Zodiac GPS Receiver Family

Designers' Guide

C O N E X A N T ™

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

APPENDIXES

TABLE OF CONTENTS (continued)

FIGURES

TABLES

TABLE OF CONTENTS (continued)

TABLES (continued)

1 INTRODUCTION

Conexant's Zodiac family of Global Positioning System (GPS) receivers are single-board, 12 parallel-channel receiver engines. Each board is intended as a component for an Original Equipment Manufacturer (OEM) product. While the body of this Designers' Guide provides information common to the entire Zodiac family, specific technical information for a particular board product can be found in the appendixes.

Each of these receivers continuously tracks all satellites in view and provides accurate satellite positioning data. They are designed for high performance and maximum flexibility in a wide range of OEM configurations including handhelds, panel mounts, sensors, and in-vehicle automotive products. The highly integrated digital receivers incorporate two custom Conexant devices including the Conexant Zodiac chip set: the Gemini/Pisces MonoPac™ and the Scorpio Digital Signal Processor (DSP). The combination of custom devices minimizes the receivers' size to about 28 square centimeters and satisfies harsh industrial requirements.

1.1 Product Overview _____

1.1.1 Description. The Conexant Zodiac family of GPS receivers (the Jupiter model is shown in Figure 1-1) decodes and processes signals from all visible GPS satellites. These satellites, in various orbits around the Earth, broadcast radio frequency (RF) ranging codes and navigation data messages. The Zodiac receivers use all available signals to produce a highly accurate and robust navigation solution that can be used in a wide variety of end product applications.

The Zodiac receivers are packaged on 28 square centimeter printed circuit boards intended for harsh industrial applications. The receivers require conditioned DC power and a GPS signal from a passive or active antenna. To provide the lowest total system cost with minimal power consumption, each of the receivers provide only those components that are required for the majority of applications. For instance, if a passive antenna can be used in close physical proximity to the receiver, no preamplifier is required.

The all-in-view tracking of the Zodiac receiver family provides robust performance in applications that require high vehicle dynamics and in applications that
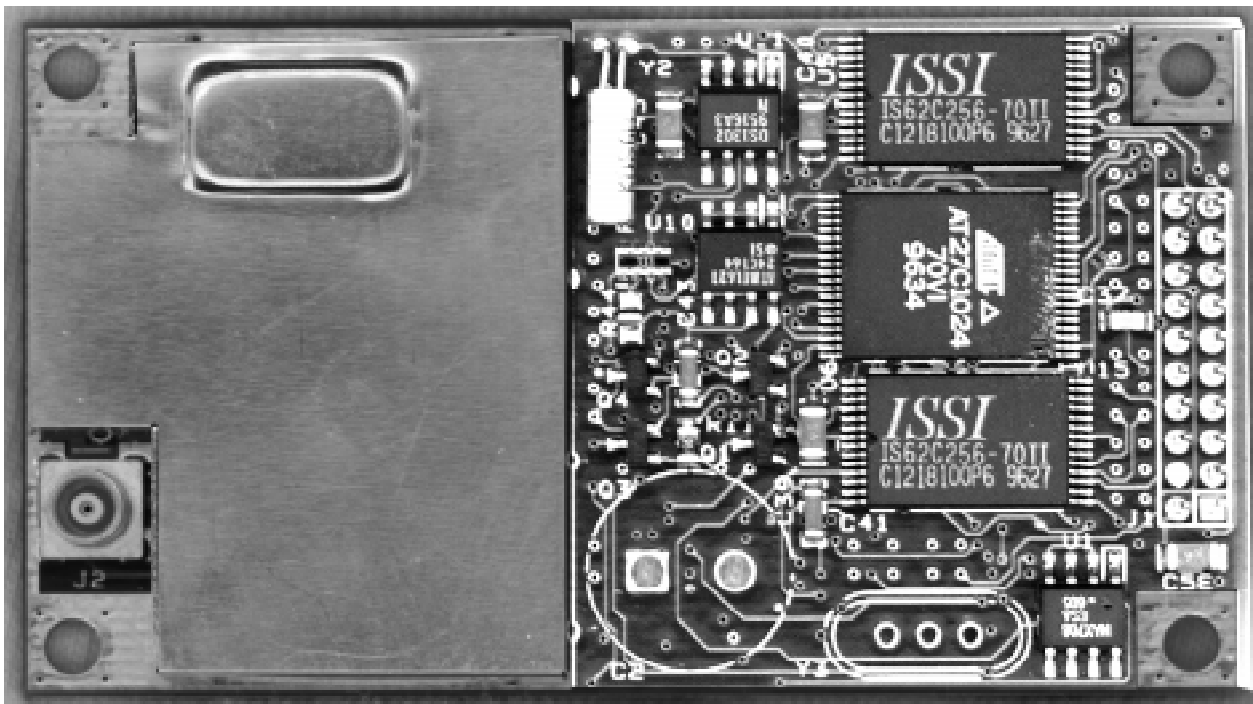
Figure 1-1. The Conexant Jupiter GPS Receiver (Top View Shown Approximately 4x Actual Size)

operate in areas of high signal blockage such as dense urban centers. The receivers continuously track all visible GPS satellites and use all the measurements to produce an overdetermined, smoothed navigation solution. This solution is relatively immune to the position jumps induced by blockage that can occur in other receivers with fewer channels.

The 12-channel architecture provides rapid Time-To-First-Fix (TTFF) under all startup conditions. While the best TTFF performance is achieved when time of day and current position estimates are provided to the receiver, the flexible Zodiac signal acquisition system takes advantage of all available information to provide a rapid TTFF. Acquisition is guaranteed under all initialization conditions as long as visible satellites are not obscured.

To minimize TTFF following a power down, each of the Zodiac receivers can accept external voltage to maintain power to the Static Random-Access Memory (SRAM) and Real-Time Clock (RTC) for periods following the loss of prime power. The use of external voltage assures the shortest possible TTFF following a short power down. The OEM may extend the operation of the RTC by providing standby power on a connector pin in which case a short TTFF is achieved by using the RTC time data and prior position data from the receiver's Electrical Eraseable Programmable Read-Only Memory (EEPROM).

The Zodiac family supports two dimensional (2-D) operation when less than four satellites are available or when required by operating conditions. Altitude information required for 2-D operation is determined by the receiver or may be provided by the OEM.

The Zodiac receivers contain two independent serial ports, one of which is configured for primary input and output data flow using the National Marine Electronics Association (NMEA-0183) format or Conexant binary message format. The second port is used to receive Differential GPS (DGPS) corrections in the Radio Technical Commission For Maritime Services (RTCM SC-104) format. The receivers support DGPS operations for dramatically improved accuracies over standard GPS.

A complete description of the serial data interface for the entire Zodiac family of GPS receivers is contained in this Designers' Guide.

For applications that require timing synchronization to GPS accuracies, the Zodiac receivers provide an output timing pulse that is synchronized to one second Universal Time Coordinated (UTC) boundaries.

1.1.2 Receiver Architecture. Figure 1-2 illustrates the internal architecture of the Zodiac receivers. Each receiver is designed around two custom Conexant devices that contain most of the required GPS functionality. The Gemini/Pisces MonoPac™ contains all the RF downconversion and amplification circuitry, and presents sampled data to the Scorpio device. The Scorpio device contains an integral microprocessor and all GPS specific signal processing hardware. Memory and other supporting components configure the receiver into a complete navigation system.

