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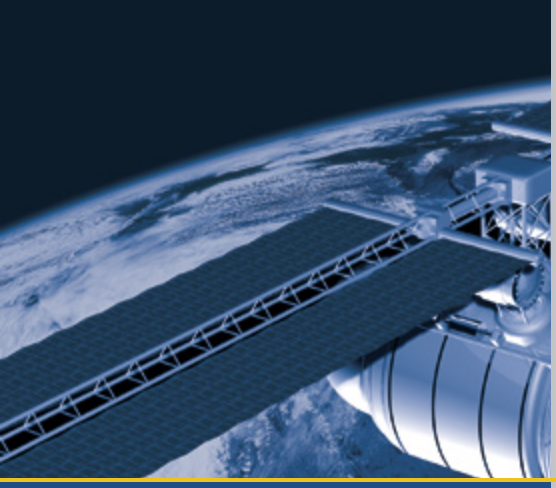
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REFERENCE MANUAL

Copernicus™ GPS Receiver

For Modules with firmware version 2.01 (or later)

Part Number 58052-00

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CHAPTER

1

STARTER KIT

In this chapter:

- Receiver Overview
- Starter Kit
- Antenna
- Quick Start Guide
- Trimble GPS Monitor Toolkit

The Copernicus GPS module is a drop-in receiver solution that provides position, velocity, and time data in a choice of three protocols.

This chapter provides a detailed description of the starter kit components and instructions for getting started with interface, hardware setup, and configuration procedures.

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Receiver Overview

Trimble's Copernicus™ GPS receiver delivers proven performance and Trimble quality for a new generation of position-enabled products. The Copernicus GPS features the Trimble revolutionary TrimCore™ software technology enabling extremely fast startup times and high performance in foliage canopy, multipath and urban canyon environments.

Designed for the demands of automated, pick and place, high-volume production processes, the Copernicus is a complete 12-channel GPS receiver in a 19mm x 19mm x 2.54mm, thumbnail-sized shielded unit. The small, thin, single-sided module is packaged in tape and reel for pick and place manufacturing processes; 28 reflow-solderable edge castellations provide interface to your design without costly I/O and RF connectors. Each module is manufactured and factory tested to Trimble's highest quality standards.

The ultra-sensitive Copernicus GPS receiver can acquire GPS satellite signals and generate fast position fixes with high accuracy in extremely challenging environments and under poor signal conditions. The module consumes less than 94mW typically at full power with continuous tracking. It has been designed to meet restrictions on the use of hazardous substances under the RoHS European Directive.

The Copernicus GPS receiver provides position, velocity and time data in a choice of three protocols: TSIP, TAIP, and NMEA. Trimble's TSIP protocol offers complete control over receiver operation and provides detailed satellite information. The TAIP protocol is an easy-to-use ASCII protocol designed specifically for track and trace applications. The bi-directional NMEA 0183 v3.0 protocol offers industry-standard data messages and a command set for easy interface to mapping software.

Compatible with active or passive antenna designs, the Copernicus GPS receiver is perfect for portable handheld, battery-powered applications. The receiver's small size and low power requirement make it ideal for use in Bluetooth appliances, sport accessories, personal navigators, cameras, computer and communication peripherals, as well as vehicle and asset tracking, navigation, and security applications.

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Starter Kit

The Copernicus GPS Starter Kit provides everything you need to get started integrating state-of-the-art GPS capability into your application. The reference board provides a visual layout of the Copernicus GPS receiver on a PCB including the RF signal trace, the RF connector, and the I/O connections of the 28 signal pins. In addition, the starter kit contains a power converter, power adapter, a GPS antenna, and software to evaluate the ease with which you can add Copernicus GPS to your application.

Starter Kit Components

The RoHS compliant (lead-free) Copernicus GPS Starter Kit includes the following:

- Interface unit with reference board and Copernicus GPS receiver
- AC/DC power supply converter
- Universal power adapters for the major standard wall outlets
- Magnetic-mount GPS antenna, 3.3 V, MCX connector, 5 meter cable
- USB cable
- Cigarette lighter adapter power cable
- Copernicus GPS SMT receivers (3 pieces)
- 14 Jumpers
- Quick Start Guide
- CD containing the SW tools and the Copernicus GPS Reference Manual

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Interface Unit

Inside the starter kit interface unit, the Copernicus GPS reference board sits on a shelf supported by 4 standoffs above the motherboard. The antenna transition cable is mounted to the outside of the unit and connects to the MCX connector on the reference board. An 8-wire ribbon cable interfaces the power and I/O between the reference board and motherboard.

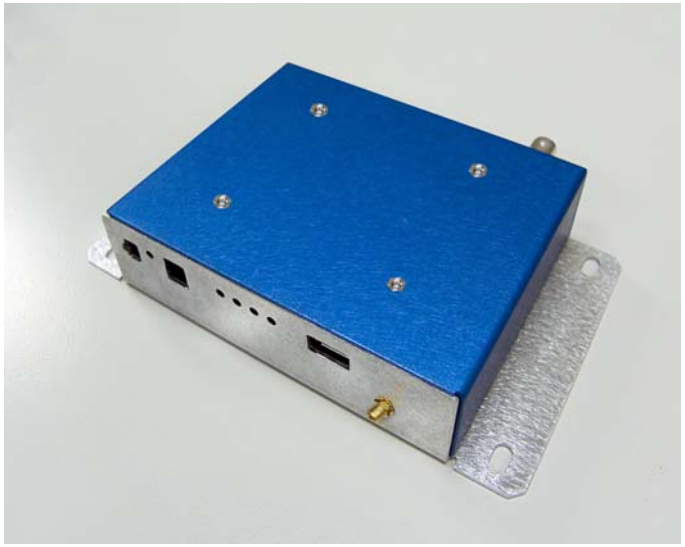


Figure 1.1 Starter Kit Interface Unit



Figure 1.2 AC/DC Power Supply Converter

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Figure 1.3 USB Cable

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Serial Port Interface

The Copernicus GPS interface unit has a dual port USB interface that is available through a single A-type USB connection. Before the starter kit can be used with a USB 2.0-equipped Microsoft Windows (2000, XP)-based PC, the appropriate USB 2.0 drivers must be installed on the PC.

Loading the FTDI Driver

The Copernicus GPS uses a USB 2.0 interface chip from Future Technology Devices International Ltd. (FTDI). The FTDI driver must be downloaded and installed on your PC before you can run the Trimble GPS Monitor (TGM) application used to communicate with the Copernicus GPS.

1. Use the following URL to access the FTDI drivers: http://www.ftdichip.com/Drivers/VCP.htm
2. Download and install the appropriate VCP (Virtual COM Port) driver for your operating system (Win'98 / ME /2000 / XP). Select the option with FT2232C series support. Follow the instructions provided on the Web site and with the driver. (http://www.ftdichip.com/Documents/InstallGuides.htm)
3. Use the supplied USB cable to connect the Copernicus GPS interface unit to your PC. The FTDI driver automatically assigns two (2) virtual COM ports to the USB port. Use the Windows Device Manager to determine which COM Ports have been assigned to the USB port.

Default Settings

The default settings on the interface unit USB Port are provided in Table 1.1.

Table 1.1 Serial Port Default Settings

Virtual Ports	Port Direction	Protocol	Baud Rate	Data Bits	Parity	Stop Bits	Flow Control
A	TXD-A RXD-A	TSIP-Out TSIP-IN	38.4 K 38.4 K	8 8	None None	1 1	NO NO
B	TXD-B RXD-B	NMEA-Out NMEA-IN	4800 4800	8 8	None None	1 1	NO NO

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Interface Connections

Following is a description of the Copernicus GPS interface unit (numbered references correlate to numbers in the image below).

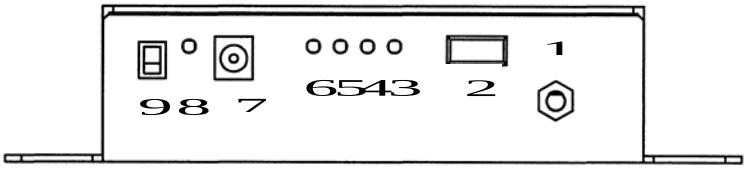


Figure 1.4 Front side of the Interface Unit

1. Antenna Connector

   The antenna connector is an MCX type connector that is intended to be used with the supplied 3.0V antenna. This interfaces to the Copernicus GPS reference board antenna connector.

2. USB Connector

   The USB connector is an A-type USB connector that is USB 2.0 and 1.1 compatible. This connection can also be used to power the starter kit and GPS receiver.

   When using the USB connection for power, the PC should be running on AC power (not battery power) to ensure proper voltage levels to the interface unit.

3. Port A-TX LED

   When blinking red, user is transmitting data to the Copernicus GPS receiver on port A.

4. Port A-RX LED

   When blinking red, the Copernicus GPS receiver is transmitting data to the user device on port A.

5. Port B-TX LED

   When blinking red, user is transmitting data to the Copernicus GPS receiver on port B.

6. Port B-RX LED

   When blinking red, the Copernicus GPS receiver is transmitting data to the user device on port B.

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7. Power Connector

   The power connector (barrel connector) is located on the front right side of the starter kit. The power connector connects to the AC/DC power converter supplied with the starter kit. The power converter converts 100 -240 VAC To 12 or 24VDC. The power connector can accept 9 to 32 VDC.

8. Power LED

   The Power LED indicates when main power, VCC, is available to the receiver. Main power is controlled by the Power Switch (#8). When the switch is in the ON position the LED illuminates Green and VCC is supplied to the receiver. When the switch is in the OFF position the LED is not lit and the receiver is powered only by the standby regulator or battery.

Note – *For the Copernicus GPS receiver to operate with standby power, the power source must be from the main power connector (#6) (not from the USB connector).*

9. Power Switch

   The power switch is used to enable or disable VCC to the receiver.

10. PPS BNC (located on the backside of the interface unit)

    The BNC connector provides a 5V TTL level PPS pulse output by the receiver. The output configuration is controlled by the receiver, not the starter kit driver circuit. This output is able to drive a 50ohm load.

Note – *The Copernicus GPS receiver reference board contains a number of configuration jumpers for use with various Trimble GPS receivers. Jumpers JP5 and JP15 must be in place for use with Copernicus GPS receiver.*

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Removing the Reference Board from the Interface Unit

Follow this procedure to remove the Copernicus GPS reference board from the interface unit:.

1. Before disassembling the interface unit, disconnect the unit from any external power source and confirm that both you and your work surface are properly grounded for ESD protection.
2. Remove the four screws, which secure the bottom plate of the interface unit to the base of the metal enclosure. Set the bottom plate aside.
3. Remove the two screws securing the Copernicus GPS reference board to the standoffs. These screws are located at opposite ends of the receiver module.

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Antenna

The Copernicus GPS Starter Kit comes with an active mini magnetic mount 3.0 V GPS antenna. This antenna mates with the MCX connector on the interface unit. The reference board supplies power to the active antenna through the RF transition cable.



Using a Passive Antenna

To test performance with a passive antenna (not supplied in the Copernicus GPS Starter Kit) the passive antenna should be connected directly to the MCX connector on the reference board, to ensure minimal signal loss. Since the passive antenna has no LNA, the antenna detection and short circuit will not report a true antenna condition. If the passive antenna is a (DC open) patch antenna, the FW reports an antenna open condition. If the antenna power jumper is removed, the antenna is reported as shorted.

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Quick Start Guide

1. Confirm that you have the following:
   - The Copernicus GPS Starter Kit.
   - Windows desktop or laptop computer with a USB port.
2. Connect the computer's power cable to the power converter.
3. Plug the power cable into the interface unit.

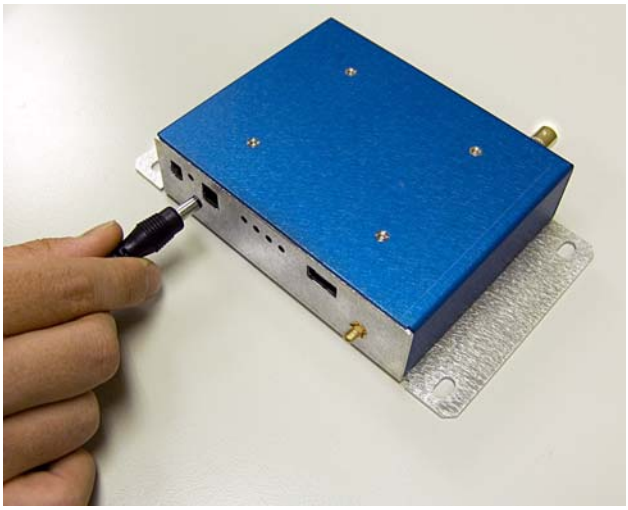


Figure 1.5 Connecting Power

4. Plug the power cable into a wall outlet.
5. Connect the magnetic mount GPS antenna to the interface unit.

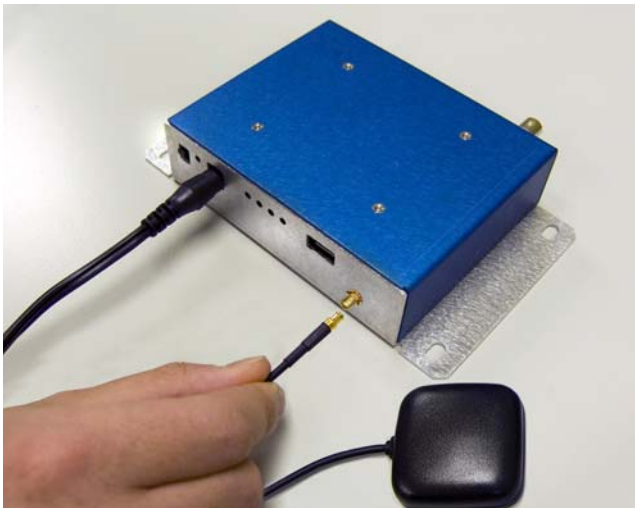


Figure 1.6 Antenna Connection

6. Place the antenna on the window sill or put the antenna outside.

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7. Connect the USB cable to the USB connector on the interface unit.

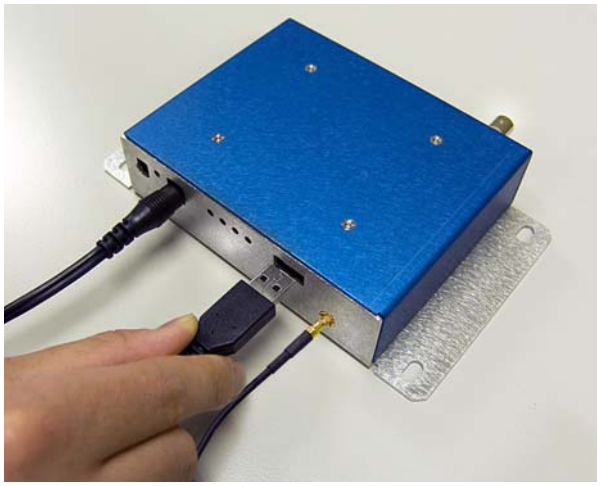


Figure 1.7 Connecting the PC

8. Power-on your computer.
9. Insert the CD found in the starter kit box into your computer CD drive.
10. Install the Trimble GPS Monitor Program from the supplied CD. (see Trimble GPS Monitor Toolkit, page 17).
11. Download and install the appropriate FTDI driver on your PC (see Install the FTDI USB/Serial Driver Software, page 17).
12. Execute the Trimble GPS Monitor Program.
13. Select one of the USB virtual COM ports. Either the TSIP or NMEA data stream is visible on your monitor. To view the other protocol, select a different USB virtual COM port.

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Trimble GPS Monitor Toolkit

The Trimble GPS Monitor Tookit is designed to assist you in configuring your Trimble GPS receiver. The application works with a standard RS-232 serial interface or the USB interface supplied in the Copernicus GPS starter kit.

TGM includes helpful features such as “Detect Receiver” to test a GPS receiver port for protocol and baud rate in the event that these settings are lost, the ability to log the output of multiple GPS devices simultaneously, and the ability send and view received raw data.

Prior to using the TGM application with a USB interface, you must first download and install the FTDI USB serial driver software (see instructions below).

Note – *The Trimble GPS Monitor application (TGM) replaces many of the previous “monitor” and “chat” programs used for Trimble Embedded and Resolution T products.*

Install the FTDI USB/Serial Driver Software

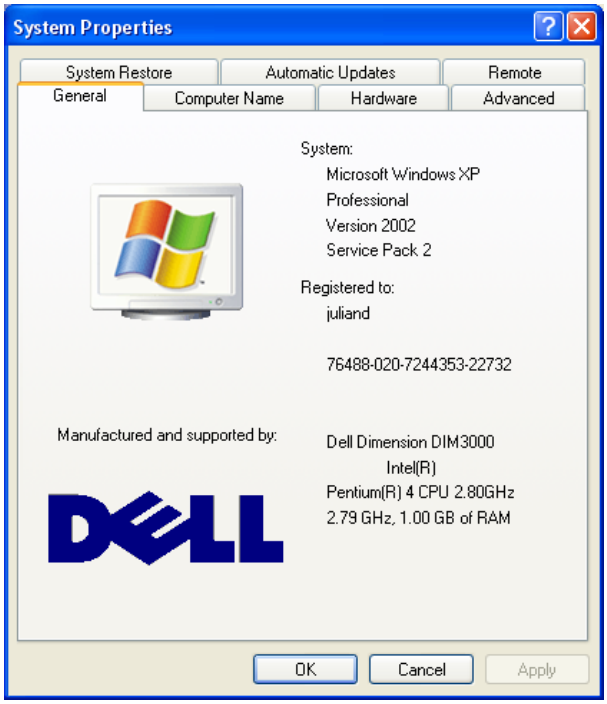
The Copernicus GPS starter kit uses a USB 2.0 dual serial port emulator interface chip from Future Technology Devices International Ltd. (FTDI). Prior to using the TGM application with a USB interface, you must first download and install the FTDI USB serial driver software on your PC.

1. Confirm that you have the following:
   - A PC with Windows Vista, Windows XP Service Pack 2, or Windows 2000 Service Pack 4 installed and a free USB port.
   - Internet access to complete the installation
2. Download the software for your Trimble product from the Trimble Support web site http://www.trimble.com/support.shtml, and select the relevant product link and then the Software Tools option.
3. Select and Save all files to a directory on the hard drive.
4. Install the FTDI driver on your PC.
5. Locate the file called “CDM_Setup.exe” you just saved, and double click it. If properly installed you should see a FTDI CDM Driver Installation popup window with the message “FTDI CDM Drivers have been successfully installed”. Click the OK button.

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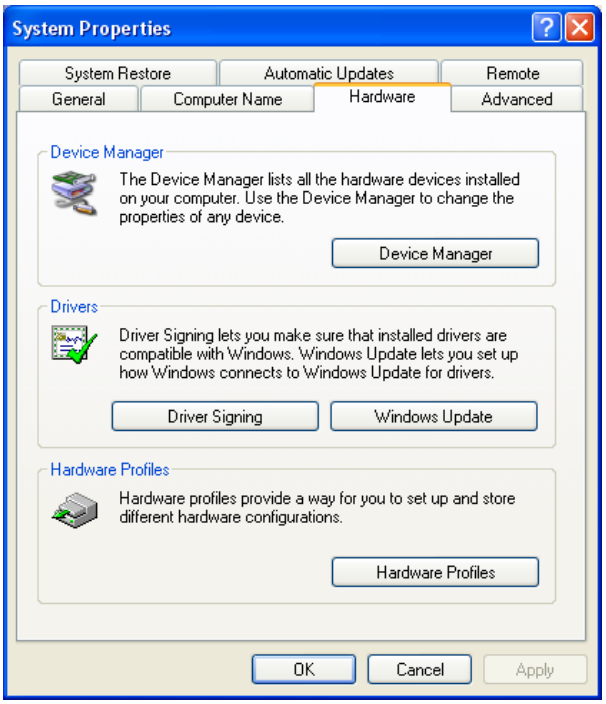
Connect the PC via the USB Cable

1. Right-click the MyComputer icon.
2. Select the Properties option to view the System Properties Window.

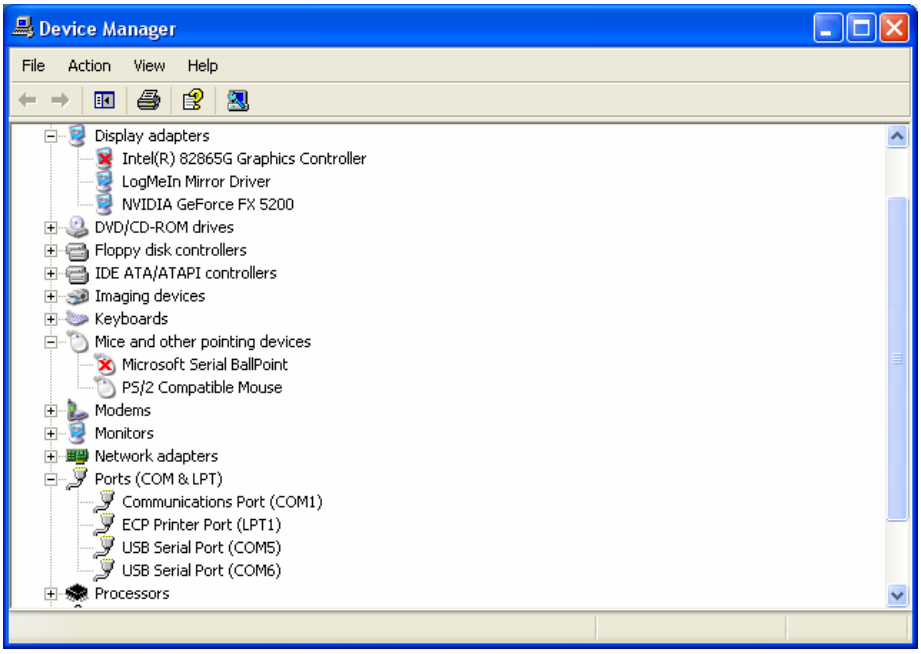


3. Select the Hardware tab.

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4. Click the Device Manager button.

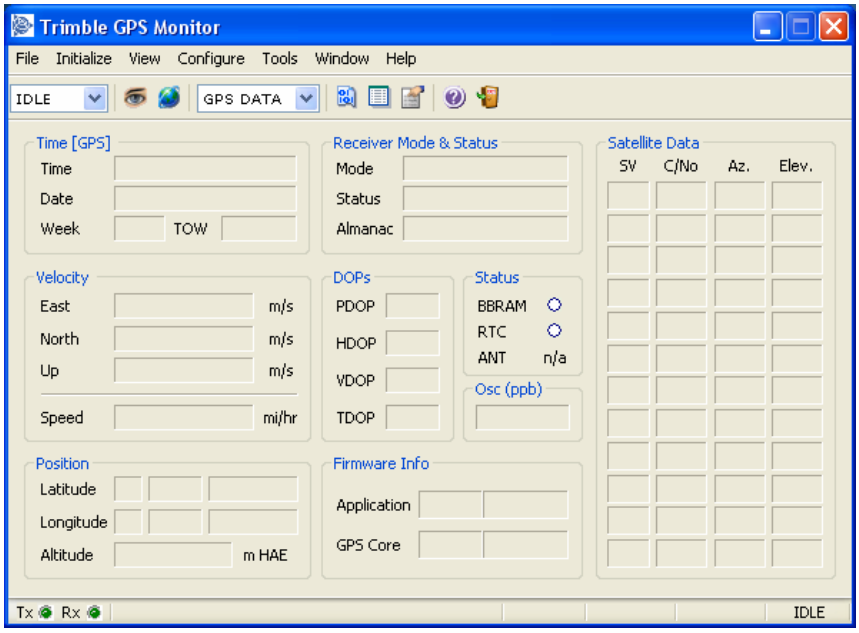


5. Open the Ports (Com & LPT) section and note down the two USB Serial Port COM numbers. In the example above they are COM5 and COM6. In general Port A of the GPS device will be on the lower COM number and Port B will be on the higher.

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Start the TGM Application

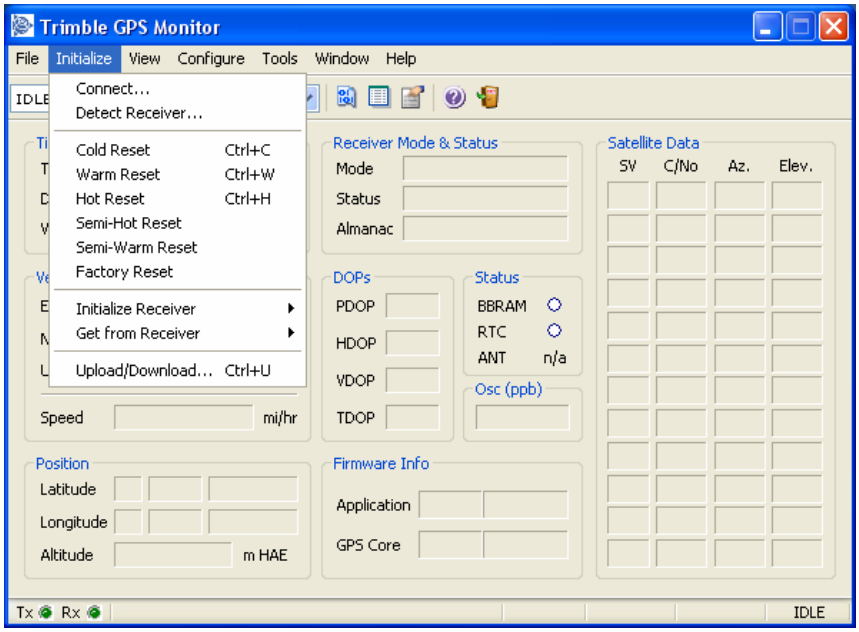
1. Go to the directory in which the Trimble GPS Monitor application is stored and open the application. The main window displays.



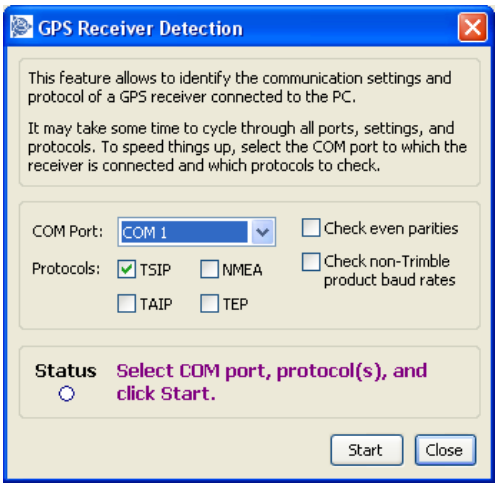
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Connect to the GPS Receiver

1. Select Initialize > Detect Receiver

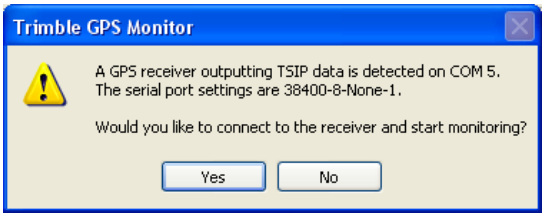


2. Select the port and protocol being used on the module.
   If you do not know which protocol is being used you can select TSIP, TAIP and NMEA. TGM will try each in turn at different baud rates.



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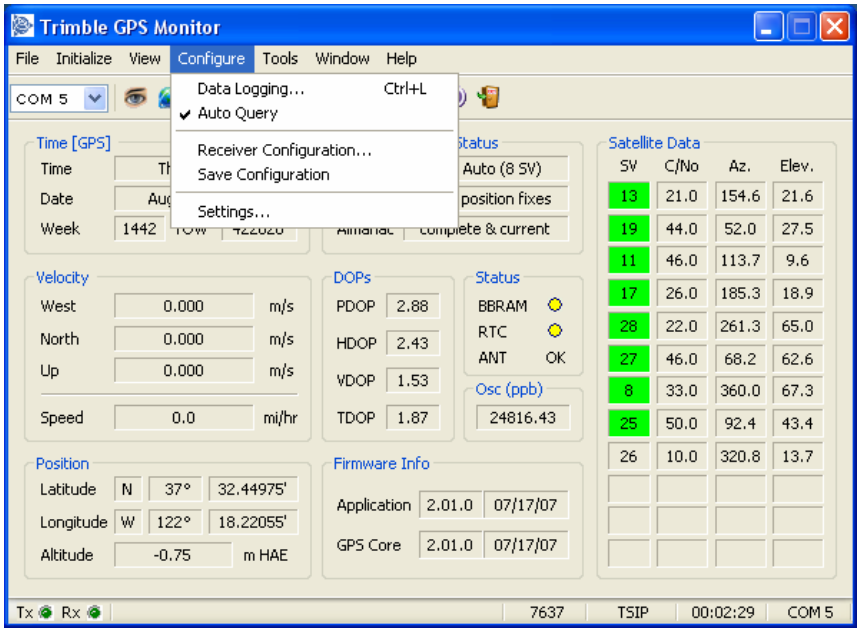
3. Click on Yes to accept the discovered connection parameters.



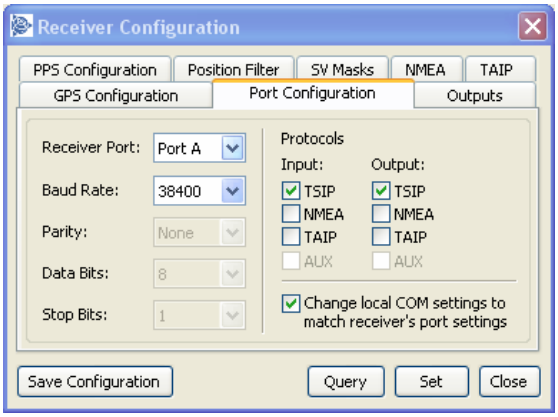
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Configure GPS Ports

1. Select the Configure pull down menu from the main screen, and select Receiver Configuration.



2. Select the Port Configuration tab.

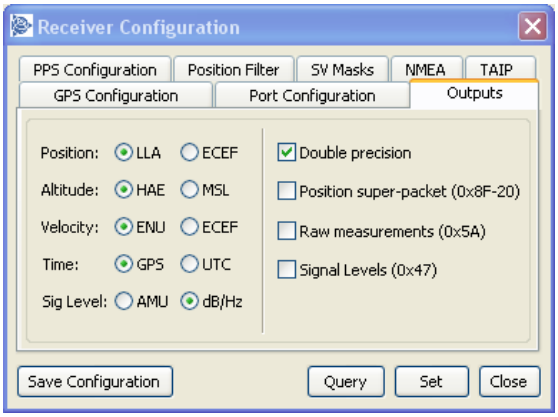


3. Select the required receiver port, baud rate, parity, data bits and stop bits.
4. Select one input and one output protocol.
5. Click the Set button.
6. If the configuration is to be permanent, click Save Configuration.

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Configure Output Formats

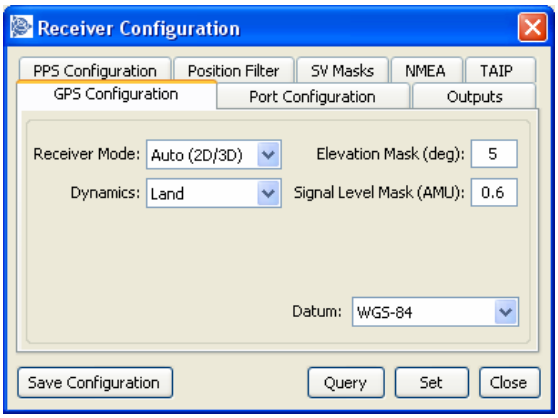
1. Select the Configure pull down menu from the main screen.
2. Select Receiver Configuration.
3. Select the Outputs tab.



4. After selecting the required setup options, click on Set.
5. If the configuration is to be permanent, click Save Configuration.

Configure GPS

1. Select the Configure pull down menu from the main screen.
2. Select Receiver Configuration.
3. Select the GPS Configuration tab.

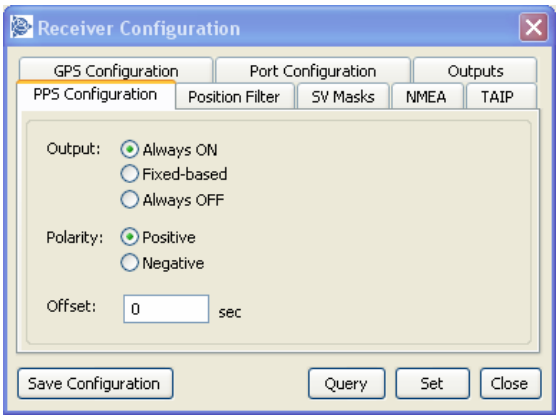


4. After selecting the required setup options, click on Set.
5. If the configuration is to be permanent, click Save Configuration.

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Configure PPS Output

1. Select the Configure pull down menu from the main screen.
2. Select Receiver Configuration.
3. Select the PPS Configuration tab.

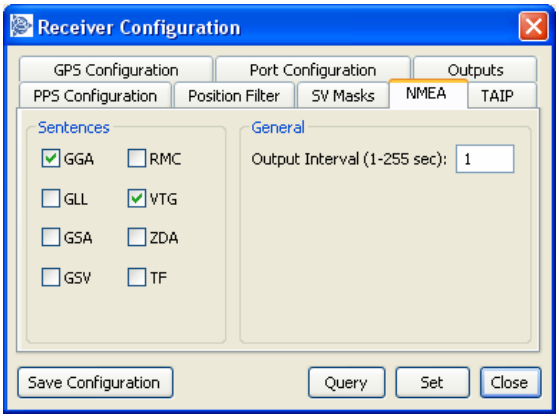


Note – *Always ON – the PPS is present even without a GPS fix, it will free run until fix is obtained. Fixed-based – the PPS will only be output when the receiver has a fix.*

4. After selecting the required setup options, click on Set.
5. If the configuration is to be permanent, click Save Configuration.

Configure NMEA Output

1. Select the Configure pull down menu from the main screen.
2. Select Receiver Configuration.
3. Select the NMEA tab.

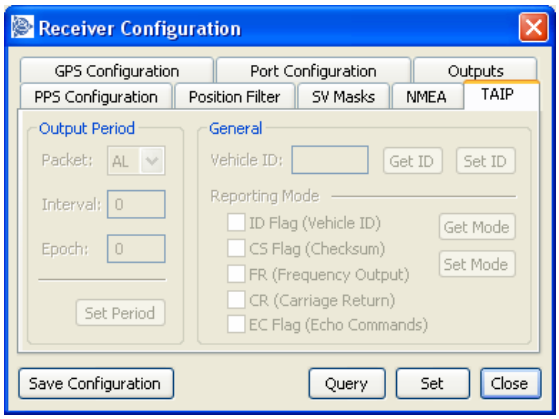


4. After selecting the required setup options, click on Set.
5. If the configuration is to be permanent, click Save Configuration.

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Configure TAIP Output

1. Select the Configure pull down menu from the main screen.
2. Select Receiver Configuration.
3. Select the TAIP tab.



4. After selecting the required setup options, click on Set.
5. If the configuration is to be permanent, click Save Configuration.

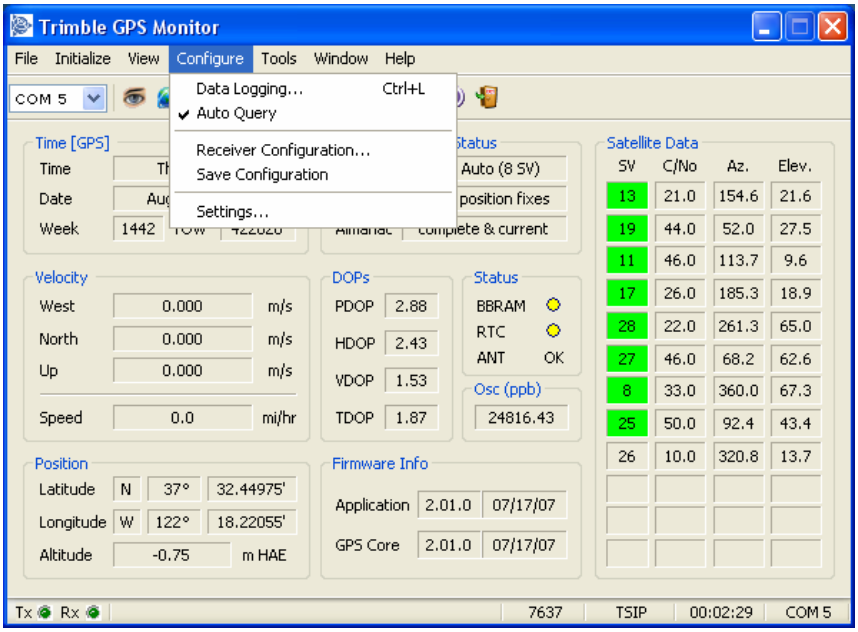
Note – *This screen can only be edited if TAIP is enabled as a port output.*

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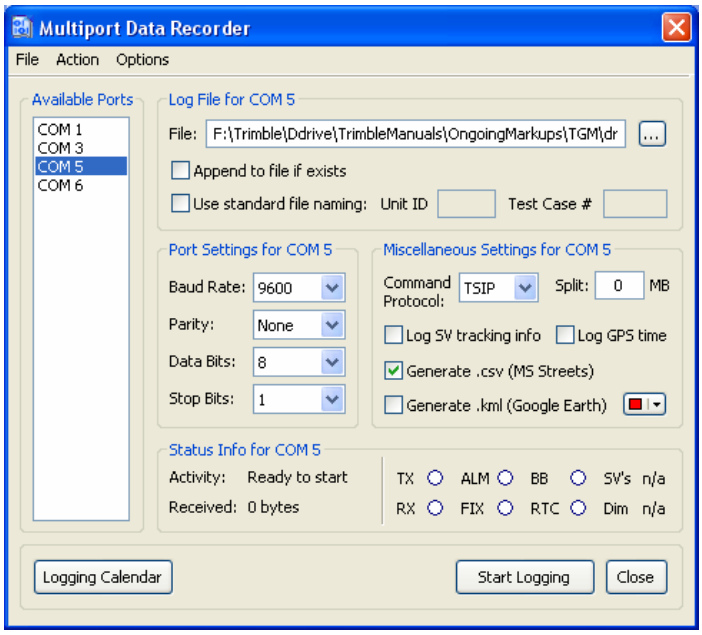
Creating a Log

Follow these steps to log the output of the GPS receiver.

1. Select Configure > Data Logging



2. From the available ports select the com port that connects to your device.

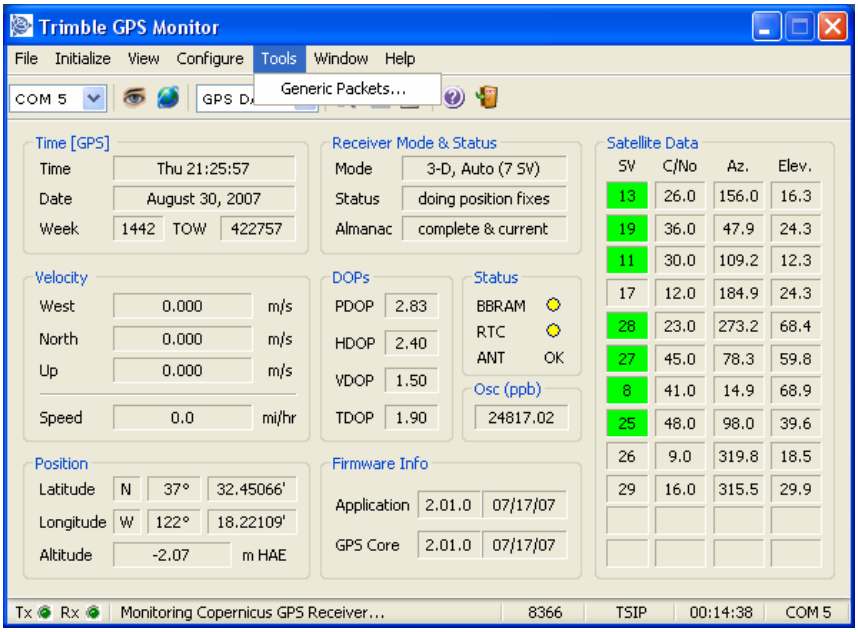


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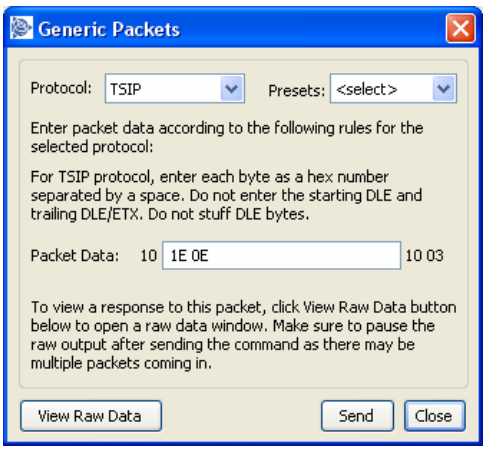
3. Create a filename and path in the file field. Use standard file naming if appropriate with the Unit ID and Test Case number
4. Select the correct protocol and logging options.
5. Click Start Logging.

