verify that adequate power is being supplied to the receiver.

If none of these options solve the problem, check your operating system error log for failure reports.

E.2.4 Running NTP with Event Polling Disabled

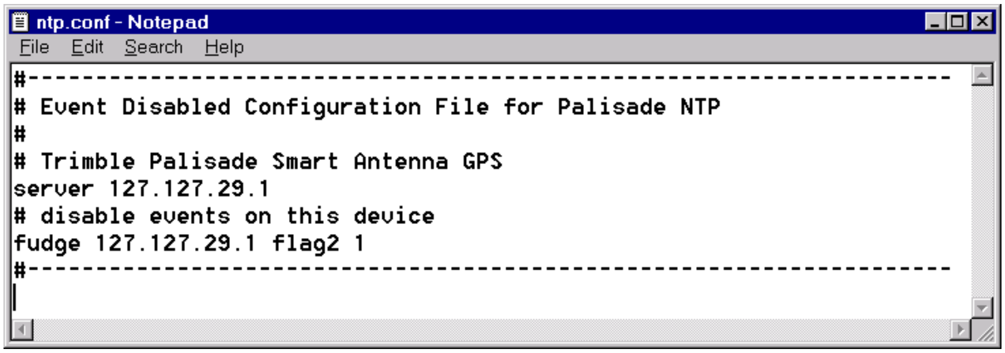
The Palisade NTP reference clock can be operated without event polling.

This mode can be used to confirm communication between the Palisade NTP Reference Clock and NTP, without relying on the event trigger connection. The event trigger feature may not be functional on all systems. If the Palisade NTP driver detects a problem using the event trigger, it reverts to **event disabled** mode.

Note – Running NTP without the Event Trigger degrades performance to the level of a conventional serial NTP reference clock.

To configure NTP to disable output you need to edit the configuration file and add the line:

`fudge 127.127.127.x flag2 1`



Then run NTP in debug mode (ntpd -d), to observe `palisade_receive` events.

Receive events generated without event polling should be reported as poll events of this format:

`palisade_poll: unit x: polling synchronous packet`

```
xterm
lucky_first# ntpd -d
create_sockets(123)
bind() fd 5, family 2, port 123, addr 0.0.0.0, flags=1
bind() fd 6, family 2, port 123, addr 127.0.0.1, flags=0
bind() fd 7, family 2, port 123, addr 155.63.33.57, flags=1
init_io: maxactivefd 7
refclock_open: fd 9 modem status 6
refclock_ioctl: fd 9 flags 20
peer_config: 127.127.29.0 mode 3 vers 4 min 5 max 10 flags 0x00a1 ttl 0 key 0
resolving terrapin.trimble.com
resolving iq.trimble.com
loop_config: state 2 freq -40.642
report_event: system event 'event_restart' (0x01) status 'sync_alarm, sync_unspe
c, 1 event, event_unspec' (0xc010)
auth_agekeys: at 1 keys 1 expired 0
key_expire_all: at 1 private 3ca12abf
peer_config: 155.63.31.220 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
peer_config: 155.63.32.173 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
refclock_transmit: at 16 127.127.29.0
palisade_poll: unit 0: polling synchronous packet
palisade_receive: unit 0: 1999 131 06:55:24.000000
palisade_receive: unit 0: bae252dc.06cb4289  Mon, May 10 1999 23:55:24.026
refclock_receive: at 16 127.127.29.0
peer GPS_PALISADE(0) event 'event_reach' (0x84) status 'unreach, conf, 1 event,
event_reach' (0x8014)
refclock_sample: offset -0.026539 disp 0.000000 std 0.000000
clock_filter: offset -0.026539 delay 0.000000 disp 7.937502 std 0.024825, age 0
transmit: at 17 to 155.63.31.220 mode 3
transmit: at 17 to 155.63.32.173 mode 3
receive: at 17 from 155.63.31.220 mode 4
pkt_mode 4 action 1
peer 155.63.31.220 event 'event_reach' (0x84) status 'unreach, conf, 1 event, ev
ent_reach' (0x8014)
clock_filter: offset -0.005294 delay 0.003325 disp 7.937510 std 0.004953, age 0
receive: at 17 from 155.63.32.173 mode 4
pkt_mode 4 action 1
peer 155.63.32.173 event 'event_reach' (0x84) status 'unreach, conf, 1 event, ev
ent_reach' (0x8014)
clock_filter: offset -0.005417 delay 0.004297 disp 7.937506 std 0.005067, age 0
```

The ***seconds*** value reported by the Palisade NTP reference clock is always an integer, since the synchronous packets are always transmitted at the beginning of the second.

After confirming functionality of NTP using synchronous packets, you can remove fudge flag2 from the configuration file and restart NTPD in debug mode to observe event polling receive events.

E.2.5 Incorrect Port and Bad Data

If the Palisade NTP driver detects invalid packet data on the serial line, it generates debug messages similar to the following. Run NTP in a higher level debug mode to observe this message: `ntpd -d -d`

```
clock GPS_PALISADE(1) event 'clk_badformat' (0x02)
TSIP_decode: unit 1: bad packet 6d-4d event 0 len 21
clock GPS_PALISADE(1) event 'clk_badformat' (0x02)
TSIP_decode: unit 1: bad packet 82-02 event 0 len 1
clock GPS_PALISADE(1) event 'clk_badformat' (0x02)
TSIP_decode: unit 1: bad packet 46-00 event 0 len 2
clock GPS_PALISADE(1) event 'clk_badformat' (0x02)
TSIP_decode: unit 1: bad packet 4b-5b event 0 len 3
clock GPS_PALISADE(1) event 'clk_badformat' (0x02)
TSIP_decode: unit 1: bad packet 54-48 event 0 len 12
```

Table E-2 shows troubleshooting options.