Figure 1-3 illustrates an architecture that might be used to integrate a particular Zodiac receiver with an applications processor that drives peripheral devices such as a display and keyboard. The interface between the applications processor and the Zodiac receiver is through the serial data interface.
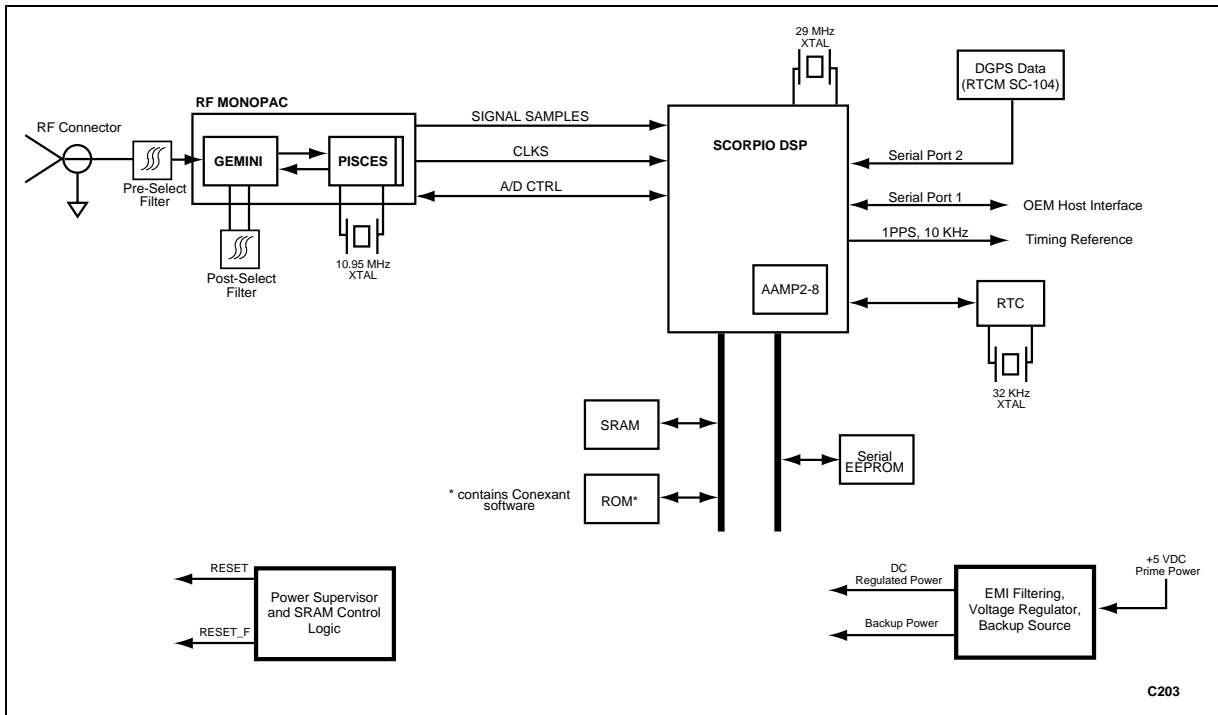
Figure 1-2. Internal Zodiac Architecture
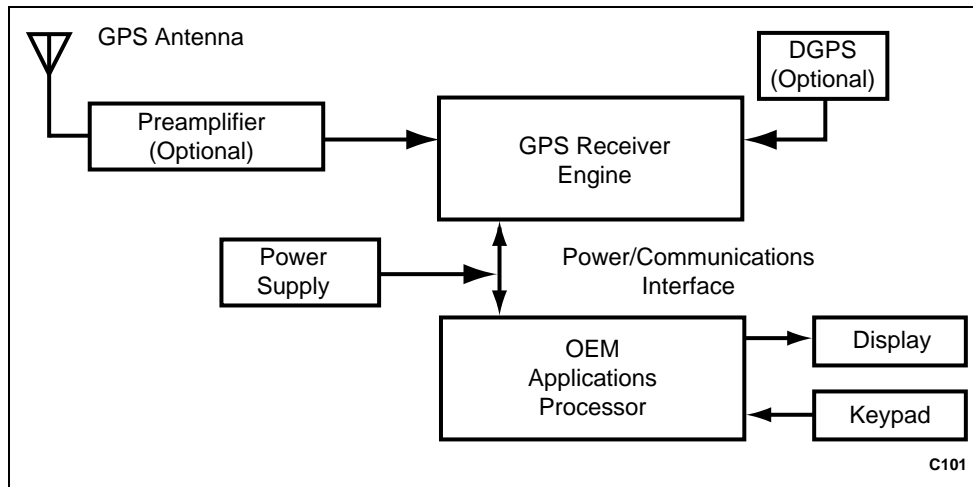
Figure 1-3. Possible Zodiac/OEM Architecture

1.2 Features_____

The Zodiac family of GPS receivers offers the following physical, operational, and support features:

- OEM product development is fully supported through applications engineering.
- One of the smallest, most compact GPS receiver footprints measuring 2.800" x 1.575" x 0.480" (approximately 70 x 40 x 12 mm).
- Twelve parallel satellite tracking channels.
- Supports NMEA-0183 data protocol.
- Direct, differential RTCM SC-104 data capability dramatically improves positioning accuracy. Available in both Conexant binary and NMEA host modes.
- Static navigation enhancements to minimize wander due to SA.
- Designed for passive or active antennas for lowest system cost.
- Adaptive threshold-based signal detection for improved reception of weak signals.
- Maximum navigation accuracy achievable with the Standard Positioning Service (SPS).
- Enhanced TTFF upon power-up when in a "Keep-Alive" power condition before start-up.
- Meets rigid shock and vibration requirements including low-frequency vibration.
- Automatic Altitude Hold Mode from Three-Dimensional to Two-Dimensional navigation.
- Automatic cold start acquisition process (when no initialization data is entered by the user).
- Maximum operational flexibility and configurability via user commands.
- Ability to accept externally supplied initialization data.
- Three-Satellite Navigation startup from acquisition.
- User selectable satellites.
- User selectable visible satellite mask angle.
- Standard microminiature coaxial RF jack receptacle.
- Standard 2x10 pin-field I/O connector.

2 DEVELOPMENT KIT SETUP AND OPERATION

The Conexant Zodiac™ Development Kit is designed to facilitate evaluation of Conexant's Jupiter Global Positioning System (GPS) receiver engine based on the Zodiac chip set. The receiver can be used in both static and mobile operations for evaluation purposes.

The Development Kit implements the receiver control operation and input/output (I/O) functions of the GPS receiver using an IBM-AT compatible personal computer (PC), a serial port, external antenna, and power supply. The GPS receiver is contained in a housing with I/O connectors, status LEDs, and configuration DIP switches as shown in Figure 2-1.

This section explains how to configure the Development Kit and the receiver, and how to set up the test equipment.

LABMON, the GPS monitor and controller software, is provided with the Development Kit to communicate with the receiver. This software runs on the PC and allows the user to control the receiver and to display the receiver output message data. Externally supplied Radio Technical Commission for Maritime Services (RTCM SC-104) data can also be logged using a second PC serial port if desired. The LABMON software source code is included to provide a reference for similar Original Equipment Manufacturer (OEM) code implementations. Refer to Section 3 for details on how to use LABMON.

2.1 Equipment Supplied_____

The Development Kit contains the following items as depicted in Figure 2-2:

1. Jupiter receiver, power supply, voltage regulators, and RS-232 drivers in housing.

2. Active patch antenna with male SMA connector.

3. Two RS-232 cables with female DB-9 connectors at both ends.

4. 120V AC, 60 Hz/12 VDC power adapter.

5. 12 VDC automotive power adapter.

6. Jupiter GPS Receiver Data Sheet.

7. Zodiac GPS Receiver Family Designers' Guide.

8. Zodiac LABMON software on a 3.5-inch diskette.
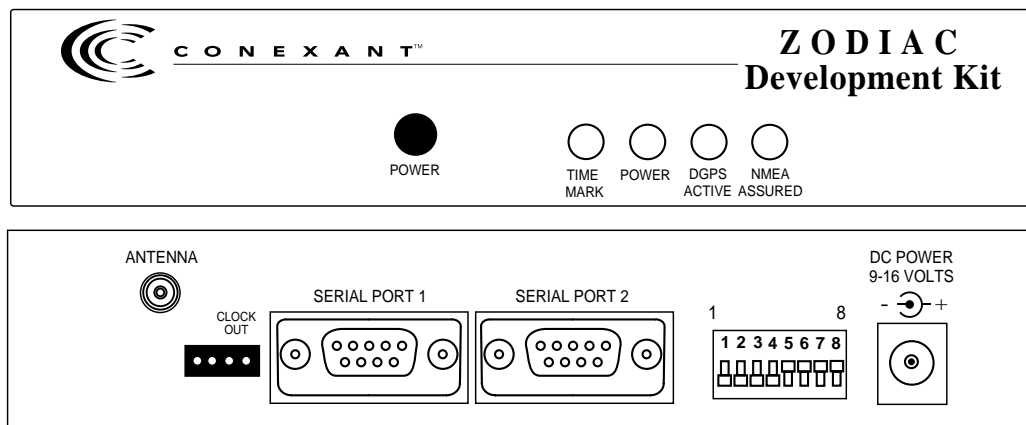
Figure 2-1. Front (Top) And Rear (Below) Panels Of The Development Kit
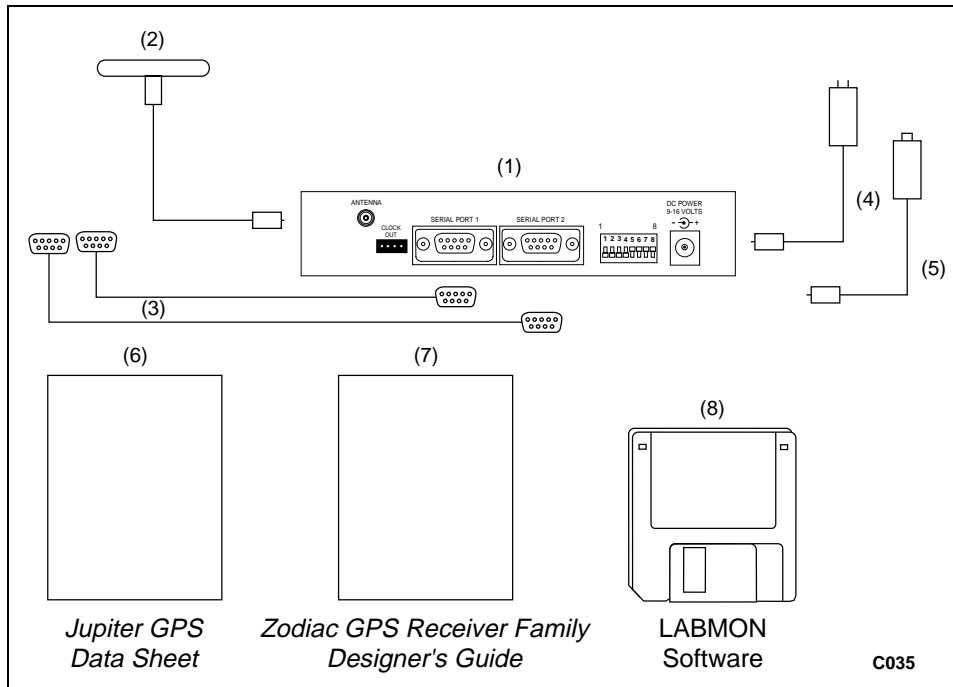
Figure 2-2. Development Kit Components

2.2　Equipment Needed_____

The following OEM supplied equipment is also required, as a minimum, to test the Jupiter GPS receiver:

1.　IBM-AT compatible PC processor with at least one available serial port, a 3.5-inch diskette drive, at least 640 kB RAM and DOS version 3.0 or greater.