Sending Raw Data to device

1. From the Tools Menu select the Generic Packets option.



2. Select the required protocol to send the raw data.

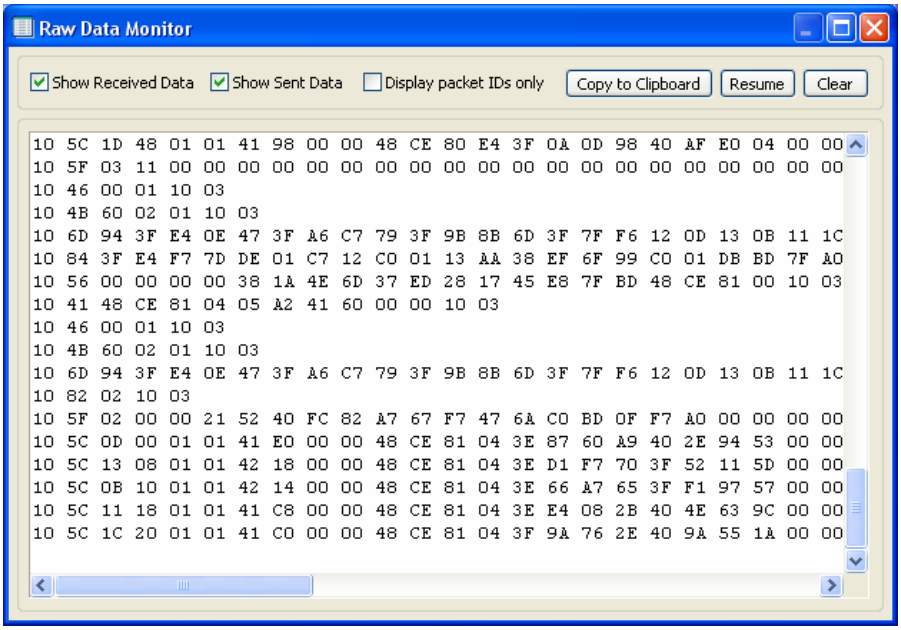


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3. Select one of the provided messages from the Presets pull down, or enter your own data in the Packet Data field.

Note – *If entering your own message in the Packet Data, the TGM only requires the user data not the surrounding start and end bytes. In the example above TSIP user data is being entered, but TGM already adds the starting DLE and ending DLE/ETX.*

4. Click View Raw Data.



5. To view the sent and received data, select the Show Sent Data box.

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CHAPTER

2

PRODUCT DESCRIPTION

In this chapter:

- Key Features
- Specifications
- Interface
- MTBF
- Absolute Minimum and Maximum Limits
- Normal Operating Conditions
- Power Consumption Over Temperature and Voltage
- ESD Protection
- Ordering Information

This chapter describes the Copernicus GPS Receiver features and performance specifications.

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Key Features

The Copernicus module is a complete 12-channel GPS receiver in a 19mm x 19mm x 2.54mm, thumbnail-sized shielded unit. The small, thin, single-sided module is packaged in tape and reel for pick and place manufacturing processes; 28 reflow-solderable edge castellations provide interface to your design without costly I/O and RF connectors. Each module is manufactured and factory tested to Trimble's highest quality standards.

- Thumbnail-sized, 19 mm W x 19 mm L (0.75" W x 0.75" L)
- Ultra-thin design, 2.54 mm H (0.1")
- Fast manufacturing: Pick & place assembly, Tape & reel packaging, Reflow solderable
- No I/O or RF connector; 28 Edge castellations
- Ultra-low power usage, less than 94 mW (typical)
- Highly sensitive:

  –150 dBm Tracking Sensitivity

  –142 dBm Acquisition Sensitivity
- Fast TTFF (cold start): 39.7 sec
- Supports active or passive antenna designs
- 12-channel simultaneous operation
- Supports SBAS
- Supports NMEA 0183, TSIP and TAIP protocols
- Reference board and starter kit available
- RoHS compliant (lead-free)

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Block Diagram

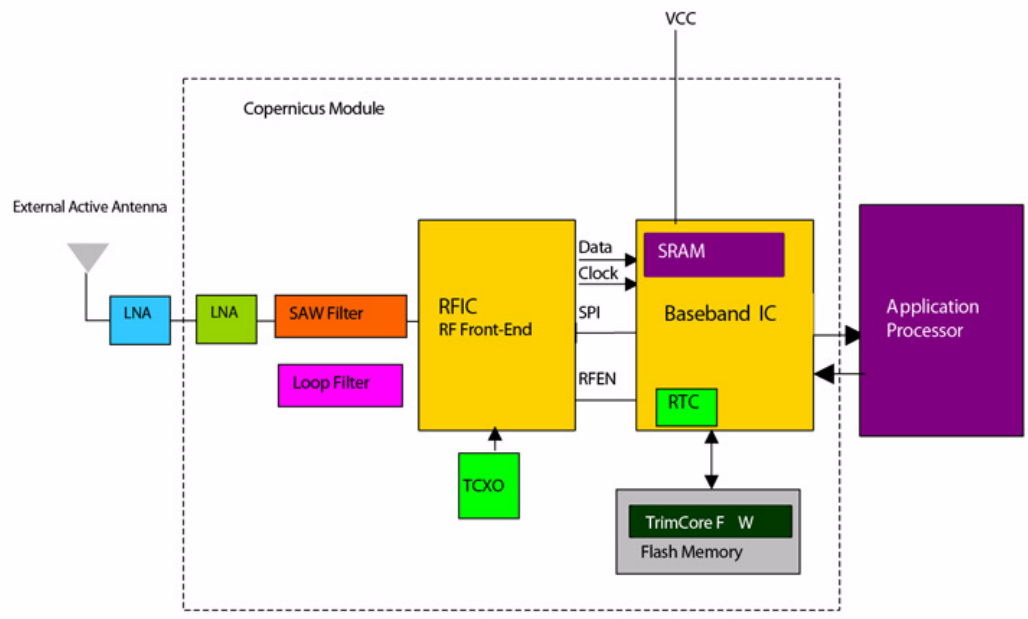


Figure 2.1 Copernicus GPS Block Diagram

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Specifications

Performance

Performance Specifications	
L1 (1575.42 MHz) frequency, C/A code, 12-channel, continuous tracking receiver	
Update Rate	
TSIP	1 Hz
NMEA	1 Hz
TAIP	1 Hz
Accuracy (24 hour static)	
Horizontal (without SBAS)	<2.5 m 50%, <5 m 90%
Horizontal (with SBAS)	<2.0 m 50%, <4 m 90%
Altitude (without SBAS)	<5 m 50%, <8 m 90%
Altitude (with SBAS)	<3 m 50%, <5 m 90%
Velocity	0.06 m/sec
PPS (static)	±100 ns RMS
Acquisition (Autonomous Operation)	
Reacquisition	2 sec
Hot Start	3.1 sec
Warm Start	35.4 sec
Cold Start	39.4 sec
Out of the Box	41 sec
Sensitivity	
Tracking	-150 dBm
Acquisition	-142 dBm
Operational	
Speed Limit	515 m/s

Interface

Interface Characteristics	
Connectors	28 surface mount edge castellations
Serial Port	2 serial ports (transmit/receive)
PPS	3.0 V CMOS-compatible TTL-level pulse, once per second
Protocols	Supports the Trimble Standard Interface Protocol (TSIP), the Trimble ASCII Interface Protocol (TAIP), and the National Marine Electronics Association (NMEA) 0183 v3.0 Bi-directional NMEA Messages

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Electrical

Electrical Specifications	
Prime Power	+2.7 VDC to 3.3 VDC
Power Consumption	(typ.) 30.7 mA (82.9 mW) @ 2.7 V (typ.) 31.3 mA (93.9 mW) @ 3.0 V
Backup Power	+2.7 VDC to +3.3 VDC
Ripple Noise	Max 50 mV, peak-to-peak from 1 Hz to 1 MHz

Physical

Physical Specifications	
Enclosure	**Metal shield**
Dimensions	19 mm W x 19 mm L x 2.54 mm H (0.75" W x 0.75" L x 0.1" H)
Weight	1.7 grams (0.06 ounce) including shield

Environmental

Environmental Specifications	
Operating Temperature	-40° C to +85° C
Storage Temperature	-55° C to +105° C
Vibration	0.008 g^2/Hz 5 Hz to 20 Hz 0.05 g^2/Hz 20 Hz to 100 Hz -3 dB/octave 100 Hz to 900 Hz
Operating Humidity	5% to 95% R.H. non-condensing, at +60° C

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MTBF

The Mean Time Between Failures (MTBF) of the GPS receiver module was calculated based on parts count - serial reliability using Telecordia Analysis and Industry field data for the PCB and Trimble Navigation's field return data (i.e. similar product or technology parts). This is generally referred to as the Trimble Navigation Reliability Database, and it consists of the following components:

- Repair Center Data and Field Assessment Analysis
- Supplier FIT goals collected through Commodities Engineering
- Commercial Databases (i.e. Telecordia and MIL-STD-217)
- Trirnble Navigation's Internal Qualification Test Data
- Assumed Duty Cycle, 8760 hours per year
- MTBF at Rated Duty Cycle, 819050 hours MTBF

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Absolute Minimum and Maximum Limits

Absolute maximum ratings indicate conditions beyond which permanent damage to the device may occur. Electrical specifications shall not apply when operating the device outside its rated operating conditions.

Parameter	Min	Max	Unit
Power Supply			
Power Supply Voltage (VCC) on Pin 12	-0.3	3.6	V
STANDBY Voltage (VCC) on Pin 12 *	-0.3	3.6	V
Antenna			
Input Power at RF Input		+10	dBm
Input Gain at RF Input	0 (passive antenna)	36	dB

Note *– See Copernicus Standby Current, page 55 for information on the standby current.*

Input / Output Pin Threshold Levels			
Input Pin Voltage (RXD-A, RXD-B, Open, Short, Reserved Pins, Xreset, Xstandby)			
Status	**Min**	**Max**	**Unit**
High	2.0	3.6	V
Low	0	0.8	V
Output Pin Voltage (TXD-A, TXD-B, LNA_XEN)			
Status	**Min**	**Max**	**Unit**
High (Ioh = 1 mA)	0.8 * VCC	VCC	V
Low (Iol = 1 mA)	0	0.22 * VCC	V

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Normal Operating Conditions

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

Parameter	Conditions	Min	Typ	Max	Unit
Primary Supply Voltage *	The rise time to VCC MUST be greater than 140 μsecs	2.7		3.3 *	V
Current Draw Continuous Tracking,	Max: 85° C, 3.3 V Min: -40° C, 2.7V Typ: 25° C, 3.0 V	23.9	34.8	38.3	mA
Power Consumption Continuous Tracking,	Max: 85° C, 3.3 V Min: -40° C, 2.7V Typ: 25° C, 3.0 V	79	93.9	115	mW
Power Consumption Absolute Maximum				50 165	mA mW
Current Draw ** Standby Mode	Max: 85° C, Min: -40° C Typ: 25° C, 3.0 V	7.1	8.5	60	uA
Current Draw Standby Mode RTC Service				30 Please see section Serial Port Activity	mA
Supply Ripple Noise	1Hz to 1MHz GPS TCXO Frequency ±5kHz			50 1	mVpp mVpp
Hardware RESET	Assert XRESET pin to clear STANDBY memory	100			us

* The rise time to VCC MUST be greater than 140 μsecs. The user can use one source of power on Pin 12 (VCC) for both main and Standby power.

** If using two sources of power, the Main and Standby power must be connected to VCC via an external diode-pair. During the Standby Mode, the main power can be removed so the unit can be run on Standby power. Standby power must be at least 0.3V less than main power. The voltage at Pin 12 must be 2.7V to 3.3V including the diode voltage drop. (See Chapter 5 for information on application circuits.)

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Power Consumption Over Temperature and Voltage

Run Mode

(Tracking with Almanac Complete): < 90 mW average @ 2.7 VDC, -40 to 85° C

Standby Mode: < 30 µW @ 3.0 VDC, typical at 25° C, < 200 µW under all conditions except during service time for the 18-hour real time clock roll over.

At 2.7 volts	Avg Current (mA)	Avg power consumption (mW)
-40° C	29.7	80.2
Room Temp	30.7	82.9
85° C	31.5	85.1
At 3.0 volts	**Avg Current (mA)**	**Avg power consumption (mW)**
-40° C	30.3	90.9
Room Temp	31.3	93.4
85° C	34.9	104.7
At 3.3 volts	**Avg Current (mA)**	**Avg power consumption (mW)**
-40° C	31.5	104
Room temp	31.4	104
85 v	31.9	105

ESD Protection

ESD testing was performed using JDEC test standard JESD-A114C.01. All inputs and outputs are protected to ±500 volts ESD level. The RF IN pin is protected up to 1kV.If a higher level of compliance is required, additional electrostatic and surge protection must be added.

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Ordering Information

Ordering Information	
Copernicus GPS Receiver Module	Single module in metal enclosure P/N 58048-10
Reference Board	P/N 58054-10 Copernicus GPS module mounted on a carrier board with I/O and RF connectors for evaluation purposes, including the RF circuitry with the antenna open detection, as well as antenna short detection and protection.
Starter Kit	RoHS (Lead-free version): P/N 58050-20 Includes Copernicus Reference Board mounted on interface motherboard in a durable metal enclosure, AC/DC power converter, compact magnetic-mount GPS antenna, serial interface cable, cigarette lighter adapter, TSIP, NMEA, and TAIP protocols.

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CHAPTER

3

INTERFACE CHARACTERISTICS

In this chapter:

- Pin Assignments
- Pin Description
- Serial Port Default Settings
- GPS Timing
- A-GPS
- Pulse-Per-Second (PPS)

This chapter provides a detailed description of the Copernicus GPS Receiver interface.

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Pin Assignments

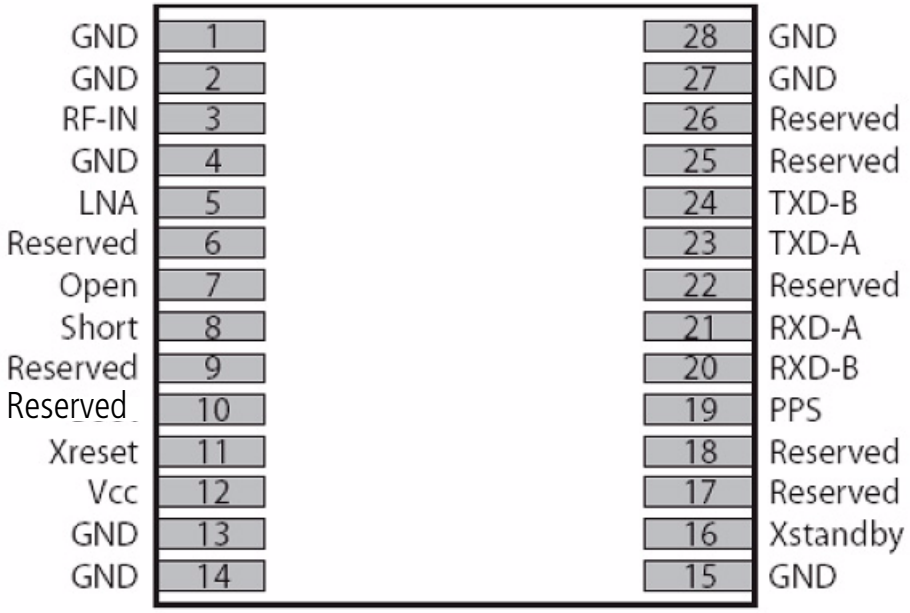


Figure 3.1 Copernicus Pin Assignments

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Pin Description

Table 3.1 Pin Description

Pin	Name	Description	Function	Note
1	GND	Ground	G	Signal ground. Connect to common ground.
2	GND	RF Ground	G	One of two RF grounds adjacent to RF input. Connect to RF ground system.
3	RF Input	GPS RF input	I	50-ohm unbalanced (coaxial) RF input.
4	GND	RF Ground	G	One of two RF grounds adjacent to RF input. Connect to RF ground system.
5	LNA_XEN	LNA Enable	O	Can be used with active antennas only. Active low logic level signal to control external LNA.
6	Reserved	Reserved	I/O	Do not connect.
7	OPEN	Antenna OPEN	I	Logic level from external antenna detection circuit. See “Antenna Detect Truth Table”.
8	SHORT	Antenna SHORT	I	Logic level from external antenna detection circuit. See “Antenna Detect Truth Table”.
9	Reserved	Reserved	I	Connect to VCC.
10	Reserved	Reserved	I	Connect to VCC.
11	XRESET	Reset	I	Active low logic level reset. Connect to VCC with or without a pullup resistor, if not used.
12	VCC	Supply voltage	P	Module power supply 2.7 - 3.3 VDC
13	GND	Ground	G	Signal ground. Connect to common ground.
14	GND	Ground	G	Signal ground. Connect to common ground.
15	GND	Ground	G	Signal ground. Connect to common ground.
16	XSTANDBY	Run/Standby	I	Selects “RUN” or “STANDBY” mode. Connect to VCC if not used (run only).
17	Reserved	Reserved	I/O	Do not connect.
18	Reserved	Reserved	I/O	Do not connect.
19	PPS	Pulse per second	O	Logic level timing signal at 1 Hz. Do not connect if not used.
20	RXD_B	Serial port B receive	I	Logic level secondary serial port receive.
21	RXD_A	Serial port A receive	I	Logic level primary serial port receive.
22	Reserved	Reserved	I/O	Do not connect.
23	TXD_A	Serial port A transmit	O	Logic level primary serial port transmit.
24	TXD_B	Serial port B transmit	O	Logic level secondary serial port transmit.
25	Reserved	Reserved	I/O	Do not connect.
26	Reserved	Reserved	I/O	Do not connect.
27	GND	Ground	G	Signal ground. Connect to common ground.
28	GND	Ground	G	Signal ground. Connect to common ground.

G: Ground; I: Input; O: Output; P: Power

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Detailed Pin Descriptions

RF Input

The RF input pin is the 50 ohm unbalanced GPS RF input, and can be used with active or passive antennas.

Passive antennas: The RF input pin may be connected by a low-loss 50 ohm unbalanced transmission system to the passive GPS antenna if loss is minimal (< 2 dB). It is recommend that you use an external LNA with a passive antenna.

Active Antennas: The RF input pin can also be connected to the output of an external low-noise amplifier, which is amplifying GPS signals from the antenna. The gain of the LNA must be great enough to overcome transmission losses from the LNA output to this pin. The specification for noise figure for the module is < 3 dB at room temperature and < 4 dB over the specified temperature range, -40 to +85 C. The external LNA must be located such that the loss from the GPS antenna connection to the LNA input is minimized, preferably < 1 dB. The noise figure of the LNA should be as low as possible, preferably< 2 dB. This specification is provided to enable a cascaded noise figure design calculation. Active antennas must be powered with a single bias-Tee circuit.

LNA_XEN

This logic level output can be used to control power to an external LNA or other circuitry. The logic of this signal is such that when the module is running (not in standby), this signal is low. During “STANDBY” mode, this signal is high. This pin may be used to control the gate of a p-channel FET used as a switch.

Open/Short Pins

When using an active antenna, it is recommended that you implement an antenna detection circuit with short circuit protection. There are two pins provided for reporting the antenna status: OPEN and SHORT.

The logic level inputs outlined in Table 3.2 may be used with a detection circuit (with or without protection) to monitor the status of the external LNA of an active antenna by the module.

The truth table for the logic of these signals is provided in Table 3.2. These input pins conform to the Input / Output Pin threshold levels specified in.

A typical active antenna draws between 10 to 20mA.The antenna Protect/Detect circuit will trip as a short circuit at around 100mA. It is best to keep the antenna current below 75mA. An open circuit will be determined if the antenna current falls below approximately 2mA.

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Table 3.2 Antenna Status Truth Table

	Condition of logic signals	
ANTENNA REPORTS	**SHORT**	**OPEN**
Antenna Open Reported	1	1
Antenna Normal Reported	1	0
Antenna Shorted Reported	0	0
Undefined	0	1

When using a passive antenna with the SHORT and OPEN pins floating, the receiver will report an open condition. If a normal condition from the receiver is desired when using a passive antenna, set the logic levels of the SHORT pin High and the OPEN pin Low.

XRESET

This logic-level, active low input is used to issue hardware or power-on reset to the module. It may be connected to external logic or to a processor to issue reset. To reset the module, take this pin low for at least 100 microseconds. This pin must be tied to VCC with a resistance of less than 10 K Ohms if not used.

The hardware reset deletes all the information saved in SRAM (position time, almanac, ephemeris and customers' user set configurations if not previously saved in non-volatile Flash memory) and restarts the Copernicus receiver. See Absolute Minimum and Maximum Limits, page 37 for pin threshold values.

VCC

This is the primary voltage supply pin for the module. This pin also provides power during Standby Mode (Backup Mode). To setup separate power supplies for main power and Standby Mode (Backup Mode) power, an external diode-pair must be provided.

XSTANDBY

This logic level input is used to control the RUN/STANDBY state of the module. If this signal is High, the unit will run normally. If this signal is Low, the unit will go to “STANDBY” mode. See Absolute Minimum and Maximum Limits, page 37 for pin threshold values.

PPS

Pulse-per-second. This logic level output provides a 1 Hz timing signal to external devices. The positive going 4.2 usec pulse width is controllable by TSIP packet 0x8E-4F. The cable delay and polarity is controllable by TSIP packet 0x8E-4A. The PPS mode is set by TSIP packet 0x35. This output meets the input/output pin threshold specifications (see Absolute Minimum and Maximum Limits, page 37.)

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RXD_A and RXD_B

These logic level inputs are the primary (A) and secondary (B) serial port receive lines (data input to the module). This output meets the input/output pin threshold specifications (see Absolute Minimum and Maximum Limits, page 37.) The baud rate for the two ports is under software control.

TXD_A and TXD_B

These logic level outputs are the primary (A) and secondary (B) serial port transmit lines (data moving away from the module). This output meets the input/output pin threshold specifications (see Absolute Minimum and Maximum Limits, page 37.) The baud rate for the two ports is under firmware control.

Reserved Pins

There are 8 reserved pins on the Copernicus GPS Receiver. For the recommended pin connections for these reserved pins, see Table 3.1.

Protocols

Table 3.3 Copernicus GPS Receiver Available protocols

Protocols	Specification	Direction	Serial Port Support
NMEA	NMEA 0183 v3.0; Bi-directional with extended NMEA sentences	Input / Output	Both Serial Ports
TSIP (Trimble Standard Interface Protocol)	Trimble propriety binary protocol	Input / Output	Both Serial Ports
TAIP (Trimble ASCII Interface Protocol)	Trimble propriety ASCII protocol	Input / Output	Both Serial Ports

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Serial Port Default Settings

The Copernicus GPS Receiver supports two serial ports. The default settings are provided in the table below.

Table 3.4 Copernicus GPS Receiver Serial Port Default Settings

Port	Port Direction	Pin #	Protocol	Characteristics				
				Baud Rate	**Data Bits**	**Parity**	**Stop Bits**	**Flow Control**
A	TXD-A	23	TSIP-Out	38.4 K	8	None	1	NO
	RXD-A	21	TSIP-IN	38.4 K	8	None	1	NO
B	TXD-B	24	NMEA-Out	4800	8	None	1	NO
	RXD-B	20	NMEA-IN	4800	8	None	1	NO

Note – *Data Bits, Parity, Stop Bits and Flow Control are not configurable. Only Protocol and Baud rates are configurable. Detailed descriptions of these protocols are defined in the Appendices.*

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GPS Timing

In many timing applications, such as time/frequency standards, site synchronization systems, and event measurement systems, GPS receivers are used to discipline local oscillators.

The GPS constellation consists of 24 orbiting satellites. 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 24 orbiting clocks with worldwide 24-hour coverage.

GPS receivers use the signals from these GPS clocks to correct their internal clock which is not as stable or accurate as the GPS atomic clocks. GPS receivers like the Copernicus GPS output a highly accurate timing pulse (PPS) generated by an internal clock which is constantly corrected using the GPS clocks. This timing pulse is synchronized to UTC within ±100 ns rms.

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

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 ns. The hardware and software implementation affects the GPS receiver's PPS accuracy level. The receiver's clocking rate determines the PPS steering resolution.

Serial Time Output

Time must be taken from the timing messages in the TSIP, TAIP, or NMEA protocols because position messages contain a timestamp which is usually 1 to 2 seconds in the past.

Table 3.5 Serial Time Output

Protocol	Timing Message
TSIP	Report packets 41 and 8F-21
TAIP	TM message
NMEA	ZDA message

Note – *GPS time differs from UTC (Universal Coordinated Time) by a variable, integer number of seconds UTC=(GPS time)-(GPS UTC offset).*

As of January 2006, the GPS UTC offset was 14 seconds. The offset has historically increased by 1 second about every 18 months. System designers should plan to read the offset value as a part of the timing interface to obtain UTC. The GPS week number is in reference to a base week (Week #0), starting January 6, 1980.

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Acquiring the Correct Time

To acquire the correct time:

1. Confirm that the almanac is complete and the receiver is generating 3D fixes. This will eliminate the UTC offset jump.
2. Confirm that the receiver is configured for the late PPS option (i.e., it is only outputting a PPS on a 3D fix).
3. Capture the time from TSIP packet 0x41 or TSIP packet 0x8F-20 (if using TSIP).
4. Once time is acquired, on the next PPS add 1 to the whole second to read the correct time.

Note – *The minimum time resolution is 1 second.*

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A-GPS

The Copernicus GPS Receiver is equipped with assisted GPS (A-GPS), which enables the receiver to obtain a position fix within seconds using almanac, ephemeris, time, and position data. This position data can be uploaded to the device via TSIP packets or the Trimble GPS Monitor (TGM) application. When A-GPS is enabled, the Copernicus GPS Receiver can achieve fast start-up times characteristic of a hot start.

Follow the procedures below to download current almanac, ephemeris, time, and position information, and then upload this data to the starter kit module via TGM or TSIP (to upload position data within the customer application).



Warning – To ensure proper format of the ephemeris file and almanac file, a Trimble receiver must be used to gather this data. Almanac files from non-Trimble receivers may not be in proper format and thus may not work, (i.e. almanac files downloaded from the Internet).

Enabling A-GPS with the Trimble GPS Monitor Application (TGM)

1. Attach the Copernicus GPS interface unit to your PC.
2. Place the GPS antenna where there is a clear view of sky.
3. Allow the starter kit to run and calculate fixes.
4. On the main screen, wait for the almanac indicator to turn green confirming that the receiver has collected a current almanac.

Note – *It takes 12,5 minutes of uninterrupted Copernicus operation to collect almanac from the satellites.*

5. Click on the initialized pull-down menu and use the download features on the bottom of the pull-down to download the almanac, position, time and ephemeris files on your PC.
6. Now that you have collected these files, you can upload them using the upload features on the initialize pull-down window in TGM.

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

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Enabling A-GPS with TSIP

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

Note – *It takes 12,5 minutes of uninterrupted Copernicus operation to collect almanac from the satellites.*

2. Use packet 0 x 26 to request the health of the receiver. The response packets 0x46 and 0x4B indicate when the almanac is complete and current.
3. Use packet 0x38 to request the almanac and the ephemeris. The receiver responds with packet 0 x 58.
4. Use packet 0 x 21 to request time from the receiver. The receiver responds with packet 0x 41. This data can be used to set your own off-board clock.
5. Use packets 0x42, 0x4A, 0x83 0r 0x84 to request a position from the receiver.

To upload this information back to the receiver, follow this procedures in the specified order:

1. Upload the time using TSIP packet 0x2E. Wait for upload confirmation report packet 0x41.
2. Upload position using TSIP packet 0x31 or 0x32. No confirmation report packet available.
3. Upload the ephemeris using TSIP packet 0x38. Wait for the upload confirmation report TSIP packet 0x58.

Note – *See Appendix A for details on the TSIP protocol.*

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Pulse-Per-Second (PPS)

The Copernicus GPS receiver provides a CMOS compatible TTL level Pulse-Per-Second (PPS). The PPS is a positive pulse available on pin 19 of the Copernicus GPS Receiver. The rising edge of the PPS pulse is synchronized with respect to UTC. The timing accuracy is ±100 rms when valid position fixes are being reported.

The precise UTC or GPS time is reported in TSIP message 0x41 and NMEA message EDA. The line reports are sent within 500ms after the corresponding PPS.

The rising edge of the pulse is typically less than 6 nanoseconds. The distributed impedance of the attached signal line and input circuit can affect the pulse shape and rise time. The PPS can drive a load up to 1mA without damaging the module. The falling edge of the pulse should not be used.

The Copernicus' default PPS output mode is Always On, sometimes called or “Early PPS”. In Always On mode, PPS is output immediately after main power is applied. The PPS is driven by the Real Time Clock (RTC) until the receiver acquires GPS time from the satellite and begins outputting fixes. In Always On mode, the PPS continues even if the receiver loses GPS lock. The drift of the PPS, when the Copernicus GPS receiver is not tracking satellites, is unspecified and should not be used for synchronization.

The PPS output modes can be controlled with TSIP packet 0x35 and NMEA “PS” Packet. The modes are Always On (default), Fix Based, or Always Off. Cable delay compensation is available through the use of TSIP packet 0x8E-4A and NMEA “PS” Packet. PPS pulse width is controlled by TSIP packet 0x8E-4F and the NMEA “PS” Packet.

After a specific mode is selected, it can be stored in non-volatile memory (FLASH) using TSIP command 0x8E-26.

Note – *PPS can be configured as positive or negative polarity; factory default is positive. The PPS pulse width is also configurable; factory default is 4.2 microseconds.*

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CHAPTER

4

OPERATING MODES

In this chapter:

- Copernicus Receiver Operating Modes
- Run Mode
- Standby Mode
- Monitor Mode
- Changing the Run/Standby Modes
- 18-Hour RTC Roll Over
- Saving Almanac, Ephemeris and Position to Flash Memory
- WAAS

This chapter describes the primary Copernicus GPS Receiver operating modes and provides guidelines for receiver operation.

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Copernicus Receiver Operating Modes

Table 4.1 Copernicus GPS Receiver Operating Modes

Operating Modes	Description
Run Mode	Continuous tracking or normal mode
Standby Mode	Backup power or low power mode
Monitor Mode	Flash upgrading mode

Run Mode

The RUN mode is the continuous tracking or the normal mode.

Standby Mode

The Copernicus GPS Receiver provides a Standby Mode in which the module's RAM memory is kept alive and the real-time clock is running while the rest of the receiver is turned off. RAM memory is used to store the GPS almanac, ephemeris, and last position.

Using this information, together with the time information provided by the real-time clock, the receiver normally provides faster startup times. The type of start-up after Standby Mode depends on the state of the receiver prior to entering Standby Mode and on the length of time the receiver spent in the Standby Mode.

If the receiver has almanac, ephemeris, and position information before entering Standby Mode, and the time spent in Standby Mode is less than two hours, the receiver will typically perform a hot start.

If the receiver has all of the information listed above, but the time spent in Standby Mode is more than two hours, the receiver will typically perform a warm start.

The GPS almanac, ephemeris and recent position are automatically stored in non-volatile Flash memory. Even without time, the receiver can use the information stored in Flash memory to shorten the start-up time. In all cases, the receiver will use all of the available information to do the fastest start-up possible.

Note – *In the Standby Mode, the power consumption of the unit is very low. See* *Copernicus Standby Current, page 55*.

Monitor Mode

Monitor Mode is the operating mode for upgrading the firmware stored in the Flash memory. See Chapter 11 for the firmware upgrade procedure.

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Changing the Run/Standby Modes

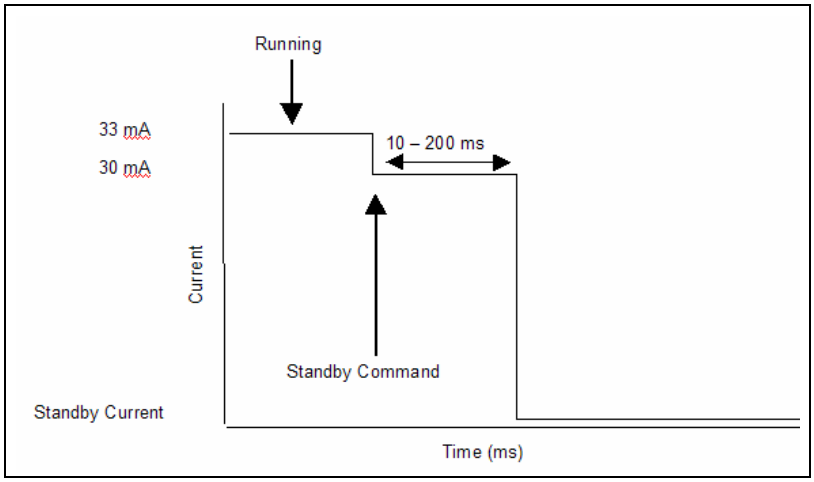
There are two methods you can follow to switch the receiver between the Run Mode and the Standby Mode. Only one of these methods may be used at a time.

1. Using the XSTANDBY pin or
2. Using the serial ports under user control

Note – *If you are using the XSTANDBY pin, do not use the serial ports for controlling the modes. If you are using the serial port option, the XSTANDBY pin should always be held high. You cannot use serial ports to switch to RUN mode if the XSTANDBY pin was used to enter STANDBY mode.*

Copernicus Standby Current

When the Copernicus GPS Receiver is sent a command to go into Standby Mode, there is a period of time between 10 and 200 ms (milli seconds) when the power supply still has to supply almost full operating current. Only after this period has elapsed will the current draw go down to the specified standby current which is typically 8.5 uA (micro Amps).



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Using the XSTANDBY Pin to Switch Modes

The first method for putting the receiver into Standby Mode or exiting this mode back to the Run Mode is through the pin XSTANDBY, pin #16. As long as the pin is held high, the receiver will operate normally in Run Mode.

Entering Standby Mode

When the pin is taken low, the receiver will go to the STANDBY mode.

Exiting Standby Mode

When the pin is taken high again, the receiver will perform a hot or warm restart and return to normal operation. The receiver will hot start if the ephemeris is still valid.

Note – *Excessive noise on the XSTANDBY pin could trigger the receiver to reset.*

Using Serial Ports to Switch Modes

The second method for putting the receiver into Standby Mode is with TSIP packet 0xC0 or NMEA packet RT.

There are two possible conditions that would trigger the receiver to exit Standby Mode and reset to normal operations:

1. Serial port activity
2. Exit after X elapsed seconds

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Serial Port Activity

When the receiver enters Standby Mode through the software protocol commands, the first condition for exiting Standby Mode is using serial port A activity or serial port B activity. The condition is identical for both ports A and B.

To ensure the receiver detects and responds to serial port activity, issue a NULL character on the selected serial port to bring the unit out of Standby Mode. In Standby Mode, the receiver samples for serial port activity at a rate of 32.768 kHz. A NULL character will bring the selected RX line low for 9 bits so even at the highest baud rate of 115200, a NULL character should be detectable at the sample rate.

There are two exceptions where serial activity may not trigger the unit to exit Standby Mode:

- During the 3 seconds following the command to enter Standby Mode.

  The Copernicus GPS receiver may not detect serial port activity during the 3 seconds immediately after receiving a software command to enter Standby Mode. During that 3 seconds, the unit is processing the shut-down command and will ignore serial port activity. Therefore the minimum time between issuing the shut-down command and the use of serial port activity to return the unit to Run Mode is 3 seconds. Standby time cannot be less than 3 seconds.

- During the 10 msec RTC service time.

  During the 10 msec RTC service time, there exists a 91.6 µsec window where the receiver cannot detect serial port activity. Using a series of three NULL characters in a row should ensure that the unit responds. (See 18-Hour RTC Roll Over, page 58 for an explanation of the RTC service time.)

Exit after X elapsed seconds.

The second condition that will trigger the receiver to exit Standby Mode is the elapse of a pre-defined time. When the receiver is placed into the Standby Mode using protocol commands, the receiver can be made to exit the Standby Mode after a defined elapsed time using TSIP command Packet 0xC0 or NMEA packet RT. In this case, the user specifies the number of seconds the receiver should stay in Standby Mode. After this time has elapsed, the unit will perform a reset and start operating normally.

Note – *These conditions are provided to the receiver in the serial command packet, and the user can specify any combination of these conditions as desired. For exiting the Standby Mode, either of the 2 methods can be applied. The first one that occurs will bring the receiver to the RUN Mode to start normal operations.*

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18-Hour RTC Roll Over

If the Standby Mode lasts longer than 18 hours, a special condition will occur. The real-time clock has a maximum time count of 18 hours, so that every 18 hours the receiver must briefly power on the processor and read the elapsed time before the real-time clock rolls over.

The Diagram below describes the Copernicus GPS Receiver current draw levels after initiating a Standby command, as well as the service time for the 18-hour real time clock roll over.

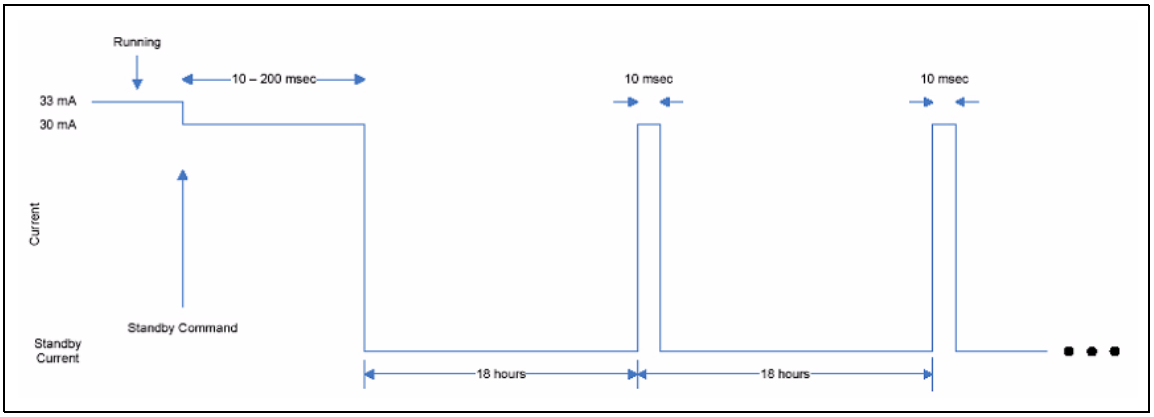


Figure 4.1 Current Draw Levels in Standby Mode

During the 10 msec RTC service is time, there exists a 91.6 µsec window where the receiver cannot detect state transitions on the RX pins. If NULL characters are being used to bring the unit out of Standby as described earlier, using three NULL characters in a row should ensure that one of the NULL characters happens outside of the vulnerable window so that the serial port activity is detected.