Table E-2 Troubleshooting: Incorrect Port and Bad Data

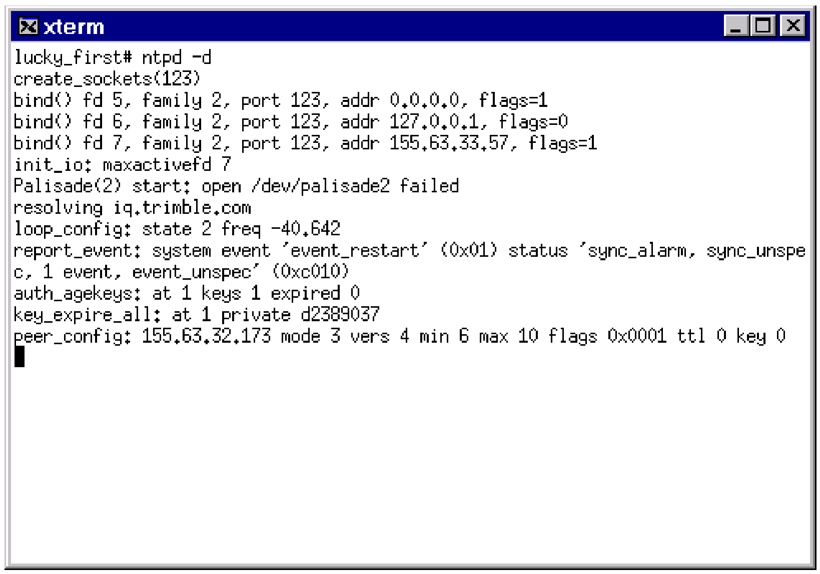
Possible Problem	Solution
The host is connected to the wrong Palisade port. NTP requires connection with Palisade Port A.	Connect Palisade Port A to the host serial port.
The Palisade Port A serial port configuration does not match the NTP configuration.	Verify Palisade Baud Rate, Parity, Start and Stop Bits and Protocol settings.

E.2.6 Serial Port is Unavailable

When NTP is unable to open a serial port, the following debug message is generated, along with an error report in the system log:

```
Palisade(2) start: open /dev/palisade2 failed
```

A failed serial port open attempt is shown below:



```
xterm
lucky_first# ntpd -d
create_sockets(123)
bind() fd 5, family 2, port 123, addr 0.0.0.0, flags=1
bind() fd 6, family 2, port 123, addr 127.0.0.1, flags=0
bind() fd 7, family 2, port 123, addr 155.63.33.57, flags=1
init_io: maxactivefd 7
Palisade(2) start: open /dev/palisade2 failed
resolving iq.trimble.com
loop_config: state 2 freq -40.642
report_event: system event 'event_restart' (0x01) status 'sync_alarm, sync_unspe
c, 1 event, event_unspec' (0xc010)
auth_agekeys: at 1 keys 1 expired 0
key_expire_all: at 1 private d2389037
peer_config: 155.63.32.173 mode 3 vers 4 min 6 max 10 flags 0x0001 ttl 0 key 0
```

On a Windows NT system, the device name would refer to a device such as COM1:

Possible Problems:

- The configured serial port is not actually present on the system.

  Solution: Edit the configuration file and select a valid serial port.

- The link to the actual UNIX device file is incorrect.

  Solution: Delete and re-link the UNIX serial device using the procedures outlined in Set Up Device Links, page 6-21.

- Other services or applications are attempting to use the same port as NTP.

  Solution: Reconfigure NTP or the conflicting application to resolve the conflict.

E.3 Compiling the NTP Distribution

To obtain compatibility updates, download the latest published versions of the Palisade NTP reference clock I/O module and associated documentation from:

ftp://ftp.trimble.com/pub/ntp/palisadedrv

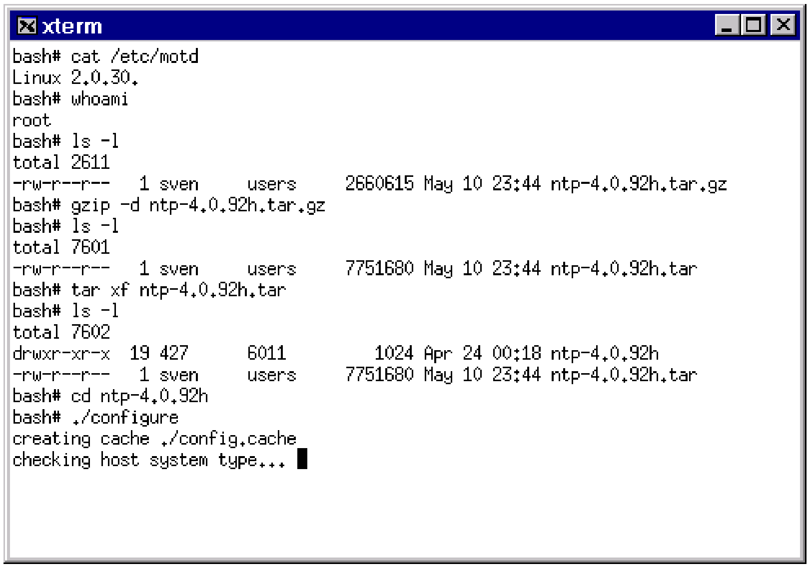
If you cannot locate a copy of an **NTP** executable for your system that supports Palisade, you can download and compile NTP yourself. You will need to build NTP on a system with a compiler.

1. Download the current version of NTP to your working directory.
2. Use GZIP to uncompress the NTP distribution archive file: **`gzip –d ntp-4.xx.xx.tar.gz`**
3. Unpack the archive file using **`tar xf ntp-4.xx.xx.tar`**

   A directory named NTP-4.XX.XX will be created in your working directory.
4. Change to the new directory: **`cd ntp-4.xx.xx`**

   NTP is distributed with an automatic configuration utility.

5. Start configuration by typing: **`./configure`**



6. If the configuration program fails, or does not complete by creating make files, you will need to consult with your software or system administrator to obtain the correct compiler and libraries for your system.