   A laptop or portable PC is highly recommended since it allows the receiver to be easily evaluated in an outdoor environment where GPS signals are more accessible.

2.　Color monitor with VGA or EGA, or monochrome monitor with VGA (no monochrome with EGA).

3.　RTCM data source (required only if the differential capability is being tested).

4.　Cabling to connect the RTCM data source to the second PC serial port and the receiver's Auxiliary port for simultaneous RTCM SC-104 data collection and DGPS operation. A ribbon cable with three connectors is recommended.

2.3　Description of The Development Kit _____

The Development Kit features dual RS-232 level serial data I/O ports, selectable bias voltages for active GPS antennas, port configurations, message protocols, and flexible internal "Keep-Alive" back-up power modes for both the Static Random-Access Memory (SRAM) and the low power time source.

The kit also includes the necessary circuitry to convert the receiver's Complimentary Metal Oxide Semiconductor (CMOS) level output to RS-232 level,

serial data I/O. The two serial data ports are RS-232, 9-pin D-Subminiature connectors.

2.3.1 Host Serial Port. The Host serial port, labelled Serial Port 1, is used to send and receive both binary and National Marine Electronics Association (NMEA-0183) initialization and configuration data messages.

2.3.2 Auxiliary Serial Port. The Auxiliary serial port, labelled Serial Port 2, is dedicated to the reception of RTCM SC-104 Differential GPS (DGPS) correction

messages. No data is output from the receiver through the Auxiliary port.

2.3.3 Auxiliary Test Connector. An auxiliary output connector, labelled Clock Out, on the Development Kit allows the OEM processor to access the 1 pulse-per-second (1 PPS) time mark and 10 kHz time mark signals. The signals available at the auxiliary test connector are buffered CMOS level outputs driven by a 74LS04 CMOS inverting buffer device.

2.3.4 DC Power Regulation. The kit also includes the necessary circuitry to regulate the DC power input and to provide the necessary supply voltages to the receiver.

The Development Kit board contains jumper blocks which allow the OEM to insert a current measuring device inline with the primary and Real-Time Clock (RTC) power lines to the receiver to monitor power usage under various conditions. To isolate the receiver from the Development Kit, an electronic bus switch is used. This switch is controlled externally by a DIP switch on the kit. The bus switch also provides control over the bus voltage level. A jumper block is provided to select the interface voltage level to be used.

DC power for the Development Kit is provided by either an AC/DC converter or automobile adapter. The AC/DC converter operates from a nominal 120 VAC @ 60 Hz input and provides a 12 VDC @ 500 mA out. For mobile operation, an automotive adapter intended for use in 12V vehicles is provided. Four front panel LEDs provide the Development Kit's basic status indicators. A momentary pushbutton switch is provided on the Development Kit board to generate a master reset signal to the receiver.

2.3.5 Interface Cables. Ribbon cables are provided to interface between the Development Kit and the customer's PC, and between the Development Kit and a DGPS receiver. These cables are terminated at both ends with female connectors to match the male connectors on the Development Kit and the PC.

2.3.6 The Active Antenna. A magnetic mount, active antenna is supplied with the kit. An 8-foot long RF cable (RG-316) is provided for the antenna with the proper connector already terminated. The nominal measured attenuation of the cable with connector is approximately 3 dB. The supplied active antenna should be biased at +5 VDC, but a different active antenna with a bias of either +5 or +12 VDC may be used. Switches located on the back panel of the Development Kit are used to select the proper bias.

CAUTION: Make certain the antenna power switches are properly set before connecting the antenna. An antenna designed for +5 VDC operation will be damaged if connected to a +12 VDC source.

2.3.7 On/Off And Reset Switches. A pushbutton ON/OFF power switch is provided to control primary power to the Jupiter board. A pushbutton reset switch is also provided on the Development Kit circuit board to generate a receiver system hardware reset. This reset switch is not accessible unless the cover is removed from the Development Kit.

There is also a provision to supply external backup power to the SRAM and RTC devices after primary power has been removed from the board. This feature provides the receiver with a "hot start" capability by maintaining last position, current time, and satellite ephemeris data in SRAM.

The supply of an external backup voltage to the SRAM and RTC is accomplished by properly configuring a jumper block and a configuration DIP switch. This external backup power is maintained to the SRAM and RTC unless it is disabled using the DIP switches, by removing the appropriate jumper on the kit, or by removing +12 VDC power to the kit.

2.4 Configuring The Development Kit_____

CAUTION: If the Development Kit cover is removed during configuration, proper Electro-Static Discharge (ESD) precautions should be observed when handling the unit to prevent possible damage to circuits. Failure to observe these precautions may result in permanent damage to the unit.

The Development Kit should be correctly configured before it is connected to the PC and powered up.

2.4.1 Configuration Devices. The Jupiter board is configured using a bank of eight dip switches, three jumper blocks, and a single, two-position jumper switch block. The relative position of each configuration device on the Jupiter board, as well as the auxiliary I/O connector, is shown in Figure 2-3.
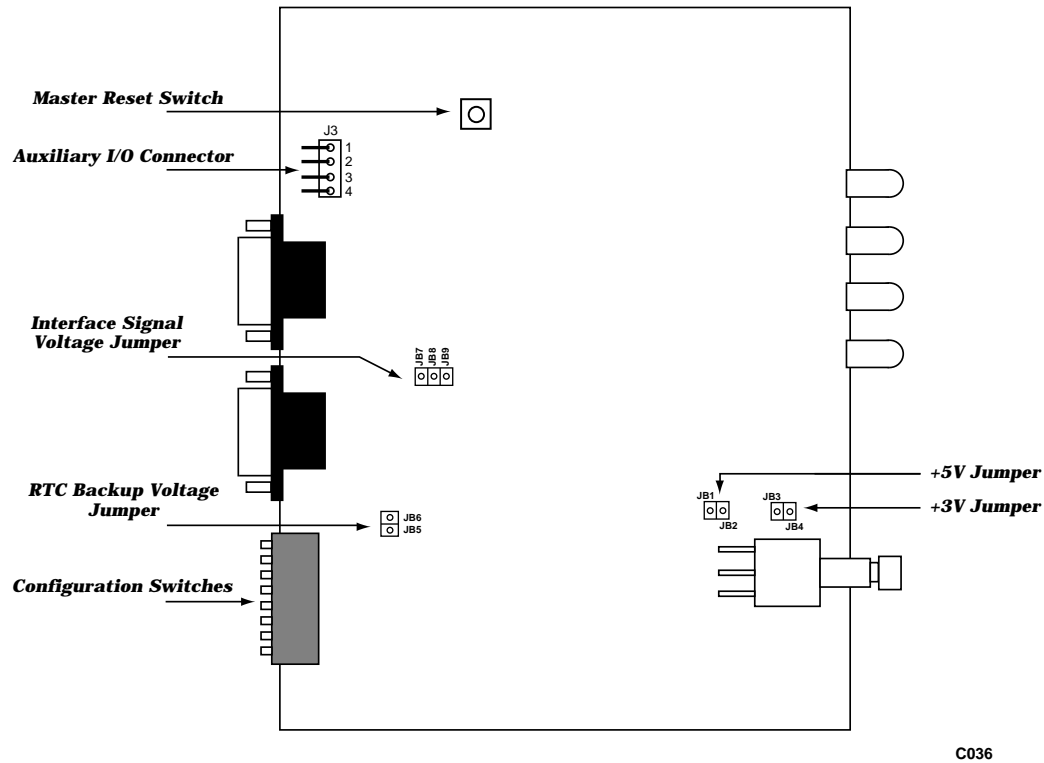
Figure 2-3. Jupiter Board With Location Of Configuration Devices

The primary configuration switches, located on the rear of the Development Kit, are illustrated in Figure 2-4. They are shown in their normal default positions.