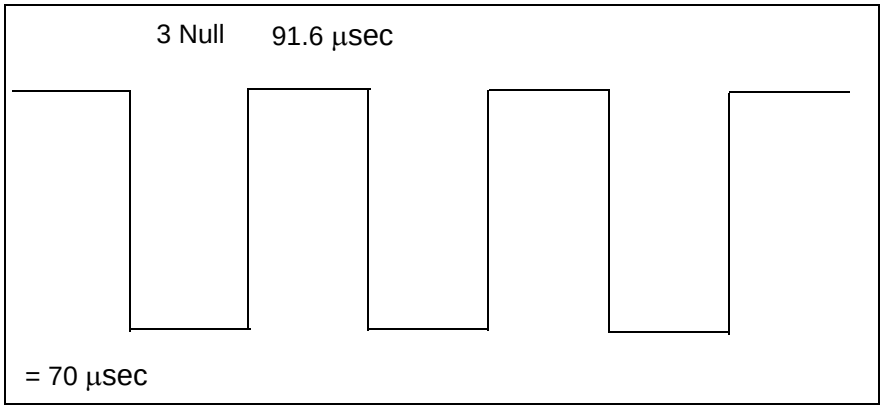


Figure 4.2 Issuing three (3) NULL Characters for Exiting Standby Mode

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Saving Almanac, Ephemeris and Position to Flash Memory

The Almanac, Ephemeris, and recent Position data contained in RAM is automatically saved to Flash memory.

Graceful Shutdown

The Graceful Shutdown command is issued using TSIP packet 0xC0 or NMEA command RT with the store RAM to flash flag enabled. The reset type will depend on the Graceful Shutdown command parameters. On start-up, the unit will use the almanac, ephemeris, and position from RAM first. If RAM is not available, the unit will use the almanac from the Flash Memory.

SBAS

The Satellite Based Augmentation System (SBAS) includes implementation of the current standard for WAAS and the European Geostationary Navigation Overlay Service (EGNOS) operated by the European Space Agency and other compatible systems that will come online in the future.

WAAS

Wide Area Augmentation System (WAAS) is an extremely accurate navigation system developed for civil aviation by the Federal Aviation Administration (FAA). The system augments GPS to provide the additional accuracy, integrity, and availability necessary to enable users to rely on GPS for all phases of flight for all qualified airports within the WAAS coverage area.

The worst-case accuracy is within 7.6 meters of the true position 95% of the time. This is achieved via a network of ground stations located throughout North America, which monitor and measure the GPS signal. Measurements from the reference stations are routed to two master stations, which generate and send the correction messages to geostationary satellites. Those satellites broadcast the correction messages back to Earth, where WAAS-enabled GPS receivers apply the corrections to their computed GPS position.

Number of channels

The Copernicus GPS Receiver tracks one WAAS satellite at a time. When acquiring and tracking a WAAS satellite, one tracking channel is set aside for this purpose, leaving eleven tracking channels which are used for the GPS satellites.

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Acquisition

The Copernicus GPS Receiver will acquire a WAAS satellite after it has a GPS-based position fix. After a two minute position fix outage, the Copernicus module will stop tracking and acquiring the WAAS satellite. The WAAS satellite will be re-acquired after a GPS-based position fix is re-established.

Usage

The Copernicus GPS Receiver will only use the data from a WAAS satellite for position fix corrections. It shall not use a WAAS satellite for the position solution computation.

Almanac collection

The Copernicus GPS Receiver collects WAAS almanac data and automatically stores the WAAS Satellite location, and abbreviated almanac and health data to BBRAM and NVS storage.

Ephemeris collection

The Copernicus GPS Receiver will NOT collect or store WAAS ephemeris data. The module stores 1 set of WAAS corrections.

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CHAPTER

5

APPLICATION CIRCUITS

In this chapter:

- Passive antenna—Minimum Connections
- Active Antenna—Full Connection
- Active Antenna—No Antenna Status

This chapter describes the Copernicus GPS Receiver passive and active antenna connections.

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Passive antenna—Minimum Connections

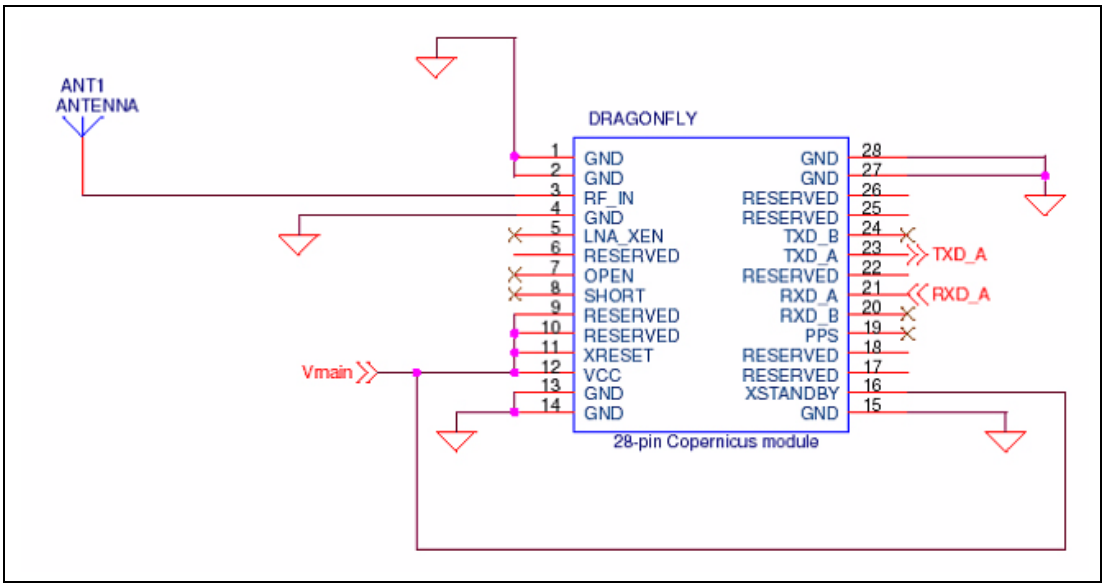


Figure 5.1 Passive Antenna - Minimum Connections

The minimum connection set for the Copernicus GPS Receiver is illustrated in Figure 5.1. Following is a description of the schematic.

- A passive antenna is used. The Copernicus GPS Receiver has an on-board LNA and an Automatic Gain Control circuit.
- The Pin LNA_XEN is not necessary and not connected.
- No Antenna open and short detection or protection is provided.
- If the Open (Pin 7) and Short (Pin 8) are kept unconnected (floating), the Copernicus GPS Receiver reports an open antenna condition. If a normal condition report is desired, tie Open low and Short high. (See Table 3.2).
- There is no HW reset ability through the pin XRESET, since XRESET pin is tied High to VCC.
- There is no HW initiated Standby Mode through the Pin XSTANDBY, since XSTANDBY pin is tied High to VCC. The software serial command to Standby Mode will still apply.
- There is no separate power for STANDBY power.
- One serial port is utilized.

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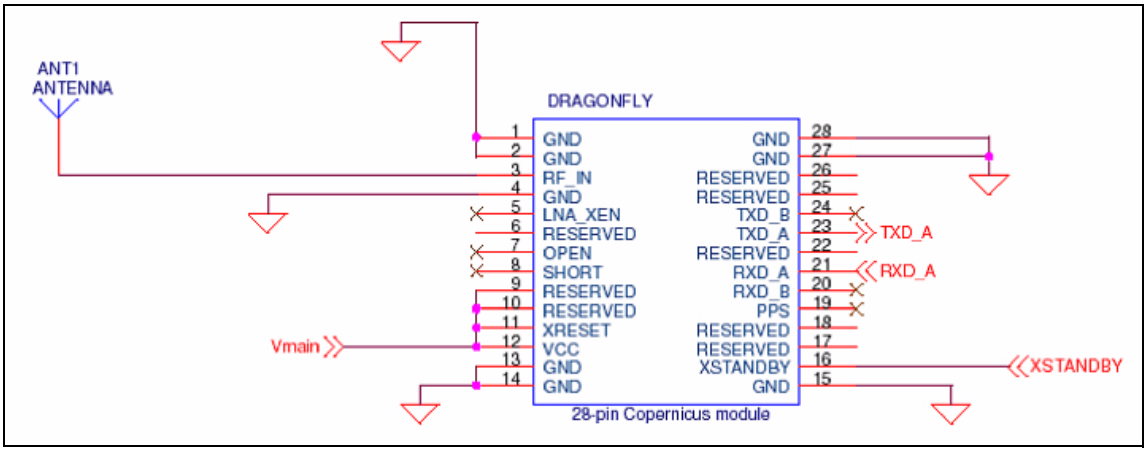


Figure 5.2 Passive antenna - HW Activated Standby Mode Available

Following is a description of the schematic:

- Passive Antenna is used. The Copernicus GPS Receiver has an on-board LNA and an Automatic Gain Control circuit.
- The Pin LNA_XEN is not necessary and not connected.
- There is no HW reset ability through the pin XRESET, since XRESET pin is tied High to VCC.
- HW initiated Standby Mode through the Pin XSTANDBY is possible, since XSTANDBY pin is not tied High to VCC. The software serial command to Standby Mode can still be used as a second method to force the module into Standby Mode.
- There is no separate power for STANDBY power.
- One serial port is utilized.
- No Antenna open and short detection or protection is provided. When Open (Pin 7) and Short (Pin 8) are kept unconnected (floating), the Copernicus GPS Receiver reports an open antenna condition. If a normal condition is desired, tie Open Low and Short High. See Table 3.2.

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Active Antenna—Full Connection

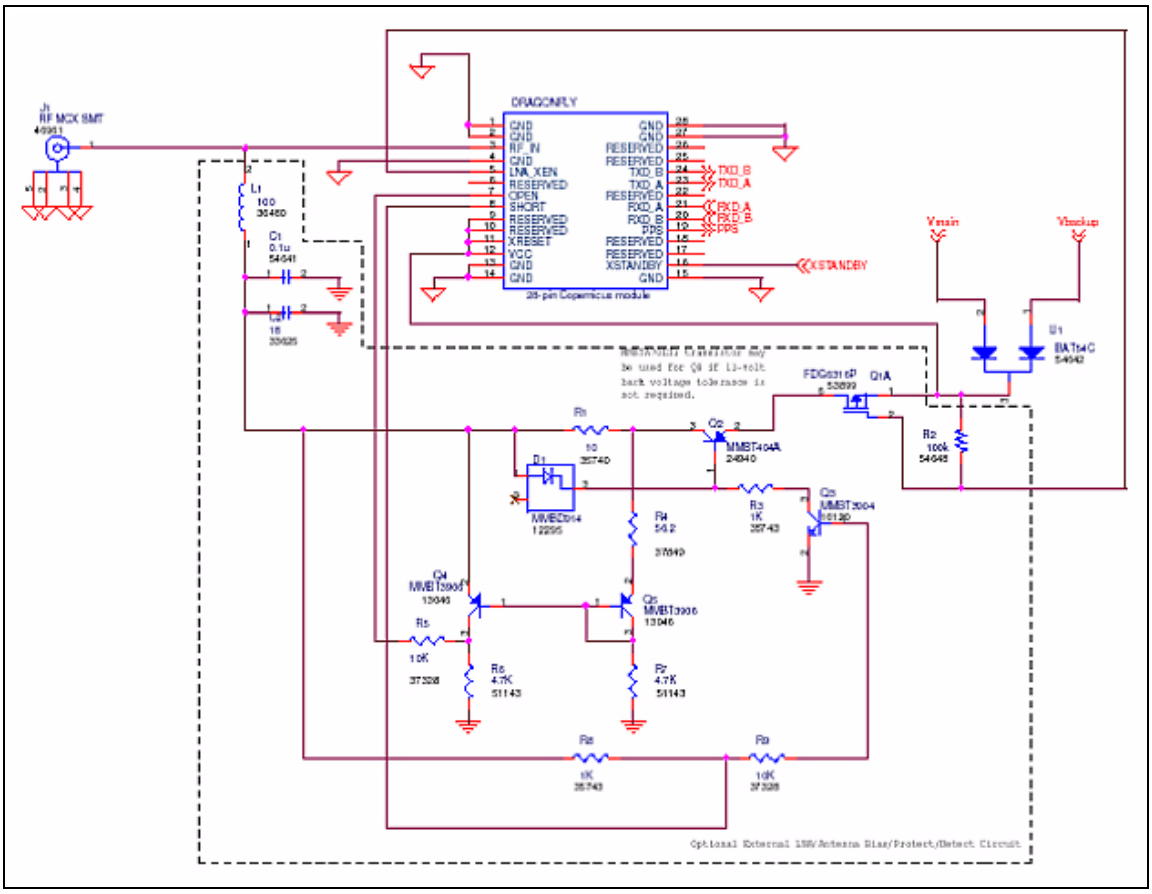


Figure 5.3 Active antenna - Full connection

Following is a description of the schematic with antenna detection, when using a second source to power the unit when in Standby Mode.

- An active antenna is used.
- The Pin LNA_XEN is connected.
- HW reset ability through the pin XRESET is possible, since XRESET pin is not tied High to VCC.
- HW initiated Standby Mode through the Pin XSTANDBY is possible, since XSTANDBY pin is not tied High to VCC. Serial Command to Standby Mode can still apply as the second method to force the module to Standby Mode.
- A second power source for the standby voltage is applied (see the note below).
- Both serial ports are utilized.

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- Antenna open and short detection and protection is provided. The combination of the two pins Open (Pin 7) and Short (Pin 8) report the antenna status (see Table 3.2).

Note – *When using two power sources, main and standby, an external diode pair must be used to OR the Vcc and Vbackup power to ensure that the voltage at the module VCC pin is always 2.7-3.3 VDC.*

Table 5.2 Component Information

Component	Description	Manufacturer	Part Number
C1	18 PF, 0402 capacitor, C0G	KEMET	C0402C180J5GAC
C2	0.1 uF, 0402 capacitor, X7R	CAL-CHIP	GMC04X7R104K16NTLF
J1	MCX Connector	Johnson Components	133-3711-312
L1	100 nH, 0603 inductor, surface mount	Coil Craft	0603CS - R10XJLU
Q2	PNP Transistor	Central Semiconductor	CMPT404A (MMBTA70LT1 may be used if 12 Volt back voltage tolerance is not required)
Q3	NPN Transistor	Philips	MMBT3904
Q4	PNP Transistor	Philips	MMBT3906
Q5	PNP Transistor	Philips	MMBT3906
U1	Dual schottky diode	Diodes Inc.	BAT 54 CT
DI	Switching Diode	ON Semiconductor	MMBD914LTIG

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Active Antenna—No Antenna Status

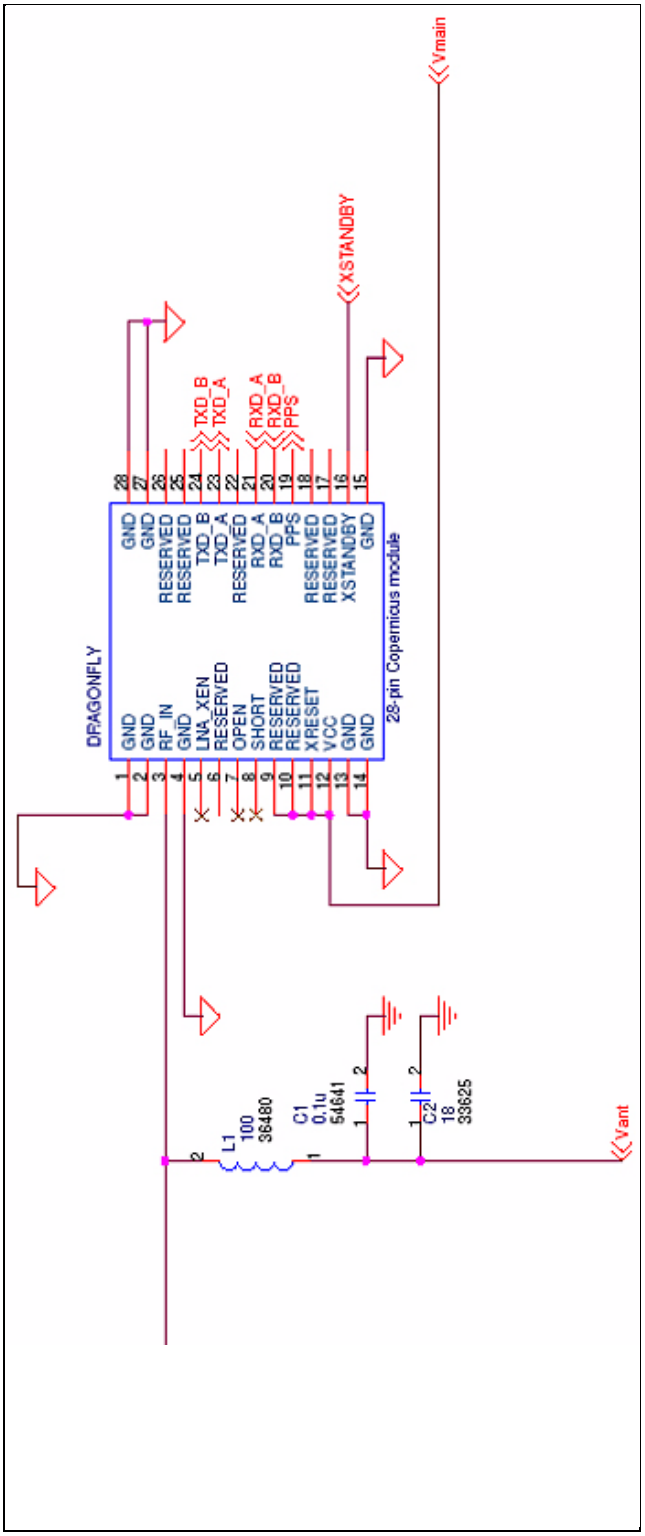


Figure 5.4 Active antenna - No Antenna Status

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Following is a description of this schematic without antenna detection or a separate power source for Standby Mode:

- An active Antenna is used.
- The Pin LNA_XEN is not connected.
- There is no HW reset ability through the pin XRESET, since XRESET pin is tied High to VCC.
- HW initiated Standby Mode through the Pin XSTANDBY is possible, since XSTANDBY pin is not tied High to VCC. Serial Command to Standby Mode can still apply as the second method to force the module to Standby Mode.
- There is no separate power for STANDBY power.
- Both serial ports are utilized.
- Antenna open and short detection or protection is not provided. If pins 7 and 8 are left floating, they will cause the unit to report an antenna open condition (see Table 3.2).

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CHAPTER

6

RF LAYOUT CONSIDERATIONS

In this chapter:

- General Recommendations
- Design considerations for RF Track Topologies
- PCB Considerations

This chapter outlines RF design considerations for the Copernicus GPS Receiver.

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General Recommendations

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

The radio frequency (RF) input on the Copernicus GPS module is a 50 ohm, unbalanced input. There are ground castellations, pins 2 and 4, on both sides of the RF input castellation, on pin 3. This RF input may be connected to the output of an LNA which has a GPS antenna at its input or to a passive antenna via a low-loss 50 ohm, unbalanced transmission line system.

In the case where the GPS antenna must be located any significant distance from the Copernicus GPS Receiver, the use of an LNA at the antenna location is necessary to overcome the transmission losses from the antenna to the Copernicus GPS module. It is recommended that in the case of a passive antenna, the transmission line losses from the antenna to the module be less than 2 dB. Otherwise an LNA should be added to the system.

The specifications for the external LNA required can be determined as follows. The specification of noise figure for the Copernicus GPS module is 3 dB at room temperature and 4 dB over the temperature range –40 C to ±85 C. The noise figure for this external LNA should be as low as possible, with a recommended maximum of 1.5 dB. It is recommended that the gain of this LNA exceed the loss as measured from the LNA output to the module input by 10 dB. For example, if the loss from the external LNA output is 10 dB, the recommended minimum gain for the LNA is 20 dB. In order to keep losses at the LNA input to a minimum, it is recommended that the antenna be connected directly to the LNA input, with as minimum loss as possible.

Connections to either the LNA output or to a passive antenna must be made using a 50 ohm unbalanced transmission system. This transmission system may take any form, such as microstrip, coaxial, stripline or any 50 ohm characteristic impedance unbalanced, low-loss system.

It is important to keep any noise sources with frequencies at or near 1575 MHz away from the RF input. In the case of a passive antenna, it is important that the antenna is not placed in a noisy location (such as too close to digital circuitry) or performance may be degraded. Shielded transmission line systems (stripline, coaxial) may be used to route this signal if noise ingress is a concern.

If an active antenna is used and it is desired to power this antenna from the RF transmission line, a bias-tee will be required at the Copernicus GPS module end. A simple series inductor (that is parallel resonant at 1575 MHz) and shunt capacitor (series resonant at 1575 MHz) to which the bias voltage is supplied is sufficient. An open/short detection and over current protection circuit may also be employed. Please see Chapter 5, APPLICATION CIRCUITS.

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In the printed circuit board (PCB) layout, it is recommended to keep the copper layer on which the Copernicus GPS Receiver is mounted clear of solder mask and copper (vias or traces) under the module. This is to insure mating of the castellations between the Copernicus GPS module and the board to which it is mounted, and that there is no interference with features beneath the Copernicus GPS Receiver causing it to lift during the re-flow solder process.

For a microstrip RF transmission line topology, it is recommended that the layer immediately below the one to which the Copernicus GPS Receiver is mounted be ground plane. Pins 2 and 4 should be directly connected to this ground plane with low inductance connections. Pin 3, the RF input, can be routed on the top layer using the proper geometry for a 50 ohm system.

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Design considerations for RF Track Topologies

The following items need to be considered for the Copernicus GPS Receiver RF layout:

- PCB track connection to the RF antenna input must have impedance of 50 ohms.
- PCB track connection to the RF antenna input must be as short as possible.
- If an external antenna is used, PCB track connection to the RF antenna input must transition from the circuit board to the external antenna cable, which is typically a RF connector.
- If there are any ground planes on the same layer as the microstrip trace, please refer to the Coplaner Waveguide design. Not covered in this manual.
- PCB track connection to the RF antenna input must be routed away from potential noise sources such as oscillators, transmitters, digital circuits, switching power supplies and other sources of noise.
- RF and bypass grounding must be direct to the ground plane through its own low-inductance via
- Active or passive antennas may be used. If using a passive antenna the connection to the antenna input shall be very short. It is possible to mount the patch antenna on the same PCB as the Copernicus GPS module. Designers must be aware of noise generating circuitry and proper design precautions taken (shielding,.).

The PCB track connection to the RF antenna input must not have:

- Sharp bends.
- Components overlaying the track.
- Routing between components to avoid undesirable coupling.

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PCB Considerations

The minimum implementation is a two-layer PCB substrate with all the RF signals on one side and a solid ground plane on the other. Multilayer boards can also be used.

Two possible RF transmission line topologies include microstrip and stripline.

Microstrip Transmission Lines

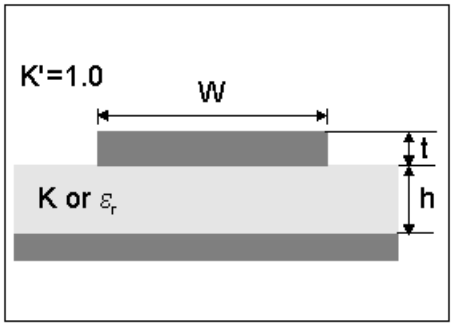


Figure 6.1 Microstrip Transmission Lines

Ground Plane Design Recommendation

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

Design of Microstrip Transmission Line

Connections to either the LNA output or to a passive antenna must be made using a 50 ohm unbalanced transmission system. The PCB parameters that affect impedance are:

- Track width (W)
- PCB substrate thickness (H)
- PCB substrate permittivity (ε_r)

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- To a lesser extent, PCB copper thickness (T) and proximity of same layer ground plane.

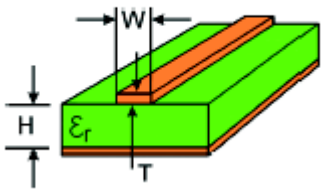


Figure 6.2 PCB Microstrip Topology

Table 6.1 shows typical track widths for an FR4 material PCB substrate (permittivity ε_r of 4.6 at 1.5 GHz) and different PCB thickness. One ounce copper is assumed for the thickness of the top layer. If a Multi layer PCB is used, the thickness is the distance from signal track to nearest ground plane.

Table 6.1 Typical Track Widths for an FR4 material PCB Substrate in Microstrip Topology

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

Microstrip Design Recommendations

It is recommended that the antenna connection PCB track be routed around the outside of the module outline, kept on a single layer and have no bends greater than 45 degrees. It is not recommended, for production reasons, to route the track under the module.

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Stripline Transmission Lines

.

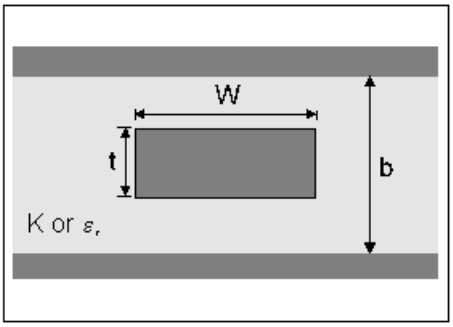


Figure 6.3 Stripline Transmission Lines

Ground plane design in stripline topology

- The stripline topology requires three PCB layers: two for ground planes and one for signal. One of the ground plane layers may be the layer to which the Copernicus GPS module is mounted. If this is the case,
- The top layer must be flooded with ground plane and connected to all ground castellations on the Copernicus GPS module.
- The RF input should be connected to the signal layer below using a via.
- The layer below the signal layer is the second ground plane.
- Connect the two ground planes with vias typically adjacent to the signal trace.
- Other signals of the Copernicus GPS module may be routed to additional layer using vias.

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

Table 6.2 Typical track widths for an FR4 material PCB substrate in Stripline topology

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

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CHAPTER

7

MECHANICAL SPECIFICATIONS

In this chapter:

- Mechanical Outline Drawing
- Soldering the Copernicus GPS Receiver to a PCB

This chapter provides product drawings and instructions for soldering the Copernicus GPS Receiver to a PCB.

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Mechanical Outline Drawing

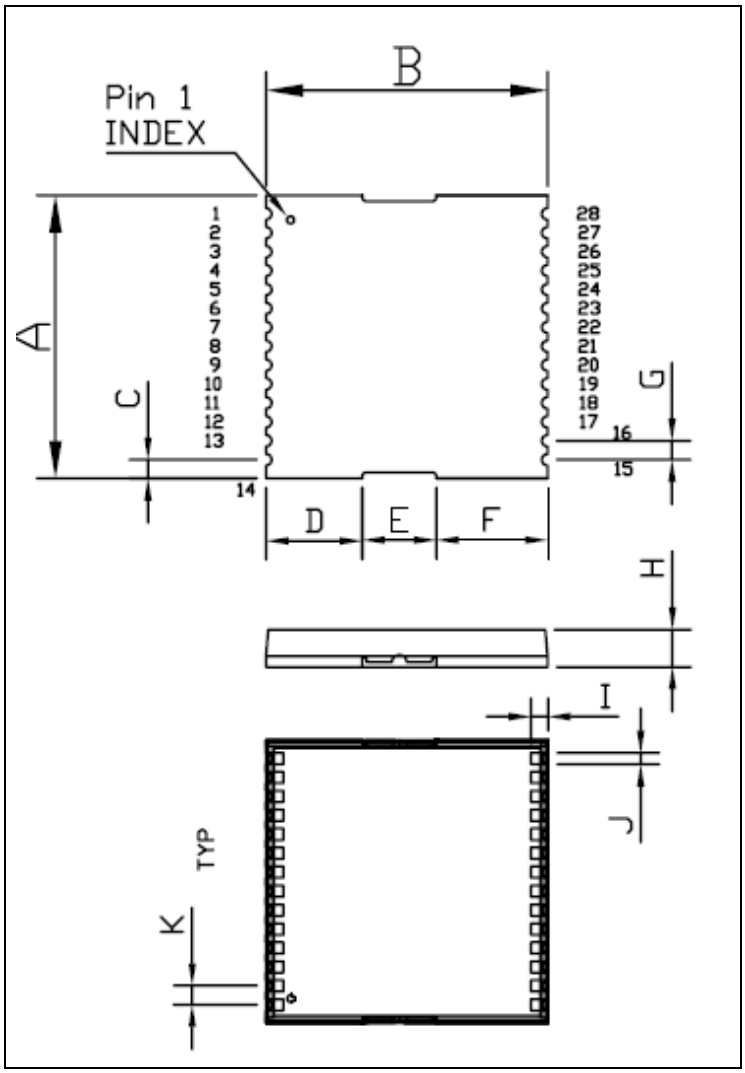


Figure 7.1 Copernicus GPS Receiver, Footprint

Outline Dimensions (Inch ±0.004 / mm ±0.10)

A	B	C	D	E	F	G	H	I	J	K
0.75	0.75	0.049	0.256	0.197	0.295	0.050	0.100	0.045	0.030	0.050
19.00	19.00	1.25	6.50	5.00	7.50	1.27	2.54	1.14	0.76	1.27

Figure 7.2 Copernicus GPS Receiver, Outline Dimensions

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Soldering the Copernicus GPS Receiver to a PCB

Solder mask

When soldering the Copernicus GPS Receiver to a PCB, keep an open cavity underneath the Copernicus module (i.e., do not place copper traces or solder mask underneath the module). The diagram below illustrates the required user solder mask. The units in brackets, [ ], are in millimeters.

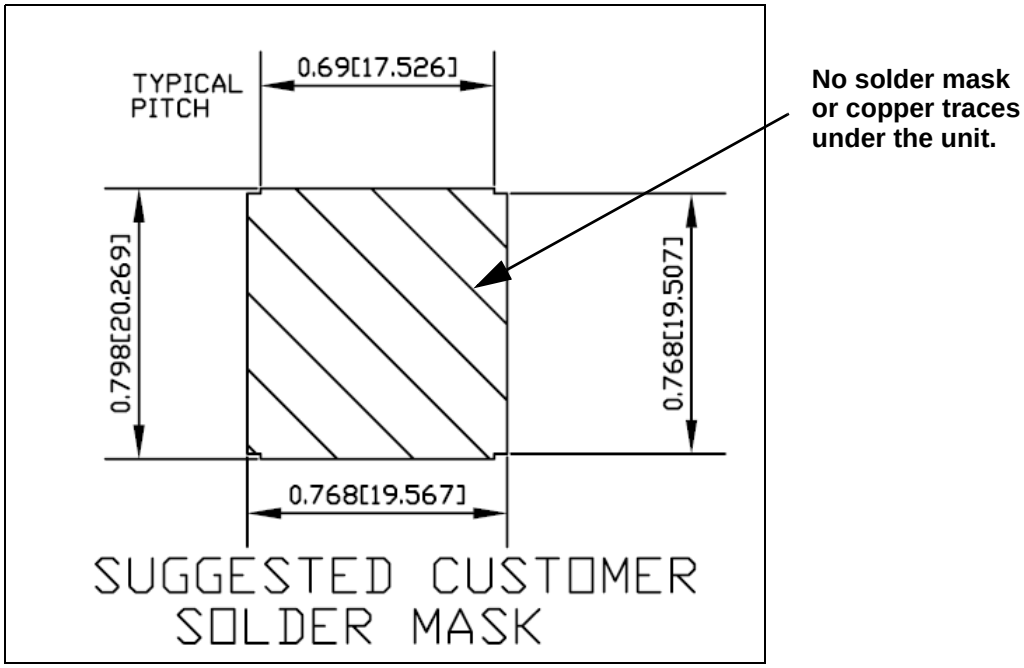


Figure 7.3 Solder Mask Diagram

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Pad Pattern

Below is the required user pad pattern. The units in brackets, [ ], are in millimeters.

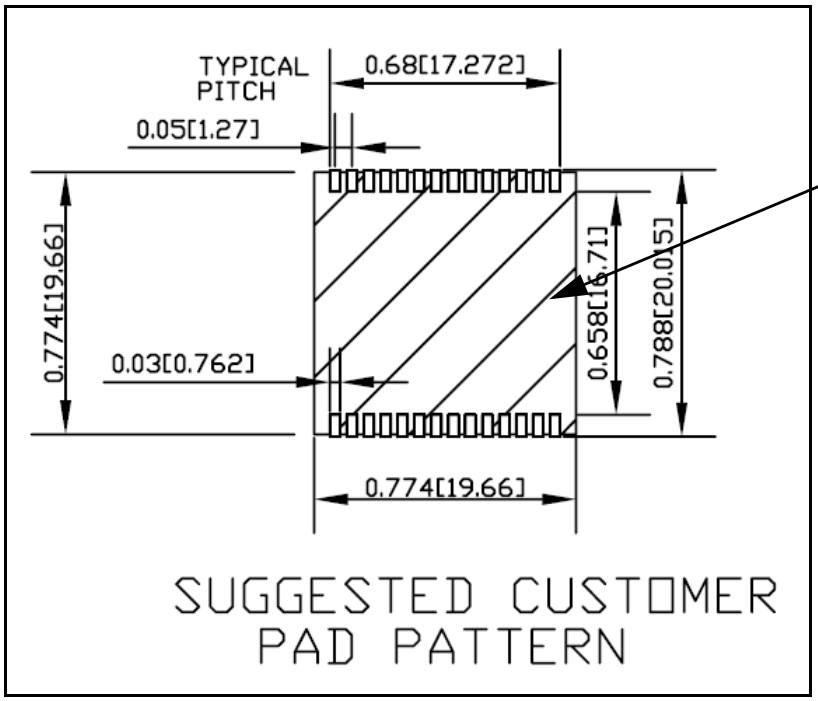


Figure 7.4 Pad Pattern Diagram

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Paste Mask

To ensure good mechanical bonding with sufficient solder to form a castellation solder joint, use a solder mask ratio of 1:1 with the solder pad. When using a 5 ±1 Mil stencil to deposit the solder paste, we recommend a 4 Mil toe extension on the stencil. The units in brackets, [ ], are in millimeters.

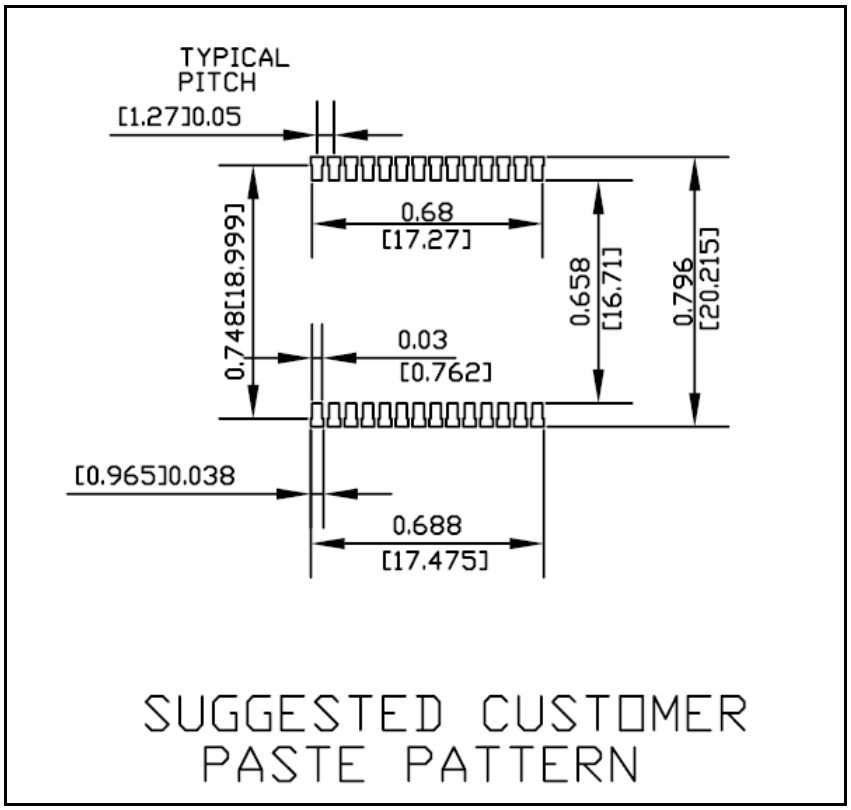


Figure 7.5 Paste Mask Diagram

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CHAPTER

8

PACKAGING

In this chapter:

- Introduction
- Reel
- Tapes

Follow the instructions in this chapter to ensure the integrity of the packaged and shipped Copernicus GPS Receiver modules.

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Introduction

The Copernicus GPS modules is packaged in tape and reel for mass production. The reel is sealed in a moisture proof Dry Pack bag. Please follow all the directions printed on the package for handling and baking.

The Copernicus GPS modules are packaged in two quantities: reel with 100 pieces and reel with 500 pieces.

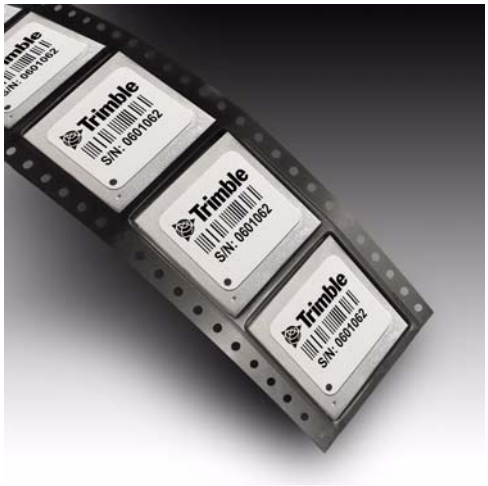


Figure 8.1 Copernicus GPS Receiver Packaged in Tape

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Reel

The 13-inch reel that can be mounted in a standard feeder for the surface mount pick and place machine. The reel dimensions are the same regardless of the quantity on the reel.

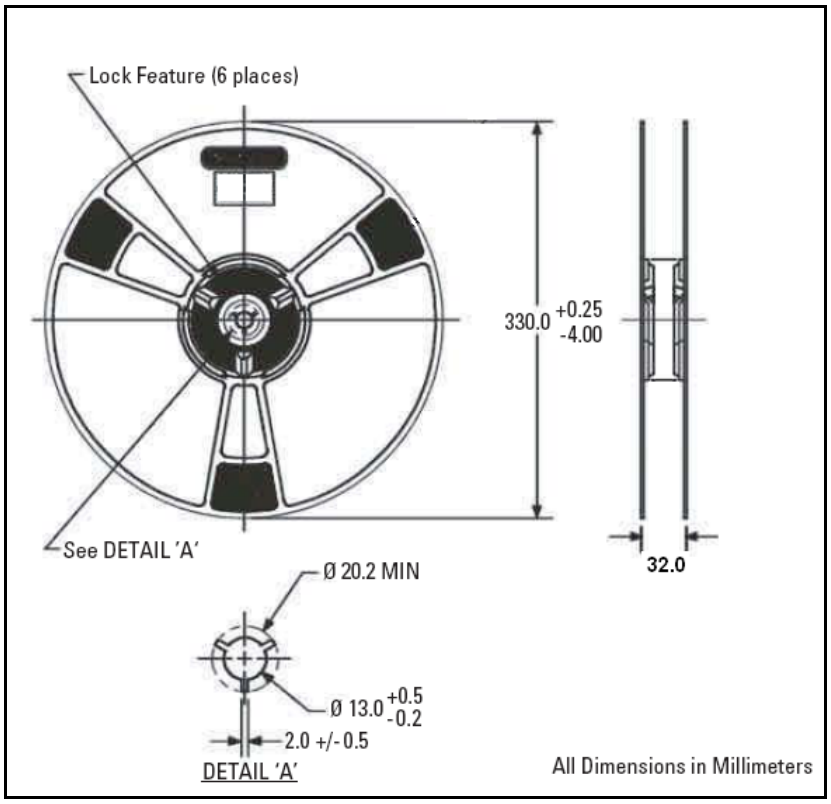


Figure 8.2 Reel Diagram

Weight

100 pcs with reel packaging + desiccant + humidity indicator = approximately 0.79Kg (1.74 lbs.)

500 pcs with reel packaging + desiccant + humidity indicator = approximately 1.47Kg (3.24 lbs.)

100 pcs with reel packaging + desiccant + humidity indicator + white pizza box = approximately 1.02Kg (2.24 lbs.)

500 pcs with reel packaging + desiccant + humidity indicator + white pizza box = approximately 1.70Kg (3.74 lbs.)