7. After configuration is complete, type **`make`** to begin the software build. If the build does not complete sucessfully, please consult with your software or system administrator to diagnose the problem.

```
xterm
updating cache ./config.cache
creating ./config.status
creating Makefile
creating adjtimed/Makefile
creating clockstuff/Makefile
creating include/Makefile
creating kernel/Makefile
creating kernel/sys/Makefile
creating libntp/Makefile
creating libparse/Makefile
creating ntpd/Makefile
creating ntpdc/Makefile
creating ntpdate/Makefile
creating ntpq/Makefile
creating ntptrace/Makefile
creating parseutil/Makefile
creating scripts/ntpver
creating util/Makefile
creating config.h
bash#
bash#
bash#
bash# make
Compiling with GCC now generates lots of new warnings.
```

NTP installs into the directory /USR/LOCAL/BIN. If you wish to install into a different directory, please consult the NTP documentation.

8. To install NTP into the default directory, log in as super user, or root, and type **`make install`** from the NTP-4.XX.XX directory.

```
xterm
tickadj.c:584: warning: initialization discards `const' from pointer target type
tickadj.c:592: warning: initialization discards `const' from pointer target type
tickadj.c:593: warning: initialization discards `const' from pointer target type
tickadj.c:596: warning: unused variable `kernels'
tickadj.c: In function `openfile':
tickadj.c:738: warning: declaration of `fd' shadows global declaration
tickadj.c: At top level:
tickadj.c:756: warning: declaration of `fd' shadows global declaration
tickadj.c: In function `writevar':
tickadj.c:760: warning: declaration of `fd' shadows global declaration
tickadj.c: At top level:
tickadj.c:783: warning: declaration of `fd' shadows global declaration
tickadj.c: In function `readvar':
tickadj.c:787: warning: declaration of `fd' shadows global declaration
gcc  -g -O2 -Wall -Wshadow -Wwrite-strings -Wconversion -Wpointer-arith -Wcast-q
ual -Wstrict-prototypes -pipe   -o tickadj  tickadj.o ../libntp/libntp.a -lsocke
t -lposix4 -lnsl -lkvm -lelf
make[2]: Leaving directory `/usr/local/ntp/ntp-4.0.92h/util'
make[2]: Entering directory `/usr/local/ntp/ntp-4.0.92h'
make[2]: Leaving directory `/usr/local/ntp/ntp-4.0.92h'
make[1]: Leaving directory `/usr/local/ntp/ntp-4.0.92h'
bash# make install
Making install in include
make[1]: Entering directory `/usr/local/ntp/ntp-4.0.92h/include'
```

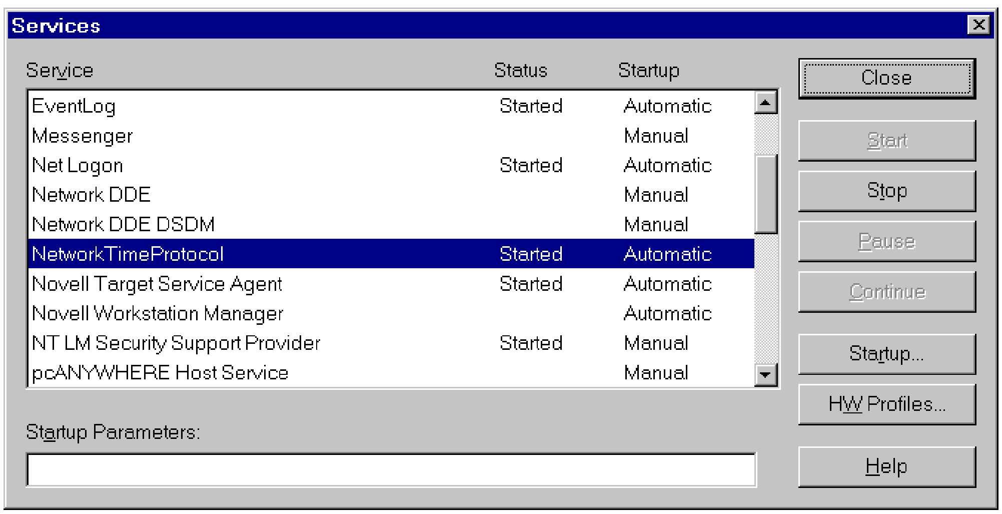
To complete installation of NTP on your system, see UNIX Installation, page 6-19.

E.4 Windows NT Administration

This section describes starting and stopping NTP on Windows NT, and removing the NTP service from the system.

E.4.1 Controlling the NTP Service

Use the Control Panel Services Applet to Stop or Disable the NTP service at any time. This procedure is the same whether you installed the NTP service manually or using the installation program.



E.4.2 Removing the NTP Service

If you used the automatic installation procedure for installing NTP, de-install the NTP software using the Control Panel Add/Remove programs applet.

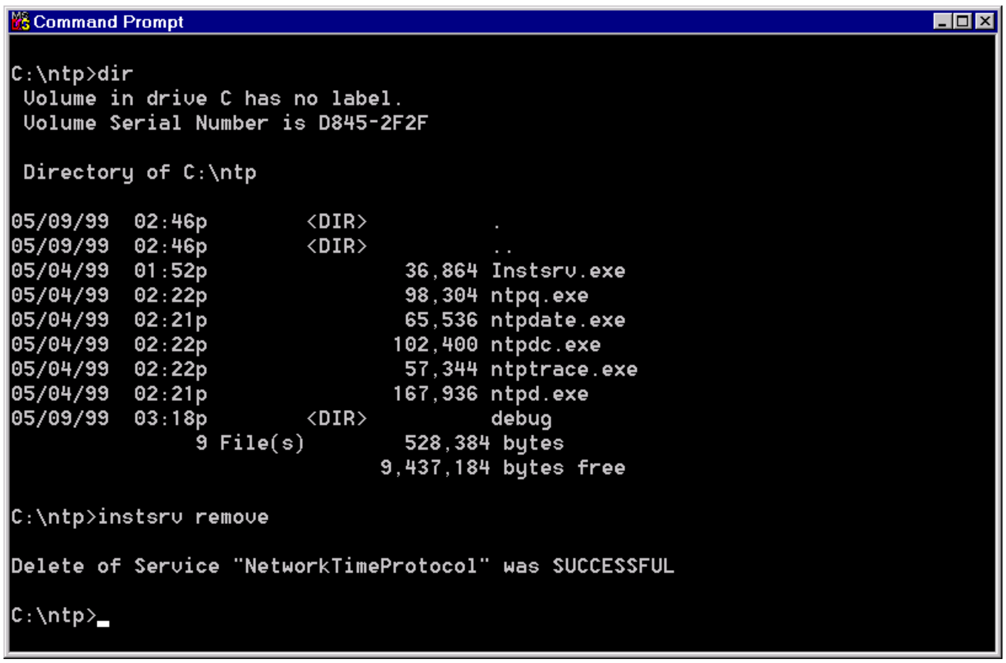
The NTP service can only be removed using the INSTSRV.EXE utility.