CAUTION: The antenna bias may be set to either 0, +5, or +12 VDC for an active antenna. The switches must be set correctly to avoid possible damage to the unit. The active antenna supplied with the Development Kit must be set to +5 VDC only. If a passive antenna is used, be sure to set the antenna bias to 0 volts VDC. Remember to set the Development Kit's power switch to OFF or remove power from the unit before changing these switches.

Switch 1 is reserved and should be set to the OFF position.

Switch 2 is used to select the receiver's output message protocol. If switch 2 is set to the ON position, the receiver's output message format will be set to NMEA-0183 with Host port settings of 4800 bps, no parity, 8 data bits, and 1 stop bit. If switch 2 is set to the OFF position, the receiver's output message format and communication parameters are determined by the configuration of switch 3 as follows:

- If switch 3 is ON when switch 2 is OFF, ROM defaults are used and the receiver will output Conexant binary format messages with Host port settings of 9600 bps, no parity, 8 data bits, and 1 stop bit.

- If switch 3 is OFF when switch 2 is off, the receiver's output protocol, communication parameters, and initialization parameters will be determined from data stored in SRAM or EEPROM (whichever is valid). That is, the receiver recalls the settings from its last operating session.

Switch 3 is used to enable or disable the Electrically Eraseable Programmable Read-Only Memory (EEPROM). When switch 3 is ON, EEPROM is disabled and ROM defaults such as message format, host port communication settings, and receiver default message set are used. When switch 3 is off, user-configurable settings stored in EEPROM are used. This switch should normally be OFF to use data such as clock parameters, last position, and receiver configuration from EEPROM.

Switch/Function:	On:	Off:
1 Reserved	N/A	N/A
2 Host Port Protocol	NMEA Assured	Conexant Binary or NMEA depending on Switch 3
3 EEPROM Enable/Disable	EEPROM Disable	EEPROM Enabled
4 Reserved	N/A	N/A
5 I/O Control	Enable I/O signals	Disable I/O signals
6 RTC Control	RTC Backup Power Enabled	RTC Backup Power Removed
7 Preamp Voltage Select	Apply +5 VDC to Active Antenna	Apply +12 VDC to Active Antenna
8 Preamp Power Enable	Preamp Power On for Active Antenna	Preamp Power Off For Passive Antenna

C037

Figure 2-4. Development Kit Configuration Switches

NOTE: Be advised that if the Development Kit is operated with switch 3 in the ON position (EEPROM disabled), then each power cycle or reset of the receiver may result in a longer Time-To-First-Fix (TTFF). This is because the receiver will use the default initialization parameters stored in ROM rather than more current initialization parameters that may be available in SRAM or EEPROM.

Switch 3 must be in the Off position for the receiver to output the results of a commanded Built-In Test (BIT).

Switch 4 is reserved and should be set to the OFF position.

Switch 5 is used to control the I/O signals to the receiver. Set switch 5 ON to enable and OFF to completely disable the receiver's I/O signals.

Switch 6 is used to control whether the Development Kit will supply SRAM and RTC backup power when the receiver has been switched off. Set switch 6 ON to supply backup power and OFF to remove backup power. When switch 6 is ON, SRAM and RTC back-up power is supplied to the receiver as long as the Development Kit is receiving +12 VDC power from the supplied AC/DC adapter or car adapter.

Switch 7 is used to select the voltage applied to an active antenna when switch 8 is in the ON position. Set switch 7 to ON to apply +5 VDC and to OFF to apply +12 VDC (only +5 VDC should be applied when the active antenna supplied with the Development Kit is used).

Switch 8 is used to select between an active and a passive antenna. Set switch 8 to OFF for a passive antenna and to ON for an active antenna. The ON setting allows DC voltage (selected by switch 7) to be applied to the center conductor of the RF cable.

2.4.2 RTC Backup Voltage Jumper. A jumper block on the Development Kit, with pins labeled **JB5** and **JB6**, may be used to disable the backup power to the receiver's SRAM and RTC from the kit. Remove the jumper to disable the backup power; leave the jumper in place to supply voltage to the SRAM and RTC even when primary power has been removed from the receiver.

To supply a backup voltage from an external source, remove the jumper and connect the voltage source to pin JB6. Additional information on backup power requirements can be found elsewhere in this Designers' Guide.

2.4.3 +5V and +3V Jumpers. Two additional jumper blocks are provided to enable +3.3 VDC or +5 VDC primary power. To enable the +5 VDC primary power to the receiver interface connector, the jumper should be in place over the pins labeled **JB1** and **JB2** on the circuit board.

To supply the primary voltage from an external source, remove the jumper from pins **JB1** and **JB2** and connect the voltage source to pin **JB2**. Additional information on power requirements can be found elsewhere in this Designers' Guide.

2.4.4 Interface Signal Voltage Jumper. A switch jumper block is provided to select either +3.3 VDC or

+5 VDC for the receiver's I/O interface. The three-pin jumper block is labeled **JB7**, **JB8**, and **JB9** on the circuit board. When the +5 VDC Jupiter board is operated with the Development Kit, the jumper should be over pins labeled **JB7** and **JB8**.

2.4.5 Auxiliary I/O Connector. There is a 4-pin AUX I/O connector on the Development Kit as shown in Figure 2-5. This connector is a Molex 70553 series right-angle pin header. The connector provides access to the buffered 10 kHz UTC signal and the one pulse-per-second timing signal. These may be used by the OEM's processor for synchronization.

The pin assignments are as follows:

1. K10. Buffered 10 kHz UTC output frequency reference signal. This is a synchronous 10 kHz output clock with a 50 ±5 percent duty cycle.

2. TM (inverted version of the Time Mark pulse). This is a 1 pulse-per-second (1 PPS) CMOS output signal buffered through a 74LS04 device.

3. No connect.

4. GROUND.

For further information on the characteristics of these signals, consult the Jupiter receiver Data Sheet included with this Development Kit.

CAUTION: Do not connect an antenna and apply power to the Development Kit before reviewing this entire section and checking the antenna bias switch settings. The settings must be correct before power is applied to the receiver.

When connected, a passive antenna provides a low resistance path. Therefore, an abnormally high current will occur in the supply circuits of the Jupiter board if the switches are set for an active type. Although the preamp power supply internal

to the Development Kit is current-limited to 65 milliamps, this feature will only prevent damage to the receiver, itself, but not necessarily to the Development Kit or antenna.

 Failure to observe these precautions may result in permanent damage to the unit and/or the antenna.

2.4.6 Positioning The RF Antenna. Since GPS is a line of sight system, the antenna can only receive signals from visible satellites. Therefore, a location for the test equipment should be selected so that the GPS antenna is placed where the view of the sky is least obstructed for optimal reception of the satellite signals.

NOTE: GPS signals are severely attenuated or totally obscured by the roofs or walls of wood, metal, brick, or stucco buildings. The signals are also attenuated by coated glass found in many office structures. The Development Kit should be taken outside or to the roof of a building to effectively evaluate receiver performance. With stationary evaluations, care should also be taken to keep the antenna away from the side of a building since GPS signals can reflect off of metal or coated glass. These reflections have a longer path than direct signals and can cause multi-path errors.

2.4.7 Connecting an RTCM Differential Source. The Development Kit, PC, and the RTCM SC-104 differential correction source are connected as shown in Figure 2-6. If RTCM SC-104 data needs to be logged at the same time it is sent to the receiver, the OEM must supply a cable with three connectors to connect the RTCM correction source to the Development Kit's Auxiliary port and to an unused serial port on the PC. In this case, data is only logged when LABMON is invoked with filenames as command line arguments as described in Section 3 of this Designers' Guide.

Logging and subsequent review of RTCM correction data often proves useful to resolve performance or compatibility issues. A utility program, RTCMCHK, is contained on the LABMON disk included with the Development Kit. This software tool checks the integrity of RTCM SC-104 data sources.