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Tapes

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

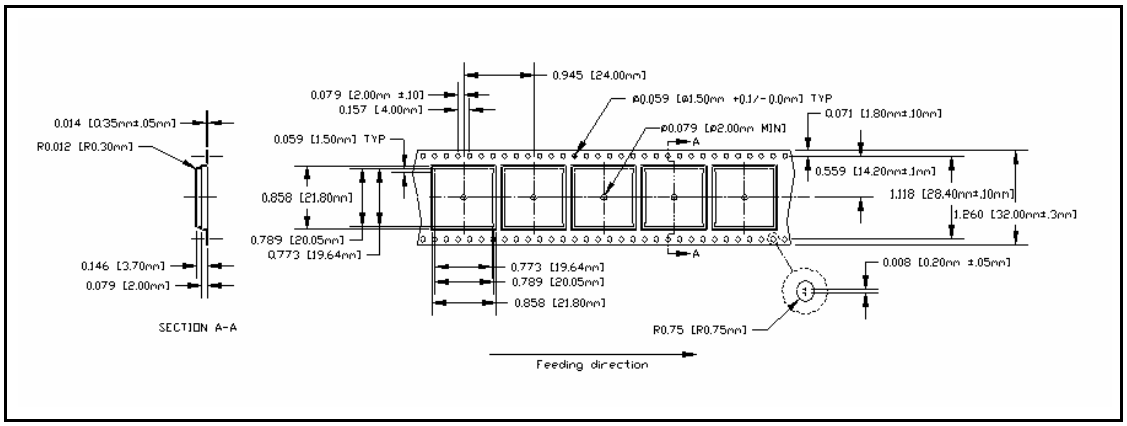


Figure 8.3 Tape Diagram

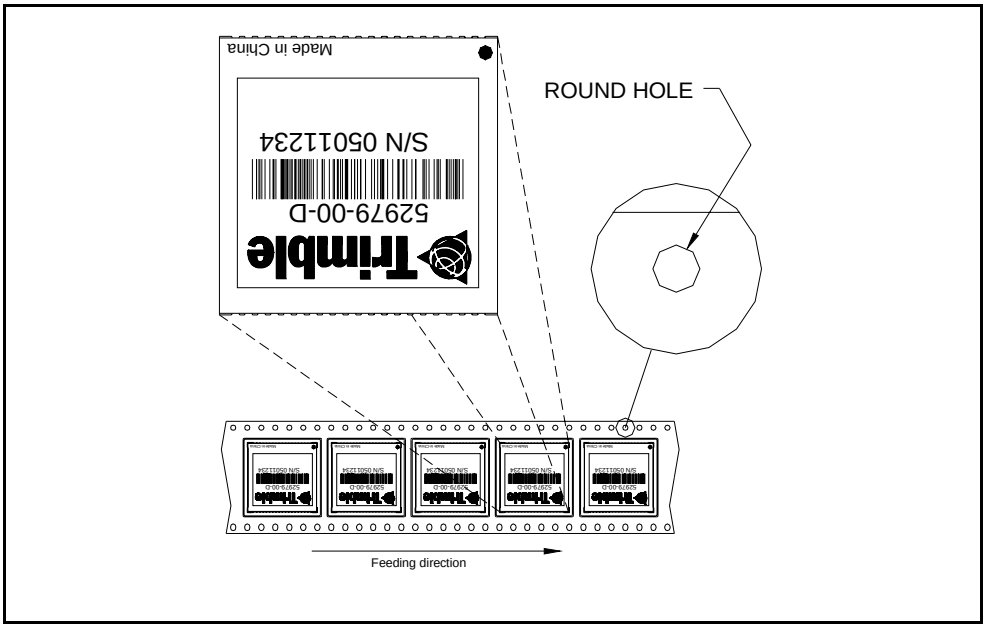


Figure 8.4 Feeding Direction Diagram

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CHAPTER

9

SHIPPING and HANDLING

In this chapter:

- Shipping and Handling Guidelines
- Moisture Precondition
- Baking Procedure
- Soldering Paste
- Solder Reflow
- Recommended Soldering Profile
- Optical Inspection
- Cleaning
- Soldering Guidelines
- Rework
- Conformal Coating
- Grounding the Metal Shield

This chapter provides detailed guidelines for shipping and handling the Copernicus GPS Receiver to ensure compliance with the product warranty.

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Shipping and Handling Guidelines

Handling

The Copernicus GPS module is shipped in tape and reel for use with an automated surface mount machine. This is a lead-free module with silver plating. Do not allow bodily fluids or lotions to come in contact with the bottom of the module.



WARNING – The Copernicus GPS module is packed according to ANSI/EIA-481-B and J-STD-033A. All of the handling and precaution procedures must be followed. Deviation from following handling procedures and precautions voids the warranty.

Shipment

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

Storage

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

Moisture Indicator

A moisture indicator is packed individually in each DryPac to monitor the environment. All five indicating spots are shown blue from the factory. If the indicator shows pink, follow the instructions printed on the indicator and bake as necessary. See Baking Procedure, page 90 for baking instructions.

Floor Life

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

The Copernicus GPS is a lead free component for RoHS compliance. This unit is also plated with immersion silver for better solderability. The silver may tarnish over time and show yellow in color, but tarnish should not affect the solderability.



WARNING – Operators should not touch the bottom silver solder pads by hand or with contaminated gloves. No hand lotion or regular chlorinated faucet water can be in contact with this module before soldering.

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Moisture Precondition

Precautions must be taken to minimize the effects of the reflow thermal stress on the module. Plastic molding materials for integrated circuit encapsulation are hygroscopic and absorb moisture dependent on the time and the environment. Absorbed moisture will vaporize during the rapid heating of the solder reflow process, generating pressure to all the interface areas in the package, followed by swelling, delamination, and even cracking of the plastic. Components that do not exhibit external cracking can have internal delamination or cracking which affects yield and reliability.

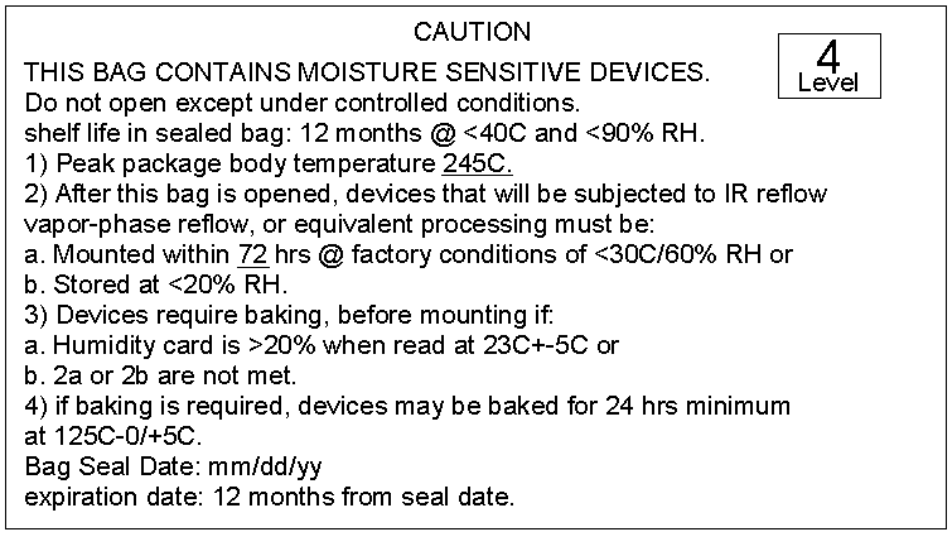


Figure 9.1 Moisture Precondition Label

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Baking Procedure

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

Temperature: 125 °C

Duration: 24 Hours.

After Baking: Store in a nitrogen-purged cabinet or dry box to prevent absorption of moisture.

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

Soldering Paste

The Copernicus GPS module itself is not hermetically sealed, Trimble strongly recommends using the “No Clean” soldering paste and process. The castellation solder pad on this module is plated with silver plating. Use Type 3 or above soldering paste to maximize the solder volume. An example is provided below.

Solder paste: Kester EM909

Alloy composition: Sn96.5Ag3Cu.5 (SAC305) 96.5% Tin/ 3%Silver/ 0.5% Copper

Liquidus Temperature:221 °C

Stencil Thickness: 5 Mil (0.005")

Stencil opening requires 4-mil toe over paste in the X and Y directions.

Note – *Consult solder paste manufacturer and the assembly process for the approved procedures.*

Solder Reflow

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

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

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

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Recommended Soldering Profile

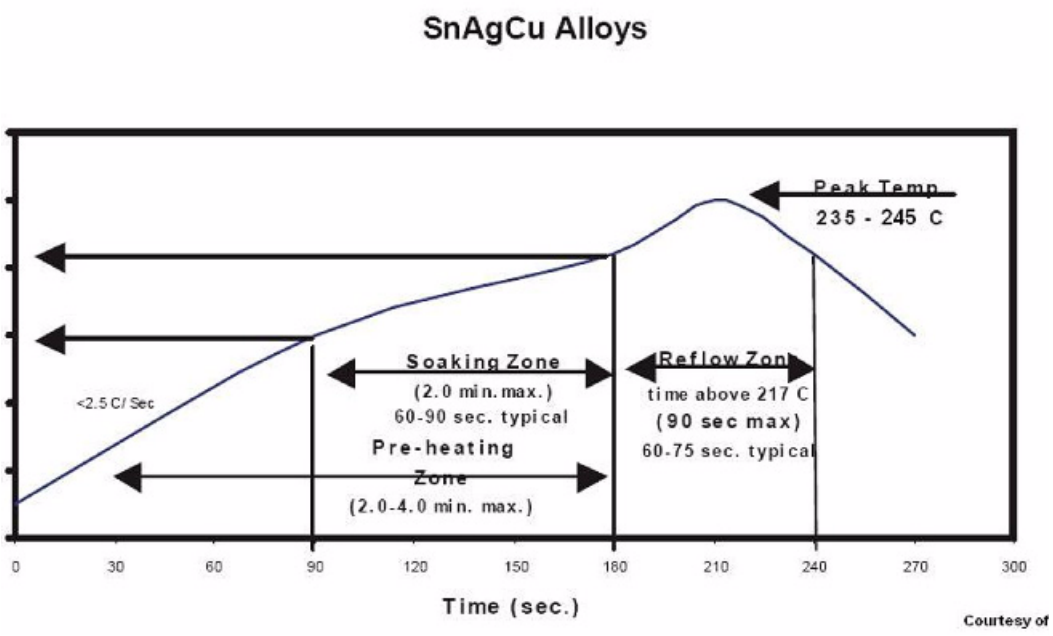


Figure 9.2 Recommended Soldering Profile

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

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

Optical Inspection

After soldering the Copernicus GPS module to the carrier board, follow IPC-610 specification to visually inspect using 3X magnification lens to verify the following:

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

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Cleaning

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

Soldering Guidelines

Repeated Reflow Soldering

The Copernicus GPS lead-free silver plated module can withstand two-reflow solder processes. If the unit must mount on the first side for surface-mount reflow, add glue on the bottom of the module to prevent falling off when processing the second side.

Wave Soldering

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

Hand Soldering

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

Rework

The Copernicus GPS module can withstand one rework cycle. The module can heat up to the reflow temperature to precede the rework. Never remove the metal shield and rework on the module itself.

Conformal Coating

Conformal coating on the Copernicus GPS module is not allowed. Conformal coating will void the warranty.

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Grounding the Metal Shield

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

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CHAPTER

10

COPERNICUS REFERENCE BOARD

In this chapter:

- Reference Board Block Diagram
- Reference Board Schematic (page 1 of 3)
- Reference Board Schematic (page 2 of 3)
- Reference Board Schematic (page 3 of 3)
- Reference Board I/O and Power Connector
- Reference Board Power Requirement
- Reference Board Jumper Table
- Reference Board Component Locations Drawing

This chapter provides schematics for the Copernicus GPS Receiver board.

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Introduction

The Copernicus surface-mount GPS receiver is installed on a carrier board defined as the Copernicus Reference Board. This board can also be used as a design reference, providing a visual layout of the Copernicus module on a PCB including the RF signal trace, RF connector, and the I/O connections of the 28 signal pins. The reference board demonstrates how an 8-pin header connector can be connected to the I/O and power sections of Copernicus, and how an RF connector can be attached to the RF section. An antenna open and short detection and protection application circuit has also been included on the reference board. The Copernicus GPS reference board is RoHS compliant (lead-free).



Figure 10.1 Copernicus Reference Board, Frontside

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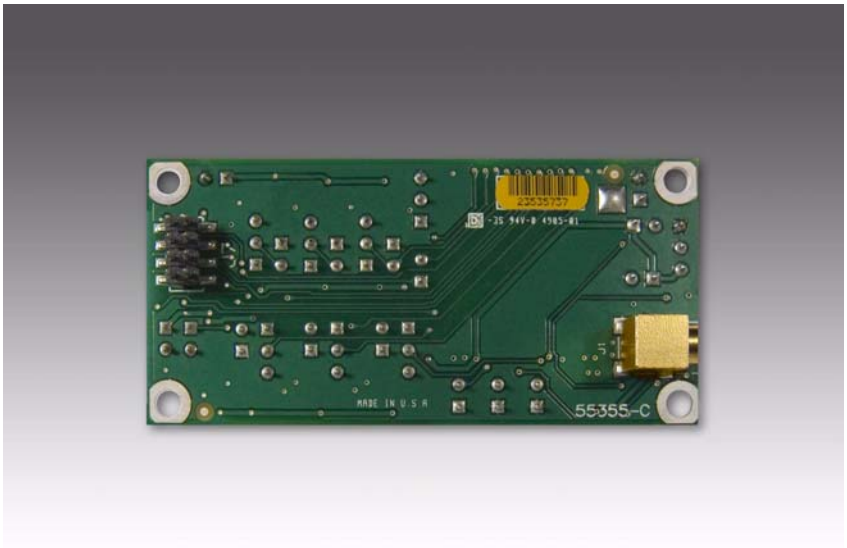
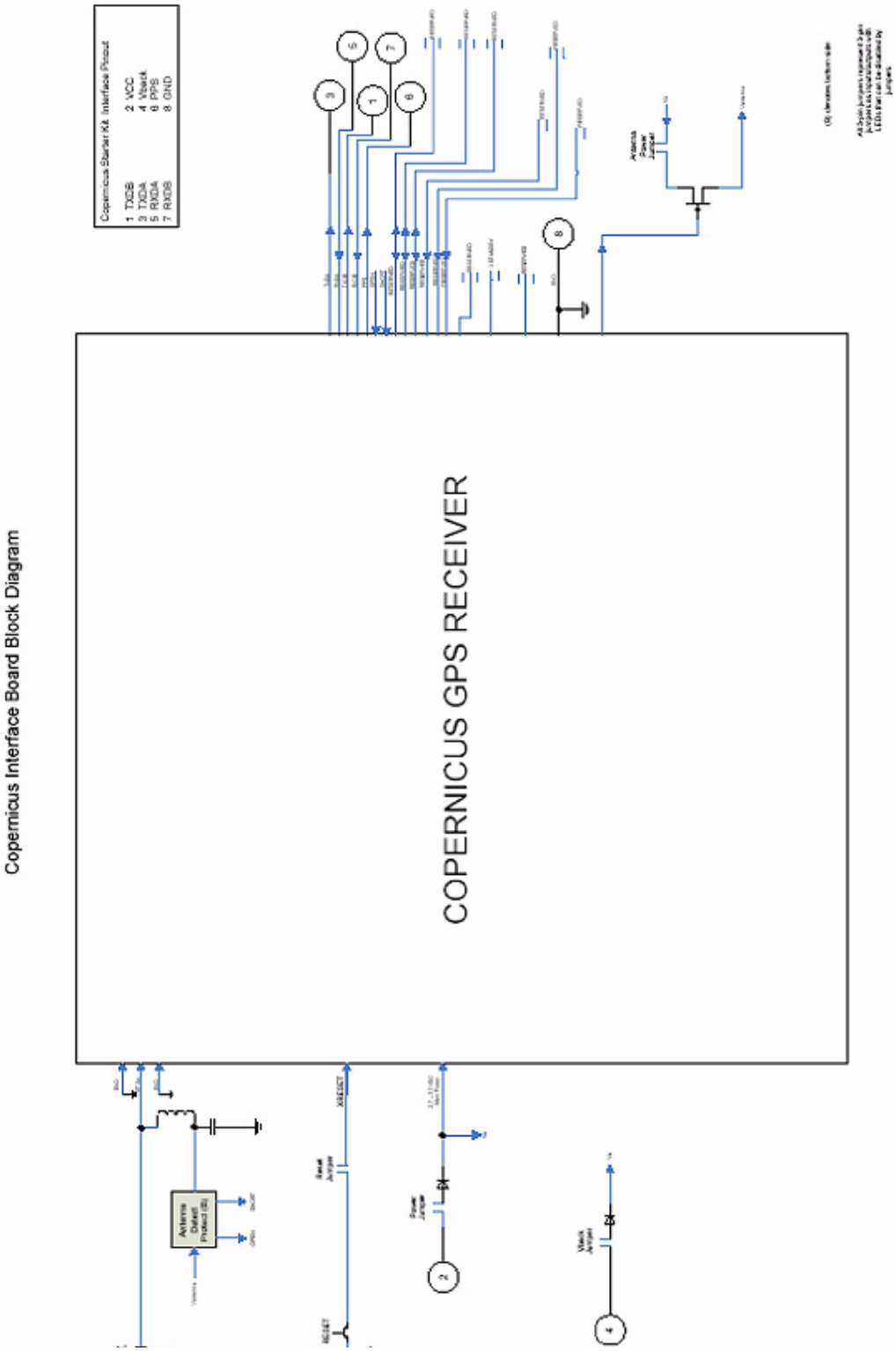


Figure 10.2 Copernicus GPS Reference Board, Backside

The Copernicus GPS reference board is installed on the starter kit motherboard to facilitate testing and evaluation of the Copernicus GPS Receiver. It provides everything the user needs to get started integrating state-of-the-art GPS capability into an application.

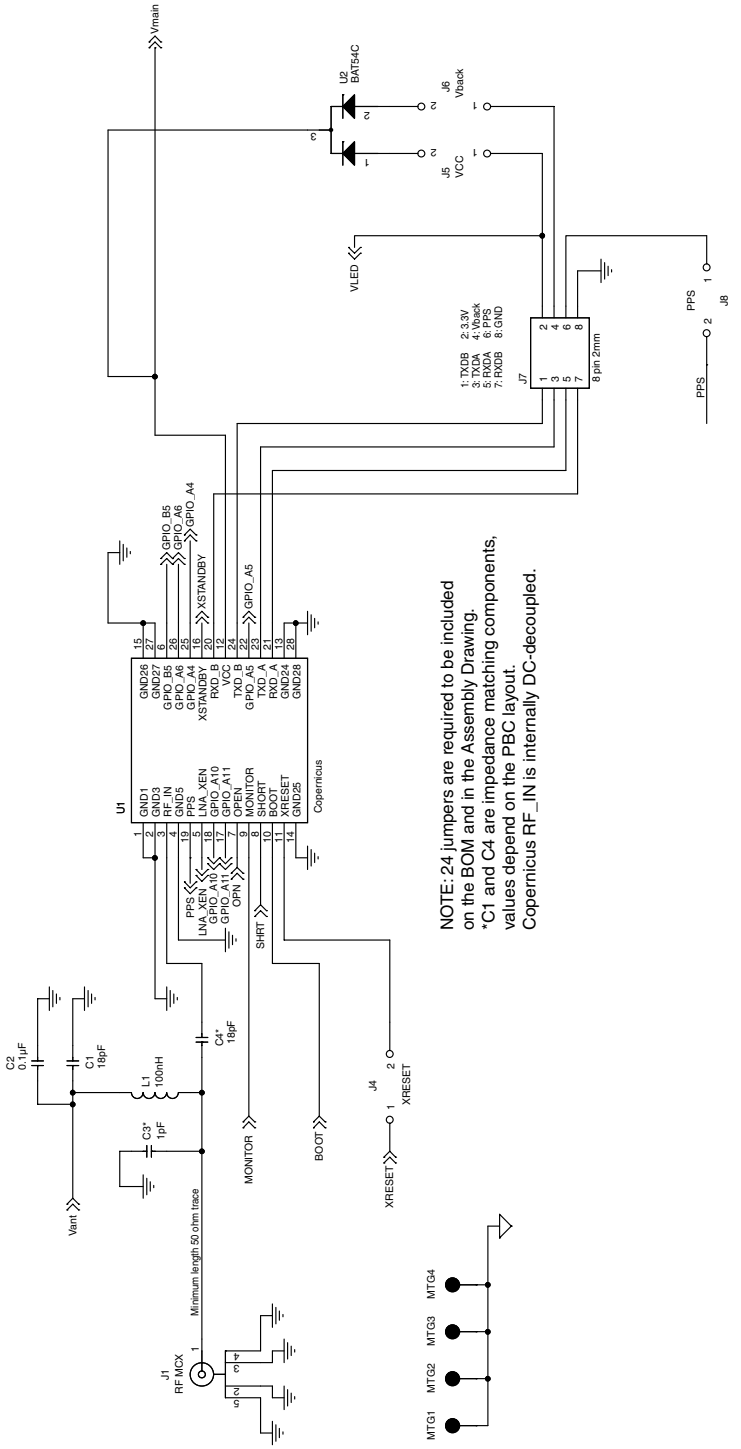
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Reference Board Block Diagram



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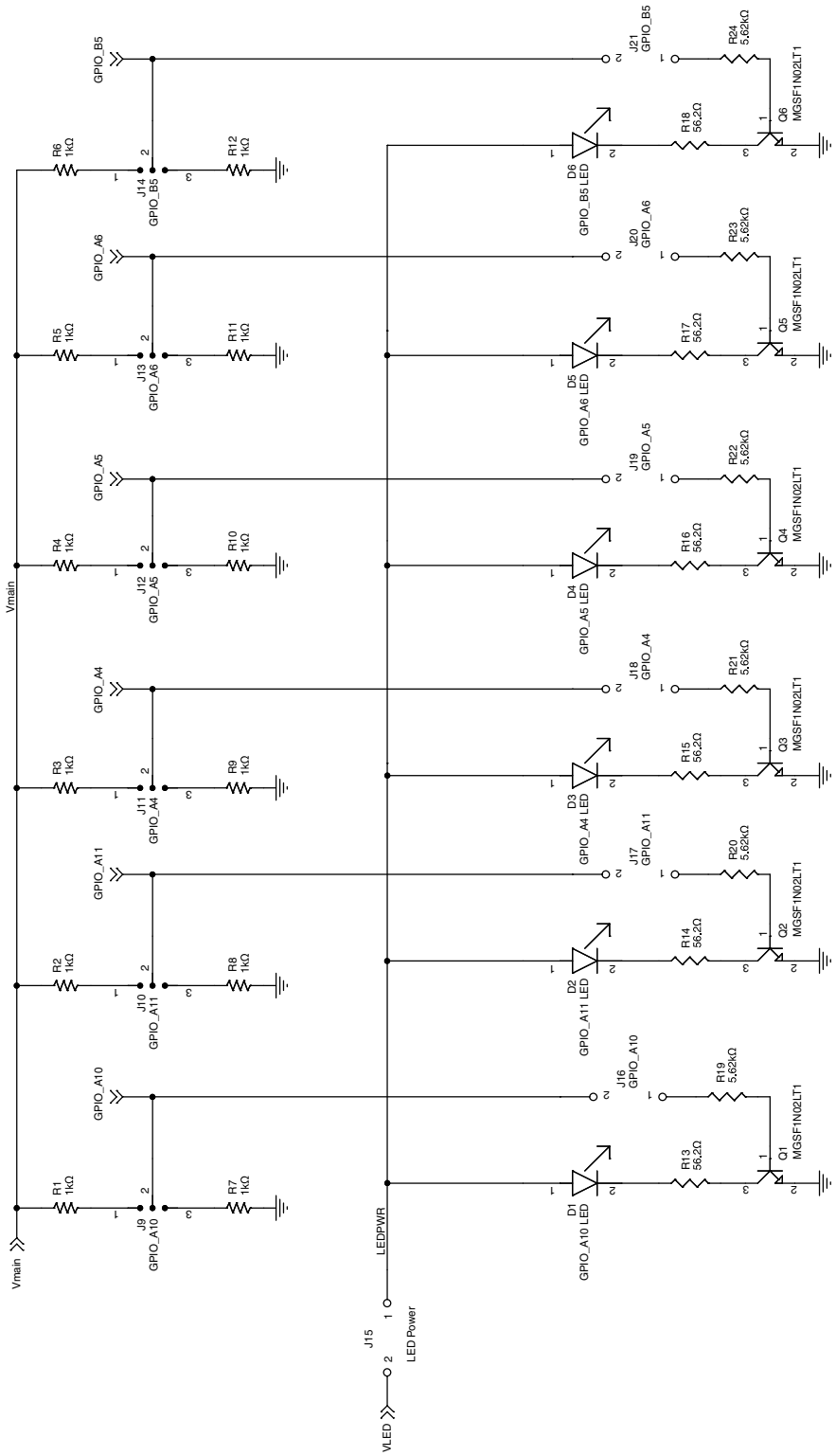
Reference Board Schematic (page 1 of 3)



Note – *Reference board schematics may differ from the recommendations outlined in Table 3.1 due to the test mode requirements for Trimble's internal use.*

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Reference Board Schematic (page 2 of 3)



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Reference Board Schematic (page 3 of 3)

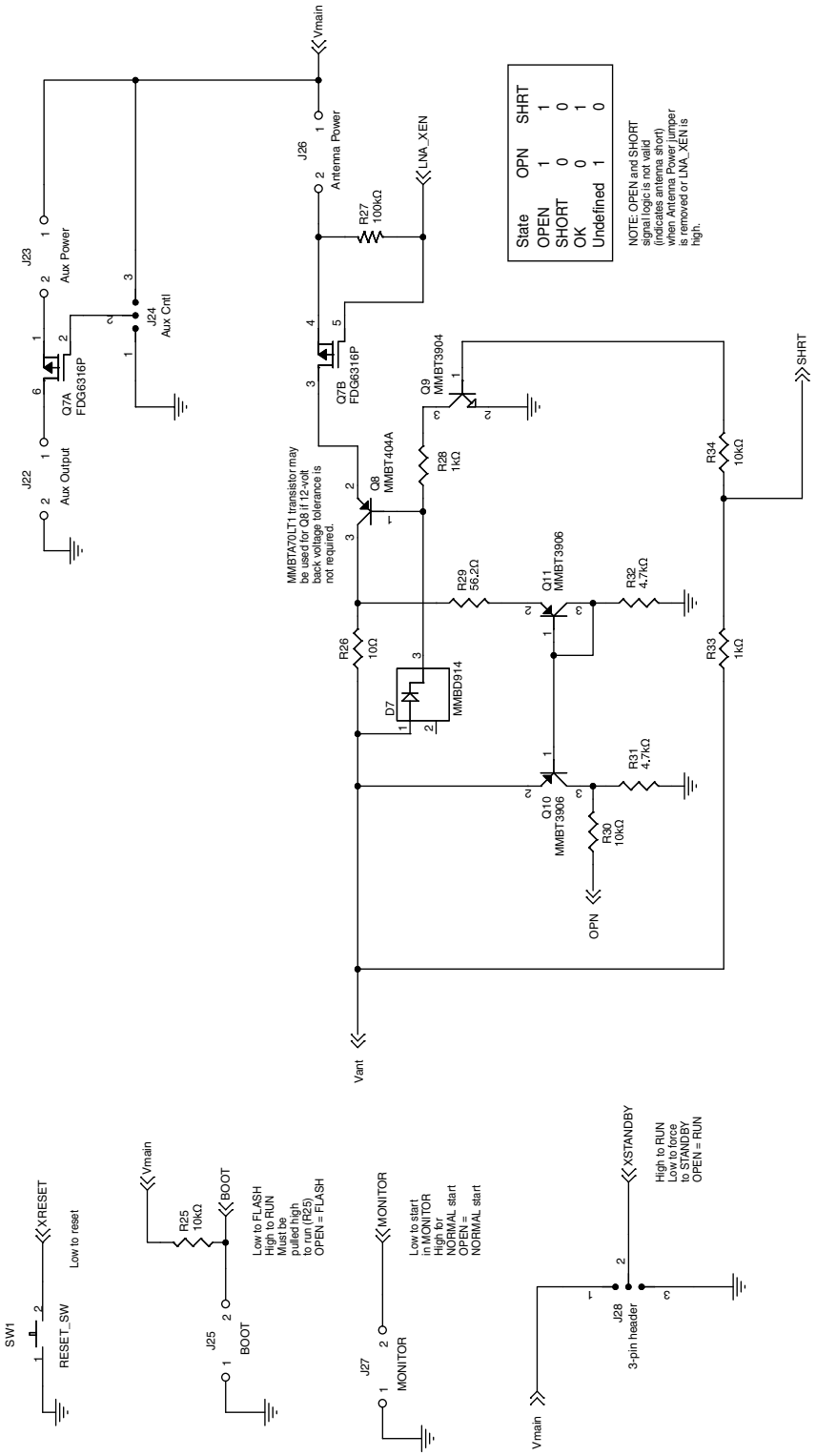


Figure 10.3 Copernicus Reference Board Schematic (Page 3)

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Reference Board I/O and Power Connector

The Copernicus GPS reference board power and data I/O functions are integrated into a single 8-pin header connector designated J7. The J7 connector uses 0.15 inch (3.8 mm) high pins on 0.0787 inch (2 mm) spacing. See the Copernicus GPS reference board schematics, earlier in this chapter.

Table 10.1 Copernicus Reference Board Pin Description.

Pin #	Function	Description
1	TXD-B	Port B transmit, CMOS/TTL
2	VCC	3.0 VDC to 3.6 VDC
3	TXD-A	Port A transmit, CMOS/TTL
4	VBack	3.0 VDC to 3.3 VDC The STANDBY supply shall be at least 0.3V less than VCC.
5	RXD-A	Port A receive, CMOS/TTL
6	1 PPS	Pulse-Per-Second, CMOS/TTL
7	RXD-B	Port B receive, CMOS/TTL
8	GND	Ground, Power and Signal

Reference Board Power Requirement

The Copernicus GPS reference board requires +3.0 VDC to 3.6 VDC. The receiver power is supplied through pin 2 of the I/O connector.

The Copernicus GPS reference board also provides an input for back-up power used when Copernicus is put in Standby mode and prime power is turned off. Back-up power is used to keep the Copernicus RAM memory alive and to power the real-time clock. RAM memory is used to store the GPS almanac, ephemeris, last position, and user configuration data, including port parameters.

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Reference Board Jumper Table

Table 10.2 Copernicus Reference Board Jumper Table

Reference Designator	Name	Description
J1	RF Input	MCX Jack (Female Connector)50 Ohms unbalanced
J4	XRESET	**Normal Operation:** Jumper in place (connects XRESET to VCC) **Reset Operation:** Removing the Jumper and asserting pin 2 of J4 low for greater than 100 usec resets the unit. *Switch SW1 can also reset the unit. Please see below.
SW1	Reset Switch	Press the button resets the unit.
J5	VCC	**Normal Operation:** Jumper in place (Applies VCC to unit) **Test Mode:** Jumper may be removed and ampere meter may be inserted for current measurement.
J6	Vback	**Normal Operation:** Jumper in place.(Applies VBack to unit). The user can use VCC as the STANDBY Supply.
J7	8-Pin Header	See Table 10 for Reference Board pin Description.
J8	PPS	**Normal Operation:** Jumper in place.(It outputs PPS at pin 9 of both DB9 connectors of the Starter Kit through J7 pin 6 of the Reference Board).
J9-J21	Reserved	Reserved
J25	Reserved	Reserved **Normal Operation:** No Jumper (Run Mode).
J27	Reserved	Reserved
J28	XSTANDBY	**Normal Operation:** Jumper between pins 1 and 2 of the jumper J28 (Run Mode). * **Standby Mode:** Jumper between pins 2 and 3 of J28. *For external control, Jumper may be removed and pin 2 of the jumper can be externally controlled, e.g. via a host processor.
J22-24	Spare	Spare driver transistor
J26	Antenna Power	**Normal Operation:** Jumper in place.(Active antenna powered from VCC).If a separate power supply is desired for active antenna, jumper may be removed and an external antenna power can be applied to pin 2 of J26. *

* See Copernicus Reference Board Schematics in this chapter.

Note – *See Table 3.1 for pin numbers.* ⊡ *indicates pin 1.*

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Reference Board Component Locations Drawing

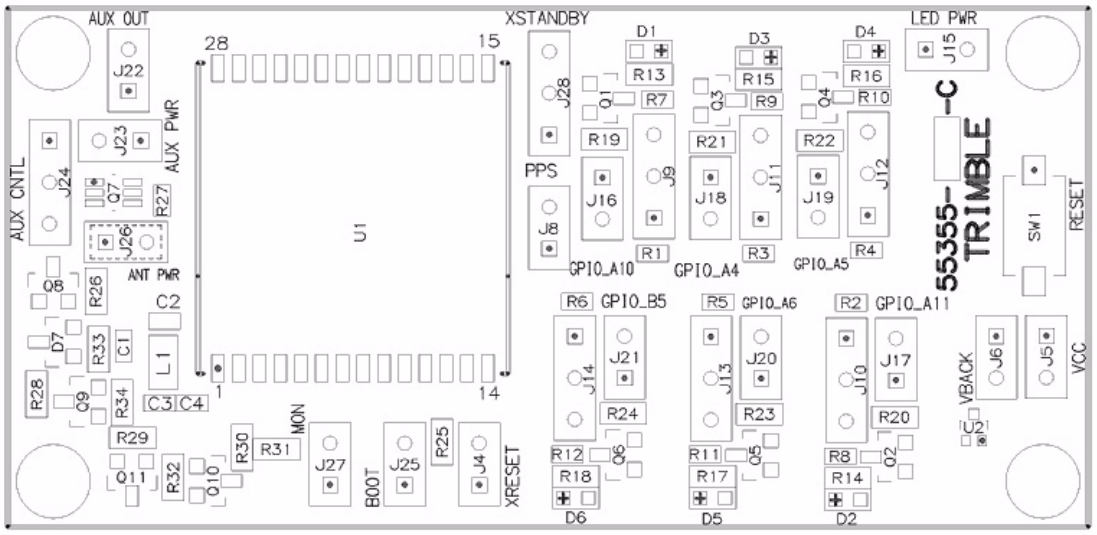


Figure 10.4 Copernicus Reference Board, Top Side

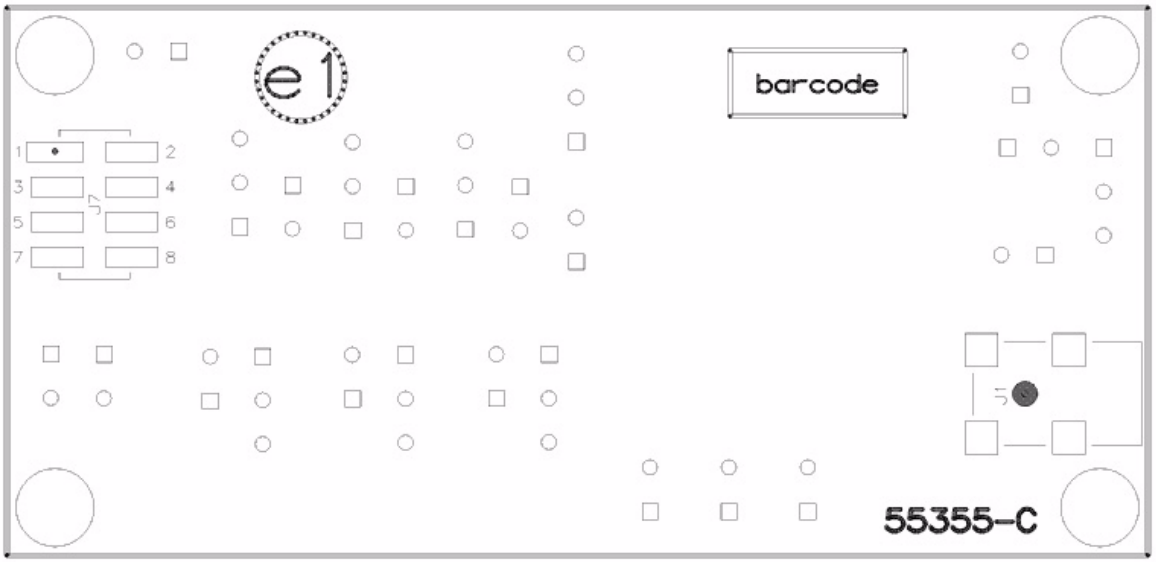


Figure 10.5 Copernicus Reference Board Schematic, Bottom Side

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CHAPTER

11

FIRMWARE UPGRADE

In this chapter:

- This chapter describes an interface for programming (loading) firmware into the Copernicus GPS receiver. The interface can be used to develop a tool to upgrade firmware in the field. Sample source code of a tool for Microsoft® Windows is available to demonstrate implementation of the interface described in this document.
- Software Architecture
- Boot Monitor
- Firmware Binary File Format
- Firmware Loading Procedure
- Monitor Interface Protocol
- FlashLoader Tool Reference Guide

This chapter describes an interface for programming (loading) firmware into the Copernicus GPS receiver. The interface can be used to develop a tool to upgrade firmware in the field. Sample source code of a tool for Microsoft® Windows is available to demonstrate implementation of the interface described in this document.

The information contained in this chapter is applicable only to the Copernicus GPS receiver developed by the Advanced Devices group of Trimble Navigation Ltd. It may not be relevant to other products.

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Software Architecture

The Flash memory chip of the GPS receiver is divided into several functional sections. The Boot ROM section is loaded during production and cannot be changed or erased without special packets with password protection. The User Data section is maintained by the application. The Copernicus GPS Receiver Firmware section holds the main software application, and can be erased and loaded with a newer version through the GPS receiver's serial port.

Table 11.1 Functional Software Components and Memory Map

Word Address	Software Component/Section
0x3FC000 – 0x3FFFFF	Boot ROM
0x3F8000 – 0x3FBFFF	<reserved>
0x3E0000 – 0x3F7FFF	User Data
0x360000 – 0x3DFFFF	Copernicus GPS Firmware
0x300000 – 0x35FFFF	<reserved>

Boot Monitor

The boot monitor module is a part of the Boot ROM section. It provides facilities to perform checksum verification and RAM tests, and to read/write data from/to a specified location in RAM or Flash, thus allowing the user to update the firmware.

The GPS receiver will enter the boot monitor mode if either of the following conditions occurs:

- Application firmware checksum verification failed at power-up;
- RAM test failed at power-up;
- A special protocol packet is issued by the user.

Once the system is in the monitor mode, a special Monitor protocol is used to communicate with the Copernicus GPS Receiver (here after referred as the Target). The necessary details about this protocol are presented in Appendix A.

To return from the monitor to the normal GPS operating mode (i.e. execute the application firmware), either

- Cycle the main power or
- Toggle the reset pin, or
- Send a "Restart Target" packet described on page 115.

The default settings for the Copernicus GPS receiver's serial ports in the monitor mode are:

- Serial port A: 38400 baud, 8 data bits, 1 stop bit, and no parity
- Serial port B: 4800 baud, 8 data bits, 1 stop bit, and no parity

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Firmware Binary File Format

The firmware is distributed as a 16 Mbit binary file that includes the whole Flash image, i.e. the Copernicus GPS Firmware, Boot ROM, and all the other Flash sections. The Monitor protocol requires that the actual loadable raw data bytes be sent to the target to program into Flash. The loadable data is expected to be sent in a sequential manner, in the order from the lowest to the highest loading address. Data will be programmed starting at the base address specified when initiating firmware loading. Therefore, the GPS Firmware portion of the binary file must be extracted prior to sending it to the target. Appendix A provides a reference to example source code that shows how to extract data from the binary file.

Firmware Loading Procedure

This section describes the procedure for loading firmware into the Flash chip of the Copernicus GPS receiver (referred to as “target” throughout this document).

The following pseudo-code shows the general sequence of steps. The details of each step are provided later in this section.Appendix A provides a reference to the sample C source code that shows how to implement this pseudo-code.