The NTP service must be stopped prior to removing.

1. To stop the NTP Service, click **Stop** in the Control Panel Services Applet.

2. Start a *command prompt* window, and change to the directory containing the INSTSRV.EXE utility**.**

3. Type **`instsrv remove`**.



The program reports successful removal of the service. The executable files copied during installation, as well as the configuration file must be manually removed from the system if a permanent installation is desired.

This concludes the manual Windows NT installation. The remaining part of this section describes the Windows NT specific control, event logging and diagnostics features available.

E.5 Additional Information

For up-to-date hardware, software, and configuration information, please refer to the Trimble Navigation NTP Web Site at **www.trimble.com/oem/ntp**.

F Theory of Operation

The smart antenna's satellite acquisition and tracking algorithms can achieve a position solution without any initialization. The receiver tracks up to 8 satellites and automatically selects the best combination of satellites to compute position, velocity and time. As satellites move out of view, the smart antenna automatically acquires new satellites and includes them in the solution set as required.

This chapter describes the smart antenna's satellite acquisition and tracking processes, performance characteristics and system architecture. This discussion assumes the reader is familiar with the basic theory of the Global Positioning System. Before proceeding to the detailed discussion of the satellite acquisition and tracking process, please review the GPS satellite message description on the next page.

F.1 GPS Satellite Message

Every GPS satellite transmits the Coarse/Acquisition (C/A) code and satellite data modulated onto the L1 carrier frequency (1575.42 MHz). The C/A code is a unique pseudo-random sequence for each satellite. The satellite data transmitted by each satellite includes a satellite almanac for the entire GPS system, its own satellite ephemeris and its own clock correction.

The satellite data is transmitted in 30-second frames. Each frame contains the clock correction and ephemeris for that specific satellite, and two pages of the 50-page GPS system almanac. The time required to transmit the complete system almanac is 12.5 minutes and the time to transmit the satellite ephemeris is 30 seconds.

The system almanac contains information about each of the satellites in the constellation, ionospheric data, and special system messages. The ephemeris contains detailed orbital information for a specific satellite. The GPS system almanac changes infrequently and is typically valid for weeks. Ephemeris data changes hourly, but is valid for up to four hours. The GPS control segment updates the system almanac weekly and the ephemeris hourly through three ground-based control stations. During normal operation, the smart antenna updates the ephemeris stored in its memory at 30 minute intervals.

The performance of a GPS receiver at power-on is determined largely by the availability and accuracy of the satellite ephemeris data and the availability of a GPS system almanac.

F.2 Satellite Acquisition and Time to First Fix

This section describes satellite acquisition times for different start conditions.

F.2.1 Cold Start

The term "cold start" describes the performance of a GPS receiver at power-on when no navigation data is available. "Cold" signifies that the receiver does not have a current almanac, satellite ephemeris, initial position, or time. The cold start search algorithm applies to an smart antenna which is powered on without the memory backup circuit connected to a source of DC power. Since Palisade has no provision for external backup power, it always operates from a cold start. This is the out-of-the-box condition of the GPS module as received from the factory.

In a cold start condition, the receiver automatically selects a set of satellites and dedicates an individual tracking channel to search the Doppler frequency for each satellite in the set. If none of the selected satellites are acquired after a pre-determined period of time (time-out), the receiver will select a new search set of satellites and will repeat the process, until the first satellite is acquired. As satellites are acquired, the receiver automatically collects ephemeris and almanac data. The smart antenna uses the knowledge gained from acquiring a specific satellite to eliminate other satellites, those below the horizon, from the search set. This strategy speeds the acquisition of additional satellites required to achieve the first position fix.

The cold start search sets are established to ensure that at least three satellites are acquired within the first two time-out periods. As soon as enough satellites are found, the receiver computes an initial position fix. The Palisade 8-channel design typically achieves a cold start in under two minutes.

A complete system almanac is not required to achieve a first position fix. The almanac is used in subsequent warm starts, and to aid in acquiring GPS satellites that come into view.

F.2.2 Warm Start

In a warm start condition, the receiver has a current almanac, an initial position (within 3,000 km) and current time (within 5 minutes) stored in memory. Although the smart antenna does not have an onboard battery for preserving memory, it can be initialized using the TSIP protocol. The almanac, time and initial position must be uploaded to the receiver to force a warm start.

During a warm start, the smart antenna identifies the satellites that are expected to be in view, given the system almanac, the initial position and the time. The receiver calculates the elevation and expected Doppler shift for each satellite in this expected set and directs the eight tracking channels in a parallel search for these satellites. If the internal oscillator error is known, the smart antenna compensates for the offset to optimize the search. If the offset is not known, the search algorithms will be set wide enough to allow for oscillator tolerance, aging, and temperature errors.

If the receiver has an almanac and an initial position, but does not have the current time, it executes a cold start search until the first satellite is acquired. Once this first satellite is acquired, the receiver can obtain an approximate time and will convert to warm start mode to acquire additional satellites. Although the time to first fix is slightly longer in this case, it is significantly shorter than a complete cold start.