J3
- 1 *10 kHz Signal*
- 2 *Time Mark*
- 3 *No Connect*
- 4 *Ground*
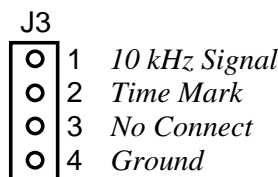
C038

Figure 2-5. Auxiliary I/O Connector
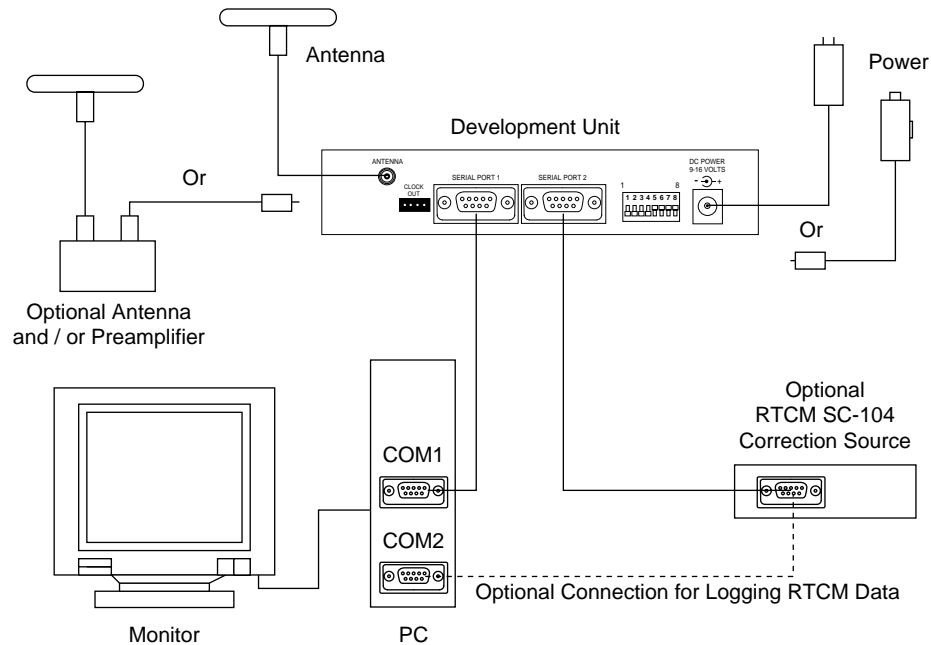
Figure 2-6. Development Kit Test Equipment Setup

Normally, the Development Kit should be set up as shown in Figure 2-6 with only the RTCM correction source connected to the receiver. If the RTCM cable is not connected to the receiver's Auxiliary port, DGPS operation will not be possible.

Note that the Development Kit may be connected to either the COM1, COM2, COM3, or COM4 serial ports and the RTCM differential correction data source connected either directly to the receiver's Auxiliary I/O port, to one of the remaining serial ports of the PC, or to both using an OEM-supplied three-connector serial cable.

2.4.8 Operating The Development Kit's GPS Receiver. To operate the Jupiter receiver, press the pushbutton on/off switch on the front panel of the Development Kit once. When power is applied to the receiver, the POWER LED illuminates and the TIME

MARK LED flashes at a 1 Hz rate to indicate the receiver is operating.

When the NMEA protocol for the Host port is selected, the NMEA ASSURED LED illuminates. When data is received by the Auxiliary port, the DGPS ACTIVE LED illuminates. The DGPS ACTIVE LED does not indicate the integrity of the RTCM SC-104 data or the receiver mode.

Press the pushbutton switch again to remove primary DC power from the receiver.

The POWER LED on the Development Kit should indicate off before changing the configuration switch settings. The receiver operating settings will not change after re-configuration until the receiver is restarted by pressing the front panel pushbutton on/off switch.

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3 USING LABMON

The Conexant Zodiac™ Development Kit is designed to facilitate evaluation of Conexant's Jupiter Global Positioning System (GPS) receiver engine based on the Zodiac chip set. The receiver can be used in both static and mobile operations for evaluation purposes.

This Section explains the use of the GPS monitor and controller software, referred to as LABMON, provided with the Development Kit (Refer to Section 2 of this Designer's Guide for details on how to set up and configure the Development Kit). LABMON runs on a PC and allows the user to control the receiver and to display the receiver outputs. Externally supplied Radio Technical Commission for Maritime Services (RTCM SC-104) data can also be logged using a second PC serial port. ASCII files containing the LABMON source code, included on the same diskette as the executable, provide a reference for similar Original Equipment Manufacturer (OEM) code implementations.

3.1 Introduction_____

The Development Kit implements the receiver control operation and input/output (I/O) functions of the GPS receiver using an IBM-AT compatible PC, a serial port, external antenna, and power supply. The GPS receiver is contained in a housing with I/O connectors, status LEDs, and configuration DIP switches.

3.1.1 LABMON Compatibility With Conexant Receivers. There are two series of Conexant commercial GPS receivers to date. The first was the NavCore series and the latest is the Zodiac family. The NavCore series consists of the NavCore V, MicroTracker, MicroTracker LP, NavCard, and NavCard LP receivers. The Zodiac family currently consists of the Jupiter board level product and the Zodiac chip set product.

LABMON v5.4 is designed primarily to support the Zodiac family of receivers. Since it is also backwardly compatible with the NavCore series of receivers, this version of LABMON may be used to monitor and control them as well.

3.1.1.1 Serial Communication Protocols. The receivers may use either a binary or NMEA-0183 type of serial interface protocol for communication. The Zodiac and NavCore receivers share a similar Conexant binary message format, but the messages themselves have different IDs and content. To differentiate between these binary types in this document, they are referred to as Zodiac binary and NavCore binary.

The NMEA-0183 protocol consists of a number of standard messages, and also allows manufacturer specific or proprietary messages for more complete control or monitoring of receivers.

While the Zodiac and NavCore receiver NMEA-0183 protocols share a number of standard messages, the number and type of Conexant proprietary messages differ. To differentiate between these NMEA types in this document, they are referred to as Zodiac NMEA and NavCore NMEA.

The Zodiac receiver series comes standard with both Zodiac binary and Zodiac NMEA. The type used is selected either by software command or by controlling the voltage applied to an external pin on the receiver.

The NavCore series is available with Conexant NavCore binary and NavCore NMEA protocols depending on the model and software options. The type used is selected by controlling the voltage applied to an external pin on the receiver.

The NavCard supports only NavCore binary. The NavCard LP is available with either Conexant NavCore binary or NavCore NMEA-0183 protocols.

To communicate with a receiver, the message protocol used by LABMON is changed to match the current message type in use by that receiver.

It is important to select the correct protocol for LABMON to operate properly. The two binary protocols are not compatible. The NMEA-0183 protocols are similar enough that standard messages can be displayed or received properly, but not all Conexant proprietary NMEA messages will be output or accepted.

3.2   Installing LABMON_____

3.2.1 Operating Environment. LABMON was designed to run using an MS-DOS/PC-DOS or compatible DOS operating system. It is also possible to run LABMON from the DOS prompt under Windows 3.x.

NOTE: Sometimes, both Windows and DOS will attempt to use the same interrupt for the serial ports and a conflict may occur. If problems are encountered running LABMON under Windows, exit to DOS to run LABMON.

If a mouse driver is installed on a serial port used by LABMON, serial data may be prevented from reaching LABMON. The mouse driver should be removed if LABMON does not function properly.

While LABMON can be run from the 3.5-inch diskette, copying the program and associated files to a hard disk and retaining the diskette as a backup is recommended.

The current version of LABMON can be used to operate the Zodiac family of receivers and is also compatible with the MicroTracker/MicroTracker LP, NavCore V, and PCMCIA NavCard/NavCard LP receivers. However, some of the keys and commands used to enable certain features of the current hardware configuration may not be supported by these receivers.

3.2.2 DOS Installation. To install LABMON for use with DOS, do the following:

1.   Create a directory on the PC's hard drive and copy all the LABMON disk files to it.

2.   Edit your AUTOEXEC.BAT file to include this directory as part of the path.

3.   Remove the LABMON disk and save it as a backup.

4.   Reboot the PC to update the path.

3.2.3 Windows 3.x Installation. To install LABMON for use with Windows 3.x, do the following:

1.   Perform steps 1 through 4 as for DOS installation above.

2.   Start Windows, select the Program Manager, and select New under the File menu.

3.   Click on the Program Item within the dialog box which appears and click on OK to exit the dialog box.

4.   Enter "LABMON" for the Description.

5.   Enter "LABMON" for the Command Line.

6.   Enter the full path to the LABMON directory or use Browse to set the Working Directory (i.e., C:\LABMON).

7.   To select the program icon, click on Change Icon. Then, enter the full path or use Browse to select the LABMON.ICO file located in the LABMON installation directory and click on OK twice to exit the dialog boxes.

3.2.4 Windows 95 Installation. To install LABMON for use with Windows 95, do the following:

1.   Create a directory on the PC's hard drive and copy all the LABMON disk files to it.

2.   Remove the LABMON disk and save it as a backup.

3.   Create a "shortcut" to the LABMON executable (see the Win95 manual or use the Win95 on-line Help feature).

3.3   Configuring LABMON _____

3.3.1 The LABMON.CFG File. Using function keys or certain <Alt>/function key combinations, LABMON can be configured for the message protocol mode (binary or NMEA), display datum, the UTC time offset, speed units, display colors, reference position, and filtering parameters. This is the easiest way to change the configuration settings.

These parameters can also be changed by editing the LABMON.CFG file. If difficulties are encountered processing the settings, the LABMON.CFG file should be examined to see if extraneous or incorrect information has corrupted it. This file may be deleted since the program will automatically reconstruct it with defaults which can then be modified.

LABMON checks for the presence of the LABMON.CFG file when the program is invoked and reads parameters from the file if it is present. If the LABMON.CFG file is not present, default configuration parameters are used, and a LABMON.CFG file containing the following lines is created in the local directory:

```
DATA TYPE   4

DATUM NUMBER   0

UTC OFFSET   7

SPD UNITS   0

COLORS   10   15   0   14   15   10

LAT   33.661446   LON   - 117.861252
ALT - 8.716304

FILTERS   STATMASK   FFFF   FOM   5
QUALITY   1   SATS   3   PDOP   6.000000
HDOP   6.000000   VDOP   6.000000
```

NOTE: Although the latitude, longitude, altitude, and filter parameters are shown on more than one line above, they must all appear on the same line in the configuration file.