Pseudo-code

```
Load Firmware to Target:
{
    Read the firmware BIN file, extract the application firmware, and
    load into a memory buffer.

    Set local serial port settings depending on serial port used.
    For Port A, set 38400-8-none-1; for Port B, set 4800-8-none-1;

    If using TSIP, establish connection using the TSIP protocol:
        Send TSIP version request packet 0x1F;
        Wait for TSIP version response packet 0x45;
        If TSIP version response packet not received:
            Exit/power-cycle target and repeat from beginning;

    If using NMEA, establish connection using NMEA protocol:
        Send NMEA version request packet VR;
        Wait for NMEA version response packet VR;
        If NMEA version response packet not received:
            Exit/power-cycle target and repeat from beginning;

    Force target into Monitor mode;
```


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```
        Send “force-to-monitor” command (TSIP or NMEA depending on the
        port used);

        Wait 0.5 secs to let the target switch to the monitor mode;

        Establish connection to target using Monitor mode protocol:

            Send hand-shaking packet ENQ;

            Wait for response packet ACK;

            If ACK packet not received:
                Exit/power-cycle target and repeat from beginning;

    If the local host’s hardware can support it, change Monitor mode
    baud rate and local serial port settings to 115200 baud for faster
    loading:

        Send “Change Baud” packet 0x86;

        Wait 0.5 secs

        Change local serial port settings;

        Send hand-shaking packet ENQ;

        Wait for response packet ACK;

        If ACK packet not received:
            Exit/power-cycle target and repeat from beginning;

    Send “Erase Firmware” packet 0x8F;

        Wait for response packet ACK;

        If ACK packet not received:
            Exit/power-cycle target and repeat from beginning;
    Send “Start Firmware Programming” packet 0x8B;

        Wait for response packet ACK;

        If ACK packet not received:
            Exit/power-cycle target and repeat from beginning;
      Send firmware data bytes, one word (2 bytes) at a time. For faster loading, data
    can be sent up to 200 bytes at a time (must be a multiple of 2 bytes).

        Wait for response packet ACK after all data has been sent;

        If NAK packet received:
            Try again starting with the “Erase Firmware” step;

        If ACK packet not received at all:
            Power-cycle target and repeat from beginning;