The warm start time to first fix, is usually less than 50 seconds (40 seconds typical).

F.2.3 "Garage Search" Strategy

During a warm start search, the smart antenna knows which satellites to search for, based on the system almanac, the initial position and the current time. In some cases, the receiver may not be able to acquire the expected satellite signals (for example, if the Palisade is in a jamming environment). Trimble's patented "garage search" strategy, also known as a split search, is designed for such situations.

If the receiver does not acquire the expected set of satellites within 5 minutes of a warm start, one of the channels is directed in a cold start search. This strategy minimizes the time to first fix in cases where the stored almanac, position and time are invalid. The stored information is flushed from memory, if the cold start search proves effective and the garage search fails.

F.2.4 Hot Start

A hot start strategy applies when the almanac, position, time and ephemeris in memory are valid. The hot start search strategy is similar to a warm start, but since the ephemeris data in memory is considered current and valid, the acquisition time is typically less than 30 seconds. This may occur if the GPS signals are temporarily obscured or jammed.

F.3 Position Accuracy

GPS position accuracy is degraded by atmospheric distortion, satellite and receiver clock errors, and Selective Availability (S/A). Effective models for atmospheric distortion of satellite signals have been developed to minimize the impact of tropospheric and ionospheric effects. The impact of satellite clock errors is minimized by incorporating the clock corrections transmitted by each satellite used in the position solution. S/A is the most significant contributor to position error and cannot be effectively combated except with differential GPS.

F.3.1 Selective Availability (S/A)

The U.S. Department of Defense, through a program called Selective Availability, intentionally degrades GPS accuracy for civilian users. The S/A program creates position errors by modifying the apparent position of each satellite and introducing random dither into each satellite's clock.

In extreme cases, all sources of error (natural, PDOP, and S/A) can combine to produce large position errors. The DOD's definition of accuracy under S/A is 100 meters 2 dRMS (horizontal 2-dimensional, 95% of the time).

F.4 Coordinate Systems

This section lists the coordinate system formats supported by the TSIP and NMEA 0183 protocols.

F.4.1 TSIP

In the default TSIP configuration, position is output in a Latitude-Longitude-Altitude (LLA) format based on a default datum, WGS-84. The LLA format can be easily converted by the host system to other coordinate systems using the appropriate translation algorithm. By sending the appropriate TSIP command, the smart antenna's position output can be changed to a Cartesian (XYZ) coordinate format. The datum used for LLA transformations can also be changed using the TSIP 8E packet. The smart antenna offers a selection of 179 datums, which are listed in Appendix A.

The TSIP velocity output format is also 3-dimensional. The default format is X-Y-Z with the option of an East-North-Up (ENU) coordinate format. Time tags on fix messages default to UTC (Universal Coordinated Time), but can be switched to GPS time by sending the appropriate TSIP command.

F.4.2 NMEA 0183

The NMEA 0183 protocol supports time outputs in the ZDA format only. In NMEA 0183 messages, time and date information is always based on UTC.

F.5 Performance Characteristics

This section lists performance information for the Palisade.

F.5.1 Update Rate

Palisade updates position at one-second intervals during self-survey. The surveyed position is frozen after survey completes

F.5.2 Dynamic Limits

The dynamic operating limits for the various receiver designs are listed below. These operating limits assume that the smart antenna is correctly installed and that the overall system is designed to operate under the same dynamic conditions.

Table F-1 Dynamic Operating Limits

Dynamic	Upper Bound
Velocity	500 m/s
Acceleration	4 g (39.2 m/s^2)
Jerk	20 m/s^3

F.5.3 Re-Acquisition

When a satellite signal is momentarily interrupted during normal operation, the receiver continues to search for the lost signal at the satellite's last known Doppler frequency. If the lost signal is not re-acquired within 15 seconds, the receiver initiates a broader frequency search. The smart antenna takes advantage of the last known information about the dynamics of the receiver and the satellite to establish the center frequency and range for the search. Every 15 seconds, until the lost signal is re-acquired, a new center frequency and search range is computed. Each frequency range is searched in 500 Hz increments. The duration of the code search at a given frequency is approximately one second and switches automatically.

If ephemeris or almanac data is available for the lost satellite, then the satellite's velocity is factored into the center frequency calculation. The diminished accuracy of an older almanac is accounted for in the width of the search range. If neither the ephemeris or almanac is available, then the Doppler frequency at last lock is searched for two minutes. If the satellite has not been re-acquired after two minutes, then the maximum expected Doppler frequency, based on satellite dynamics, is searched.

The search width is also increased, if the current position is not accurately known. If the smart antenna is computing velocity or velocity aiding is provided, then the receiver's motion is also factored into the Doppler frequency. If velocity information is not available, then the dynamics code is used to determine the maximum expected Doppler frequency.

Re-acquisition time for momentary signal blockages is typically under 2 seconds.

F.6 System Architecture

Palisade incorporates an eight-channel (DSP) which operates at the L1 frequency (1575.42 MHz) and processes the Coarse/Acquisition (C/A) code portion of the GPS signal The RF and digital signal processing components of the GPS module are custom gate arrays designed by Trimble. In addition to the signal processing functions, these gate arrays also contain support circuitry for the microprocessor. The microprocessor performs the navigation computations in addition to controlling the DSP channels and managing the I/O operations.

GPS satellite signals are collected by the antenna, filtered and amplified by the antenna's pre-amp and then fed to the RF down converter. A highly stable, crystal reference oscillator, operating at 25.000 MHz, supports the down converter in producing the correct signals for the digital signal processor. The signal processing stage tracks the GPS satellite signals and extracts the carrier code information, as well as the navigation data at 50 bits per second.

In addition to supporting the down conversion process, the crystal oscillator also serves as the reference clock for the navigation processor. This microprocessor controls the operation of the signal processing channels by allocating the channels during satellite acquisition and tracking. In the overdetermined mode of operation, the smart antenna automatically tracks the highest eight satellites above the horizon and selects the optimal set of satellites for the position solution.