3.3.1.1 DATA TYPE Parameter. This parameter determines the desired message protocol mode, binary or NMEA. Use 1 for Conexant NavCore binary, 2 for NavCore NMEA-0183, 4 for Conexant Zodiac binary, and 8 for Zodiac NMEA-0183. This is done using the <Alt>F2 keys.

3.3.1.2 DATUM NUMBER Parameter. The datum number for display of position output is no longer set from within the configuration file when using the Zodiac family of GPS receivers. Instead, use the Ctrl-<F6> keys to enter any of the datum numbers shown in Appendix E of this Designer's Guide.

The Zodiac family supports many datums internally while the NavCore series of receivers supported only WGS-84 with the desired transformation being performed by LABMON. LABMON v5.4 ignores the datum number contained in the LABMON.CFG file when processing Zodiac data. The inclusion of the datum number in the configuration file is for backward compatibility of LABMON with Conexant NavCore GPS receivers.

When using LABMON v5.4 with one of these earlier receivers, the datum number may either be changed in the configuration file (using an appropriate text editor) or by using the Ctrl<F6> keys to enter any of the datums shown in Appendix E.

3.3.1.3 UTC OFFSET Parameter. The UTC time offset between local time and UTC should be set to UTC minus local time. The time zones in the United States, for example, have positive time offsets. This time is added to the PC time and used as the default for receiver initialization. It is important to verify and correct, if necessary, the PC time for correct initialization when using the defaults provided by LABMON. This is done using the F1 key.

3.3.1.4 SPD UNITS Parameter. This parameter configures the speed units displayed in the SPD field on the LABMON display. Unless modified in the LABMON.CFG file (since there are no keys or key combinations that will do this), the speed units will default to meters per second (m/s). The setting for speed units in the LABMON.CFG file should be set to 0 for m/s, 1 for miles per hour (mph), or 2 for kilometers per hour (kph).

3.3.1.5 COLORS Parameters. Screen colors are changed using the <Alt>-Function key combinations shown on the screen menu.

3.3.1.6 LAT, LON, ALT Parameters. The receiver's reference position can be changed using the <Alt>F3 keys. When this position is changed, the LAT, LON, and ALT parameters in the LABMON.CFG file are changed. The new location becomes the default reference position (the start-up location).

3.3.1.7 FILTERS Parameters. The data filtering parameters STATMASK, FOM, QUALITY, SATS, PDOP, HDOP, and VDOP should be set to the desired criteria for solution evaluation using the <F> key. The parameters used depend on the message protocol in use.

When the criteria are not all met, the FILTER ON indicator is shown on the display screen and if data is being extracted into a text file for post processing, the data is not written to the file. When the criteria are all met, the indicator is not displayed and the data is extracted and written to the file. This allows filtering or screening of outputs that are computed under conditions which do not meet the user's criteria for solution quality.

NOTE: The filter does not prevent any data from being written to the log file when recording data.

The STATMASK parameter is a 16-bit bitmask that is used to mask out any desired invalid bits returned in Message 1000. These invalid bits report the reasons for not being in navigation, and the STATMASK parameter masks out any of these reasons. The format of this bitmask is shown in Figure 3-1.

XXXX XXXX XXX1 1111

Don't Care

Exceeded MEVPE (if bit set)

Exceeded MEHPE (if bit set)

Minimum Satellites Used (if bit set)

No DGPS, But Required (if bit set)

Altitude Used In Solution But Not Wanted (if bit set)

C462
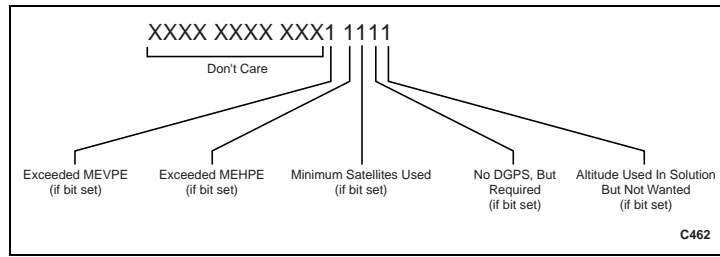
Figure 3-1. STATMASK Filter Parameter Format (0xFFFF Mask)

3.3.2 The LABMON.INI File. LABMON can also be configured to select the COM ports it uses for serial I/O either by choosing settings from within the program or by editing the initialization file, LABMON.INI, before starting the program.

LABMON checks for the presence of the LABMON.INI file when it is invoked and reads parameters from the file if it is present. If this file is not present, default parameters are used for the GPS and RTCM ports, and a LABMON.INI file is created in the local directory. The I/O addresses and interrupts used are shown at the bottom of the screen when LABMON is first started.

The LABMON.INI file contains one line of parameters each for the GPS and for the RTCM ports. These are used to define the port number, interrupt level, baud rate, parity scheme, number of data bits, and stop bits for each. The I/O address used is the default for the port number selected.

3.3.2.1 Default Settings. The default settings for the Zodiac receiver are COM1, IRQ4, 9600 baud, no parity, 8 data bits, and 1 stop bit (if this version of LABMON is used with earlier Conexant GPS receivers, these same settings should be used except that parity should be set to "odd").

The default parameters provided for the RTCM port are COM0 (which disables the port), IRQ3, 9600 baud, no parity, 8 data bits, and 1 stop bit. However, the user should consult the RTCM receiver hardware documentation or contact the provider of the RTCM data to determine the proper settings for the RTCM port.

The easiest way to change the GPS and RTCM port default settings is to start the program and use the <Alt>F1 keys to check or modify the port settings. Alternately, the user may edit the LABMON.INI file. If difficulties are encountered setting the ports, the user should examine the LABMON.INI file to see if extraneous or incorrect information has corrupted it (this file may be deleted since the program will automatically reconstruct it).

The LABMON.INI file initially contains the following lines which provide default values for the GPS port and the RTCM port:

```
GPS    COM1  IRQ4  9600   n   8   1
RTCM   COM0  IRQ3  9600   n   8   1
```

The port parameters may be changed using either lower or uppercase letters, separated by spaces. The syntax for the configuration commands is as follows:

```
[Port][COMn][IRQm][Baud][Parity]
[DataBits][StopBits]
```

NOTE: Although these configuration commands are shown on two lines above, they must all appear on the same line in the initialization file.

Only the following configuration values are currently allowed:

Port	GPS for the GPS port RTCM for the RTCM port
COMn	n = 1, 2, 3, or 4 (to open the port) n = 0 (to ignore the port)
IRQm	m = 0 to 15 (note that the use of IRQ values must be verified by the user when writing this file. The <ALT><F2> keys will configure default values for each port. The <ALT><I> keys are used to configure any allowable IRQ available.
Baud	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 76800, or 115200
Parity	n, o, e (None, Odd, or Even)
DataBits	6, 7, or 8
StopBits	1 or 2

The modified settings are saved in the LABMON.INI file.

3.4   Using Differential RTCM Data _____

3.4.1 Differential RTCM Data and Zodiac GPS Receivers. When using differential corrections with a Zodiac receiver, the data is directly input using the Zodiac's Auxiliary port. The baud rate, parity, and number of data and stop bits required by the source needs to be determined and the source protocol established using Message 1330 (Serial Port Communication Parameters).

The source is then connected using either a straight-through cable or a null-modem cable. The required cable type may be different than that recommended by the provider of the specific correction source.

To change the Auxiliary port parameters, the receiver must be using Zodiac binary protocol. The protocol may be changed to Zodiac NMEA after setting port parameters.

Normally, RTCM data is sent directly to the Auxiliary port of the receiver. In the event that RTCM data needs to be recorded for analysis, a cable with three connectors may be used to send data to both the receiver's Auxiliary port and a second PC serial port. The user must then set the parameters for the second port to match the RTCM SC-104 source protocol as described in Section 3.3. Refer to Section 2 of this Designer's Guide for additional details.

NOTE: An indirect DGPS data input capability is available with Zodiac GPS receivers for those applications that are limited to one serial port. Message 1351 is the Zodiac equivalent of the NavCore Message 210. Setup and operation of LABMON using this feature are identical to the NavCore indirect RTCM input method described in the next paragraph.

3.4.2 Differential RTCM Data and NavCore GPS Receivers. When using differential corrections with NavCore series receivers, the data may be directly input

using the receiver's Auxiliary port or indirectly input with a Message 210 (Differential GPS RTCM SC-104 Data Message) using the Host port. The method used depends on the receiver type and the system configuration. The direct input method is recommended since it is the simplest.

When using direct input, the baud rate, parity, and number of data and stop bits required by the source must be established using Message 217 (Port Configuration Message) if in NavCore binary mode or using the ICOM message if in NavCore NMEA-0183 mode. The source is then connected using either a straight-through cable or a null-modem cable. The required cable type may be different than that recommended by the provider of the specific correction source.