        If ACK packet received:
            Send “Restart Target” packet 0x8C;
            Loading was successful;
}
```


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Pseudo-Code Explanation

The following provides details about the steps shown in the above pseudo-code for the firmware loading procedure.

1. Read firmware BIN file and load into a memory buffer.
   (See Appendix A for an example function that shows how this is achieved.)

2. Establish a serial port connection to the target in the TSIP or NMEA mode.

   Communication with the target over its serial port must be established first. Change the local host's port settings to match those of the target. Refer to the GPS receiver's user manual for details.

   If using TSIP, issue a TSIP version request (packet 0x1F) and wait for the response (packet 0x45). The receipt of the packet 0x45 shows that the host port settings and the target port settings match and the host is communicating with the target. If the packet 0x45 is not received, the host and target port settings are not in agreement.

   If using NMEA, issue NMEA version request (packet VR) and wait for the response. The user manual includes the TSIP and NMEA protocol specification. The receipt of the response of the packet VR shows that the host port settings and the target port settings match and the host is communicating with the target. If the response of the packet VR is not received, the host and target port settings are not in agreement.

   In some cases, the target may enter the monitor mode automatically when power is applied. For example, if the previous firmware loading process has not been finished, the firmware checksum won't match, and the target will automatically start up in the monitor mode. In such cases, Step 2 will fail, and the loading procedure should continue at Step 4 as described below.

3. Force the target into the monitor mode.

   Assuming the communication has been established, issue the "Force to Monitor" command. If using TSIP, the following byte string (hex values) must be sent to the target to force it into the monitor mode:

   10 1E 4D 10 03

   If using NMEA, the following character string must be sent to the target to force it into the monitor mode:

   $PTNLSEM*

   Once the system is in the monitor mode, a special Monitor protocol is used to communicate with the Copernicus GPS Receiver.

   See the Appendices in this manual for detailed information on both TSIP and NMEA Force to Monitor commands.

   After issuing the command, wait 0.5 seconds before proceeding with the next step to allow the target to switch to the monitor mode and be ready to accept Monitor mode commands.

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4. Establish a serial port connection to the target in the Monitor mode.

   Once the target enters the monitor mode, it changes the GPS receiver's serial port settings to 38400 baud (port A) or 4800 baud (port B), 8 data bits, 1 stop bit, and no parity. To establish communication to the target in the monitor mode, the local host's settings must be changed to the same value, and the ENQ packet sent to the target. The target will respond with ACK to indicate the communication has been established. Refer to Section ENQ, ACK, NAK for details on this packet.

5. Change baud rate for faster loading.

   If the local host's hardware can support higher baud rates, it is better to change the baud rate to maximum possible for the fastest loading time. First send "Change Baud" Monitor Mode packet 0x86 to the target with the desired baud rate. See page 113 for details on this packet. Wait 0.5 seconds to let the packet be transmitted, change the local baud rate to the same settings, and send ENQ packet to the target. The target will respond with ACK at the new baud rate to indicate the communication has been established.

6. Erase firmware section.

   Before the firmware can be programmed, the GPS firmware section in Flash must be erased. The "Erase Firmware Section" Monitor Mode packet 0x8F must be sent to the target. The target will respond with ACK when the section is erased. See page page 113 for details on this packet.

7. Send size and start address of the firmware.

   In this step, the size and start (base) address of the firmware is sent to the target using the "Start Firmware Programming" Monitor Mode packet 0x8B. This packet initiates the firmware loading process. The target will respond with ACK as soon as this packet is received. See page 114 for details on this packet.

8. Send firmware data.

   Once the "Start Firmware Programming" packet is sent, the target expects a stream of 2-byte words. The host must send this data one word at a time, with the most significant byte of each word sent first. There is no protocol formatting for this data stream. For faster loading, data can be sent up to 200 bytes at a time. Note that whatever the size, it must be a multiple of 2 bytes. See Appendix A for example source code, which shows how this is done. Once the target received and programmed all of the data into Flash, it will send ACK to indicate success. If NAK is received, an error occurred, and the process must be repeated from Step 6.

9. Restart the target.

   Once firmware loading is complete, the "Restart Target" Monitor Mode packet 0x8C should be issued to reset the GPS receiver. Upon reset, the new firmware will start up. See page 115 for details on this packet.

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Error Recovery

The GPS receiver is designed in such way that the system will not be damaged during a firmware update. When there is an unexpected error while loading firmware, the target can always be restarted by cycling the main power. At power-up, the target will automatically enter the monitor mode if the firmware loading process has not completed successfully. In such a case, the host will able to repeat the firmware loading procedure as described above.

If the Boot Code in the Flash memory is inadvertently overwritten, the module can become unusable. See Warning at the end of the description of the Monitor Mode Packet ID – 0x8B.

Monitor Interface Protocol

Protocol Format

The following packet structure is used by the Monitor Mode Protocol:

Table 11.2 Monitor Mode Protocol

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTES 4 … N	BYTE N+1	BYTE N+2
STX 0x02	NULL_C 0x00	ID	LEN	DATA	CHKSM	ETX 0x03

Byte 0 – start of new packet (value: 0x02)

Byte 1 – delimiter byte (value: 0x00)

Byte 2 – packet ID

Byte 3 – size (in bytes) of packet data (DATA field only)

Bytes 4 … N – packet data

Byte N+1 – packet checksum [NOTE 1].

Byte N+2 – end of packet (value: 0x03)

Note – *The checksum is computed as the sum of all bytes from the packet ID to the end of the packet data truncated to an 8-bit value, i.e.:*

CHKSM = (unsigned char)(ID + LEN + DATA[0] + … + DATA[N-1]);

Data Transmission

Data values are transmitted with the most significant byte of the value sent first. For example, transmitting a 4-byte memory address 0x004101F0 means sending byte 0x00 first, 0x41 second, 0x01 third, and 0xF0 last.

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Monitor Mode Packet Descriptions

ENQ, ACK, NAK

ENQ, ACK, and NAK are special bytes that are sent out without being formatted as described in Protocol Format, page 111.

The target responds to a formatted packet with either ACK (hex byte: 0x06) or NAK (hex byte: 0x15) unless specified otherwise. ACK indicates a successful operation. NAK indicates a failure in executing the command.

ENQ (hex byte: 0x05) provides a simple hand-shaking mechanism to verify that the target is alive and running in the Monitor Mode. The target sends ACK for every ENQ received.

Packet ID – 0x76 (Boot ROM Version Query)

This packet requests the boot ROM version information. Upon receiving this packet, the target replies with packet 0x96.

Table 11.3 Boot ROM Version Query

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5
0x02	0x00	0x76	0x00	0x76	0x03

Packet ID – 0x96 (Boot ROM Version Report)

This packet is sent by the target in response to packet 0x76. It returns Boot ROM version information.

Note – *The field "Year" is 2 bytes long with the most significant byte sent first.*

Table 11.4 Boot ROM Version Report

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTES 8-9	BYTE 10	BYTE 11
0x02	0x00	0x96	0x06	Major Ver	Minor Ver	Month	Day	Year	CHKSM	0x03

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Packet ID – 0x86 (Change Baud Rate)

This packet forces the target system to change the serial baud rate to the specified rate. The valid baud rate values are listed in the table below. The target system returns ACK in the old baud rate before the change and another ACK in the new baud rate if the change succeeds. If the baud rate change fails, the unit returns NAK in the old baud rate.

Table 11.5 Change Baud Rate

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5
0x02	0x00	0x86	Baud	CHKSM	0x03

Table 11.6 Change Baud Rate

Parameter	Data Type	Description
Baud Rate	Byte	Baud Rate: 5 – 2400 bps 6 – 4800 bps 7 – 9600 bps 8 – 19200 bps 9 – 38400 bps 10 – 57600 bps 11 – 115200 bps

Packet ID – 0x8F (Erase Firmware Section)

This packet initiates the erase operation on the target. It only erases the firmware portion of the Flash chip. The target returns either ACK or NAK indicating the result of the operation.

Table 11.7 Erase Firmware Section

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5
0x02	0x00	0x8F	0x00	0x8F	0x03

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Packet ID – 0x8B (Start Firmware Programming)

This packet initiates firmware loading. It has two parameters. The first parameter (4-byte value) contains the size of the firmware in bytes. This is the actual number of bytes that will be written to Flash. The second parameter contains the starting address in Flash where the data will be written.

Once the target receives this packet, it will respond with ACK and wait for the actual data, one word at a time. Each word must be sent with the most significant byte first. All data from the host will be written to the target in the order in which it is received. The target will not recognize any other packets until the loading is completed. If successful, the target will return ACK upon completion, or NAK if an error has occurred.



WARNING – The target does not check validity of the starting address nor the size. It is the host's responsibility to ensure that all parameters are within the system specification. If incorrect specification of the starting address overwrites Boot Code, the module will be unusable.

Table 11.8 Start Firmware Programming

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTES 4-7	BYTES 8-11	BYTE 12	BYTE 13
0x02	0x00	0x8B	0x08	Size	Address	CHKSM	0x03

Table 11.9 Start Firmware Programming

Parameter	Data Type	Description
Size	unsigned long	Size of loadable data in bytes.
Address	unsigned long	Starting physical address where data will be written to.

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Packet ID – 0x8C (Restart Target)

This packet returns the target from the monitor to the normal operating mode. As at startup, the target will initialize all system resources and perform all system tests. The target returns ACK to acknowledge the received packet before the execution.

This packet is designed to bring the receiver from the monitor mode to the normal mode after a firmware update.

Note – *This packet also clears all BBRAM sections to guarantee a cold start after a firmware update.*

Table 11.10 Restart Target

BYTE 0	BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5
0x02	0x00	0x8C	0x00	0x8C	0x03

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FlashLoader Tool Reference Guide

Introduction

Flash Loader is a tool for Microsoft Windows that loads firmware into the Flash chip of the GPS receiver. This tool is used to upload new firmware into the Copernicus GPS Receiver mounted on the Reference Board installed in the Copernicus Starter Kit.

The source code of the tool is documented to provide an example of how to develop a custom application to perform firmware updates. It shows how to use the Monitor protocol to implement the firmware loading procedure (see Firmware Loading Procedure, page 107). It can be used, for example, to develop a program to update firmware remotely over a network connection.

FlashLoader has been created using the Microsoft Visual C++® v6.0 development environment. It uses the MFC framework to implement the graphical user interface. While the compiled executable of the tool is provided together with the source code, Microsoft Visual C++ v6.0 or .NET is required to re-compile the source files and generate a fresh executable if desired.

File and Folder Structure

The FlashLoader tool directory contains the following 3 sub-directories:

- *bin* – contains the FlashLoader binary executable file;
- *mak* – contains the project files for Microsoft Visual C++ v6.0 and .NET development environments;
- *src* – contains the C++ source and header files.

Source Code Reference

All source code files referenced in this section are located in the *src* directory of the FlashLoader tool distribution. The source files are fully commented throughout.

Parsing Firmware BIN File

The function *LoadBinFile()* defined in Util.cpp shows how to parse the firmware BIN file, extract the loadable data, and store into a local buffer for sending to the target.

Creating Packets in the Monitor Protocol Format

The functions *GetXxxxxPkt()* defined in Util.cpp show how to format various packets using the monitor interface protocol.

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Loading Firmware to the Target

The function *FlashProgrammingThread()* defined in FlashLoaderDlg.cpp shows how to implement the firmware loading procedure described above.

Compiling and Generating the Executable

The FlashLoader tool can be re-compiled using the provided project make files.

If using Microsoft Visual C++ v6.0, open the workspace file *FlashLoader.dsw* located in the *mak* directory of the tool distribution. From the main menu, select *Build → Rebuild All*. This will compile the source files, generate the executable, and place it in the *bin* directory.

If using Microsoft Visual C++ .NET, open the solution file *FlashLoader.sln* located in the *mak* directory of the tool distribution. From the main menu, *select Build → Rebuild Solution*. This will compile the source files, generate the executable, and place it in the *bin* directory.

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APPENDIX

A

TRIMBLE STANDARD INTERFACE PROTOCOL (TSIP)

In this appendix:

- Interface Scope
- Run Mode Packet Structure
- Appendix , Automatic Output Packets
- Automatic Position and Velocity Reports
- Initialization Packets to Speed Start-up
- Packets Output at Power-Up
- Timing Packets
- Satellite Data Packets
- Backwards Compatibility to Lassen iQ
- Recommended TSIP Packets
- Command Packets Sent to the Receiver
- Report Packets Sent by the Receiver to the User
- Key Setup Parameters or Packet BB
- Packet Descriptions
- Command Packet 0x82 - SBAS Correction Status
- TSIP Superpackets
- Datums

The Trimble Standard Interface Protocol (TSIP) provides the system designer with over 20 commands that may be used 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.

This appendix provides the information needed to make judicious use of the powerful features TSIP has to offer, to greatly enhance overall system performance, and to reduce the total development time. The provided reference tables will help you determine which packets apply to your application. See page 129 for a detailed description of key setup parameters. Application guidelines are provided for each TSIP Command Packet, beginning on page 131.

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Interface Scope

The Trimble Standard Interface Protocol is used extensively in Trimble receiver designs. The protocol was originally created for the Trimble Advanced Navigation Sensor (TANS) and is colloquially known as the TANS protocol even though the protocol applies to many other devices.

The Lassen IQ GPS Receiver has two serial I/O communications ports. These are bi-directional control and data ports. The data I/O port characteristics, protocol definitions, and other options are user programmable and can be stored in non-volatile FLASH memory.

The TSIP protocol is based on the transmission of packets of information between the user equipment and the unit. 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. As will be discussed, 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.

The Copernicus Monitor included in the Tool Kit is designed to exercise many of the TSIP packets.

Run Mode Packet Structure

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

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

Where:

- <DLE> is the byte 0x10
- <ETX> is the byte 0x03
- <id> is a packet identifier byte, which can have any value excepting <ETX> and <DLE>.

The bytes in the data string can have any value. To prevent confusion with the frame sequences <DLE> <ID> and <DLE> <ETX>, every <DLE> byte in the data string is preceded by an extra <DLE> byte ('stuffing'). These extra <DLE> bytes must be added ('stuffed') before sending a packet and removed after receiving the packet. Notice that a simple <DLE> <ETX> sequence does not necessarily signify the end of the packet, as these can be bytes in the middle of a data string. The end of a packet is <ETX> preceded by an odd number of <DLE> bytes.

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Multiple-byte numbers (integer, float, and double) follow the ANSI/IEEE Std. 754 IEEE Standard for binary Floating-Point Arithmetic. They are sent most-significant byte first. This may involve switching the order of the bytes as they are normally stored in Intel based machines. Specifically:

- UINT8 = Byte: An 8 bit unsigned integer.
- UINT16 = Word: A 16 bit unsigned integer.
- INT16 = Integer: A 16 bit integer.
- INT32 = Long: A 32 bit integer.
- UINT32 = ULong: A 32 bit unsigned integer.
- Single — Float, or 4 byte REAL has a precision of 24 significant bits, roughly 6.5 digits.
- Double — 8 byte REAL has a precision of 52 significant bits. It is a little better than 15 digits.

Automatic Output Packets

The Lassen IQ GPS Receiver is configured to automatically output the following packets. For minimal system implementations, these output packets provide all of the information required for operation including time, position, velocity, and receiver and satellite status and health. Position and velocity are reported using one or more of the packets listed below, depending on the selected I/O options. While there are other packets automatically output, the following packets provide the information most commonly used. No input packets are required.

Table A.1 Automatic Output Packets

Output Packet ID	Description	Reporting Interval
0x41	GPS time	1 second
0x42, 0x83, 0x4A, 0x84, 0x8F-20	position (choose packet with I/O options)	1 second
0x43, 0x56, 0x8F-20	velocity (choose packet with I/O options)	1 second
0x46	health of receiver	1 second
0x4B	machinecode/status (includes antenna fault detect)	1 second
0x6D	all-in-view satellite selection, DOPs, Fix Mode	1 second
0x82	SBAS fix mode (always the last packet of the fix information)	1 second

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Automatic Position and Velocity Reports

The receiver automatically outputs position and velocity reports at set intervals. Automatic report packets are controlled by Packet 35. Setting the control bits as indicated in the table below allows you to control which position and velocity packets are output.

Table A.2 Automatic Position and Velocity Reports

Report Packet ID	Request Settings	Packet 0x35, Byte 0				Packet 0x35, Byte 1	
		Bit 9	Bit 1	Bit 4	Bit 5	Bit 0	Bit 1
0x42	single precision XYZ position	1		0			
0x83	double-precision XYZ position	1		1			
0x4A	single-precision LLA position		1	0			
0x84	double-precision LLA position		1 (default)	1			
0x43	velocity fix (XYZ, ECEF)					1	
0x56	velocity fix (ENU)						1(default)
0x8F-20	LLA and ENU				1		

Note – *In packets 0x42, 0x83, 0x4A, 0x84, 0x43, 0x56, 0x8F-17 and 0x8F-18 when the Time of Fix parameter is reported as -1, this means that the fix information is not calculated by the Copernicus GPS Receiver, but comes from another source such as SRAM, Flash Memory or user input. In Packet 8F-20, this information is denoted by the Invalid Fix parameter: being set to 1 denotes that the fix comes from another source besides the Copernicus GPS Receiver.*

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Initialization Packets to Speed Start-up

If you are not supplying the receiver with battery power when main power is off, you can still “warm-start” the receiver by sending the following sequence of commands after the receiver has completed its internal initialization and has sent Packet 82. Hot start times can be achieved using packet 0x38-06 to upload the ephemeris. Only time and position are necessary for the hot start since the almanac and ephemeris are stored in flash. Position is also stored in flash which improves first fix accuracy.

Table A.3 Initialization Packets to Speed Start-up

Input Byte	Description
0x2E	Initial Time
0x38	Almanac (for each SV)
0x38	Ephemeris
0x38	Ionosphere Page
0x38	UTC Corrections
0x38	Almanac Health
0x2B	Initial Position

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 as listed in the table below. After Packet 82 is output, the sequence is complete and the receiver is ready to accept commands.

Table A.4 Packets Output at Power-up

Output ID	Description	Notes
0x45	software version	--
0x46	receiver health	--
0x4B	machine code/status	--
As chosen, default: 0x84, 0x56	position/velocity output	As chosen, see Table A.2.
0x41	GPS time	
0x82	SBAS fix mode	See command 0xBB to enable/disable SBAS

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Timing Packets

If you are using the Lassen IQ GPS Receiver as a timing reference, you may need to implement the following TSIP control commands.

Table A.5 Timing Packets

Input ID	Description	Output ID
0x21	get the current GPS time	0x41
0x38-05	request UTC parameters	0x58-05

Satellite Data Packets

The following packets contain a variety of GPS satellite data.

Table A.6 Satellite Data Packets

Input ID	Description	Output ID
0x27	request signal levels	0x47
0x38	request/load satellite system data	0x58
0x3C	request tracking status	0x5C

Backwards Compatibility to Lassen iQ

The following General Packets and Differences between TSIP Used in Lassen iQ/SQ and Copernicus GPS Receiver

- 0x41, 0x46, 0x4B automatic packets are output every 1 second instead of every 5 seconds.
- DGPS is not supported in the Copernicus GPS Receiver. Thus, the following packets are not supported:

  0x60 /0x61

  0x65/0x85
- 0x69 / 0x89 not available. The Lassen IQ GPS Receiver is a high sensitivity receiver.
- 0x70 packet is not supported in the Copernicus GPS Receiver. The Copernicus GPS Receiver supports only Kalman Filter and it can not be turned off. No PV filter is available in Copernicus Module.
- Packet 0xC0 – Graceful Shutdown and Go To Standby Mode is supported in the Copernicus GPS Receiver.
- In “Key Setup Parameters of Packet BB”, BB packet is still the same, but:

  Cannot set signal mask.

  Fix mode/DOP mask/DOP switch/DGPS correction age are not supported.

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The dynamic modes are Land, Sea and Air

- In packet description of 0xBB, Navigation Configuration:

  Byte 1, only value 0, automatic is supported

  Byte 2, is now used for SBAS

  Byte 3, only values 1, 2, and 3 are supported

  Bytes 9-12, change AMU mask (not supported)

  Bytes 13-21 are changed to reserved.

- In packet 0x1E:

  byte 0 - add 0x4D for enter Monitor Mode. The response packet is 0x5F-FF-‘*’-‘*’-‘*’-‘ ‘-‘M’-‘O’-‘N’-‘I’-‘T’-‘O’-‘R’-‘ ‘-‘*’-‘*’-‘*’-‘*’.

- 0x35/0x55 packets – “Filtered PR’s in 5A” is not supported.
- 0x3A/0x5A packets, Raw Measurement diagnostic packets have been added to the Copernicus GPS Receiver.
- 0x45 packet, Byte 9, “Year number minus 1900” instead of “Year number minus 2000.
- In the 0x7A packet of the Copernicus GPS Receiver, the NMEA sentences TF and BA have been added.
- 0xBC, Protocol Configuration:

  Byte 1, Two new baud rates have been added: value 10 (57600 baud), and value 11 (115200 baud)

  Byte 3, only value 3 (8 data bits) is supported.

  Byte 4, only value 0 (No Parity) is supported.

  Byte 5, only value 0 (1 Stop Bit) is supported.

- 8E-4A, PPS Configuration:

  Byte 3, Polarity, BYTE, 0 = Positive, 1 = Negative

- 0x8E-17/0x8E-18, Set/Request UTM output are supported in Copernicus GPS Receiver.
- The new packet 0x1C has been added to the Copernicus GPS Receiver. Lassen iQ FW v1.16 also supports this packet.

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Recommended TSIP Packets

Table A.7 Recommended TSIP Packets

Function	Description	Input	Output
Protocol and port setup	set/query port configuration	0xBC	0xBC
	set/query NMEA configuration	0x7A	0x7B
	set/query I/O options (autoreport and format options)	0x35	0x55
Navigation	GPS time	0x21	0x41
	position & velocity (superpacket)	0x8E-20 or 0x37 or auto	0x8F-20
	double-precision LLA	0x37/auto	0x84
	double-precision XYZ ECEF	0x37/auto	0x83
	ENU velocity	0x37/auto	0x56
	XYZ ECEF velocity	0x37/auto	0x43
Satellite and tracking information	query receiver state (health)	0x26	0x46, 0x4B
	query current satellite selection	0x24	0x6D
	query signal levels	0x27	0x47
	query satellite information (azimuth, elevation, etc.)	0x3C	0x5C
Receiver settings	query software version	0x1C	0x1C-81
	query receiver ID & error status	0x26	0x4B, 0x46
	set/query receiver configuration	0xBB	0xBB
GPS System	query/load GPS system data	0x38	0x58
Initialization	full reset (clear battery backup and/or non-volatile settings)	0x1E	
	soft reset	0x25	
	set GPS time	0x2E	0x4E
	set approx. LLA	0x2B	
	set approx. XYZ ECEF	0x23	
	set exact LLA	0x32	
	set exact XYZ ECEF	0x31	

Note – *Automatic output is determined by packet 0x35. See Table A.4 to determine messages output at startup.*

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Command Packets Sent to the Receiver

The table below summarizes the command packets sent to the receiver. The table includes the input Packet ID, a short description of each packet, and the associated response packet. In some cases, the response packets depend on user-selected options. These selections are covered in the packet descriptions beginning on page 131

Table A.8 Command Packets Sent to the Receiver

Input ID	Packet Description	Output ID
0x1C	Hardware and firmware versions numbers	0x1C-81
0x1E	clear battery back-up/reset	See Note 1
0x1F	software version	0x45
0x21	current time	0x41
0x23	initial position (XYZ ECEF)	--
0x24	request receiver position fix mode	0x6D
0x25	soft reset & self-test	See Note 1
0x26	receiver health	0x46, 0x4B
0x27	signal levels	0x47
0x2B	initial position (LLA)	--
0x2D	oscillator offset	0x4D
0x2E	set GPS time	0x4E
0x31	accurate initial position (XYZ ECEF)	--
0x32	accurate initial position	--
0x35	I/O options	0x55
0x37	status and values of last position and velocity	0x57
0x38	load or request satellite system data	0x58
0x3C	tracking status	0x5C, see Note 2
0x7A	set/request NMEA output configuration	0x7B
0x8E-20	last fix with extra information (fixed point)	0x8F-20
0x8E-26	store settings in Flash memory.	0x8F-26
0x8E-4A	Set Copernicus GPS Cable Delay and PPS Polarity	0x8F-4A
0xBB	set receiver configuration	0xBB
0xBC	set port configuration	0xBC
0xC0	go to BBRAM backup state and/or store BBRAM to flash	
0xC1	Bit mask for GPIOs in Standby Mode	0xC1
0xC2	SBAS SV Mask	0xC2

Note – *Automatic output is determined by packet 0x35. See Table A.4 to determine which messages are output at power-up. No response sent if data is not available.*

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Report Packets Sent by the Receiver to the User

The table below summarizes the packets output by the receiver. The auto response and power-up packets may depend on user-selected options (see Table A.22).

Table A.9 Report Packets Sent by the Receiver to the User

Output ID	Packet Description	Input ID
0x1C-81	Hardware and firmware version numbers	0x1C
0x41	GPS time	0x21, auto
0x42	single-precision XYZ position	0x37, auto
0x43	velocity fix (XYZ ECEF)	0x37, auto
0x45	software version information	0x1F, power-up
0x46	health of Receiver	0x26, auto, power-up
0x47	signal level for all satellites	0x27
0x4A	single-precision LLA position	0x37, auto
0x4B	machine code/status	0x26, auto, power-up
0x4D	oscillator offset	0x2D
0x4E	response to set GPS time	0x2E
0x55	I/O options	0x35
0x56	velocity fix (ENU)	0x37, auto
0x57	information about last computed fix	0x37
0x58	GPS system data/acknowledge	0x38
0x5C	satellite tracking status	0x3C
0x6D	all-in-view satellite selection	0x24, auto
0x82	SBAS position fix mode	0x62, auto
0x83	double-precision XYZ	auto, 0x37
0x84	double-precision LLA	auto, 0x37
0x8F-20	last fix with extra information (fixed point)	auto, 0x37, 0x8E-20
0x8F-2A	Request Fix and Channel Tracking info, Type 1	0x8E-2A
0x8F-2B	Request Fix and Channel Tracking info, Type 2	0x8E-2B
0x8F-4A	Set Copernicus GPS Cable Delay and PPS polarity	0x8E-4A
0xBB	GPS navigation configuration	0xBB
0xBC	receiver port configuration	0xBC
0xC1	Bit Mask for GPIOs in Standby Mode	0xC1
0xC2	SBAS SV Mask	0xC2

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Key Setup Parameters or Packet BB

Selecting the correct operating parameters has significant impact on receiver performance. Packet 0xBB (set receiver configuration) controls the key setup parameters.

The default operating parameters allow the receiver to perform well in almost any environment. The user can optimize the receiver to a particular application if the vehicle dynamics and expected level of obscuration are understood. If the receiver is then taken out of this environment, the specifically tuned receiver may not operate as well as a receiver with the default options

Table A.10 Key Setup Parameters or Packet BB.

Parameter	Factory Default
Dynamics code	Land
Elevation mask	5°
SBAS on/off	WAAS_Auto

The default values in Table A.10 allow the receiver to operate well under the most varied and demanding conditions. A user may choose to change the default parameters if the receiver is only required to perform in a specific or limited environment. The user should be warned that when the receiver is exposed to operating conditions which are different from the conditions described by the user setup, then the performance may be degraded.

Initially, the user must consider the environment in which the receiver is expected to operate. There is a trade-off between how frequently a position fix is output versus the absolute accuracy of the fix. The user must decide which takes priority and then make the appropriate selections. This becomes increasingly important when frequent satellite blockages are expected, as in downtown “urban canyon” environments and heavily foliated areas.

Following is a description of the key fields in Packet 0xBB.

Dynamics Code

The feature 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. In AIR mode, the search and re-acquisition routines are optimized for high acceleration conditions.

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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.

The benefit of a low elevation mask is that more satellites are available for use in a solution resulting in a better PDOP. The current mask is set to five degrees and provides a reasonable trade-off of the benefits and drawbacks. High accuracy users may prefer a mask angle around ten degrees, where the ionosphere and troposphere begin to be more predictable

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Packet Descriptions

Packet Descriptions Used in Run Mode

Command Packet 0x1C - Firmware Version 01

The command packet 0x1C: 01 may be issued to obtain the firmware version. The product name is “Copernicus GPS Receiver”. The packet format is defined in the following table.

Table A.11 Command Packet 0x1C

Byte	Item	Type	Value	Definition
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x01	Sub-code 0x01 for software component version information request

Table A.12 Report Packet 0x1C: 81

Byte	Item	Type	Value	Definition
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x81	Sub-code 0x81 for software component version information report
2	Reserved	U8	Any	Reserved
3	Major version	U8	Any	Firmware major version
4	Minor version	U8	Any	Firmware minor version
5	Build number	U8	Any	Firmware build number
6	Month	U8	1-12	Firmware build month
7	Day	U8	1-31	Firmware build Day
8…9	Year	U16	Any	Firmware build Year
10	Length of first module name	U8	Any	The length of the product name (L1)
11… (10+L1)	Product name	U8	String	Product name in ASCII

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Command Packet 0x1C: 03 - Hardware Component Version Information

- The command packet 0x1C: 03 may be issued to obtain the hardware component version information.
- The report packet is of variable length, depending on the length of the hardware ID.
- The serial number, build date fields, and the hardware ID are programmed into the Copernicus GPS at production.
- The hardware code for Copernicus GPS Receiver is 1002.
- ID for Copernicus GPS Receiver is COPERNICUS GPS RECEIVER.

The packet format is defined below.

Table A.13 Command Packet 0x1C:03

Byte	Item	Type	Value	Definition
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x03	Sub-code 0x03 for hardware component version information request

Report Packet 0x1C: 83 - Hardware Component Version Information

Table A.14 Report Packet 0x1C:83

Byte	Item	Type	Value	Definition
0	Packet ID	U8	0x1C	Packet ID 0x1C
1	Sub-code	U8	0x83	Sub-code 0x83 for hardware component version information report
2…5	Serial number	U32	Any	Board serial number
6	Build day	U8	1-31	Day of the board's build date
7	Build month	U8	1-12	Month of the board's build date
8…9	Build year	U16	Any	Year of the board's build date
10	Build hour	U8	0-23	Hour of the board's build date
11…12	Hardware Code	U16	Any	Hardware Code associated with Hardware ID
13	Length of Hardware ID	U8	Any	The length of the Hardware ID (L)
14... (13+L)	Hardware ID	U8	String	Hardware ID string in ASCII

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Command Packet 0x1E - Clear Battery Backup, then Reset

This packet commands the GPS receiver to clear all battery back-up data and to perform a software reset. This packet contains one data byte.

Table A.15 Command Packet 0x1E

Byte	Item	Type	Value	Definition
0	Reset mode	UINT 8	0x4B 0x46 0x4D	Cold start: Erase BBRAM and restart Factory reset: Erase BBRAM and Flash and restart Enter Monitor Mode



WARNING – All almanac, ephemeris, current position, mode, and communication port setup information are reset to the default values when executing the "Factory Reset" command. In normal use this packet should not be sent.

Command Packet 0x1F - Request Software Versions

This packet requests information about the version of software running in the Navigation and Signal Processors. This packet contains no data. The GPS receiver returns Packet 0x45.

Command Packet 0x21 - Request Current Time

This packet requests current GPS time. This packet contains no data. The GPS receiver returns Packet 0x41.

Command Packet 0x23 - Initial Position (XYZ 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 since 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 data format is shown below.

Note – *To initialize using the Latitude-Longitude-Altitude representation, use Command Packet 0x2B.*

Table A.16 Command Packet 0x23

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

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Command Packet 0x24 - Request GPS Receiver Position Fix Mode

This packet requests current position fix mode of the GPS receiver. This packet contains no data. The GPS receiver returns Packet 0x6D.

Command Packet 0x25 - 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 start-up messages (see Table A.4). The GPS receiver sends Packet 0x45 only on power-up and reset (or on request); thus if Packet 0x45 appears unrequested, then either the GPS receiver power was cycled or the GPS receiver was reset.

Command Packet 0x26 - Request Health

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

Command Packet 0x27 - Request Signal Levels

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

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

This packet provides the GPS receiver with an approximate initial position in latitude and longitude coordinates (WGS-84). This packet is useful if the user has moved more than about 1,000 miles since the previous fix. (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 data format is shown in the table below.

Table A.17 Command Packet 0x2B

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

Note – *To initialize with ECEF position, use Command Packet 0x23.*

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Command Packet 0x2D - 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 0x4D. This packet is used mainly for service. The permissible oscillator offset varies with the particular GPS receiver unit.

Command Packet 0x2E - Set GPS Time

This packet provides the approximate GPS time of week and the week number to the GPS receiver. The GPS receiver returns Packet 0x4E. The 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. This packet is usually not required when the battery back-up voltage is applied as the internal clock keeps time to sufficient accuracy. **This packet is ignored if the receiver has already calculated the time from tracking a GPS satellite**.

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

Table A.18 Command Packet 0x2E Data Formats

Byte	Item	Type	Units
0-3	GPS time of week	Single	Seconds
4-5	Extended GPS week number	INT16	Weeks

Command Packet 0x31 - Accurate Initial Position (XYZ ECEF)

This packet is identical in content to Packet 0x23. 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. 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.

Table A.19 Command Packet 0x31 Data Format

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

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

This packet is identical in content to Packet 0x2B. This packet provides the GPS receiver with an accurate 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. 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.

Table A.20 Command Packet 0x32 Data Format

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

Command Packet 0x35 - Set Request I/O Options

This packet requests the current I/O options and allows the I/O options to be set. To request the options settings without any changes, send the packet with no data bytes. To change the options settings, include four data bytes with the values. The I/O options, their default settings, and the byte values for all possible configurations are shown below.

The Set/Request I/O options are stored in battery-backed memory. To store them in non-volatile RAM (Flash), use the 0x8E-26 command. The GPS receiver returns Packet 0x55.

These abbreviations are used in the following table:

- ALT Altitude
- ECEF Earth-centered, Earth-fixed
- XYZ Coordinates
- LLA Latitude, Longitude, Altitude
- HAE Height Above Ellipsoid
- WGS-84 Earth Model (ellipsoid)
- MSL Geoid Mean Sea Level
- UTC Coordinated Universal Time

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This packet can also be used to set the Automatic output to 1/second for packets 0x47 and 0x5A.

Table A.21 Command Packet 0x35 Data Format

Byte	Bit	Item	Type	Value	Definition
Position					
0	0 (LSB)	XYZ ECEF	Bit	0 1	XYZ ECEF output off XYZ ECEF output on
	1	LLA Output	Bit	0 1	LLA output off LLA output on
	2	LLA ALT Output	Bit	0 1	HAE (See Note) MSL geoid
	3	Reserved			
	4	Precision-of-position output	Bit	0 1	Send single-precision packet Send double-precision packet
	5	Super Packet Output	Bit	0 1	Output no Super Packets Output all enabled Super Packets
	6-7	Reserved			

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Byte	Bit	Item	Type	Value	Definition
Velocity					
1	0	XYZ ECEF	Bit	0 1	XYZ ECEF output off XYZ ECEF output on
	1	ENU Output	Bit	0 1	ENU output off ENU output on
	2-7	Reserved			
Timing					
2	0	Time Type	Bit	0 1	GPS Time UTC
	1-4	Reserved			
	5-6	PPS Mode	Bits	00 01 10 11	Always On Fix Based Always Off Reserved
	7	Reserved			
Auxiliary/Pseudo Range Measurements					
3	0	Raw Measurement	Bit	0 1	Raw measurements off Raw measurements on
	1	Reserved			
	2	Reserved			
	3	Signal Level Unit	Bit	0 1	Output AMUs Output dB Hz
	4	Reserved			
	5	Signal levels for all satellites	Bit	0 1	Signal levels Off Signal levels On
	6-7	Reserved			

Note – *Packet 8E must be used to specify which Superpackets are output.*

The Lassen iQ GPS supports automatic output of 0x5A messages for backwards compatibility with older TSIP applications.

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Command Packet 0x37 - Request Status and Values of Last Position and Velocity

This packet requests information regarding the last position fix and should only be used when the receiver is not automatically outputting positions. The GPS receiver returns Report Packet 0x57 followed by the position/velocity packets specified in Command Packet 0x35.

Command Packet 0x38 - 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 0x58. (Note that the GPS receiver can initialize itself without any data from the user; it merely requires more time.)

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

Table A.22 Command Packet 0x38 Data Formats

Byte	Item	Type	Value	Definition
0	Operation	UINT8	1 2	Request data from Lassen IQ GPS Receiver; Load data into Lassen IQ GPS Receiver
1	Type of data	UINT8	2 3 4 5 6	Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN#	UINT8	0 1 - 32	Data that is not satellite - ID specific Satellite PRN number
3	Length (n)	UINT8		Number of bytes of data to be loaded
4 to n+3	Data	UINT8		Satellite data



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

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Command Packet 0x3A - Request Last Raw Measurement

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

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Table A.23 Command Packet 0x3C Data Format

Byte	Item	Type	Value	Definition
0	Satellite #	UINT8	0 1 - 32	All satellites in the current track set. Desired satellite.

Command Packet 0x3C - Request Current Satellite Tracking Status

This packet requests the current satellite tracking status. The GPS receiver returns Packet 0x5C if data is available.

Table A.24 Command Packet 0x3C Data Format

Byte	Item	Type	Value	Definition
0	Satellite #	UINT8	0 1 - 32	All satellites in the current track set. Desired satellite.

Report Packet 0x41 - 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 0x21 and during an automatic packets update cycle. The data format is shown below.

Table A.25 Report Packet 0x41 Data Formats

Byte	Item	Type	Units
0-3	GPS time of week	Single	seconds
4-5	Extended GPS week number	INT16	weeks
6-9	GPS UTC offset	Single	seconds

Note – *UTC time lags behind GPS time by an integer number of seconds; UTC = (GPS time) - (GPS UTC offset).*



WARNING – GPS week number runs from 0 to 1023 and then cycles back to week #0. week # 0 began January 6, 1980. The first cycle back to week #0 was on August 22, 1999. The extended GPS week number however, does not cycle back to 0. For example: the week # for August 22, 1999 = 1024; the Week # for April 1, 2002 = 1160.

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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 0x41, and the Packet 0x46 status code.

Table A.26 Packets 0x41 and 0x46 Status Code Relationships

Approximate Time Accuracy	Time Source	Sign (TOW)	Packet 46 Status Code
none	no time at all	-	0x01
unknown	approximate time from real-time clock or Packet 2E	+	0x01
20-50 msec + clock drift	time from satellite	+	0x02 - 0x0C
full accuracy	time from GPS solution	+	0x00

Note – *Before using the GPS time from Packet 0x41, verify that the Packet 0x46 status code is 00 (“Doing position fixes”). This will ensure the most accurate GPS time.*

Report Packet 0x42 - 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
(byte 0: bit 0, Packet 0x35)and the I/O Precision-of-Position Output (byte 0: bit 4, Packet 0x35) 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.27 Report Packet 0x42 Data Formats

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. Packet 83 provides a double-precision version of this information.

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Report Packet 0x43 - 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 (byte 1, bit 0, Packet 0x35), then the GPS receiver sends this packet each time a fix is computed. The data format is shown below.

Table A.28 Report Packet 0x43 Data Formats

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 (byte 2, bit 0, Packet 0x35).

Report Packet 0x45 - 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 0x1F.

Table A.29 Report Packet 0x45 Data Formats

Byte	Item	Type
0	Major version number	UINT8
1	Minor version number	UINT8
2	Month	UINT8
3	Day	UINT8
4	Year number minus 1900	UINT8
5	Major revision number	UINT8
6	Minor revision number	UINT8
7	Month	UINT8
8	Day	UINT8
9	Year number minus 2000	UINT8

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

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Report Packet 0x46 - 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 0x26 and, every second. Packet 0x4B is always sent along with this packet.

Table A.30 Report Packet 0x46 Data Formats

Byte	Bit	Item	Type	Value	Definition
0		Status code	UINT8	0x00 0x01 0x02 0x03 0x04 0x08 0x09 0x0A 0x0B 0x0C and above	Doing position fixes Don't have GPS time yet Reserved PDOP is too high The chosen SV is unusable No usable satellites Only 1 usable satellite Only 2 usable satellites Only 3 usable satellites Fix criteria not met
1	0	Battery backup	Bit	0 1	OK BBRAM was not available at start-up
1	4	Antenna feedline fault	Bit	0 1	OK Short or open detected
1	5	Type of fault	Bit	0 1	Open detected Short detected

The error codes in Byte 1 of Packet 0x46 are encoded into individual bits within the byte. The bit positions are shown below.

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Report Packet 0x47 - Signal Levels for all Satellites

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (i.e., above the elevation mask and healthy according to the almanac). The receiver sends this packet only in response to Packet 0x27. The data format is shown below.

Table A.31 Report Packet 0x47 Data Formats

Byte	Item	Type
0	Count	UINT8
1	Satellite number 1	UINT8
2- 5	Signal level 1	Single
6	Satellite number 2	UINT8
7-10	Signal level 2	Single
(etc.)	(etc.)	(etc.)

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.

Note – *The signal level provided in this packet is a linear measurement of the signal strength after correlation or de-spreading. Units, either AMU or dBHz, are controlled by Packet 0x35.*

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Report Packet 0x4A - 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 (all controlled by Packet 35), then the receiver sends this packet each time a fix is computed. Command Packet 35 controls position output (XYZ or LLA) and (single or double) output precision. The data format is shown in below.

Table A.32 Report Packet 0x4A Data Formats

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 (HAE or MSL)
2-15	Clock Bias	Single	meters
6-19	Time-of-Fix	Single	seconds (GPS or UTC)

The default datum is WGS-84. Altitude is referred to the datum 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 is also sent at start-up with a negative time-of-fix to report the current known position. Packet 0x84 provides a double-precision version of this information



WARNING – When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant PI). The value of the constant PI as specified in ICD-GPS-200 is 3.1415926535898. Single precision LLA has a quantization of approximately 2 meters.

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

The receiver transmits this packet in response to packets 0x25 and 0x26 and following a change in state. In conjunction with Packet 0x46, “health of receiver,” this packet identifies the receiver and may present status 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.33 Report Packet 0x4B Data Formats

Byte	Item	Type/	Definition
0	Machine ID	UINT8	96
1	Status 1	UINT8	See Table A.1
2	Status 2	UINT8	Bit 0 set = Superpackets supported

The status codes are encoded into individual bits within the bytes. The bit positions and their meanings are listed in the table below.

Table A.34 Report Packet 0x4B Bit Positions and Descriptions

Status 1 Bit Positions	Meaning if bit value = 1
0 (LSB)	Not used
1	Real-time Clock was not available at power-up.
2	Not used
3	The almanac stored in the receiver is not complete and current.
4-7	Not used

Report Packet 0x4D - Oscillator Offset

This packet provides the current value of the receiver master oscillator offset in Hertz at carrier. This packet contains one single precision number. The receiver sends this packet in response to Packet 0x2D. The permissible offset varies with the receiver unit.

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Report Packet 0x4E - Response to Set GPS Time

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

Table A.35 Report Packet 0x4E Data Formats

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

Report Packet 0x55 - I/O Options

These abbreviations apply to the following table: ALT (Altitude), ECEF (Earth-centered, Earth-fixed), XYZ (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.36 Command Packets 0x55 and 0x35 Data Descriptions

Byte	Bit	Item	Type	Value	Definition
Position					
0	0	XYZ ECEF	Bit	0 1	XYZ ECEF output off XYZ ECEF output on
0	1	LLA Output	Bit	0 1	LLA output off LLA output on
0	2	LLA ALT Output	Bit	0 1	HAE (WGS-84 datum) MSL geoid
0	3	Reserved			
0	4	Precision-of-position output	Bit	0 1	Send single-precision packet. Send double-precision packet.
0	5	Super Packet Output	Bit	0 1	Output no Super Packets. Output all enabled Super Packets.
0	6-7	Reserved			
Velocity					
1	0	XYZ ECEF	Bit	0 1	XYZ ECEF output off XYZ ECEF output on
1	1	ENU output	Bit	0 1	ENU output off ENU output on
1	2-7	Reserved			
Timing					
2	0	Time Type	Bit	0 1	GPS Time UTC
	1-4	Reserved			
	5-6	PPS Mode			

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Table A.36 Command Packets 0x55 and 0x35 Data Descriptions (continued)

Byte	Bit	Item	Type	Value	Definition
	7	Reserved			
Auxiliary/Pseudo Range Measurements					
3	0	Raw Measurement	Bit	0 1	Raw measurements off Raw measurements on
	1	Reserved			
	2	Reserved			
	3	Signal Level Unit	Bit	0 1	Output AMUs Output dB Hz
	4	Reserved			
	5	Sig levels for SVs	Bit	0 1	Signal levels Off Signal levels On
	6-7	Reserved			

Notes – *See the associated superpacket output, described later in this appendix. Packet 8E must be used to specify which superpacket is to be output.*

Automatic output of 0x5A raw measurement messages is supported in the Lassen IQ GPS Receiver for backwards compatibility with older TSIP applications.

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

If East-North-Up (ENU) coordinates have been selected for the I/O “velocity” option (see Packet 0x35), the receiver sends this packet under the following conditions:

- Each time that a fix is computed
- In response to Packet 0x37 (last known fix)

The data format is shown below.

Table A.37 Report Packet 0x56 Data Formats

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 (GPS or UTC)

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

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Report Packet 0x57 - Information About Last Computed Fix

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

Table A.38 Report Packet 0x57 Data Formats

Byte	Item	Type	Units	Byte 0 Value/Velocity
0	Source of information	UINT8	--	00 temporary no fix 01 good current fix
1	Mfg. diagnostic	UINT8	--	
2-5	Time of last fix	Single	seconds, GPS time	
6-7	Week of last fix	INT16	weeks, GPS time	

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

This packet provides GPS data (almanac, ephemeris, etc.). The receiver sends this packet in response to Packet 0x38 (acknowledges the loading of data). The data format is shown below..

Table A.39 Report Packet 0x58 Data Formats

Byte	Item	Type	Value	Definition
0	Operation	UINT8	1 2	Request data from receiver; Load data into receiver
1	Type of data	UINT8	2 3 4 5 6	Almanac Health page, T_oa, WN_oa Ionosphere UTC Ephemeris
2	Sat PRN#	UINT8	0 1 - 32	Data that is not satellite - ID specific satellite PRN number
3	Length (n)	UINT8		Number of bytes of data to be loaded
4 to n+3	Data			

Table A.40 Report Packet 0x58 Almanac Data

Byte	Item	Type	Definition / ICD-GPS-200
4	t_oa_raw	UINT8	Sec 20.3.3.5.1.2
5	SV_HEALTH	UINT8	Sec 20.3.3.5.1.2
6-9	e	Single	Sec 20.3.3.5.1.2
10-13	t_oa	Single	Sec 20.3.3.5.1.2
14-17	i_o	Single	Sec 20.3.3.5.1.2
18-21	OMEGADOT	Single	Sec 20.3.3.5.1.2
22-25	sqrt_A	Single	Sec 20.3.3.5.1.2
26-29	OMEGA_0	Single	Sec 20.3.3.5.1.2
30-33	omega	Single	Sec 20.3.3.5.1.2
34-37	M_0	Single	Sec 20.3.3.5.1.2

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Table A.40 Report Packet 0x58 Almanac Data

38-41	a_f0	Single	Sec 20.3.3.5.1.2
42-45	a_f1	Single	Sec 20.3.3.5.1.2
46-49	Axis	Single	Sec 20.3.3.5.1.2
50-53	n	Single	Sec 20.3.3.5.1.2
54-57	OMEGA_n	Single	Sec 20.3.3.5.1.2
58-61	ODOT_n	Single	Sec 20.3.3.5.1.2
62-65	t_zc	Single	Sec 20.3.3.5.1.2. see Note 2.
66-67	weeknum	INT16	Sec 20.3.3.5.1.2
68-69	wn_oa	INT16	Sec 20.3.3.5.1.2

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

Table A.41 Report Packet 0x58 Almanac Health Data

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

Table A.42

Byte	Item	Type	Definition / IDC-GPS-200
4-11	---	---	not used
12-15	alpha_0	Single	Sec 20.3.3.5.1.9
16-19	alpha_1	Single	Sec 20.3.3.5.1.9
20-23	alpha_2	Single	Sec 20.3.3.5.1.9
24-27	alpha_3	Single	Sec 20.3.3.5.1.9
28-31	beta_0	Single	Sec 20.3.3.5.1.9
32-35	beta_1	Single	Sec 20.3.3.5.1.9
36-39	beta_2	Single	Sec 20.3.3.5.1.9
40-43	beta_3	Single	Sec 20.3.3.5.1.9

Table A.43

Byte	Item	Type	Definition / IDC-GPS-200
4-16	---	---	not used
17-24	A_0	Double	Sec 20.3.3.5.1.8
25-28	A_1	Single	Sec 20.3.3.5.1.8
29-30	delta_t_LS	Integer	Sec 20.3.3.5.1.8
31-34	t_ot	Single	Sec 20.3.3.5.1.8
35-36	WN t	Integer	Sec 20.3.3.5.1.8

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Table A.43

Byte	Item	Type	Definition / IDC-GPS-200
37-38	WN_LSF	Integer	Sec 20.3.3.5.1.8
39-40	DN	Integer	Sec 20.3.3.5.1.8
41-42	delta_t_LSF	Integer	Sec 20.3.3.5.1.8

Table A.44

Byte	Item	Type	Definition / IDC -GPS-200
4	sv_number	UINT8	SV PRN number
5-8	t_ephem	Single	time of collection (note, if data is missing or invalid, t_ephem will be negative)
9-10	weeknum	INT16	Sec 20.3.3.3, Table 20-I