In addition to controlling the DSP stage, the navigation processor also collects the ephemeris and almanac data for all of the satellites and manages the Universal Asynchronous Receiver/Transmitter (UART or DUART) interface. The UART supports full-duplex serial communication with the smart antenna.

The basic block diagram for the GPS smart antenna is illustrated below.

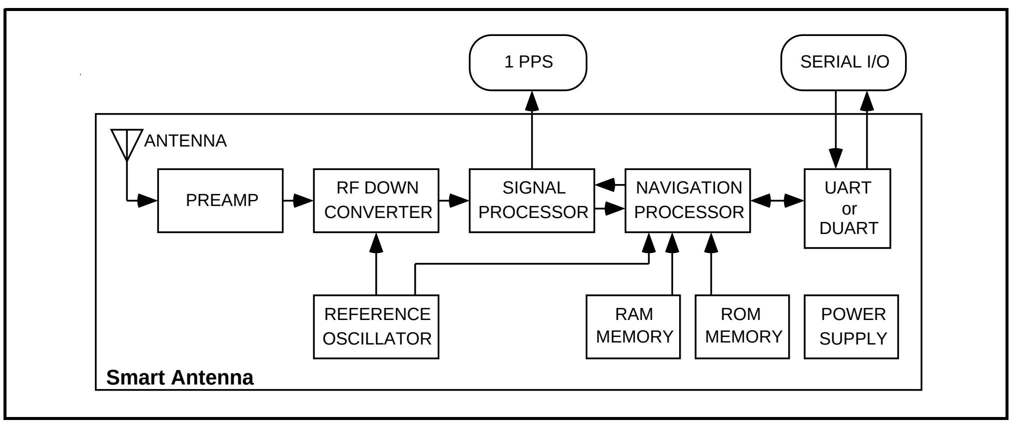


Figure F-1 Smart Antenna Block Diagram

G Glossary

2-D

Two Dimensional. A 2-D position is defined as latitude and longitude. Altitude is assumed to be fixed.

2-D GPS mode

A procedure of determining a 2-D position using signals received from the best (or only) three available GPS satellites. Altitude is assumed to be known and constant. A 2-D position solution will only be determined if signals from three or more satellites are available.

2 dRMS

Twice the distance root mean squared. The error distance within which 95% of the position solutions will fall.

3-D

Three Dimensional. A 3-D position is defined as latitude, longitude, and altitude.

3-D GPS mode

A procedure of determining a 3-D position using signals received from the best (or only) four available GPS satellites. A 3-D position solution will only be determined if signals from four or more satellites are available.

almanac

A reduced-precision subset of the ephemeris parameters. Used by the receiver to compute the elevation angle, azimuth angle, and estimated Doppler of the satellites. Each satellite broadcasts the almanac for all the satellites in the system.

ASCII

American Standard Code for Information Interchange. A standard set of 128 characters, symbols and control codes used for computer communications. ASCII characters require 7 bits of data to send, but are often sent 8 bits at a time with the extra bit being a zero.

asynchronous communication

A method of sending data in which the bits can be sent at random times. Data transmission is not synchronized to a clock. With asynchronous transmission, each character is transmitted one at a time with a "start" bit at the beginning and one or more "stop" bits at the end. Any amount of time can elapse before the next character is sent.

auto GPS mode

A procedure of automatically determining either a 2-D or 3-D position using signals received from GPS satellites. The solution automatically transitions between 2-D and 3-D depending on the number of satellites available, the PDOP of the available satellites, and the defined PDOP switch value. (See PDOP and PDOP constellation switch).

azimuth angle

The angle of the line-of-site vector, projected on the horizontal plane, measured clockwise from true North.

bandwidth

The range of frequencies occupied by a signal. Also, the information carrying capability of a communication channel or line.

baud

A measure of the speed of data transmission. Baud and bit rate are the same for direct equipment interconnections (for example, through RS-232). Baud and bit rate are not the same for modulated data links, whether wire or radio.

bit

Binary digit. The smallest unit of information into which digital data can be subdivided and which a computer can hold. Each bit has only two values (e.g., on/off, one/zero, true/false).

bit rate

The rate at which bits are transmitted over a communication path. Normally expressed in bits per second (bps).

byte

A set of contiguous bits that make up a discrete item of information. A byte usually consists of a series of 8 bits, and represents one character.

C/A code

The Coarse/Acquisition code. This is the civilian code made available by the Department of Defense. It is subject to selective availability (SA). Users can reduce the effects of SA by using differential GPS.

carrier

The radio signal on which information is carried. The carrier can be sensed to determine the presence of a signal.

channel

Either a single frequency or a pair of radio frequencies used as a communication path.

chip

The length of time to transmit either a zero or a one in a binary pulse code.

chip rate

Number of chips per second (e.g., C/A code = 1.023 MHz).

configuration

A set of conditions or parameters that define the structure of an item. In regards to Placer, a configuration defines the GPS processing and characteristics of the RS-232 interface ports. The term configuration can also define the hardware components that comprise a subsystem or system.

data bits

The bits in a byte of data which carry the actual information.

datum

Refers to a mathematical model of the earth. Many local datums model the earth for a small region: for example, Tokyo datum, Alaska, NAD-27 (North America). Others, such as WGS-84, model the whole earth.

DCE

Data Communications Equipment. The equipment that provides the functions required to establish, maintain, and terminate a communication connection. Any equipment that connects to DTE using an RS-232 or CCITT V.24 standard interface.

default setting

A preset or initial value that is assumed to be the preferred or appropriate selection for most situations. The Placer GPS sensor is shipped with factory default configuration settings; the settings were determined by Trimble Navigation.

differential relative positioning

Determination of relative coordinates of two or more receivers which are simultaneously tracking the same satellites. Static differential GPS involves determining baseline vectors between pairs of receivers. Also see *differential GPS*

dilution of precision

A description of the purely geometrical contribution to the uncertainty in a position fix, given by the expression DOP = SQRT TRACE (A A) where A A is the design matrix for the instantaneous position solution (dependent on satellite-receiver geometry). The DOP factor depends on the parameters of the position-fix solution. Standard terms for the GPS application are:

GDOP	Geometric (three position coordinates plus clock offset in the solution)
PDOP	Position (three coordinates)
HDOP	Horizontal (two horizontal coordinates)
VDOP	Vertical (height only)
TDOP	Time (clock offset only)
RDOP	Relative (normalized to 60 seconds)

DOP

see *dilution of precision*.