When using indirect input of RTCM SC-104 data, the user connects the source to a second serial port on the PC. LABMON checks for the presence of RTCM SC-104 data on the second serial port and processes it when available.

The user needs to set the source protocol used by LABMON as described in Section 3.3. LABMON packages RTCM SC-104 data received from the second serial port into a series of 210 messages. When data is input directly to the receiver using the Auxiliary I/O port, the LABMON port settings are not used and do not affect RTCM receiver operation.

Note that LABMON does not send RTCM data using Message 210 until the required number of RTCM words are received. This number can be set by the user with the <Ctrl>F10 keys (see Section 3.8). By reducing the number of required RTCM words, the delay between reception of RTCM data by LABMON and the use of that data by the receiver can be minimized.

3.5   Starting LABMON _____

3.5.1 Command Line Parameters. LABMON software uses several command line options:

-R   Record GPS port data. This command must be followed by the log file name (ex: -RLogfile.log).
-S   Save DGPS port data. This command must be followed by the log file name (ex: -SLogfile.log).
-C   Default Configuration. This command must be followed by a sequence of two parameters.

The first parameter is the desired COM port number (1, 2, 3, or 4) and the second parameter is the desired message protocol type (ZB, ZN, NB, or NN). For example, -C1ZB would be the command line for setting COM1 with Zodiac binary messages as the default.

Note: each command line option may be entered in upper or lower case and each must be preceded by a dash. The message protocol

codes ZB, ZN, NB, and NN may also be entered in upper or lower case.

When running under DOS, the data filenames are selected on the command line. When running under Windows 3.x, either select the LABMON icon or use the Run command from the Program Manager and specify the files on the command line. When running under Windows 95, the 'Run' window under the 'Start' icon must be used so that the command line parameters can be included on the command line.

3.5.2 Starting LABMON From DOS. To run LABMON from DOS, do the following (the filenames used are examples only; others may be used):

1. Type "LABMON" for no data recording.

   Or type "LABMON -RGPS.DAT" to record all data to and from the Host port.

   Or type "LABMON -RGPS.DAT -SRTCM.RTC" to record both Host and Auxiliary port data.

3.5.3 Starting LABMON From The DOS Prompt In Windows 3.x or Windows 95. To run LABMON from Windows 3.x using the DOS prompt, do the following (the filenames used are examples only; others may be used):

1. Select the MS DOS prompt icon.

2. Type "LABMON" for no data recording.

   Or type "LABMON -RGPS.DAT" to record all data to and from the Host port.

   Or type "LABMON -RGPS.DAT -SRTCM.RTC" to record both Host and Auxiliary port data.

3. Type "EXIT" to return to Windows after quitting LABMON.

3.5.4 Starting LABMON Within Windows 3.x. To run LABMON from within Windows 3.x, do the following (the filenames used are examples only; others may be used):

1. Double-click the LABMON icon to start LABMON. (To record data, the program item Command Line field must be changed to include the GPS and/or RTCM filenames. To do this, select the LABMON icon and choose Properties from the File menu under the Windows Program Manager.)

NOTE: To display data, both the GPS message type and serial communication protocol parameters used for LABMON must be set to match those used by the receiver. If data is being received but not displayed by the receiver, a buffer overflow will result after a short time and a message will be displayed to indicate this. If the settings of the receiver are unknown and communication cannot be established, the receiver should be reset after enabling ROM defaults using the appropriate configuration switch as described in Section 2 of this Designer's Guide.

3.5.5 Starting LABMON Within Windows 95. To run LABMON from within Windows 95, do the following (the filenames used are examples only; others may be used):

For no data recording:

1. Start Windows, select Start, select Programs, and finally select Windows Explorer.

2. Select the LABMON folder.

3. Double click on the LABMON application file.

4. To create a Shortcut to LABMON, select the LABMON application file and drag to a location within the main screen.

To record all data to and from the Host port:

1. Start Windows, select Start, then select Run. Type "LABMON -RGPS.DAT" on the command line.

To record both Host and Auxiliary port data:

1. Start Windows, select Start, then select Run. Type "LABMON -RGPS.DAT -SRTCM.RTC" on the command line.

Figure 3-2. LABMON Main Display For Zodiac GPS Receivers

3.6   Stopping LABMON _____

Avoid using either Ctrl-Break or Ctrl-C to exit LABMON. LABMON replaces certain interrupt handlers that may be required by other programs during its initialization and restores them upon exiting. Therefore, any abnormal termination may affect the execution of another program. If this occurs, the PC may need to be rebooted.

To terminate the execution of LABMON software, press the <Q> key. This will stop LABMON and return the user to either the DOS prompt or to Windows.

3.7   LABMON Displays_____

To support the many new features available in the Zodiac family of GPS receivers, the screen display and key functions have been revised from earlier versions of LABMON. There is space provided for many new data items on the screen. Some of these items are not shown if LABMON v5.4 is used with NavCore GPS receivers.

There are two types of displays that LABMON uses to output information, the main display and the Built-In Test (BIT) display.

3.7.1 Main Display. Depending on the message protocol type used (binary or NMEA), the data labels shown on the main display change slightly to more accurately reflect the data available from that configuration. The actual label used for the data is

described, together with the output message description, in Section 3.8.

The main display, shown in Figure 3-2, appears when LABMON processes Zodiac binary data. There are two portions to this display: data and menu options. Additional data is displayed behind the menu that may be viewed by pressing <N>, the No Menu key. The data portion is comprised of satellite data and status information from binary or NMEA messages.

In addition to data from the receiver, additional useful information such as the number of data bytes recorded, the number of messages sent or received, the number of checksum errors, and the number of message "no acknowledgements" is also displayed.

```
                ZODIAC BUILT-IN TEST RESULTS

        FUNCTIONAL TEST                       FAILURES

        READ-ONLY MEMORY (ROM)                   1
        RANDOM ACCESS MEMORY (RAM)               0
        NON-VOLATILE STORAGE (EEPROM)            0
        DUAL PORT RAM (DPRAM)                    0
        DIGITAL SIGNAL PROCESSOR (DSP)           0
        REAL-TIME CLOCK (RTC)                    0
        SERIAL PORT 1                            0
        SERIAL PORT 2                            0

        SERIAL PORT 1 RECEIVE COUNT             16
        SERIAL PORT 2 RECEIVE COUNT              0

                SOFTWARE VERSION 1.02
```

Figure 3-3. LABMON BIT Display For Zodiac GPS Receivers

3.7.2 The BIT Display. The LABMON BIT display screen is different depending on whether a Zodiac GPS receiver or a NavCore GPS receiver is used.

3.7.2.1 BIT Display For Zodiac Receivers. For Zodiac receivers, a typical LABMON BIT display is shown in Figure 3-3. This display contains information from Message 1100 (Built-In Test Results). Refer to Section 5 of this Designer's Guide for detailed information on the Zodiac BIT message.

3.7.2.2 BIT Display For NavCore Receivers. The BIT display screen for Conexant NavCore receivers is different from the Zodiac receivers. The BIT display for Conexant NavCore receivers is shown in Figure 3-4. On this display, information from Message 101, Built-In Test Results, is shown.

For detailed information on the NavCore series BIT message, refer to the Designer's Guide that corresponds to the specific NavCore series GPS receiver (NavCore, MicroTracker LP, NavCard LP, etc.).

3.8   Receiver Output Messages _____

LABMON decodes and displays most of the available messages. Either Conexant binary or NMEA messages can be in use at a time. Data from these messages is shown in various fields on the screen. Some of the data from binary messages is converted into more commonly used units of measurement (such as degrees and minutes instead of radians).

NOTE: Some of the data contained in messages is not shown on the screen due to space limitations. Data which is omitted is not needed to evaluate receiver performance.

Each of the data fields on the LABMON main display screen is listed alphabetically in Table 3-1 along with a

brief description of the data item and the source of the data (i.e., the binary or NMEA messages containing that data item).

Refer to Section 5 of this Designer's Guide for detailed information on each message used by the Zodiac receiver.

For detailed information on each message used by the NavCore series of GPS receivers, refer to the Designer's Guide that corresponds to the specific receiver (NavCore, MicroTracker LP, NavCard LP, etc.).

```
                          B.I.T. RESULTS

SUMMARY:    SYSTEM      ROM      LOW RAM    HIGH RAM      SPI      RAM ADDRESS
             PASS       PASS       PASS       PASS       PASS        PASS

LOW RAM =  PASS      HIGH RAM =  PASS      PRE_PROCESSOR RAM =  PASS

        PP SELF    PP WRAP    CODE VCO    CAR VCO    CODE GEN    SIG PROC
CH1      PASS       PASS        PASS       PASS       PASS        PASS
CH2      PASS       PASS        PASS       PASS       PASS        PASS
CH3      PASS       PASS        PASS       PASS       PASS        PASS
CH4      PASS       PASS        PASS       PASS       PASS        PASS
CH5      PASS       PASS        PASS       PASS       PASS        PASS

INTERRUPT CONTROL: PASS    LOW POWER TIME SOURCE: PASS    OPTIONS REGISTER: PASS

SERIAL I/O:       TRANS ERRORS =    0      CHECKSUM ERRORS =    0
EEPROM:        PROGRAMS ERRORS =    0      CHECKSUM ERRORS =    0

LINK ID:   DGPS WITH SV MEASUREMENTS WITH POWER MANAGEMENT
SOFTWARE VERSION:  3.61


                    PRESS ANY KEY TO CONTINUE
```

Figure 3-4. LABMON BIT Display For NavCore GPS Receivers

3.9 Receiver Input Messages _____

LABMON makes extensive use of the keyboard function keys to control program and receiver operation. Most of the keys result in a message being sent to the receiver. The message sent depends on the message protocol in use.