11	codeL2	UINT8	Sec 20.3.3.3, Table 20-I
12	L2Pdata	UINT8	Sec 20.3.3.3, Table 20-I
13	SVacc_raw	UINT8	Sec 20.3.3.3, Table 20-I
14	SV_health	UINT8	Sec 20.3.3.3, Table 20-I
15-16	IODC	INT16	Sec 20.3.3.3, Table 20-I
17-20	T_GD	Single	Sec 20.3.3.3, Table 20-I
21-24	t_oc	Single	Sec 20.3.3.3, Table 20-I
25-28	a_f2	Single	Sec 20.3.3.3, Table 20-I
29-32	a_f1	Single	Sec 20.3.3.3, Table 20-I
33-36	a_f0	Single	Sec 20.3.3.3, Table 20-I
37-40	SVacc	Single	Sec 20.3.3.3, Table 20-I
41	IODE	UINT8	Sec 20.3.3.4
42	fit_interval	UINT8	Sec 20.3.3.4
43-46	C_rs	Single	Sec 20.3.3.4
47-50	delta_n	Single	Sec 20.3.3.4
51-58	M_0	Double	Sec 20.3.3.4
59-62	C_uc	Single	Sec 20.3.3.4, radians
63-70	e	Double	Sec 20.3.3.4
71-74	C_us	Single	Sec 20.3.3.4, radians
75-82	sqrt_A	Double	Sec 20.3.3.4
83-86	t_oe	Single	Sec 20.3.3.4
87-90	C_ic	Single	Sec 20.3.3.4, radians
91-98	OMEGA_0	Double	Sec 20.3.3.4
99-102	C_is	Single	Sec 20.3.3.4, radians
103-110	i_0	Double	Sec 20.3.3.4
111-114	C_rc	Single	Sec 20.3.3.4
115-122	omega	Double	Sec 20.3.3.4
123-126	OMEGADOT	Single	Sec 20.3.3.4
127-130	IDOT	Single	Sec 20.3.3.4
131-138	Axis	Double	= $(sqrt_A)^2$

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Table A.44 (continued)

Byte	Item	Type	Definition / IDC -GPS-200
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

Report Packet 0x5A - Raw Measurement Data

This packet provides raw GPS measurement data. If the I/O Auxiliary options has been selected, the receive sends this data automatically as measurements are taken. The data format is shows in the table below.

Table A.45 Report Packet 0x5A Data Formats

Byte	Item	Type	Units
0	Satellite PRN number	UINT8	----
1-3	reserved		
4	Integer msec of pseudo-range If Bit 7 =1, pseudo-range is out of bounds	UINT 8	msec
5	Signal level	Single	AMU or dBHz
9	Code phase	Single	1/16th chip
13	Doppler	Single	hertz
17	Time of Measurement	Double	sec

Note – *Packet 0x5A provides the raw satellite signal measurement information used in computing a fix.*

Satellite PRN (Byte 0) is a unique identification number for each of the 32 GPS satellites. The integer millisecond of the pseudo-range has valid values of 0 to 19 milliseconds. If the pseudo-range is out of bounds, this is indicated by setting Bit 7 of Byte 4 to 1.

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 int 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 (module mS) to a user determined integer number of mS between user and satellite.

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The receiver codephase is expressed in 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 meter

Note – *The receiver occasionally adjusts its clock to maintain time accuracy within 1 msec. At this time, all pseudo-range values for all satellites are adjusted upward or downward by one millisecond. Report packet 0x5A checks packet 0x83 or 0x84 for clock bias.*

Report Packet 0x5F

For Trimble diagnostic use only, please ignore.

Report Packet 0x5C - 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 0x3C. The data format is shown below.

Table A.46 Report Packet 0x5C Data Formats

Byte	Bit	Item	Type	Value	Definition
0		Satellite PRN number	UINT8	number 1 - 32	
1	0-2	reserved	Bits	reserved	
1	3-7	Channel	Bits	0-11	
2		Acquisition flag	UINT8	0 1 2	Never acquired Tracking Re-opened search
3		Ephemeris flag	UINT8	0 1	Flag not set Ephemeris is decoded
4-7		Signal level	Single	Same as in Packet 0x47	
8-11		GPS time of last measurement	Single	<0 >0	No measurements have been taken. Center of the last measurement taken from this satellite.
12-15		Elevation	Singles	radians	Approximate elevation of this satellite above the horizon. Updated about every 15 sec.s. Used for searching and computing measurement correction factors.

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Table A.46 Report Packet 0x5C Data Formats (continued)

Byte	Bit	Item	Type	Value	Definition
16-19		Azimuth	Single	radians	Approximate azimuth from true north to this satellite. Updated typically about every 3 to 5 minutes. Used for computing measurement correction factors.
20-23		reserved	UINT8	0	

Report Packet 0x6D - 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 where “nSVs” is the number of satellites used in the solution.

The GPS receiver sends this packet in response to Packet 0x24. The data format is shown below.

Table A.47 Report Packet 0x6D Data Formats

Byte	Bit	Item	Type	Value	Definition
0	0-2	Dimension	UINT8	3 4	2D 3D
0	3			0 1	Auto Manual
0	4-7			-	nSVs
1-4		PDOP	Single		PDOP
5-8		HDOP	Single		HDOP
9-12		VDOP	Single		VDOP
13-16		TDOP	Single		TDOP
(16+nSVvs)		SV PRN	UINT8		

Note – *The Lassen IQ GPS Receiver sends this packet automatically after a position fix or every second if no position fix occurs.*

Command Packet 0x7A

The NMEA message determines whether or not a given NMEA message will be output. If the bit for a message is set, the message will be sent every “interval” second. Use the values shown below to determine the NMEA interval and message mask. While fixes are being generated, the output order is: ZDA, GGA, GLL, VTG, GSA, GSV, RMC.

Table A.48 Command Packet 0x7A and Report Packet 0x7B Data Formats

Byte	Bit	Item	Type	Value	Definition
0		Subcode	UINT8	0	
1		Interval	UINT8	1-255	Fix interval in seconds

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Table A.48 Command Packet 0x7A and Report Packet 0x7B Data Formats

Byte	Bit	Item	Type	Value	Definition
2		Reserved			
3		Reserved			
4	D	RMC	Bit	0 1	Off On
4	1	TF	Bit	0 1	Off On
4	5	BA	Bit	0 1	Off On
4	6-7	Reserved			
5	0	GGA	Bit	0 1	Off On
5	1	GLL	Bit	0 1	Off On
5	2	VTG	Bit	0 1	Off On
5	3	GSV	Bit	0 1	Off On
5	4	GSA	Bit	0 1	Off On
5	5	ZDA	Bit	0 1	Off On
5	6-7	Reserved			

Report Packet 0x7B

This packet provides the NMEA settings and interval.

Command Packet 0x7E - TAIP Message Output

TSIP packet 0x7E is used to setup the output configuration for TAIP messages. This packet expands the features similar to what have been provided by packet 0x8E-40 found in some older generation Trimble receiver products.The settings provided by the packet can be divided into 4 groups:

1. Reporting Flags – byte 1.
2. The Top-of-Hour Offset – byte 2,3. This setting applies to all eight messages included in this packet. (If different values have to be applied to each message individually, use the Time-Distance feature from TAIP protocol.)
3. Automatic Output Intervals for the 8 commonly used messages – bytes 4 - 19
4. Device ID – bytes 20-23.

This packet provides the capability to set the output frequencies for the eight commonly used messages individually. This is the same as the F<message type><output interval> command in TAIP. In contrast to packet 0x8E-40, the settings in this packet are not just for the so-called Heartbeat messages, meaning the output

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frequency settings are not only applied when the receiver is not generating a position fix. In practice, this packet provides a comprehensive but straightforward means to set up the TAIP output configuration. It can also be used to reset the output configuration. For example, if any of these eight messages was set up as Time-Distance mode from the TAIP protocol, this packet would reset any such message back to plain periodic output mode or no automatic output mode (frequency=0).

For customization, the settings in this packet can be stored into the Flash by either TSIP packet 0x8E-26 or TAIP command SRTSAVE_CONFIG. The flash storage commands store the latest output configuration which may be set up by either this packet or any other commands from the TAIP protocol. For example, if this packet was executed first from the TSIP protocol and then the Lassen iQ GPS was switched to TAIP protocol and the output settings were changed (e.g. changed to Time-Distance mode), or vise-versa, then the latest settings would be stored into the Flash (when the flash storage command is used).

Note – *See Appendix D for a full explanation of the TAIP protocol messages.*

Byte	Bit	Item	Type	Value	Definition	Default
0		Subcode	UINT8	0	Setting the packet	0
1	0	ID Flag	Bit	0/1	On/Off	0
	1	CS Flag	Bit	0/1	On/Off	1
	2	EC Flag	Bit	0/1	On/Off	1
	3	FR Flag	Bit	0/1	On/Off	1
	4	CR Flag	Bit	0/1	On/Off	0
	5-7	Reserved				
2,3		TOH	UINT16	0-3599	Top of hour offset	0
4,5		AL output period	UINT16	0-3599	Auto output period for AL (sec)	0 (see note)
6.7		CP output period	UINT16	0-3599	Auto output period for CP (sec)	0
8,9		ID output period	UINT16	0-3599	Auto output period for ID (sec)	0
10,11		LN output period	UINT16	0-3599	Auto output period for LN (sec)	0
12,13		PV output period	UINT16	0-3599	Auto output period for PV (sec)	0
14,15		ST output period	UINT16	0-3599	Auto output period for ST (sec)	0
16,17		TM output period	UINT 16	0-3599	Auto output period for TM (sec)	0
18,19		VR output period	UINT 16	0-3599	Auto output period for VR (sec)	0
20-23		Veh ID	String	See TAIP ID	Vehicle ID	“0000”

Note – *0 second period means the corresponding message is not to be output at all.*

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Command Packet 0x82 - SBAS Correction Status

This packet provides the SBAS position fix mode of the receiver. This packet contains only one data byte to specify the mode. If SBAS is enabled in packet 0xBB, Copernicus will acquire a SBAS satellite after it has a GPS-based position fix. The packet is sent in response to Packet 0x62.

Table A.49 Command Packet 0x82 - SBAS Correction Status

Byte	Bit	Item	Type	Value	Definition
0	0 (LSB)	Last fix status	Bit	0 1	0 not corrected, 1 SBAS corrected
	1	Reserved	Bit	0	Reserved
	2	Last fix correction source	Bit	0 1	0 is no correction, 1 is SBAS corrected
	3	Reserved	Bit	0	Reserved
	4	Reserved	Bit	0	Reserved
	5	Reserved	Bit	0	Reserved
	6	Reserved	Bit	0	Reserved
	7	Reserved	Bit	0	Reserved

* To allow the user to disable/enable individual SBAS SVs:

TSIP - new packet, 0xC2, bytes 0-4 for SBAS SV bit masks

NMEA - new packet, SV, field 0 is for GPS SV bit masks, field 1 is for SBAS SV bit masks

$PTNLRSV, xxxxxxxx,xxxxxxxx

10 C2 00 04 80 00 10 03

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Report Packet 0x83 - 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 Precision of Position option is set to Double (see Packet 0x35), the receiver sends this packet each time a fix is computed. The data format is shown below.

Table A.50 Report Packet 0x83 Data Formats

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.

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

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

This packet provides current GPS position fix in LLA coordinates. If the I/O Position option is set to LLA and the Precision of Position option is set to Double (see Packet 0x35), the receiver sends this packet each time a fix is computed. The data format is shown below.

Table A.51 Report Packet 0x84 Data Formats

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.



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

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Packets 0x8E and 0x8F - Superpacket

See page 159 for information on Packets 0x8E and 0x8F.

Command Packet 0xBB - Navigation Configuration

In query mode, Packet 0xBB is sent with a single data byte and returns Report Packet 0xBB.

Note – *This Command Packet replaces Packets 0x2C, 0x62, 0x75, and 0x77.*

Table A.52 Command Packet 0xBB Query Mode Data Format

Byte #	Item	Type	Value	Definition	Default
0	Subcode	UINT8	0x00	Query mode	

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

Table A.53 Command and Report Packet 0xBB Field Descriptions

Byte #	Item	Type	Value	Definition	Default
0	Subcode	UINT8	0x00	Query mode	0x03
1	Reserved				
2	SBAS	UINT8	0 1	WAAS_OFF WAAS_AUTO	WAAS_AUTO
3	Dynamics Code	UINT8	1 2 3	Land Sea Air	Land
4	Reserved				
5-8	Elevation Mask	Single	0.0 - 1.57 (radian)	Lowest satellite elevation for fixes	0.0873 (5^{O})
9-12	Reserved				
13-16	Reserved				
17-20	Reserved				
21	Reserved				
22-39	Reserved				

Note – *The dynamic limits for Dynamics Codes are:*
Land: acceleration < 10m/s^2; velocity < 120m/s; altitude < 9000m
Sea: acceleration < 10m/s^2; velocity < 45m/s; altitude < 9000m
Air: acceleration < 10m/s^2; velocity < 515m/s; altitude < 50000m

Note – *Byte #2 is for all SBAS, not just WAAS.*

Command Packet 0xBC - Protocol Configuration

TSIP Packet 0xBC is used to query the port characteristics. In query mode, Packet 0xBC is sent with a single data byte and returns Report Packet 0xBC. (See Table A.4 for information on saving the settings to non-volatile memory.)

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TSIP Packet 0xBC is used to set the communication parameters on port A. The table below lists the individual fields within the Packet 0xBC and provides query field descriptions. The BC command settings are retained in battery-backed RAM.

Table A.54 Command Packet 0xBC Port Characteristics

Byte	Bit	Item	Type	Value	Definition
0		Port to Set	UINT 8	0 1 0xFF	Port A Port B Current port
1		Input Baud Rate	UINT 8	2 3 4 5 6 7 8 9 10 11	Reserved Reserved Reserved Reserved 4800 baud 9600 baud 19200 baud 38400 baud 57600 baud 115200 baud
2		Output Baud Rate	UINT 8	As above	As above (Note 1)
3		# Data Bits	UINT 8	3	8 bits
4		Parity	UINT 8	0	None
5		# Stop Bits	UINT 8	0	1 bit
6		Flow Control	UINT 8	0	0 = none
7	0	TAIP	Bit	0 1	Off On
	1	TSIP input	Bit	0 1	Off On
	2	NMEA input	Bit	0 1	Off On
	3	Reserved			
	4-7	Reserved			
8	0	TAIP	Bit	0 1	Off On
	1	TSIP output	Bit	0 1	Off On
	2	NMEA output	Bit	0 1	Off On
	3-7	Reserved			
9		Reserved			

Note – *The Copernicus GPS receiver requires that the input and output baud rates be identical.*

Command Packet 0xC0 - Graceful Shutdown and Go To Standby Mode

TSIP Packet 0xC0 is used to issue a reset or graceful shutdown to the unit and/or command the unit into Standby Mode.

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The table below lists the individual fields within the Packet 0xC0 and provides query field descriptions. Any combination of conditions in byte 2 can be specified for starting up the unit from standby mode. The condition that happens first will trigger the unit to start up. If byte 2, bit 2 is set to 1, then byte 3 must be greater than 0.

Byte	Bit	Item	Type	Value	Definition
0		Reset type or go to standby mode	BYTE	'H' 'W' 'C' 'S' 'F'	hot start warm start cold start standby mode factory reset
1		Store BBRAM to Flash flag	BYTE	0	Reserved
				1	Reserved
				2	Store user configuration to Flash Memory
				3	Store user configuration to Flash memory
				4	Erase Almanac, ephemeris and last position from Flash Memory
				5	Erase user configuration from Flash Memory
				6	Erase Almanac, ephemeris, last position and user configuration from Flash Memory
2	0	Start-up from Standby Mode condition flags	BYTE	0 1	1=start up on serial port A activity
	1			0 1	1=start up on serial port B activity
	2			0 1	1=start up after RTC alarm elapsed
3-4		Number of seconds to stay in Standby mode	UINT32	0 to 2147483647 or 0 to (2^{31} - 1)	seconds

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Command Packet 0xC1 - Set Bit Mask for GPIOs in Standby Mode

Users may designate individual pins for pull-down and pull-up while the unit is in Standby Mode. This allows the user to select external pull-down or pull-up resistors to suit their application.

Examples:

- In serial port configuration, one option would be to power down the serial port during standby in which case the corresponding GPIOs would be pull-downs.
- To keep the serial port running during standby, the corresponding GPIOs would be set to pull-ups.

Note – *The pins that are not connected should remain in their default state, pull-down.*

Use bit 5 of byte 1 to select the pull-down or pull-up resistor for the XTANDBY pin as appropriate for the application. Unlike the other GPIOs, the selection of the pull-down or pull-up resistor is applied during Run Mode.

Examples:

- When the XSTANDBY pin is tied to main power, as shown in the reference design, select the pull-down resistor for the XTANDBY pin so when main power is removed, XTANDBY is immediately pulled low to go into Standby Mode.
- When the XTANDBY pin is controlled with GPIO on the user's processor, the pull-down or pull-up resistor may be selected depending on the GPIO state.

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Table A.55 Command Packet 0xC1

Byte	Bit	Item	Type	Value	Definition
Position					
0	0 (LSB)	Pin 6, Reserved	Bit	0	Reserved
	1	Pin 7, OPEN	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	2	Pin 8, SHORT	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	3	Pin 17, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	4	Pin 18, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	5	Bit 5, Pin 19, PPS	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	6	Pin 20, RxDB	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	7	Pin 21, RxDA	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
1	0	Pin 22, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	1	Pin 23, TxDA	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	2	Pin 24, TxDB	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	3	Pin 25, Reserved	Bit	0	0 is pull-down, 1 is pull-up, default is pull-down
	4	Pin 26, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	5	Pin 16, XSTANDBY	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-up
	6-7	Reserved	Bit		Reserved

The settings will be saved to flash when the user issues the command to “Save User Configuration to Flash”.

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Command Packet 0xC2 - SBAS SV Mask.

This packet provides the SBAS SV bit mask in four bytes. The user data packet contains four bytes to specify 19 possible SBAS prn numbers. Bit 0 represents PRN 120.

Available WAAS PRN numbers are 135 and 138.

Message format is:

<DLE> <id> <byte 3> <byte 2> <byte 1> <byte 0> <DLE> <ETX>

To disable WAAS PRN 135 send 10 C2 00 00 80 00 10 03

To disable WAAS PRN 138 send 10 C2 00 04 00 00 10 03

To enable all WAAS send 10 C2 00 00 00 00 10 03

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TSIP Superpackets

Several packets have been added to the core TSIP protocol to provide additional capability for OEM receivers. In OEM Packets 0x8E and their 0x8F responses, the first data byte is a sub-code which indicates the superpacket type. For example, in Packet 0x8E-15, 15 is the sub-code that indicates the superpacket type. Therefore the ID code for OEM packets is 2 bytes long followed by the data. Command packet 0x35 is used to enable superpackets.

Command Packet 8E-15 - Set/Request Datum

This packet allows the user to change the default datum from WGS-84 to one of 180 selected datums. 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 affects all calculations of LLA in packets 0x4A and 0x84.

The datum can be changed to match coordinates with another system such as a map. Most maps are marked with the datum used. In the US, the most popular datum for maps is NAD-27. You may choose a datum optimized for the local shape of the earth, however optimized datums are truly local and provide very different results when used outside of the area for which they are intended. WGS-84 is an excellent general ellipsoid valid around the world. To request the current datum setting, one data byte is sent. Report Packet 0x8F is returned.

Table A.56 Command Packet 8E-15

Byte	Type	Meaning
0	Superpacket	0x15

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 desired datum.

Table A.57 Command Packet 8E-15

Byte	Type	Meaning
0	Superpacket ID	0x15
1-2	INT16	Datum index

Note – *To request the current datum, send Packet 8E015 with no data bytes.*

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Command Packet 0x8E-17 - Request Last Position or Auto-Report Position in UTM Single Precision Format

This packet requests Packet 0x8F-17 or marks it for automatic output. If only the first byte (packet sub-code 0x17) is sent, an 0x8F-17 report containing the last available data 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 as shown in the table below. To retain the auto-report setting for this packet, first set the setting accordingly and then save to non-volatile memory by issuing the packet 0x8E-26.

Table A.58 Command Packet 0x8E-17

Byte	Item	Type	Value	Definition
0	Packet sub-code	UINT8	0x17	Packet sub-code
1	Mark for auto-report	UINT8	0,1	0=do not mark for auto-report 1=mark for auto-report

Command Packet 8E-18 - Request Last Position or Auto Report Position in UTM Double Precision Format

This packet requests Packet 0x8F-18 or marks it for automatic output. If only the first byte (packet sub-code 0x18) is sent, an 0x8F-18 report containing the last available data 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 as shown in below. To retain the auto-report setting for this packet, first set the setting accordingly and then save to non-volatile memory by issuing the packet 0x8E-26.

Table A.59 Command Packet 8E-18

Byte	Item	Type	Value	Definition
0	Packet sub-code	UINT8	0x18	Packet sub-code
1	Mark for auto-report	UINT8	0,1	0=do not mark for auto-report 1=mark for auto-report

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

This packet requests Packet 0x8F-20 or marks it for automatic output. If only the first byte (20) is sent, an 0x8F-20 report containing the last available fix will be sent immediately. If two bytes are sent, the packet is marked/unmarked for auto report according to the value of the second byte as shown in below. 0x37 can also be used for requesting 0x8F-20 if the 0x8F-20 is scheduled for auto output.

Table A.60 Command Packet 0x8E-20 Field Descriptions

Byte	Item	Type	Definition
0	Sub-packet id	UINT8	0x20
1	Mark for Auto-report (See Packet 35 byte 0 bit 5)	UINT8	0 = do not auto-report 1 = mark for auto-report

Note – *Auto-report requires that superpacket output is enabled. Refer to Command Packet 35.*

Command Packet 0x8E-26 - Non-Volatile Memory Storage

The 0x8E-26 command is issued with no data to cause the current settings to be saved to non-volatile memory. The 0x8F-26 report is generated after the values have been saved.

Table A.61 Command Packet 0x8E-26 Definitions

Byte #	Item	Type	Value	Definition
0	Subcode	UINT8	0x26	Save Settings

Command Packet 0x8E-2A - Request Fix and Channel Tracking Info, Type 1

This packet requests Packet 0x8F-2A or marks it for automatic output. If only the first byte (packet sub-code 0x2A) is sent, an 0x8F-2A report containing the last available data 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 as shown in below.

To retain the auto-report setting for this packet, first set the setting accordingly and then save to non-volatile memory by issuing the packet 0x8E-26.

Table A.62 Command Packet 0x8E-2A

Byte	Item	Type	Value	Definition
0	Packet sub-code	UINT8	0x2A	Packet sub-code
1	Mark for Auto-report	UINT8	0,1	0 = do not auto-report 1 = mark for auto-report

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Command Packet 0x8E-2B - Request Fix and Channel Tracking Info, Type 2

This packet requests Packet 0x8F-2B or marks it for automatic output. If only the first byte (packet sub-code 0x2B) is sent, an 0x8F-2B report containing the last available data 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 as shown in below.

To retain the auto-report setting for this packet, first set the setting accordingly and then save to non-volatile memory by issuing the packet 0x8E-26.

Table A.63 Command Packet 0x8E-2B

Byte	Item	Type	Value	Definition
0	Packet sub-code	UINT8	0x2B	Packet sub-code
1	Mark for Auto-report	UINT8	0,1	0 = do not auto-report 1 = mark for auto-report

Command Packet 8E-4A - Set/Request Lassen iQ GPS Cable Delay and PPS Polarity

Using this packet, you can query and control the Lassen iQ GPS cable delay characteristics. The receiver responds to a query or control command with packet 8F-4A. The packet contains 16 bytes.

Table A.64 Command Packet 8E-4A

Byte	Item	Type	Meaning
0	Sub-packet ID	BYTE	Always 0x4A
1	Reserved		
2	Reserved		
3	Polarity	BYTE	0 Positive 1 Negative
4-11	PPS Offset of Cable Delay	DOUBLE	Seconds (default=0.0)
12-15	Reserved		

Command Packet 0x8E-4F - Set PPS Width

This command packet sets the PPS width to a value in the range of 100 microseconds to 500 milliseconds. The receiver returns packet 0x8F-4F. The current PPS width can be requested by sending this packet with no data bytes except the subcode byte.

Table A.65 Command Packet 0x8E-4F

Byte	Item	Type	Value	Meaning
0	Subcode	BYTE	0x4F	
1-8	PPS width	DOUBLE		Seconds

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Report Packet 0x8F-15 - Current Datum Values

This packet contains 43 data bytes with the values for the datum currently in use, and is sent in response to Packet 0x8E-15. Both the datum index and the 5 double precision values for that index will be returned.

Table A.66 Report Packet 0x8F-15

Byte	Type	Meaning
0	UINT8	ID for this sub-packet (always x15)
1-2	INT16	Datum index
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. Eccentricity Squared is related to flattening by the following equation:* $e^2=2p-p^2$.

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Report Packet 8F-17 - UTM Single Precision Output

This packet reports position in UTM (Universal Transverse Mercator) format. The UTM coordinate system is typically used for U.S. and international topographical maps.

The UTM coordinate system lays out a world-wide grid consisting of the following:

- 60 North/South zones in 6° increments, extending eastward from the International Data Line.
- 10 East/West zones in 8° increments, extending above and below the equator.

Coordinates within these boundaries cover all surface locations from 80° South to 84° North and encircle the earth. Locations are indicated by offset from the equator and in the zones east of the International Date Line. These offsets are known as Northing and Easting, and are expressed in meters. UTM is not usable in polar regions.

Table A.67 Report Packet 8F-17

Byte	Item	Type	Value
0	Subcode		0x17
1	Gridzone Designation	Char	
2-3	Gridzone	INT16	
4-7	Northing	Single	Meters
8-11	Easting	Single	Meters
12-15	Altitude	Single	Meters
16-19	Clock Bias	Single	Meters
20-23	Time of Fix	Single	Seconds

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Report Packet 8F-18 - UTM Double Precision Output

This packet reports position in UTM (Universal Transverse Mercator) format. The UTM coordinate system is typically used for U.S. and international topographical maps.

The UTM coordinate system lays out a world-wide grid consisting of the following:

- 60 North/South zones in 6° increments, extending eastward from the International Data Line.
- 10 East/West zones in 8° increments, extending above and below the equator.

Coordinates within these boundaries cover all surface locations from 80° South to 84° North and encircle the earth. Locations are indicated by offset from the equator and in the zones east of the International Date Line. These offsets are known as Northing and Easting, and are expressed in meters. UTM is not usable in polar regions.

Table A.68 Report Packet 8F-18

Byte	Item	Type	Value
0	Subcode		0x17
1	Gridzone Designation	Char	
2-3	Gridzone	INT16	
4-7	Northing	Double	Meters
8-11	Easting	Double	Meters
12-15	Altitude	Double	Meters
16-19	Clock Bias	Double	Meters
20-23	Time of Fix	Single	Seconds

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

This packet provides complete information about the current position velocity fix in a compact, fixed-length 56-byte packet. The fields are fixed-point with precision matched to the receiver accuracy. It can be used for automatic position/velocity reports. The latest fix can also be requested by 0x8E-20 or 0x37 commands.The data format is shown below.

Table A.69 Report Packet 0x8F-20 Data Formats

Byte	Bit	Item	Type	Value	Definition
0		Sub-packet id	UINT8		Id for this sub-packet (always 0x20)
1		Reserved	UINT8		Reserved
2-3		East velocity	INT16		0.005 m/s or 0.020 m/s See Note 1.
4-5		North velocity	INT16		0.005 m/s or 0.020 m/s See Note 1.
6-7		Up velocity	INT16		0.005 m/s or 0.020 m/s See Note 1.
8-11		Time Of Week	UINT32		GPS Time in milliseconds
12-15		Latitude	INT32	-2^{30} to 2^{30}	WGS-84 latitude, 2^{-31} semicircle (-90° - 90°)
16-19		Longitude	UINT32	0 to 2^{32}	WGS-84 longitude, 2^{-31} semicircle (0° - 360°)
20-23		Altitude	INT32		Altitude above WGS-84 ellipsoid, mm.
24	0	Velocity Scaling		0 1	0.005 m/s^2 0.020 m/s^2
	1-7	reserved			
25		reserved			
26		Datum			Datum index + 1, 0=unknown
27	0	Invalid Fix	Bit	0 1	No (Valid Fix) Yes (Invalid Fix)
	1	Reserved	Bit	0	Reserved
	2	Fix Dimension	Bit	0 1	3D 2D
	3	Alt Hold	Bit	0 1	Last 3D Altitude User-entered altitude
	4	Filtered	Bit	0 1	Unfiltered Filtered
	5-7	reserved			
28		NumSVs	UINT8		Number of satellites used for fix. Will be zero if no fix avail.
29		UTC Offset	UINT8		Number of leap seconds between UTC and GPS time.
30-31		Week	INT16		GPS time of fix, weeks.

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Table A.69 Report Packet 0x8F-20 Data Formats (continued)

Byte	Bit	Item	Type	Value	Definition
32	0-5	PRN 1	UINT8	1-32	PRN of first satellite
	6-7	reserved			
33		IODE 1	UINT8		IODE of first satellite
34	0-5	PRN 2	UINT8	1-32	PRN of second satellite
	6-7	reserved			
35		IODE 2	UINT8		IODE of second satellite
36	0-5	PRN 3	UINT8	1-32	PRN of third satellite
	6-7	reserved			
37		IODE 3	UINT8		IODE of third satellite
38	0-5	PRN 4	UINT8	1-32	PRN of fourth satellite
	6-7	reserved			
39		IODE 4	UINT8		IODE of fourth satellite
40	0-5	PRN 5	UINT8	1-32	PRN of fifth satellite
	6-7	reserved			
41		IODE 5	UINT8		IODE of fifth satellite
42	0-5	PRN 6	UINT8	1-32	PRN of sixth satellite
	6-7	reserved			
43		IODE 6	UINT8		IODE of sixth satellite
44	0-5	PRN 7	UINT8	1-32	PRN of seventh satellite
	6-7	reserved			
45		IODE 7	UINT8		IODE of seventh satellite
46	0-5	PRN 8	UINT8	1-32	PRN of eighth satellite
	6-7	reserved			
47		IODE 8	UINT8		IODE of eighth satellite
48	0-5	PRN 9	UINT8	1-32	PRN of ninth satellite
	6-7	reserved			
49		IODE 9	UNIT8		IODE of ninth satellite
50	0-5	PRN 10	UINT8	1-32	PRN of tenth satellite
	6-7	reserved			
51		IODE 10	UNIT8		IODE of tenth satellite
52	0-5	PRN 11	UINT8	1-32	PRN of eleventh satellite
	6-7	reserved			
53		IODE 11	UNIT8		IODE of eleventh satellite
54	0-5	PRN 12	UINT8	1-32	PRN of twelfth satellite
	6-7	reserved			
55		IODE 12	UINT8		IODE of twelfth satellite
56-63		Ionospheric parameters			

Note – *Velocity scale controlled by byte 24, bit 1. Overflow = 0x8000.*

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Report Packet 0x8F-26 - Non-Volatile Memory Status

This report will be issued after an 0x8E-26 command.

Table A.70 Report Packet 0x8F-26

Byte	Item	Type	Value	Definition
0	Subcode	UINT8	0x26	Save settings
1-4	Reserved			

Report Packet 0x8F-2A - Fix and Channel Tracking Info, Type 1

This packet provides compact fix and channel tracking information. This packet can be requested or set up for automatic output by 0x8E-2A. Total packet length (including header DLE, packet ID 0x8F, packet data as described below and trailing DLE/ETX bytes): 168 bytes.

Table A.71 Report Packet 0x8F-2A

Byte Offset	Item	Type	Value	Definition
0	Packet sub-code	UINT8	0x2A	Packet sub-code (always 0x2A).
1	<reserved>	UINT8	0x00	Reserved for future use.
2	<reserved>	UINT8	0x00	Reserved for future use.
3	GPS Week Number	UINT16	0 to 1023	10-bit GPS week number of measurement (in weeks).
5	GPS Millisecond	UINT32	0 to 603799999	GPS time of week of measurement (in milliseconds).
9	Fractional GPS Nanosecond	INT32	-500000 to 500000	Fractional part of the GPS millisecond (in nanoseconds). See Note 1.
13	Altitude	INT32	Any	Altitude above WGS-84 ellipsoid (in millimeters).
17	Receiver Status Code	UINT8	Any	0x00 - Doing position fixes 0x01 - Don't have GPS time yet 0x03 - PDOP is too high 0x08 - No usable satellites 0x09 - Only 1 usable satellite 0x0A - Only 2 usable satellites 0x0B - Only 3 usable satellites Other values indicate internal status codes when the receiver is not generating valid position fixes.

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Byte Offset	Item	Type	Value	Definition
18	Receiver Health	UINT8	Bit-masks	Bit 0 - if set, antenna line fault is detected. Bit 1 - if set, antenna line is shorted; if not set, antenna line is open. This bit is valid only if Bit 0 is set. Bit 2 - if set, the current fix is 2-D; if not set, the fix is 3-D. This bit is valid only if Receiver Status Code byte is 0x00. Bit 3 - if set, the current fix is SBAS-corrected. This bit is valid only if Receiver Status Code byte is 0x00. Bit 4 - if set, BBRAM was not available at power-up. Bit 5 - if set, Real-Time Clock was not available at power-up. Bit 6 - if set, the almanac stored in the receiver is not complete and current. Bit 7 - if set, the measurement clock bias is unknown.
19	<reserved>	UINT 8	0x00	Reserved for future use
Channel Tracking information for Channels 0...11 (N) NOTE2				
20+N*12	Satellite ID	UINT8	1 to 32, or 120 to 138	Satellite PRN (GPS or SBAS).
21+N*12	Signal Strength	UINT8	0 to 55	Signal strength (in dB-Hz).
22+N*12	Acquisition Status	UINT16	Bit-masks	Bit 0 - if set, Doppler is valid. Bit 1 - if set, code phase is valid. Bit 2 - if set, time ambiguity is resolved. Bit 3 - if set, measurement is valid. Other bits are reserved.
24+N*12	Pseudo Range	UINT32	any	Pseudo range (in cm).
28+N*12	Range Rate	INT32	any	Range rate (in millimeters/sec).

Note – *This value is valid only if Bit 7 of the Receiver Health byte is not set. To compute the complete GPS time of measurement to 1 ns resolution, use the following formula:*
*GPS Time of Measurement (nanosec) = GPS Millisec*1000000 + Fractional GPS Nanosec*

Note – *The channel tracking block (12 bytes in length) is repeated for all 12 channels.*

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Report Packet 0x8F-2B - Fix and Channel Tracking Info, Type 2

This packet provides compact fix and channel tracking information. This packet can be requested or set up for automatic output by 0x8E-2B. Total packet length (including header DLE, packet ID 0x8F, packet data as described below and trailing DLE/ETX bytes): 88 bytes.

Table A.72 Report Packet 0x8F-2B

Byte Offset	Item	Type	Value	Definition
0	Packet sub-code	UINT8	0x2B	Packet sub-code (always 0x2B).
1	<reserved>	UINT8	0x00	Reserved for future use.
2	<reserved>	UINT8	0x00	Reserved for future use.
3	GPS week number	UINT16	0 to 1023	10-bit GPS week number of measurement (in weeks).
5	GPS millisecond	UINT32	0 to 603799999	GPS time of week of measurement (in milliseconds).
9	Latitude	INT32	-230 to 230	Latitude (WGS-84), 2-31 semicircle (-90° - 90°). See Note 1.
13	Longitude	UINT32	0 to 232	Longitude (WGS-84), 2-31 semicircle (0° - 360°). See Note 1.
17	Altitude	INT32	any	Altitude above WGS-84 ellipsoid (in millimeters).
21	East/West Velocity	INT32	any	East/West velocity (in mm/s). Positive value - East velocity; negative - West.
25	North/South Velocity	INT32	any	North/South velocity (in mm/s). Positive value - North velocity; negative - South.
29	Up/Down Velocity	INT32	any	Up/Down velocity (in mm/s). Positive value - Up velocity; negative - Down.

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Byte Offset	Item	Type	Value	Definition
33	Receiver Status Code	UINT8	Any	0x00 - Doing position fixes 0x01 - Don't have GPS time yet 0x03 - PDOP is too high 0x08 - No usable satellites 0x09 - Only 1 usable satellite 0x0A - Only 2 usable satellites 0x0B - Only 3 usable satellites Other values indicate internal status codes when the receiver is not generating valid position fixes.
34	Receiver Health	UINT8	Bit-masks	Bit 0 - if set, antenna line fault is detected. Bit 1 - if set, antenna line is shorted; if not set, antenna line is open. This bit is valid only if Bit 0 is set. Bit 2 - if set, the current fix is 2-D; if not set, the fix is 3-D. This bit is valid only if Receiver Status Code byte is 0x00. Bit 3 - if set, the current fix is SBAS-corrected. This bit is valid only if Receiver Status Code byte is 0x00. Bit 4 - if set, BBRAM was not available at power-up. Bit 5 - if set, Real-Time Clock was not available at power-up. Bit 6 - if set, the almanac stored in the receiver is not complete and current. Bit 7 - if set, the measurement clock bias is unknown.
35	<reserved>	UINT8	0x00	Reserved for future use.
Channel Tracking information for Channels 0…11 (N) NOTE 2				
36+N*4	Satellite ID	UINT8	1 to 32, or 120 to 138	Satellite PRN (GPS or SBAS).
37+N*4	Signal Strength	UINT8	0 to 55	Signal strength (in dB-Hz).

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Byte Offset	Item	Type	Value	Definition
38+N*4	Measurement Status	UINT8	Bit-masks	Bit 2 - if set, time ambiguity is resolved (channel is acquired). Bit 4 - if set, ephemeris is decoded. Other bits are reserved.
39+N*4	Fix Mode / Rejection Code	UINT8	Any	0x00 - SV is used in computing the current position fix. 0x01…0xFF - SV is not used in fix. The value indicates the internal "rejection" code.

Note – *To convert to radians, multiply the received latitude or longitude value by* $(PI/2^{31})$*. For longitude, if the converted value is greater than PI, subtract 2*PI (PI = 3.1415926535898) to bring the final value to the (-PI…+PI) range.*

The channel tracking block (4 bytes in length) is repeated for all 12 channels.

Report Packet 0x8F-4F - Set PPS Width

Note – *This report packet is output after the command packet 0x8E-4E has been executed. See the corresponding command packet for information about the data formats.*

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Datums

Reference: DMA TR 8350.2 Second Edition, 1 Sept. 1991. DMA Technical Report, Department of Defense World GEodetic System 1984, Definition and Relationships with Local Geodetic Systems.

Trimble Datum	Local Geodetic Datum
Index	**Name**
0	WGS-84
6	WGS-72
7	NAD-83
8	NAD-02
9	Mexican
10	Hawaii
11	Astronomic
12	U.S. Navy

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
15	Adindan Mean Solution (Ethiopia and Sudan)	ADI-M
16	Adindan Ethiopia	ADI-A
17	Adindan Mali	ADI-C
18	Adindan Senegal	ADI-D
19	Adindan Sudan	ADI-B
20	Afgooye Somalia	AFG
23	ARC 1950 Mean Solution	ARF-M
24	ARC 1950 Botswana	ARF-A
25	ARC 1950 Lesotho	ARF-B
26	ARC 1950 Malawi	ARF-C
27	ARC 1950 Swaziland	ARF-D
28	ARC 1950 Zaire	ARF-E
29	ARC 1950 Zambia	ARF-F
30	ARC 1950 Zimbabwe	ARF-G
31	ARC 1960 Mean Solution	ARS
32	ARC 1960 Kenya	ARS
33	ARC 1960 Tanzania	ARS
45	Cape South Africa	CAP
47	Carthage Tunisia	CGE
82	Liberia 1964 Liberia	LIB
87	Massawa Eritrea (Ethiopia)	MAS
88	Merchich Morocco	MER
90	Minna Nigeria	MIN-B
94	Schwarzeck Namibia	SCK
118	Old Egyptian 1907 Egypt	OEG

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Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
1	Tokyo	
21	Ain El Abd 1970 Bahrain Island	AIN-A
51	Djakarta (Batavia) Sumatra (Indonesia)	BAT
71	Hong Kong 1963 Hong Kong	HKD
72	Indian 1975 Thailand	INH -A
73	Indian India and Nepal	IND-I
77	Kandawala Sri Lanka	KAN
79	Kertau 1948 West Malaysia and Singapore	KEA
91	Nahrwan Masirah Island (Oman)	NAH-A
92	Nahrwan United Arab Emirates	NAH-B
93	Nahrwan Saudi Arabia	NAH-C
124	Oman Oman	FAH
143	Quatar National Qatar	QAT
161	South Asia Singapore	SOA
164	Timbalai 1948 Brunei and East Malaysia (Sarawak and Sabah)	TIL
165	Tokyo Mean Solution (Japan, Okinawa and South Korea)	TOY-M
166	Tokyo South Korea	TOY-B
167	Tokyo Okinawa	TOY-C
176	Hu-Tzu-Shan Taiwan	HTN
179	Tokyo GIS Coordinates	TOY-B

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
5	Australian Geodetic 1966 Australia and Tasmania	AUA
14	Australian Geodetic 1984 Australia and Tasmania	AUG
39	Australian Geodetic 1966 Australia and Tasmania	AUA

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
4	European 1950 Mean Solution	EUR-M
13	European 1950 Mean Solution	EUR-M
54	European 1950 Mean Solution	EUR-M
55	European 1950 Cyprus	EUR-E
56	European 1950 Egypt	EUR-F
57	European 1950 England, Ireland, Scotland, Shetland Islands	EUR-G
58	European 1950 England, Ireland, Scotland, Shetland Islands	EUR-K
59	European 1950 Greece	EUR-B
60	European 1950 Iran	EUR-H
61	European 1950 Sardinia	EUR-I
62	European 1950 Sicily	EUR-J
63	European 1950 Norway and Finland	EUR-C

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Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
64	European 1950 Portugal and Spain	EUR-D
65	European 1979 Mean Solution	EUS
74	Ireland 1965 Ireland	IRL
125	Ordnance Survey of Great Britain Mean Solution	OGB-M
126	Ordnance Survey of Great Britain England	OGB-M
127	Ordnance Survey of Great Britain Isle of Man	OGB-M
128	Ordnance Survey of Great Britain Scotland and Shetland Islands	OGB-M
129	Ordnance Survey of Great Britain Wales	OGB-M
145	Rome 1940 Sardinia	MOD

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
0	WGS-84	
2	North American 1927 Mean Solution (CONUS)	NAS-C
3	Alaska Canada	
46	Cape Canaveral Mean Solution (Florida and Bahamas)	CAC
96	NAD 27 Western United States	NAS-B
97	NAD 27 Eastern United States	NAS-A
98	NAD 27 Alaska	NAS-D
99	NAD 27 Bahamas	NAS-Q
100	NAD 27 San Salvador	NAS-R
101	NAD 27 Canada	NAS-E
102	NAD 27 Alberta BC	NAS-F
103	NAD 27 East Canada	NAS-G
104	NAD 27 Manitoba Ontario	NAS-H
105	NAD 27 Northwest Territories Saskatchewan	NAS-I
106	NAD 27 Yukon	NAS-J
107	NAD 27 Canal Zone	NAS-O
108	NAD 27 Caribbean	NAS-P
109	NAD 27 Central America	NAS-N
110	NAD 27 Cuba	NAS-T
111	NAD 27 Greenland	NAS-U
112	NAD 27 Mexico	NAS-V
113	NAD 83 Alaska	NAR-A
114	NAD 83 Canada	NAR-B
115	NAD 83 CONUS	NAR-C
116	NAD 83 Mexico and Central America	NAR-D

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Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
42	Bogota Observatory Columbia	BOO
43	Compo Inchauspe 1969 Argentina	CAI
49	Chua Astro Paraguay	CHU
50	Corrego Alegre Brazil	COA
132	Provisional South Chilean 1963 Southern Chile (near 53°S)	HIT
133	Provisional South American 1956 Mean Solution (Bolivia, Chile, Columbia, Ecuador, Guyana, Peru, Venezuela)	PRP-M
134	Provisional South American 1956 Bolivia, Chile	PRP-A
135	Provisional South American 1956 Northern Chile (near 19°S)	PRP-B
136	Provisional South American 1956 Southern Chile (near 43°S)	PRP-C
137	Provisional South American 1956 Columbia	PRP-D
138	Provisional South American 1956 Ecuador	PRP-E
139	Provisional South American 1956 Guyana	PRP-F
140	Provisional South American 1956 Peru	PRP-G
141	Provisional South American 1956 Venezuela	PRP-H
149	South American 1969 Mean Solution (Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Guyana, Paraguay, Peru, Trinidad Tobago, Venezuela)	SAN-M
150	South American 1969 Argentina	SAN-A
151	South American 1969 Bolivia	SAN-B
152	South American 1969 Brazil	SAN-C
153	South American 1969 Chile	SAN-D
154	South American 1969 Columbia,	SAN-E
155	South American 1969 Ecuador (Excluding Galapagos Islands)	SAN-F
156	South American 1969 Guyana	SAN-G
157	South American 1969 Paraguay	SAN-H
158	South American 1969 Peru	SAN-I
159	South American 1969 Trinidad and Tobago	SAN-K
160	South American 1969 Venezuela	SAN-L
171	Zanderij Surinam	ZAN

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
34	Ascension Island 1958 Ascension Island	ASC
37	Astro Dos 71 /4 St. Helena Island	SHB
41	Bermuda 1957 Bermuda Islands	BER
70	**Hjorsey 1955 Iceland**	**HJO**
81	L.C.5 Astro 1961 Cayman Brac Island	LCF
86	Selvagem Grande 1938 Salvage Islands	SGM

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Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
95	Naparima, BWI Trinidad and Tobago	NAP
117	Observatorio Meteorologico 1939 Corvo and Flores Islands (Azores)	FLO
130	Pico De Las Nieves Canary Islands	PLN
142	Puerto Rico Puerto Rico and Virgin Islands	PUR
144	Qornoq South Greenland	QUO
146	Santa Braz Sao Miguel, Santa Maria Islands (Azores)	SAO
148	Sapper Hill 1943 East Falkland Islands	SAP
162	Porto Santo 1936 Porto Santo and Madera Islands	POS
163	Graciosa Base Southwest 1948 Faial, Graciosa, Pico, San Jorg, and Terceira Islands (Azores)	GRA
168	Tristan Astro 1968 Tristan Da Cunha	TDC

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
22	Anna 1 Astro 1965 Cocos Islands	ANO
66	Gan 1970 Republic of Maldives	GAA
75	ISTS 073 Astro 1969 Diego Garcia	IST
78	Kerguelen Island 1949 Kerguelen Island	KEG
80	Reunion Mascarene Island	REU
85	Mahe 1971 Mahe Island	MIK

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
35	Astro Beacon E 1945 Iwo Jima	ATF
36	Astro Tern Island (FRIG) 1961 Tern Island	TRN
38	Astronomical Station 1952 Marcus Island	TRN
40	Bellevue (IGN) Efate Erromango Island	IBE
44	Canton Astro1966 Phoenix Island	CAO
48	Chatham Island Astro 1971 Chatham Island (New Zealand)	CHI
52	Dos 1968 Gizo Island (New Georgia Islands)	GIZ
53	Easter Island 1967 Easter Island	EAS
67	Geodetic Datum 1948 New Zealand	GEO
68	Guam 1963 Guam	GUA
69	Gux 1 Astro Guadalcanal Islands	DOB
76	**Johnstone Island 1961 Johnstone Island**	**JOH**
83	Luzon Philippines	LUZ-A
84	Luzon Mindanao Island	LUZ-B
89	Midway Astro 1961 Midway Islands	MID
119	Old Hawaiian Mean Solution	OHA-M
120	Old Hawaiian Hawaii	OHA-A

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Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
121	Old Hawaiian Kauai	OHA-B
122	Old Hawaiian Maui	OHA-C
123	Old Hawaiian Oahu	OHA-D
131	Pitcairn Astro 1967Pitcairn Island	PIT
147	Santo (DOS) 1952 Espirito Santo Island	SAE
169	Viti Levu 1916 Viti Levu Island (Fiji Islands)	MVS
170	Wake Eniwetok 1960 Marshall Islands	ENW

Trimble Datum	Local Geodetic Datum	
Index	**Name**	**Code**
172	Bukit Rimpah Bangka and Belitung Islands (Indonesia)	BUR
173	Camp Area Astro Camp McMurdo Area, Antarctica	CAZ
174	Gunung Segara Kalimantan (Indonesia)	GSE
175	Herat North Afghanistan	HEN

This report will be issued after an 0x8E-26 command.

Table A.73 Report Packet 0x8F-26—Non-Volatile Memory Status

Byte	Item	Type	Value	Definition
0	Subcode	UINT8	0x26	Save Settings
1-4	reserved			

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APPENDIX

B

TRIMBLE ASCII INTERFACE PROTOCOL (TAIP)

In this appendix:

- Protocol Overview
- Message Format
- Sample PV Message
- Time and Distance Reporting
- Latitude and Longitude Conversion
- Message Data Strings
- Communication Scheme for TAIP

This appendix describes the Trimble ASCII Interface Protocol (TAIP), Trimble's digital communication interface.

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Protocol Overview

Trimble ASCII Interface Protocol (TAIP) is a Trimble-specified digital communication interface based on printable ASCII characters over a serial data link. TAIP was designed specifically for vehicle tracking applications but has become common in a number of other applications because of its ease of use. TAIP supports both scheduled and polled responses.

TAIP messages may be scheduled for output at a user specified rate starting on a given epoch from top of the hour. For communication robustness, the protocol optionally supports checksums on all messages. It also provides the user with the option of tagging all messages with the unit's user specified identification number (ID). This greatly enhances the functional capability of the unit in a network environment. Additionally, given the printable ASCII format of all communication, TAIP is ideal for use with mobile data terminals, modems, and portable computers. Although, receivers incorporating this protocol are shipped from the factory with a specific serial port setting, the port characteristics are fully programmable through TAIP messages.

The Copernicus GPS Receiver supports the following TAIP messages.

Message	Description
AL	Altitude/Up Velocity
CP	Compact Position Solution
ID	Identification Number
IP	Initial Position
LN	Long Navigation Message
PR	Protocol
PT	Port Characteristic
PV	Position/Velocity Solution
RM	Reporting Mode
RT	Reset Mode
ST	Status
TM	Time/Date
VR	Version Number

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Message Format

All TAIP communication uses printable, uppercase ASCII characters. The interface provides the means to configure the output of various sentences in response to queries or on a scheduled basis. Each sentence has the following general format:

>ABB{C}[;ID=DDDD][;*FF]<

where:.

Message	Description
>	Start of new message
A	Message qualifier
BB	Two character message identifier
C	Data string
DDDD	Optional 4 character vehicle ID
FF	Optional 2 character checksum
<	Delimiting character
{x}	Signifies that x can occur any number of times
[x]	Signifies that x may optionally occur once

Start of a New Message

The > character (ASCII code 62 decimal) is used to specify the start of a new sentence.

Message Qualifier

A one character message qualifier is used to describe the action to be taken on the message. The following table lists the valid qualifiers.

Qualifier	Action
Q	Query for a single sentence (sent to GPS receiver)
R	Response to a query or a scheduled report (from the receiver)
F	Schedule reporting frequency interval in seconds
S	Enables equipment to be initialized, and sets various message types
D	Specify a minimum distance traveled and a minimum and maximum time interval for the next report

Note – *All TAIP message characters must be in uppercase.*

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Message Identifier

A unique two character message identifier consisting of alphabetical characters is used to identify type messages. For example: PR for Protocol or VR for Version Number.

Data String

The format and length of a data string is dictated by the message qualifier and the message identifier. The data string may contain any printable ASCII character with the exception of the >, <, and ; characters. Detailed descriptions of each message format are provided in the specific message sections of this Appendix. Most messages are length sensitive and unless otherwise specified, field separators, including spaces are not used.

Vehicle ID

A vehicle identification (ID) may optionally be used in all the communications with the receiver. Each receiver in the fleet may be assigned a four character alpha-numeric ID and be forced to output that ID in all messages. The default is: ID set to 0000 and the ID Flag set to F (false). The receiver will check all incoming messages for ID. If no ID is specified, the receiver will accept the message. If the ID is included in messages but does not compare with the ID previously set, the message will be ignored. This applies even when the ID Flag is turned off.

Checksum

The checksum field provides for an optional two digit hex checksum value, which is computed as XOR of *all characters* from the beginning of the sentence up to and including the * character. If provided, the checksum is always the last element of the sentence before the message delimiter. The default mode of operation is to include checksum in sentences. The use of checksums can help in instances where the communication channel is noisy.

Example

The following message used to set the vehicle ID flag includes checksum.

>SRM;ID_FLAG=T;*6F<

In this example, the checksum (6F) was generated by XOR'ing the ASCII codes for > and S then XOR'ing that result with the ASCII code for R and so forth, up to and including the * character.

Message Delimiter

The < character signifies end of a sentence and is used as the message delimiter.

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Sample PV Message

The Position/Velocity Solution (PV) message is one of the more commonly used TAIP messages and most receivers using TAIP are set by default to output the PV message once every 5 seconds.

The following analysis of a typical PV message is provided to further explain the TAIP message protocol.

>RPV15714+3739438-1220384601512612;ID=1234;*7F<.

ID	Meaning
>	Start of message delimiter
R	Response qualifier
PV	PV message identifier
15714	GPS time of day
+3739438	Latitude
-12203846	Longitude
015	Speed
126	Heading
1	Source of data
2	Age of data
;ID=1234	Vehicle ID
;*7F	Checksum
<	End of message delimiter

Note – *See PV Position/Velocity Solution, page 200, for more detail on the interpretation of this message.*

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Time and Distance Reporting

The ’D’ message qualifier allows you to specify a minimum distance traveled as well as a minimum and maximum time interval for the next report. Units that are stationed at a fixed location can be programmed to report only when the unit moves “off station” or after a certain elapsed time since last report, but no more often than the specified minimum time interval.

The message format used with the ’D’ qualifier is shown below:

>DAABBBBCCCCEEEEFFFF[;ID=GGGG][;*HH]<

The distance ‘D’ in the message refers to the radial distance. A message would be issued if the receiver has moved farther than a radius of ‘D’ away from where it was previously reported. If the accumulated distance traveled is longer than ‘D’ but the final location is still within the radius of ‘D’ (e.g. circling many times around a closed perimeter of radius smaller than ‘D’), then no message would be issued.

ID	Meaning
>	Start of message delimiter
D	Distance message qualifier
AA	Message to report (i.e. PV means Position Velocity message)
BBBB	Minimum time (seconds) interval between reports (^{T}interval)
CCCC	Report epoch (number of seconds from top of the hour)
EEEE	Delta distance (meters) from last reported distance
FFFF	Maximum time (seconds) interval between reports (^{T}max)
GGGG	Optional vehicle identification number (user selected)
HH	Optional checksum
<	End of message delimiter

Note – *If BBBB = 0, then the message output is disabled. If FFFF = 0, maximum time feature is disabled (the unit will only report if current position is greater than or equal to the delta distance specified in EEEE).*

Example

When the message: >DPV0030000505000900;ID=0105< is sent to the GPS receiver, it specifies that vehicle number 105 (*GGGG* = 0105) is to report the Position Velocity message (*AA* = PV) whenever its current position differs from the previously reported position by at least 500 meters (*EEEE* = 0500), but no more often than every 30 seconds (*BBBB* = 0030) or less often than every 15 minutes (*FFFF* = 0900 seconds). The minimum and maximum time-out reports are to be issued with a 5 second offset (*CCCC* = 0005) from the top of the hour. The optional checksum was not used in this example. The square brackets, [...], shown in the format description above are used to indicate optional data. The brackets themselves are never included in the actual TAIP message string.

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Latitude and Longitude Conversion

The TAIP protocol reports latitude as positive north decimal degrees and longitude as positive east decimal degrees, using the WGS-84 datum. For your application, you may wish to convert to degrees, minutes and seconds. The following example illustrates the conversion of decimal degrees to degrees, minutes and seconds.

Example

Given latitude and longitude in decimal degrees,

Latitude: $+37.39438^{o}$

Longitude: -122.03846^{o}

Convert latitude by multiplying the decimal fraction of degrees by 60 to convert to minutes,

0.39438 x 60 = 23.6628 minutes

Retain the integer (23) portion as the minutes then multiply the decimal fraction by 60 to convert to seconds,

0.6628 x 60 = 39.768 seconds

Since the sign of the latitude in this example is positive the result is,