Doppler aiding

The use of Doppler carrier-phase measurements to smooth code-phase position measurements.

Doppler shift

The apparent change in frequency of a received signal due to the rate of change of the range between the transmitter and receiver.

earth-centered earth-fixed

Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The vectors rotate with the earth. Z is the direction of the spin axis.

elevation angle

The angle between the line of sight vector and the horizontal plane.

elevation mask angle

A measure of the minimum elevation angle, above the horizon, above which a GPS satellite must be located before the signals from the satellite will be used to compute a GPS location solution. Satellites below the elevation angle are considered unusable. The elevation mask angle is used to prevent the GPS receiver from computing position solutions using satellites which are likely to be obscured by buildings or mountains.

ellipsoid

In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid; these are usually given as the length of the semi-major axis, a, and the flattening, f = (a - b)/a, where b is the length of the semi-minor axis.

ephemeris

A set of parameters that describe the satellite orbit very accurately. It is used by the receiver to compute the position of the satellite. This information is broadcast by the satellites.

epoch

Measurement interval or data frequency, as in making observations every 15 seconds. Loading data using 30-second epochs means loading every other measurement.

firmware

A set of software computer/processor instructions that are permanently or semi-permanently resident in read-only memory.

frequency

The number of vibrations per second of an audio or radio signal. Measured in hertz (Hz), kilohertz (kHz), or megahertz (MHz).

GPS frequencies are: L1 = 1575.42 MHz
L2 = 1227.60 MHz

GDOP

Geometric Dilution of Precision. GDOP describes how much an uncertainty in pseudo-range and time affects the uncertainty in a position solution. GDOP depends on where the satellites are relative to the GPS receiver and on GPS clock offsets.

geodetic datum

A mathematical model designed to best fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude, and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point. The GPS uses WGS-84.

geoid

The actual physical shape of the earth which is hard to describe mathematically because of the local surface irregularities and sea-land variations. In geodetic terms it is the particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is everywhere perpendicular to the force of gravity.

GPD

GPS with differential corrections applied.

GPS

Global Positioning System. A satellite-based navigation system operated and maintained by the U.S. Department of Defense and consisting of a constellation of 24 satellites providing worldwide, 24-hour, three-dimensional (3-D) GPS coverage. These satellites transmit signals used (by GPS receivers) to determine precise location (position, velocity, and time) solutions. GPS signals are available in all weather conditions. This system also includes 5 monitor ground stations, 1 master control ground station, and 3 upload ground stations.

GPS is emerging as the technology of choice in many timing applications, including site and network synchronization.

GPS antenna

An antenna designed to receive GPS radio navigation signals.

GPS processor

An electronic device that interprets the GPS radio navigation signals (received by a GPS antenna) and determines a location solution. The GPS processor may also be able to apply (and determine) differential GPS corrections.

GPS receiver

The combination of a GPS antenna and a GPS processor.

GPS time

The length of the second is fixed and is determined by primary atomic frequency standards. Leap-seconds are not used, as they are in UTC. Therefore, GPS time and UTC differ by a variable whole number of seconds.

HDOP

Horizontal Dilution of Precision.

HOW

Hand-over word. The word in the GPS message that contains time synchronization information for the transfer from C/A to P-code.

interface cable

The interface cable allows data to flow between the Placer RPU and the communication equipment. One end of the cable has a single 37-pin connector; the other end of this cable has an 25-pin RS-232 connectors and a set of fused red and black power leads.

interference

Refers to the unwanted occurrences on communication channels that are a result of natural or man-made noises and signals, not properly a part of the signals being transmitted or received.

integrated Doppler

A measurement of Doppler shift frequency or phase over time.

IODE

Issue Of Data, Ephemeris. Part of the navigation data. It is the issue number of the ephemeris information. A new ephemeris is available usually on the hour. Especially important for Differential GPS operation that the IODE change is tracked at both the reference station and mobile stations.

jamming

Interference (in either transmitting or receiving signals) caused by other radio signals at exactly or approximately the same frequency

Kalman filter

A numerical method used to track a time-varying signal in the presence of noise. If the signal can be characterized by some number of parameters that vary slowly with time, then Kalman filtering can be used to tell how incoming raw measurements should be processed to best estimate those parameters as a function of time.

masks

See *satellite masks*.

maximum PDOP

A measure of the maximum Position Dilution of Precision (PDOP) that is acceptable in order for the GPS processor to determine a location solution (see PDOP).

NAVSTAR

The name given to the GPS satellites, built by Rockwell International, which is an acronym formed from NAVigation System with Time And Ranging.

NMEA

National Marine Electronics Association. An association that defines marine electronic interface standards for the purpose of serving the public interest.

NMEA 0183 message

NMEA 0183 is a standard for interfacing marine electronics navigational devices. The standard specifies the message format used to communicate with marine devices/components.

packet

An "envelope" for data, which contains addresses and error checking information as well as the data itself.

parity

A scheme for detecting certain errors in data transmission. Parity defines the condition (i.e., even or odd) of the number of items in a set (e.g., bits in a byte).

PDOP

Position Dilution of Precision. PDOP is a unitless figure of merit that describes how an uncertainty in pseudo-range affects position solutions.

PDOP constellation switch

A value, based on PDOP, that defines when the GPS receiver/processor should switch between 2-D and 3-D GPS modes. The PDOP constellation switch is only active when the GPS mode of operation is set to Auto.

PRN

Pseudo-random noise. Each GPS satellite generates its own distinctive PRN code, which is modulated onto each carrier. The PRN code serves as identification of the satellite, as a timing signal, and as a subcarrier for the navigation data.

protocol

A formal set of rules that describe a method of communication. The protocol governs the format and control of inputs and outputs.

pseudo-range

A measure of the range from the GPS antenna to a GPS satellite. Pseudo-range is obtained by multiplying the speed of light by the apparent transit time of the signal from the GPS satellite. Pseudo-range differs from actual range because the satellite and user clocks are offset from GPS time and because of propagation delays and other errors.

RAM

Random-Access Memory.

random-access memory

Memory in which information can be referred to in an arbitrary or random order. The contents of RAM are lost when the System Unit is turned off.

range

A term used to refer to the distance radio signals can travel before they must be received or repeated due to loss of signal strength, the curvature of the earth and the noise introduced because of moisture in the air surrounding the earth's surface.

range rate

The rate of change of range between the satellite and receiver. The range to a satellite changes due to satellite and observer motions. Range rate is determined by measuring the Doppler shift of the satellite beacon carrier.

read-only memory

Memory whose contents can be read, but not changed. Information is placed into ROM only once. The contents of ROM are not erased when the system unit's power is turned off.

relative positioning

The process of determining the vector distance between two points and the coordinates of one spot relative to another. This technique yields GPS positions with greater precision than a single point positioning mode can.

rise/set time

Refers to the period during which a satellite is visible (i.e., has an elevation angle that is above the elevation mask). A satellite is said to "rise" when its elevation angle exceeds the mask and "set" when the elevation drops below the mask.

ROM

Read-Only Memory.

RTCM

Radio Technical Commission for Maritime Services. Commission that recommends standards for differential GPS services. *RTCM Recommended Standards For Differential GPS Service*, prepared by RTCM Special Committee No. 104 (RTCM SC-104), defines a communication protocol for sending GPS differential corrections from a differential reference station to remote GPS receivers.

satellite masks

As satellites approach the horizon, their signals can become weak and distorted, preventing the receiver from gathering accurate data. Satellite masks enable you to establish criteria for using satellite data in a position solution. There are three types of satellite masks: Elevation, SNR, and PDOP.

SA

Selective Availability. This is the name of the policy and the implementation scheme by which unauthorized users of GPS will have their accuracy limited to 100 meters 2D RMS horizontal and 156 meters 2D RMS vertical.

SEP

Spherical Error Probability. The radius of a sphere such that 50% of the position estimates will fall within the surface of the sphere.

serial communication

A system of sending bits of data on a single channel one after the other, rather than simultaneously.

serial port

A port in which each bit of information is brought in/out on a single channel. Serial ports are designed for devices that receive data one bit at a time.

signal-to-noise level

GPS signals with SNRs that do not meet the mask criteria are considered unusable.

signal-to-noise ratio

A measure of the relative power levels of a communication signal and noise on a data line. SNR is expressed in decibels (dB).

SNR

Signal-to-Noise Ratio.

spread spectrum

The received GPS signal is a wide bandwidth, low-power signal (-160 dBW). This property results from modulating the L-band signal with a PRN code in order to spread the signal energy over a bandwidth which is much greater than the signal information bandwidth. This is done to provide the ability to receive all satellites unambiguously and to provide some resistance to noise and multi-path.

SPS

Standard Positioning Service. Refers to the GPS as available to the authorized user.

start bit

In asynchronous transmission, the start bit is appended to the beginning of a character so that the bit sync and character sync can occur at the receiver equipment.

stop bit

In asynchronous transmission, the stop bit is appended to the end of each character. It sets the receiving hardware to a condition where it looks for the start bit of a new character.

SV

Space Vehicle (GPS satellite).

synchronous communication

A method of sending digital data in which the bits come at fixed, rather than random, times and are synchronized to a clock.

TSIP

Trimble Standard Interface Protocol. A binary/hex packet bi-directional protocol, also known as the TANS protocol. Used by a large number of Trimble sensors. TSIP is the subset of TANS which is recognized by all Trimble sensors except the 4000 series. The TSIP protocol is defined in full in Appendix A.

URA

Satellite user range accuracy. The URA is sent by the satellite and is computed by the GPS operators. It is a statistical indicator of the contribution of the apparent clock and ephemeris prediction accuracies to the ranging accuracies obtainable with a specific satellite based on historical data.

UTC

Universal Time Coordinated. Uniform atomic time system/standard that is maintained by the US Naval Observatory. UTC defines the local solar mean time at the Greenwich Meridian.

UTC offset

The difference between local time and UTC (Example: UTC - EST = 5 hours).

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Reader Comment Form

Palisade NTP User Guide — **June 1999**
P/N 39139-00 — **Revision A**

We appreciate your comments and suggestions for improving this publication. Contributors of particularly helpful evaluations will receive a thank-you gift.

I use the following Trimble product ____________________

for ____________________

Please circle a response for each of the statements below:

1 = Strongly Agree 2 = Agree 3 = Neutral 4 = Disagree 5 = Strongly Disagree

The manual is well organized.	1	2	3	4	5
I can find the information I want.	1	2	3	4	5
The information in the manual is accurate.	1	2	3	4	5
I can easily understand the instructions.	1	2	3	4	5
The manual contains enough examples.	1	2	3	4	5
The examples are appropriate and helpful.	1	2	3	4	5
The layout and format are attractive and useful.	1	2	3	4	5
The illustrations are clear and helpful.	1	2	3	4	5
The manual is:	too long	just right	too short		

Please answer the following questions:

Which sections do you use the most? ____________________

What do you like best about the manual? ____________________

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Please mail to the local office listed on the back cover or to Trimble Navigation Limited, Documentation Group, 645 North Mary Avenue, P.O. Box 3642, Sunnyvale, CA 94088-3642. All comments and suggestions become the property of Trimble Navigation Limited.