Latitude: N 37^{o} 23' 39.77"

The longitude is converted in the same fashion,

Longitude: W 122^{o} 02' 18.46"

Note – *At the earth's equator, one degree of latitude and longitude represents 68.7 miles; therefore, 0.00001 degrees represents approximately 3.6 feet or 1.1 meters. Each second represents approximately 100.76 ft. (30.7 m).*

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Message Data Strings

The following table lists all the TAIP messages currently defined and comments regarding their application. The data string format of each message is described in the following pages.

Identifier	Message Format	Frequency and Distance	Query	Response Report	Set
AL	Altitude/Vertical Velocity	X	X	X	X
*AP	Auxiliary Port Characteristic	n/a	n/a	n/a	n/a
CP	Compact Position Solution	X	X	X	X
*DC	Differential Corrections	n/a	n/a	n/a	n/a
ID	Vehicle ID	X	X	X	X
IP	Initial Position	X	X	X	X
LN	Long Navigation Message	X	X	X	
PR	Protocol		X	X	X
PT	Port Characteristic	X	X	X	X
PV	Position/Velocity Solution	X	X	X	X
RM	Reporting Mode	X	X	X	X
RT	Reset				X
ST	Status	X	X	X	
TM	Time/Date	X	X	X	
VR	Version Number	X	X	X	X

Note – *The Lassen PT GPS does not support these (*) TAIP messages.*

All TAIP message characters must be in uppercase.

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AL Altitude/Up Velocity

Note – *The first character of altitude or vertical velocity (S) is "+" or "–".*

Data String Format:

AAAA(S)BBBBB(S)CCCDE

.

Item	# of Char	Units	Format	Value
GPS Time of Day	5	Sec	AAAAA	
Altitude	6	Meter	(S)BBBBB	
Vertical Velocity	4	MPH	(S)CCC	
Fix Mode	1	n/a	D	0=2D GPS 1=3D GPS 2-8 reserved 9=no fix avail.
Age of Data Indicator	1	n/a	E	2=Fresh,<10 sec. 1=Old,>10 sec. 0=Not available
Total # of Characters is 17				

Altitude is above mean sea level in WGS-84. The GPS time of day is the time of fix rounded to the nearest second. This message contains data obtained from the last 3 dimensional fix and may not be current.

Note – *The data in this message is to be considered invalid and should not be used if the Age of Data Indicator is equal to 0 (signifying data not available).*

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CP Compact Position Solution

Note – *The first character of latitude or longitude "(S)" is "+" or "-".*

Data String Format:

AAAAA(S)BBCCCC(S)DDDEEEEFG

Item	# of Char	Units	Format	Value
GPS Time of Day	5	Sec	AAAAA	
Latitude	7	Deg	(S)BBCCCC	
Longitude	8	Deg	(S)DDDEEEE	
Fix Mode	1	n/a	F	0=2D GPS 1=3D GPS 2-8 reserved 9=no fix avail.
Age of Data Indicator	1	n/a	G	2=Fresh,<10 sec. 1=Old,>10 sec. 0=Not available
Total number of characters is 22				

Position is in latitude (positive north) and longitude (positive east) WGS-84. The GPS time of day is the time of fix rounded to the nearest second.

Note – *The data in this message is to be considered invalid and should not be used, if the Age of Data Indicator is equal to 0 (signifying that data is not available).*

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ID Identification Number

Data String Format:

AAAA

Item	# of Char	Units	Format
Vehicle ID	4	n/a	AAAA
Total number of characters is 4			

This message is used to report or set the vehicle's (or receiver's) unique, four character, alpha-numeric, user assigned ID. The default at cold start is 0000.

Example

The following message will set the vehicle ID to 101.

>SID0101<

The following is simply a response to a query for vehicle ID.

>RID0101<

Note – *The receiver will always check incoming messages for ID and compare with the vehicle ID set in the receiver's memory. If no ID is included in the message, the receiver will assume a match and accept the message. If the message sent to the receiver does contain a vehicle ID but that ID does not match the ID previously set in the receiver, the message will be ignored. This process is followed even when the ID_Flag is turned off (refer to the message RM).*

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IP Initial Position

Data String Format:

(S)AA(S)BBB(S)CCCC

Item	# of Char	Units	Format
Initial Latitude	3	Deg	(S)AA
Initial Longitude	4	Deg	(S)BBB
Initial Altitude	5	10 meters	(S)CCCC
Total number of characters is 12			

This is a very coarse initial position that can be used to aid the receiver in obtaining its first fix. This is particularly useful with a receiver that does not have battery backup enabled. In such cases, every time the unit is powered up, it goes through a complete cold-start and it has absolutely no knowledge of where it is. Providing this message improves performance by decreasing the time to first fix and enhances the accuracy of the initial two dimensional navigation solutions by providing a reference altitude. In case of units with battery backed memory, sending this message is only helpful if the unit has moved more than 1,000 miles since its previous fix. In either case, the receiver can initialize itself appropriately without any data from the user; it merely requires more time.

Note – *For all the above values, the first character (S) specifies the sign "+" or "-".*

Example:

The following message will set the initial position to 37^{o} North, 122^{o} West, altitude 10 meters.

>SIP+37-122+0001<

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LN Long Navigation Message

Note – *The first character of latitude, longitude, altitude or vertical speed (S) is"+" or "–".*

Data String Format:

AAAAA.BBB(S)CCDDDDDDD(S)EEEFFFFFFF(S)GGGGGGHHIIIJ(S)KKKLM MMNOOPPQQPPQQ...PPQQRRRRRRRRRRXT

Item	# of Char	Units	Format	Value
GPS Time of Day	8	Sec	AAAAA.BBB	
Latitude	10	Deg	(S)CC.DDDDDDD	
Longitude	11	Deg	(S)EEE.FFFFFFF	
Altitude above MSL	9	Ft	(S)GGGGGG.HH	
Horizontal speed	4	MPH	lll.J	
Vertical speed	5	MPH	(S)KKK.L	
Heading	4	Deg	MMM.N	
Number of SVs used	2	n/a	OO	
SV ID (see note)	2	n/a	PP	
IODE (see note)	2	n/a	QQ	
Reserved	10	n/a	RRRRRRRRRR	
Fix Mode	1	n/a	X	0=2D GPS 1=3D GPS 2-8 reserved 9=no fix avail.
Age of Data indicator	1	n/a	T	2=fresh,<10 sec. 1=old,>10 sec. 0=not available
Total number of characters is 65 + 4x (number of SVs used)				

Note – *At least 2 satellites are required to get the LN Message.*

Position is in degrees, minutes, and decimal minutes. Latitude is (positive north); longitude is (positive east) WGS-84. Heading is in degrees from True North increasing eastwards. The GPS time of day is the time of fix rounded to the nearest second.

Note – *The data in this message is to be considered invalid and should not be used if the Age of Data Indicator is equal to 0 (signifying data not available).*

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PR Protocol

The protocol message (PR) is the method used to control which I/O protocols are active on the serial ports.

- Off
- Input only
- Output only
- Both input and output

The PR data string format is:

[;TAIP=xy] [;TSIP=xy] [;NMEA=xy]

Item	# of Char	Units	Format	Value
Port A protocol	1	n/a	X	T = Both in and out I = Input only O = Output only F = Off N = Not available
Port B protocol	1	n/a	y	T = Both in and out I = Input only O = Output only F = Off N = Not available

Sending the following message will set the receiver to TAIP-IN and TAIP-OUT on PORT A and NMEA-OUT on Port B.

>SPR;TAIP=TF;TSIP=FF;NMEA=FO

Note – *Bi-directional TSIP, TAIP and NMEA are supported on Ports 1 and 2.*

If a protocol is not implemented within the application, x and/or y will have the value N, and any set message for that protocol is ignored.

It is possible to turn off all input processing on a port. If this is done, neither TAIP nor TSIP can be used to change the active protocols.

If you do not use battery back-up and you do not have the settings saved in FLSAH memory, all port characteristics will reset to the default after power is removed.

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PT Port Characteristic

This message defines the characteristics for the TAIP port.

Data String Format:

AAAA,B,C,D

Item	# of Char	Units	Format	Value
Baud Rate	4	n/a	AAAA	4800 - 4800 bps 9600 - 9600 bps 1920 - 19200 bps 3840 - 38400 bps 5760 - 57600 bps 1152 - 115200 bps
# of data bits	1	n/a	B	
# of stop bits	1	n/a	C	1
Parity	1	n/a	D	"N" = None
Total number of characters is 10 (includes commas)				

Most TAIP using receivers use the following default port characteristics

- 4800 baud
- 8 data bits
- 1 stop bit
- No parity

Note – *The characteristics set by this message will be stored in the receiver's battery backed ram. The Lassen iQ receiver family of receivers do not include an internal battery but provide a battery back-up input line that may be used to retain memory when main power is removed.*

If you do not use battery back-up, all port characteristics will reset to either the default settings after power is removed, or to the settings previously stored in Flash.

The PT command uses commas between data fields.

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PV Position/Velocity Solution

Note – *The first character of latitude or longitude "(S)" is "+" or "-".*

Data String Format:

AAAAA(S)BBCCCCC(S)DDDEEEEEFFFGGGHI

Item	# of Char	Units	Format	Value
GPS Time of Day	5	Sec	AAAAA	
Latitude	8	Deg	(S)BBCCCCC	BB=degrees CCCC=decimal degrees
Longitude	8	Deg	(S)DDDEEEEE	DDD=degrees EEEE=decimal degrees
Speed	3	MPH	FFF	
Heading	3	Deg.	GGG	
Fix Mode	1	n/a	H	0=2D GPS 1=3D GPS 2-8 reserved 9=no fix avail.
Age of Data Indicator	1	n/a	I	2=fresh,<10 sec. 1=old,>10 sec. 0=not available
Total number of characters is 30				

Position is in latitude (positive north) and longitude (positive east) WGS-84. Heading is in degrees from True North increasing eastwards. The GPS time of day is the time of fix rounded to the nearest second.

Note – *The data in this message is to be considered invalid and should not be used if the Age of Data Indicator is equal to 0 (signifying data not available).*

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RM Reporting Mode

Data String Format:

[;ID_FLAG= A][;CS_FLAG= B][;EC_FLAG= C] [;FR_FLAG= D]

[;CR_FLAG=E]

Item	# of Char	Units	Format	Value
ID Flag	1	n/a	A	T = True F = False
CS Flag	1	n/a	B	T = True F = False
EC Flag	1	n/a	C	T = True F = False
FR Flag	1	n/a	D	T = True F = False
CR Flag	1	n/a	E	T = True F = False

ID Flag determines whether the unit is to include the vehicles ID with each report.

CS Flag determines whether the unit is to include a checksum as part of each message.

EC Flag, when set, will cause the unit to echo back all complete and properly formatted set commands with a *response qualifier*. This provides an easy way to verify that the unit did in fact receive the intended data.

FR Flag indicates whether the unit is to report messages automatically per their individually scheduled frequency. When set to false, the unit will only respond when queried for a specific message.

CR Flag, when set to True, will cause the receiver to append a carriage return and line feed [CR] [LF] to the end of each message output. This is useful when viewing the unencoded receiver responses on a terminal or a PC.

The default value at start-up for ID flag and the CR flag is false; the default for CS, EC and FR flags is true.

Example

The following command will turn checksums off and carriage return on:

>SRM;CS_FLAG=F;CR_FLAG=T<

Note – *Notice the use of semicolon before the flag name.*

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RT Reset Mode

Data String Format:

Any one of the following data strings can be set. Upper case characters are required.

[ ]

[COLD]

[FACTORY]

[SAVE_CONFIG]

Message	Description
>SRT<	Warm Start
>SRTCOLD<	Cold Start
>SRTFACTORY<	Factory Reset
>SRTSAVE_CONFIG<	Save settings to Flash memory

The following procedure is used to change the Lassen iQ receiver protocol from TSIP to TAIP:

1. Use the TSIP 0x7E command to setup the TAIP output configuration.
2. Change the protocol to TAIP using TSIP command 0xBC.
3. Save the TAIP settings to Flash memory using the TAIP command >SRTSAVE_CONFIG<.

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ST Status

Data String Format:

AABCDDEFGG

Note – *This message provides information about the satellite tracking status and the operational health of the receiver. This information is contained in five status bytes which are output as five 2 digit hexadecimal values. The data format and the meanings of the hex characters are given in the following tables.*

Item	# of Char	Units	Format	Definition
Tracking Status Code	2	n/a	AA	(see table below)
Error Codes - Nibble 1	1	n/a	B	(see table below)
Error Codes - Nibble 2	1	n/a	C	(see table below)
Machine ID	2	n/a	DD	
Error Code - Nibble 3	1	n/a	E	(not currently used)
Error Code - Nibble 4	1	n/a	F	(see table below)
Reserved	2	n/a	GG	(see table below)

Value	AA Meaning
00	Doing position fixes
01	Don't have GPS time yet
02	Not used
03	PDOP is too high
08	No usable satellites
09	Only 1 usable satellite
OA	Only 2 usable satellites
OB	Only 3 usable satellites
OC	Chosen satellite is unusable

Value	B Meaning
0	No problems reported
2	Antenna feedline open fault
6	Antenna feedline short fault

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Value	C Meaning
0	No problems reported
1	Battery-back-up failed; RAM not available at power-up (see Note below).

Value	DD Meaning
DD	Displays the machine ID

Value	E Meaning
Not used	Not used

Value	F Meaning
0	No problems reported
2	RTC not available at power-up (see Note below)
8	Stored almanac not complete and current
A	RTC not available; stored almanac not complete and current

Value	GG Meaning
Not used	Reserved

Note – *After the status is detected, this bit remains set until the receiver is reset.*

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TM Time/Date

Data String Format:

AABBCCDDDEEFFGGGGHHIJJKLLLLL

.

Item	# of Char	Units	Format	Value
Hours	2	Hour	AA	
Minutes	2	Min	BB	
Seconds	5	Sec	CC.DDD	
Date; Day	2	Day	EE	
Date; Month	2	Month	FF	
Date; Year	4	Year	GGGG	
GPS UTC Time Offset	2	Sec	HH	
Fix Mode	1	n/a	f	0=2D GPS 1=3D GPS 2-8 reserved 9=no fix avail.
Number of usable satellites	2	n/a	JJ	
GPS UTC Offset flag	1	n/a	K	(1 = valid) (0 = invalid)
Reserved	5	n/a	LLLLL	
Total number of characters is 28				

This message outputs the time and date as computed by the GPS receiver. The time is most accurate when the unit is doing fixes. It is less accurate but still usable when the unit is not doing fixes but the Number of Usable SVs is one or more. If the GPS UTC offset is available, the time will be in UTC. If not, the time will be in GPS.

Note – *GPS UTC Time Offset is the difference between GPS and UTC time standards in seconds. The UTC time of Day is only valid if the GPS UTC Offset Valid Flag is indicating valid.*

Note – *The TM message is not supported under the Set qualifier.*

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VR Version Number

Data String Format:

XXXXXXX; VERSION A.AA (BB/BB/BB);

.

Item	# of Char	Units	Format
Product Name	variable	n/a	n/a
Major version number	4	n/a	A.AA
Major release date	8	n/a	BB/BB/BB

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X1 Extended Status

The Lassen iQ receiver does not support this message.

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Communication Scheme for TAIP

Communication with the unit takes place in four different ways. Message qualifiers are used to differentiate between these.

Query for Single Sentence

The query (Q) message qualifier is used to query the GPS receiver to respond immediately with a specific message. The format is:

>QAA[;ID=BBBB][;*CC]<

where AA is the requested message identifier. Messages supported by this qualifier are

AL, AP, CP, ID, IP, LN, PT, PV, RM, ST, TM, and VR.

Scheduled Reporting Frequency Interval

The scheduled reporting frequency interval (F) message qualifier is used to tell the unit how often and when to report a specific message. The format is:

>FAABBBBCCCC[;ID=DDDD][;*FF]<

where sending this sentence tells the unit to report message specified by the two digit identifier AA at the time interval of BBBB seconds with time epoch at CCCC seconds from top of the hour. Specifying time interval of 0000 stops scheduled reporting of the message. The default is 0000 time interval for all messages except PV. The output frequency for PV at cold-start is set at once every five seconds, zero seconds from top of the hour. Messages supported by this qualifier are AL, AP, CP, ID, IP, LN, PT, PV, RM, ST, TM, and VR.

Note – *The Copernicus GPS Receiver does not support the AP TAIP message.*

The data specified by this qualifier is the timing of the message output and may be different from the time tag of the data in the message.

The Response to Query or Scheduled Report

The response (R) qualifier carry various types of data between the unit and the user equipment. The format is:

>RAA[{B}][;ID=CCCC][;*DD]<

where AA is the two character message identifier and {B} specifies the data string within the message. For the format of {B}, please refer to the message definitions in the previous section. Messages supported by the response qualifier are AL, AP, CP, ID, IP, LN, PT, PV, RM, ST, TM, and VR.

Note – *The Lassen PT GPS does not support the AP TAIP message.*

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The Set Qualifier

The set (S) qualifier enables the user equipment to initialize/set-up various types of data in the GPS unit. The format is:

>SAA[{B}][;ID=CCCC][;*DD]<

where AA is the two character message identifier and {B} specifies the data string within the message. For the format of {B}, please refer to the message definitions in the previous section. Note that all the messages have very specific formats and are length dependent.

Messages normally supported by the set qualifier are AL, AP, CP, DC, DD, ID, IP, LN, PT, PV, and RM.

The set qualifier may be used with the AL, CP, LN, or PV message to set more precise initial position data into the GPS receiver than can be set with the IP message.

Note – *The Lassen PT GPS does not support the AP TAIP message.*

Sample Communication Session

The following is a sample communication session to illustrate how message qualifiers are used. Query the receiver for version number for the TAIP firmware:

>QVR<

The receiver responds with a message in the following form:

>RVR CT COPERNICUS APP; VERSION 01.05 (05/23/06);*6E<

Note – *The receiver identified its product name, firmware version number, core signal processing version number, and release dates, then included the checksum for the message (the default for the CS Flag is TRUE). Also notice that the receiver did respond to our query even though we did not send a checksum.*

Query the receiver for its ID number:

>QID<

The receiver will respond (assuming factory default settings):

>RID0000;*70<

Set the ID to match the number for a vehicle in your fleet and then tell the receiver to include the Vehicle ID in its responses:

>SID1234<

>SRM;ID_FLAG=T<

The Lassen iQ receiver receiver is set by default to report the PV message once every 5 seconds. To schedule the PV message from vehicle 1234 to respond once every 10 seconds, starting at 5 seconds after the top of the hour, use the following command:

>FPV00100005;ID=1234<

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The receiver will check the ID included in the message for a match with its own and then reschedule the PV message. At the next scheduled time, the receiver will respond with:

>RPV15714+3739438-1220384601512612;ID=1234;*7F<

Note – *The Lassen PT GPS does not support the AP TAIP message.*

The time given in the message is the time of the last GPS fix (04:21:54 GPS), not necessarily the time of the message response. If the time of last fix is 10 or more seconds old, the age flag will be set to 1.

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APPENDIX

C

NMEA 0183

In this appendix:

- Overview
- The NMEA 0183 Communication Interface
- NMEA 0183 Message Format
- Field Definitions
- Checksum
- Exception Behavior
- NMEA 0183 Message Options
- NMEA 0183 Message Formats

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

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Overview

NMEA 0183 is a simple, yet comprehensive ASCII protocol which defines both the communication interface and the data format. The NMEA 0183 protocol was originally established to allow marine navigation equipment to share information. Since it is a well established industry standard, NMEA 0183 has also gained popularity for use in applications other than marine electronics. The Copernicus GPS receiver supports the latest release of NMEA 0183, Version 3.0 (July 1, 2000). The primary change in release 3.0 is the addition of the mode indicators in the GLL, RMC, and VTG messages. In addition, the Copernicus GPS supports bi-directional NMEA with the description of the Trimble proprietary NMEA sentences found in this Appendix

For those applications requiring output only from the GPS receiver, the standard NMEA 0183 sentences are a popular choice. Many standard application packages support the standard NMEA output messages. With the addition of the Trimble proprietary bi-directional NMEA, the user can now gain complete control of the Copernicus module including configuration and program control.

The standard NMEA output only messages are: GGA, GLL, GSA, GSV, RMC, VTG, and ZDA.

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The NMEA 0183 Communication Interface

The Copernicus GPS receiver can be configured for NMEA on either port A or port B, at any baud rate. Below are the default NMEA characteristics for Port B of the Copernicus GPS receiver.

Table C.1 Signal Characteristics

Signal Characteristic	NMEA Standard
Baud Rate	4800
Data Bits	8
Parity	None (Disabled)
Stop Bits	1

NMEA 0183 Message Format

The NMEA 0183 protocol covers a broad array of navigation data. The entire protocol encompasses over 50 messages, but only a sub-set of these messages apply to a GPS receiver like the Copernicus GPS Receiver. 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 identification is a two letter mnemonic which describes the source of the navigation information. The GP identification signifies a GPS source.
MSG	The message identification is a three letter mnemonic which describes the message content and the number and order of the data fields.
“,”	Commas serve as delimiters for the data fields.
Dn	Each message contains multiple data fields (Dn) which are delimited by commas. The length of the fields can be variable.
“*”	The asterisk serves as a checksum delimiter.
CS	The checksum field contains two ASCII characters which indicate the hexadecimal value of the checksum.
[CR][LF]	The carriage return [CR] and line feed [LF] combination terminate the message.

NMEA 0183 standard messages vary in length, but each message is limited to 79 characters or less. This length limitation excludes the “$” and the [CR][LF]. The standard message data field block, including delimiters, is limited to 74 characters or less.

Note – *Trimble proprietary messages can exceed 79 characters and the data field block of these messages can exceed 74 characters.*

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Field Definitions

Many of the NMEA data fields are of variable length, and the user should always use the comma delimiter to parse the NMEA message date field. The table below specifies the definitions of all field types in the NMEA messages supported by Trimble.

Table C.2 Field Definitions

Type	Symbol	Definition
Status	A	Single character field: A=Yes, data valid, warning flag clear V=No, data invalid, warning flag set
Special Format Fields		
Latitude	llll.lll	Fixed/variable length field: Degreesminutes.decimal-2 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Longitude	yyyyy.yyy	Fixed/Variable length field: Degreesminutes.decimal-3 fixed digits of degrees, 2 fixed digits of minutes and a variable number of digits for decimal-fraction of minutes. Leading zeros always included for degrees and minutes to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Time	hhmmss.ss	Fixed/Variable length field: hoursminutesseconds.decimal-2 fixed digits of minutes, 2 fixed digits of seconds and a variable number of digits for decimal-fraction of seconds. Leading zeros always included for hours, minutes, and seconds to maintain fixed length. The decimal point and associated decimal-fraction are optional if full resolution is not required.
Defined		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in this standard by the presence of one or more valid characters. Excluded from the list of allowable characters are the following that are used to indicated field types within this standard: “A”, “a”, “c”, “hh”, “hhmmss.ss”, “llll.ll”, “x”, “yyyyy.yy”
Numeric Value Fields		
Variable	x.x	Variable length integer or floating numeric field. Optional leading and trailing zeros. The decimal point and associated decimal-fraction are optional if full resolution is not required (example: 73.10=73.1=073.1=73).
Fixed HEX	hh	Fixed length HEX numbers only, MSB on the left
Information Fields		
Fixed Alpha	aa	Fixed length field of upper-case or lower-case alpha characters
Fixed number	xx	Fixed length field of numeric characters

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Note – *Spaces are only used in variable text fields.*

Units of measure fields are appropriate characters from the Symbol column (see Table C.2), unless a specified unit of measure is indicated.

Fixed length field definitions show the actual number of characters. For example, a field defined to have a fixed length of 5 HEX characters is represented as hhhhh between delimiters in a sentence definition.

Invalid Command Set

In the case that a command is sent with incorrect data, the NMEA sentence $PTNLRxx,V*xx is a generic response.

Checksum

The checksum is the last field in an NMEA sentence and follows the checksum delimiter character “*”. The checksum is the 8 bit exclusive OR (no start or stop bits) of a character in the sentence including “,” between but not including the “$” and the “*” delimiters. The hexadecimal value of the most significant and less significant 4 bits of the result is converted to two ASCII characters (0-9, A0F (upper case)) for transmission. The most significant character is transmitted first. Examples of the use of the checksum field are:

$GPGLL,5057.970,N,00146,110,E,142451,A*27<CR><LF>

$GPVTG,089,0,T,,,15,2,N,,*7F<CR><LF>

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Exception Behavior

When no position fix is available, some of the data fields in the NMEA messages will be blank. A blank field has no characters between the commas. There are three general cases when no fix is available: at power-up without back-up data on SRAM (cold start); at power-up with without back-up data on SRAM (warm start); and when the GPS signal is temporarily blocked. These three cases have different NMEA output behavior in the Copernicus GPS Receiver. This section describes the behavior for the current product. The specification for this behavior may change in future products.

Power-up with No Back-up Data on SRAM

In this case, no previous fix is available in battery-backed memory. If the output message list and output rate has been customized (using TSIP command packet 0x7A) and stored in Flash memory, then at power-up the receiver will output the messages according to the customized setting. Otherwise, GGA and VTG messages are output every second. Before fixes are available, the message fields will be empty.

Power-up with Back-up Data on SRAM

In this case, a previous fix is available in battery-backed memory at power-up. If the output message list and output rate has been customized (using TSIP command packet 0x7A) and stored in Flash memory, then at power-up the receiver will output the messages according to the customized setting. Otherwise, GGA and VTG messages are output every second. Before fixes are available, the message fields will be empty except for the Time field, assuming the back-up battery power is present so that time can be tracked continuously by the RTC (Real Time Clock).

Interruption of GPS Signal

If the GPS signal is interrupted temporarily, the NMEA will continue to be output according to the user-specified message list and output rate. Position and velocity fields will be blank until the next fix, but most other fields will be filled.

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General NMEA Parser Requirements

- When no position fix is available, some of the data fields in the NMEA messages will be blank (i.e., no characters between commas), but selected messages will output every second.
- Trimble varies the number of digits of precision in variable length fields, so customer parsers should be able to handle variable lengths.
- NMEA parsers should be built to be forward-compatible. Future versions of a standard message may have more fields or more choices per field.
- Checksum matching is strongly recommended.
- 9600 baud may be required if GSV messages are output.
- When multiple NMEA settings are implemented, save them to Flash memory.
- For GGA, GLL, RMC messages, time is GPS time (not UTC) until leap second parameter is known. There is no way to tell which time your are running in, until the time output suddenly decreases by 14 seconds (or by the current offset).
- For GGA, GLL, RMC messages, if the datum is changed, there is no regular DTM warning of non-WGS-84 datum as required by NMEA 2.1. You must query the datum for this information.

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NMEA 0183 Message Options

The Copernicus GPS Receiver can output any or all of the messages listed in Table C.3 and Table C.4. In its default configuration (as shipped from the factory), the Copernicus GPS Receiver outputs two messages: GGA and VTG. These messages are output at a 1 second interval with the “GP” ID and checksums. These messages are output at all times during operation, with or without a fix. If a different set of messages has been selected (using Packet 0x7A), and this setting has been stored in Flash memory (using Packet 0x8E-26), the default messages are permanently replaced until the receiver is returned to the factory default settings.

Another methodology for changing NMEA output messages is using the Trimble proprietary NMEA commands listed in Table C.4. Use the NM command to select the NMEA message, and the RT command to store the message in Flash Memory.

Note – *The user can configure a custom mix of the messages listed in Table C.4. See command packets 0xBC, 0x7A, and 8E-26 in Appendix A, and the NM and RT command descriptions in this Appendix for details on configuring NMEA output.*



WARNING – If too many messages are specified for output, you may need to increase the unit’s baud rate.

Table C.3 Copernicus GPS Receiver NMEA 0183 Messages

	Message	Description
Default Output	GGA	GPS fix data
	GLL	Geographic position - Latitude/Longitude
	GSA	GPS DOP and active satellites
	GSV	GPS satellites in view
	RMC	Recommended minimum specific GPS/Transit data
Default Output	VTG	Track made good and ground speed
	ZDA	Time & Date

.

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Table C.4 Copernicus GPS Receiver Proprietary NMEA Messages

Message	Description
AH	Query or set Almanac Health
AL	Query or set almanac data for a specific satellite
AS	Query or set almanac status
BA	Query and response to antenna status
CR	Query or set GPS receiver configuration information
EM	Set receiver into Monitor Mode. Set only.
EP	Query or set ephemeris data for a specific satellite
IO	Query or set ionosphere data.
KG	Set initial position and time info data for to aid navigation startup
NM	Query or set NMEA automatic message output control
PS	Query or set PPS configuration
PT	Query or set serial port configuration
RT	Set Reset type (cold
TF	Query or set receiver status and position fix information
UT	Query or set UTC data
VR	Query and response to version information

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NMEA 0183 Message Formats

GGA - GPS Fix Data

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

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

Table C.5 GGA - GPS Fix Data Message Parameters

Field #	Description
1	UTC of Position (when UTC offset has been decoded by the receiver)
2,3	Latitude, N (North) or S (South)
4,5	Longitude, E (East) or W (West)
6	GPS Quality Indicator: 0=invalid fix, 1=GPS fix, no SBAS correction, 2=SBAS corrected fix
7	Number of Satellites in Use
8	Horizontal Dilution of Precision (HDOP)
9, 10	Antenna Altitude in Meters, M = Meters
11, 12	Geoidal Separation in Meters, M=Meters. Geoidal separation is the difference between the WGS-84 earth ellipsoid and mean-sea-level. “-” = mean-sea-level surface below WG-84 ellipsoid surface
13	Age of Differential GPS Data. Time in seconds since the last Type 1 or 9 Update
14	Differential Reference Station ID (0000 to 1023)
hh	Checksum

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GLL - Geographic Position - Latitude/Longitude

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

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

Table C.6 GLL - Geographic Position - Latitude / Longitude Message Parameters

Field	Description
1,2	Latitude, N (North) or S (South)
3,4	Longitude, E (East) or W (West)
5	UTC of position (when UTC offset has been decoded by the receiver)
6	Status: A = Valid, V= Invalid
7	Mode Indicator A=Autonomous Mode D=Differential Mode E=Estimated (dead reckoning) Mode M=Manual Input Mode S=Simulated Mode N-Data Not Valid
hh	Checksum

GSA - GPS DOP and Active Satellites

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

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

Table C.7 GSA - GPS DOP and Active Satellites Message Parameters

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

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GSV - GPS Satellites in View

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

$GPGSV,x,x,xx,xx,xx,xxx,xx,xx,xx,xxx,xx,xx,xx,

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

Table C.8 GSV - GPS Satellites in View Message Parameters

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

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RMC - Recommended Minimum Specific GPS/Transit Data

The RMC message contains the time, date, position, course, and speed data provided by the GPS navigation receiver. A checksum is mandatory for this message and the transmission interval may not exceed 2 seconds. All data fields must be provided unless the data is temporarily unavailable. Null fields may be used when data is temporarily unavailable.

`$GPRMC,hhmmss.ss,A,llll.llllll,a,yyyyy.yyyyy,a,`

`x.x,x.x,xxxxxx,x.x,a,i*hh<CR><LF>`

Table C.9 RMC - Recommended Minimum Specific GPS / Transit Data Message Parameters

Field #	Description
1	UTC of Position Fix (when UTC offset has been decoded by the receiver).
2	Status: A = Valid, V = navigation receiver warning
3,4	Latitude, N (North) or S (South).
5,6	Longitude, E (East) or W (West).
7	Speed over the ground (SOG) in knots
8	Track made good in degrees true.
9	Date: dd/mm/yy
10,11	Magnetic variation in degrees, E = East / W= West
12	Position System Mode Indicator; A=Autonomous, D=Differential, E=Estimated (Dead Reckoning), M=Manual Input, S=Simulation Mode, N=Data Not Valid
hh	Checksum (Mandatory for RMC)

VTG - Track Made Good and Ground Speed

The VTG message conveys the actual track made good (COG) and the speed relative to the ground (SOG).

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

Table C.10 VTG - Track Made Good and Ground Speed Message Parameters

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

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ZDA - Time & Date

The ZDA message contains Time of Day in UTC: the day, the month, the year and the local time zone.

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

Table C.11 ZDA - Time & Date Message Parameters

Field #	Description
1	UTC (when UTC offset has been decoded by the receiver)
2	Day (01 to 31)
3	Month (01 to 12)
4	Year
5	Null (empty)
6	Null (empty)
hh	Checksum

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



WARNING – If UTC offset is not available, time output will be in GPS time until the UTC offset value is collected from the GPS satellites. When the offset becomes available, the time will jump to UTC time.

Note – *The time can be used as a timetag for the 1PPS. The ZDA message comes out 100-500 msec after the PPS.*

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AH - Almanac Health

This sentence can be used to query or set almanac health data. Since the maximum number of bytes that can be contained in a single NMEA sentence is less than the total almanac health length, the almanac health must be sent in two sentences. The two sentences have to be sent or received together in correct sequence. After receiving the query, the receiver sends out two messages.

Message 1

$PTNLaAH,1,hh,hhhhhhhh,hhhhhhhh,hhhhhhhh,hhhhhhhh,
hh,hh,x.x*hh<CR><LF>

Table C.12 Almanac Health, Message 1

Field	Description
a	Mode (Q = query; S = set; R = Response)
hh	Week number for health, variable length integer, 4 digits maximum
hhhhhhhh	Satellite 1 - 4 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 5 - 8 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 9 - 12 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 13 - 16 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hh	t_oa, HEX data conforming to GPS ICD 200.

Message 2

$PTNLaAH,2,hh,hhhhhhhh,hhhhhhhh,hhhhhhhh,hhhhhhhh,hh,hh,x.x*hh<CR><LF>

Table C.13 Almanac Health, Message 2

Field	Description
a	Mode (Q = query; S = set; R = Response)
hh	Week number for health, variable length integer, 4 digits maximum
hhhhhhhh	Satellite 17 - 20 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 21 - 24 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 25 - 28 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hhhhhhhh	Satellite 29 - 32 health, one byte for each satellite, HEX data conforming to GPS ICD 200.
hh	t_oa, HEX data conforming to GPS ICD 200.

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AL - Almanac Page

This sentence can be used to query or set almanac data for a specific satellite. Following is the query format:

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

Table C.14 Almanac Page

Field	Description
xx	Satellite ID

Following is the set or response format.

$PTNLaAL,xx,x.x,hh,hhhh,hh,hhhh,hhhh,hhhhhh,hhhhhh,hhhhhh,hhhhhh,hhh,hhh*hh<CR><LF>

Table C.15 Almanac Page, Set or Response Format

Field	Description
a	Mode (S = set; R = Response).
xx	Satellite ID, 01-32.
x.x	GPS week number, variable length integer, 4 digits maximum.
hh	SV health, HEX data conforming to GPS ICD 200.
hhhh	Eccentricity, HEX data conforming to GPS ICD 200.
hh	t_oa, almanac reference time, HEX data conforming to GPS ICD 200.
hhhh	sigma_I,HEX data conforming to GPS ICD 200.
hhhh	OMEGADOT, HEX data conforming to GPS ICD 200.
hhhhhh	root_a, HEX data conforming to GPS ICD 200.
hhhhhh	Omega, HEX data conforming to GPS ICD 200.
hhhhhh	Omega_0, HEX data conforming to GPS ICD 200.
hhhhhh	M_O, HEX data conforming to GPS ICD 200.
hhh	a_fO, HEX data conforming to GPS ICD 200.
hhh	a_fl, HEX data conforming to GPS ICD 200.

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AS - Almanac Status

This sentence can be used to query or set almanac status. The format is:

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

Table C.16 Query Almanac Status

Field	Description
a	Mode (Q = query; S = Set)
Hh	TimeOfAlm. Time of almanac.
xxxx	Week number of almanac
hh	HaveTimeOfAlm
hh	HaveAlmHealth
hh	NeedAlmHealth. Need Almanac Health.
hh	NeedIonUtc.
hh	HaveAlm

The corresponding response for the Set is:

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

where 'a' means action status: A = success; V= failure

BA - Antenna Status

This sentence can be used to query the antenna connection status. This sentence should only be issued when the antenna detection circuit is implemented.

The Query sentence format is:

$PTNLQBA*hh<CR><LF>

The Response to query sentence format is:

$PTNLARBA,a,b*hh<CR><LF>

Table C.17 Antenna Status

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

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CR - Configure Receiver

This sentence can query or set NMEA receiver configuration information.

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

Table C.18 Configure Receiver

Field	Description
a	Mode (Q = query; S = set; R = Response)
x.x	Reserved
x.x	Elevation mask in degrees (default = 5 degrees)
x.x	Reserved
x.x	Reserved
x.x	Reserved
a	Constellation Mode, default is 0 0 - AUTO
a	Dynamics, default is 1 1=land 2=sea 3=air
a	Reserved.
a	0=WAAS_OFF, 1=WAAS_AUTO (this applies to all SBAS)

EM - Enter Monitor Mode

This sentence is used to set the Copernicus GPS Receiver into Monitor Mode. This is Set only, no query supported.

The sentence format is:

$PTNLSEM*hh<CR><LF>

This sentence will be used by the Firmware Uploading Program.

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EP - Ephemeris

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

Following is the query format:

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

Table C.19 Ephemeris Query Format

Field	Description
Q	Query
xx	Satellite

After receiving the query, the receiver should send out three messages. Following is the first message of ephemeris format:

`$PTNLaEP,1,xx,x.x,x.x,hh,hh,hh,hh,hhh,hh,hhhh,hh,h`
`hhh,hhhhhh,x.x*hh<CR><LF>`

Table C.20 Ephemeris Message Format

Field	Description
a	Mode (S = set; R = Response)
1	Message number for EP, message 1 must be sent or received before message 2, and message 2 must be sent or received before message 3, and all three messages must be sent together with correct sequence
xx	Satellite id
x.x	T_ephem, This is a double precision floating point number.
x.x	Week number for health, variable length integer, 4 digits maximum.
hh	CodeL2, HEX data conforming to GPS ICD 200.
hh	L2Pdata, HEX data conforming to GPS ICD 200.
hh	Svacc_raw, HEX data conforming to GPS ICD 200.
hh	SV_health, HEX data conforming to GPS ICD 200.
hhh	IODC, HEX data conforming to GPS ICD 200.
hh	T_GD, HEX data conforming to GPS ICD 200.
hhhh	T_oc, HEX data conforming to GPS ICD 200.
hh	A_f2, HEX data conforming to GPS ICD 200.
hhhh	A_f1, HEX data conforming to GPS ICD 200.
hhhhhh	A_f0, HEX data conforming to GPS ICD 200.

Following is the second sentence of ephemeris format:

$PTNLa**EP,2**,xx,hh,hh,hhhh,hhhh,hhhhhhhh,hhhh,hhhhhhhh,hhhh,hhhhhhhh,hhhh*
hh<CR><LF>

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Table C.21 Ephemeris Message Format

Field	Description
a	Mode (S = set; R = Response)
2	Sentence number for EP, sentence 1 must be sent or received before sentence 2, and sentence 2 must be sent or received before sentence 3, and all three sentences must be sent together
xx	Satellite id
hh	IODE, Hex data conforming to GPS ICD 200
hh	Fit_interval, Hex data conforming to GPS ICD 200
hhhh	C_rs, Hex data conforming to GPS ICD 200
hhhh	Delta_n, Hex data conforming to GPS ICD 200
hhhhhhhh	M_0, Hex data conforming to GPS ICD 200
hhhh	C_uc, Hex data conforming to GPS ICD 200
hhhhhhhh	E, Hex data conforming to GPS ICD 200
hhhh	C_us, Hex data conforming to GPS ICD 200

Following is the third sentence of ephemeris format

$PTNLa**EP,3**,xx,hhhh,hhhhhhhh,hhhh,hhhhhhhh,hhhh,hhhhhhhh,hhhhhh,hhhh*hh<CR><LF>

Table C.22 Ephemeris Message Format

Field	Description
a	Mode (S = set; R = Response)
3	Sentence number for EP, sentence 1 must be sent or received before sentence 2, and sentence 2 must be sent or received before sentence 3, and all three sentences must be sent together
xx	Satellite id
hh	C_ic, Hex data conforming to GPS ICD 200
hh	OMEGA_0, Hex data conforming to GPS ICD 200
hhhh	C_ri, Hex data conforming to GPS ICD 200
hhhh	I_O, Hex data conforming to GPS ICD 200
hhhhhhhh	C_rc, Hex data conforming to GPS ICD 200
hhhh	OMEGA, Hex data conforming to GPS ICD 200
hhhhhhhh	OMEGA_DOT, Hex data conforming to GPS ICD 200
hhhh	IDOT, Hex data conforming to GPS ICD 200

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IO Ionosphere

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

$PTNLaIO,hh,hh,hh,hh,hh,hh,hh,hh*hh,<CR><LF>

Table C.23 Ionosphere

Field	Description
a	Mode (Q = query; S = set; R = Response)
hh	Alpha_0, HEX data conforming to GPS ICD 200.
hh	Alpha_1, HEX data conforming to GPS ICD 200.
hh	Alpha_2, HEX data conforming to GPS ICD 200.
hh	Alpha_3, HEX data conforming to GPS ICD 200.
hh	Beta_0, HEX data conforming to GPS ICD 200.
hh	Beta_1, HEX data conforming to GPS ICD 200.
hh	Beta_2, HEX data conforming to GPS ICD 200.
hh	Beta_3, HEX data conforming to GPS ICD 200.

KG - Set Initial Position

This sentence can be used to set initial position or time info data or both for accelerating navigation startup. To set time only, send valid time fields and NULL position fields. To set position only, send valid position fields and NULL time fields. Query is not supported.

$PTNLaKG,x.x,x.x,llll.llllll,a,yyyyy.yyyyy,a,x.x*hh
<CR><LF>

Table C.24 Set Initial Position

Field	Description
a	Mode (S = set; R = Response)
x.x	GPS week number, maximum 4 digits
x.x	GPS time of week in milliseconds
llll.llllll	Latitude
a	N | S
yyyyy.yyyyy	Longitude
a	E | W
x.x	Altitude from the sea level in meters (maximum 5 digits)

Note – *When uploading a position, it should be within 100 Km of the actual position and time within 5 minutes of UTC.*

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NM - Automatic Message Output

This sentence may be issued by the user to configure automatic message output.

The Query sentence format is:

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

The Response to query sentence or Set sentence format is:

`$PTNLaNM,hhhh,xx*hh<CR><LF>`

Table C.25 Automatic Message Output

Field	Description
a	Mode (Q = query; S = set; R = Response)
hhhh	Bit 0 - GGA Bit 1 - GLL Bit 2 - VTG Bit 3 - GSV Bit 4 - GSA Bit 5 - ZDA Bit 8 - RMC Bit 9 - TF Bit 13 - BA
xx	Automatic Report Interval (1 - 99)

Examples

GGA Only 0001

GLL Only0002

VTG Only0004

GSV Only0008

GSA Only0010

ZDA Only0020

RMC Only0100

TF Only0200

BA Only2000

GGA and GLL0003

GGA and TF0201

RMC and TF0300

GGA, GLL and TF0203

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PS - PPS Configuration

This sentence can query or set PPS configuration data.

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

Table C.26 PPS Configuration

Field	Description
a	Mode (Q = query; S = set; R = Response)
b	PPS mode, default is 1: 0 - PPS_OFF (Always Off) 1 - PPS_ON (Always On or Early PPS) 2 - PPS_FIX_BASED
x...x	Output pulse length in 100 nanoseconds, default is 42 corresponding to 4200 nanoseconds. Pulse length range is 100ns to 500ms. Field value range is 1 to 5000000.
c	Output pulse polarity, default is 1: 0 - output pulse is active low 1 - output pulse is active high
x...x	Antenna Cable Length Compensation. Default = 0, Units in nanoseconds. Can be positive or negative. Negative value will mean PPS comes out earlier, e.g. to compensate for cable delay.

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PT - Serial Port Configuration

This sentence may be issued by the user for configuring the current serial port.

The Query sentence format is:

$PTNLQPT*hh<CR><LF>

The Response to query or Set sentence format is:

$PTNLRPT,xxxxxx,b,b,b,h,h*hh<CR><LF>

When the Set is issued, the first Response sentence will be sent using the old parameters and the second response sentence will be sent using the new parameters. If there is an error, there will be an error response sent. If there is no error, no additional response is sent.

Table C.27 Serial Port Configuration

Field	Description
a	Mode (Q = query; R = Response; S = Set)
xxxxxx	Baud rate (4800, 9600, 19200, 38400). Default baud rate is 4800.
h	input protocol, hex value (bit 0: TAIP, bit1: TSIP, bit2: NMEA). Bits can be combined to enable multiple input protocols. This field may not be 0.
h	output protocol, hex value (bit 0: TAIP, bit1: TSIP, bit2: NMEA). It is not recommended to combine multiple output protocols.
b	Reserved
b	Reserved
b	Reserved

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RT - Reset

This sentence can be used to Set the reset type. No query is supported.

`$PTNLaRT,b,c,d..x*hh<CR><LF>`

Table C.28 Reset Type

Field	Description
a	Mode (S = set; R = Response)
b	Command C Cold software reset, Erase SRAM including the customer configuration in SRAM and restarts. W Warm software reset. Erases the ephemeris information in SRAM and restarts. H Hot software reset. Uses the entire SRAM data. F Factory software reset. Erases the customer configuration, the almanac, ephemeris and last position in Flash Memory and in SRAM S Set the receiver into Standby Mode.
c	Flash operation 0 reserved 1 reserved 2 store user configuration to Flash Memory 3 store user configuration to Flash Memory 4 Erase Almanac, ephemeris and last position from Flash Memory 5 Erase user configuration from Flash Memory 6 Erase Almanac, ephemeris, last position and user configuration from Flash Memory
d	Wakeup from Standby Mode flags: 001 Wakeup with serial Port A activity 010 Wakeup with serial Port B activity 011 Wakeup with serial Port A or B activity 100 Wakeup after elapsed time specified in the next field 101 Wakeup after elapsed time specified in the next field or serial Port A activity 110 Wakeup after elapsed time specified in the next field or serial Port B activity 111 Wakeup after elapsed time specified in the next field or serial Port A or B activity
x..x	If command is 'S', this field specifies time to stay in Backup (Standby) Mode in seconds. Maximum value 2^{31}.

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SG - Set Bit Mask for GPIOs in Standby Mode.

Users may designate individual pins for pull-down and pull-up while the unit is in Standby Mode. This allows the user to select external pull-down or pull-up resistors to suit their application.

Examples:

- In serial port configuration, one option would be to power down the serial port during standby in which case the corresponding GPIOs would be pull-downs.
- To keep the serial port running during standby, the corresponding GPIOs would be set to pull-ups.

Note – *The pins that are not connected should remain in their default state, pull-down.*

Use bit 5 of byte 1 to select the pull-down or pull-up resistor for the XTANDBY pin as appropriate for the application. Unlike the other GPIOs, the selection of the pull-down or pull-up resistor is applied during Run Mode.

Examples:

- When the XSTANDBY pin is tied to main power, as shown in the reference design, select the pull-down resistor for the XTANDBY pin so when main power is removed, XTANDBY is immediately pulled low to go into Standby Mode.
- When the XTANDBY pin is controlled with GPIO on the user's processor, the pull-down or pull-up resistor may be selected depending on the GPIO state.

$PTNLxSG,hhhh*hh, <CR><LF>

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Table C.29 SG - Set Bit Mask for GPIOs in Standby Mode

Byte	Bit	Item	Type	Value	Definition
Position					
0	0 (LSB)	Pin 6, Reserved	Bit	0	Reserved
	1	Pin 7, OPEN	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	2	Pin 8, SHORT	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	3	Pin 17, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	4	Pin 18, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	5	Bit 5, Pin 19, PPS	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	6	Pin 20, RxDB	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	7	Pin 21, RxDA	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
1	0	Pin 22, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	1	Pin 23, TxDA	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	2	Pin 24, TxDB	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	3	Pin 25, Reserved	Bit	0	0 is pull-down, 1 is pull-up, default is pull-down
	4	Pin 26, Reserved	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-down
	5	Pin 16, XSTANDBY	Bit	0 1	0 is pull-down, 1 is pull-up, default is pull-up
	6-7	Reserved	Bit		Reserved

Note – *The settings will be saved to Flash memory when the user issues the command to "Save User Configuration to Flash".*

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SV - Set Bit Mask for SBAS SV

This packet provides the SBAS SV bit mask. The user data packet contains four bytes to specify 19 possible SBAS prn numbers. Bit 0 represents PRN 120.

$PTNLSSV, xxxxxxxx, xxxxxxxx, <CR><LF>

This packet provides the SBAS SV bit mask in four bytes. The user data packet contains four bytes to specify 19 possible SBAS prn numbers. Bit 0 represents PRN 120.

Available WAAS PRN numbers are 135 and 138.

To disable WAAS PRN 135 send $PTNLSSV,00000000,00008000*58

To disable WAAS PRN 138 send $PTNLSSV,00000000,00048000*5C

To enable all WAAS send $PTNLSSV,00000000,00000000*50

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TF - Receiver Status and Position Fix

This sentence may be issued by the user to get receiver status and position fix.

The Query sentence format is:

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

The Response to query sentence format is:

`$PTNLaTF,b,c,xxxxxx,xx,x,llll.llllll,d,yyyyy.yyyyy,`
`e,xxxxx,x.x,x.x,x.x*hh<CR><LF>`

Table C.30 Receiver Status and Position Fix

Field	Description
a	Mode (Q = query; R = Response)
b	BBRAM status on startup (A = valid; V = invalid)
c	Almanac completion status (A = complete; V = incomplete)
xxxxxx	GPS time of week (in seconds)
xx	Number of satellites in use, 00 - 12, may be different from the number in view.
x	Position fix source (0 = no fix; 2 = 2D fix; 3 = 3D fix)
llll.llllll	Latitude of the current position fix
d	N | S
yyyyy.yyyyy	Longitude of the current position fix
e	E | W
xxxxx	Antenna altitude re: mean-sea-level (MSL geoid, meters)
x.x	'East' component of ENU velocity (m/s)
x.x	'North' component of ENU velocity (m/s)
x.x	'Up' component of ENU velocity (m/s)

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UT - UTC

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

$PTNLaUT,hhhhhhhh,hhhhhh,hh,hh,hhhh,hhhh,hh,hh*hh<CR><LF>

Table C.31 UTC

Field	Description
a	Mode (Q = query; S = set; R = Response)
hhhhhhhh	A_0, HEX data conforming to GPS ICD 200.
hhhhhh	A_1, HEX data conforming to GPS ICD 200.
hh	Delta_t_ls, HEX data conforming to GPS ICD 200.
hh	T_oa, HEX data conforming to GPS ICD 200.
hhhh	Wn_t, HEX data conforming to GPS ICD 200.
hhhh	Wn_LSF, HEX data conforming to GPS ICD 200.
hh	DN, HEX data conforming to GPS ICD 200.
hh	Delta_t_LSF, HEX data conforming to GPS ICD 200.

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VR - Version

This sentence may be issued by the user to get version information.

The Query sentence format is:

$PTNLQVR,a*hh<CR><LF>

where a is S = Application firmware, H=Hardware and N=Nav

The Response to query sentence format is:

$PTNLRaVR,b,c..c,xx.xx.xx,xx,xx,xxxx*hh<CR><LF>

Table C.32 Version

Field	Description
a	Mode (Q = query; R = Response)
b	Reserved
c..c	Receiver Name
xx	Major version
xx	Minor version
xx	Build version
xx	Month
xx	Day
xxxx	Year

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