When a key is pressed, there is often a prompt or series of prompts which are used to obtain the required data. These prompts may differ in content or number based on the message protocol in use. Only those that are applicable to the current message protocol are shown. In most cases, default values, units, or allowable ranges are supplied.

Each of the function keys, singly or in combination with the <Shift>, <Ctrl>, or <Alt> keys, that are used to control program operation are listed in Table 3-2 along with their respective functionality and, where applicable, the binary and/or NMEA message that is sent.

3.10 LABMON's Menu Keys _____

Many of the key functions from earlier versions of LABMON have been renamed or grouped together with related functions under a single menu or key. For example, the Cold Start Enable function is now under the Cold Start key of the Solution Control menu.

The LABMON software uses several keyboard keys and the keyboard's function keys, alone or together with the <Shift>, <Ctrl>, and <Alt> keys. The functions provided by these keys allow the user to control, and communicate with, the GPS receiver. Each key and key combination is listed in Table 3-3 together with its respective function.

While all of the key functions shown in Table 3-3 are supported in the Conexant binary mode, all of them are not supported in the NMEA data mode. An error message is displayed if a key is pressed that is not supported by the current data mode.

Table 3-1. Output Data Shown On The Main Display Screen (1 of 4)

Item Label	Description	Units	Source			
			Zodiac		NAVCORE	
			Binary	NMEA	Binary	NMEA
AGE	Age of last correction	sec	1005	GGA	n/a	GGA
ALT	Height above ellipsoid (Note 1)	m	1000	ALT, GGA	103	ALT, GGA
ATO	Acquisition timeout	sec	n/a	n/a	107	n/a
AZI	Visible satellite azimuth	deg	1003	GSV	102	GSV
CBE	Clock bias error	m	1000	n/a	n/a	n/a
CBSIG	Clock bias error standard deviation	m	1000	n/a	n/a	n/a
CDE	Clock drift error	m/sec	1000	n/a	n/a	n/a
CDSIG	Clock drift error standard deviation	m/sec	1000	n/a	n/a	n/a
CH	Channel	n/a	1002	ZCH	103, 106, 111	n/a
CLM	Climb rate	m/sec	1000	n/a	n/a	n/a
CN	Carrier to noise ratio	dBHz	1002	ZCH, GSV	103	GSV
CODE	Tracking state code	n/a	n/a	n/a	111	n/a
COG	Course over ground	deg	1000	RMC	n/a	RMC, VTG
COLDTO	Cold start timeout	sec	1012	n/a	n/a	n/a
COM	Auxiliary port settings	n/a	n/a	n/a	117	n/a
DATE	Date	n/a	1000	n/a	103	ZDA
DATUM	Datum in use	n/a	1012	n/a	n/a	n/a
DAY	UTC day	n/a	1000	n/a	103	ZDA
DGPSTO	DGPS correction timeout	sec	1012	n/a	n/a	n/a
ECULRTI	DGPS status bits	n/a	1005	n/a	n/a	n/a
ECULRTSI	DGPS status bits	n/a	n/a	n/a	106	DGP
EHPE	Expected horizontal position error	m	1000	n/a	106	n/a
EHVE	Expected horizontal velocity error	m/sec	1000	n/a	n/a	n/a
EL	Visible satellite elevation	deg	1003	GSV	102	GSV
ENAB	Receiver enable option bits	n/a	1012	n/a	103, 106, 107, 111	DGP

Table 3-1. Output Data Shown On The Main Display Screen (2 of 4)

Item label	Description	Units	Source Zodiac Binary	Source Zodiac NMEA	Source NAVCORE Binary	Source NAVCORE NMEA
ERPFLBC	Data validity/track state bits	n/a	n/a	n/a	111	n/a
ETE	Expected time error	m	1000	n/a	n/a	n/a
EVPE	Expected vertical position error	m	1000	n/a	106	n/a
FIX	Fix (2-D, 3-D, or altitude fix not available)	n/a	n/a	GSA	n/a	GSA
FOM	Figure of merit	n/a	n/a	n/a	103	n/a
GDOP	Geometric Dilution of Precision	n/a	1003	n/a	103	n/a
GPSSEC	GPS seconds into week	sec	1000	n/a	102, 103, 104	n/a
GSEP	Geoidal separation	m	1000	ALT, GGA	n/a	ALT, GGA
GPSNSEC	GPS nanoseconds from epoch	nsec	1000	n/a	n/a	n/a
HDOP	Horizontal Dilution of Precision	n/a	1003	GGA, GSA	103	GGA, GSA
HLTH	DGPS station health	n/a	1005	n/a	106	DGP
INVAL	Solution invalidity bits	n/a	1000	n/a	n/a	n/a
LAT	Latitude (Note 1)	deg	1000	GGA, RMC	103	GGA, GLL, RMC
LON	Longitude (Note 1)	deg	1000	GGA, RMC	103	GGA, GLL, RMC
LPTO	Low power acquisition timeout	sec	n/a	n/a	107	n/a
M	Measurement sequence number	n/a	1000, 1002	n/a	n/a	n/a
MAG	Magnetic variation	deg	1000	RMC	n/a	RMC
MASK	Antenna elevation mask angle	deg	1012	n/a	n/a	n/a
MEHPE	Minimum expected horizontal position error	m	1012	n/a	n/a	n/a
MESSAGE	Message sent or acknowledged	n/a	n/a	n/a	n/a	n/a
MEVPE	Minimum expected vertical position error	m	1012	n/a	n/a	n/a
NVIS	Number of visible satellites	n/a	1003	GSV	102	GSV
PDOP	Position Dilution of Precision	n/a	n/a	n/a	n/a	n/a
PLAT	Platform type	n/a	1012	n/a	n/a	n/a
PMGMT	Power management status	n/a	n/a	n/a	107	n/a
POLAR	Polar navigation flag	n/a	1000	n/a	n/a	n/a

Table 3-1. Output Data Shown On The Main Display Screen (3 of 4)

Item label	Description	Units	Source			
			Zodiac		NAVCORE	
			Binary	NMEA	Binary	NMEA
PORT1	Host port settings	n/a	1130	n/a	n/a	n/a
PORT2	Auxiliary port settings	n/a	1130	n/a	n/a	n/a
POSX	ECEF position X	m	1009	n/a	103	n/a
POSY	ECEF position Y	m	1009	n/a	103	n/a
POSZ	ECEF position Z	m	1009	n/a	103	n/a
QUAL	GPS quality indicator	n/a	n/a	GGA	n/a	GGA
RAMER	RAM status	n/a	1050	n/a	n/a	n/a
RATE	Solution update rate	sec	n/a	n/a	107	n/a
SATS	Satellite used in solution	n/a	1000	GSV	103	GSV
SEQ	Sequence number	n/a	all	n/a	n/a	n/a
SETTIME	Receiver set time	ticks	all	n/a	102, 103, 104, 107, 111	n/a
SOG	Speed over ground	knots	n/a	RMC	n/a	RMC, VTG
SPD	Speed (Note 2)	m/sec	1000	n/a	n/a	n/a
STAT	Navigation status	n/a	1000	GSA, GGA, RMC	103	GSA, GGA, RMC
STATUS	DGPS status	n/a	1005	n/a	103, 106	n/a
STNID	DGPS station ID	n/a	1005	GGA	106	GGA, DGP
SV	Satellite vehicle PRN	n/a	1002, 1003, 1005	GSA, GSV, ZCH	102, 103, 111	GSA, GSV
TDOP	Time Dilution of Precision	n/a	1003	n/a	103	n/a
TRK	Channel tracking status	n/a	n/a	n/a	103	n/a
TYPE	Solution type bits	n/a	1000	GGA, GSA	n/a	GGA, GSA
UTC	UTC seconds (Note 3)	sec	1000, 1108	GGA, RMC	n/a	GGA, GLL, RMC, ZDA
UVEC	Channel tracking status bits	n/a	1002	ZCH	n/a	n/a
VALID	Solution validity bits	n/a	1012	n/a	n/a	n/a
VDOP	Vertical Dilution of Precision	n/a	1003	GSA	103	GSA

Table 3-1. Output Data Shown On The Main Display Screen (4 of 4)

Item Label	Description	Units	Source			
			Zodiac		NAVCORE	
			Binary	NMEA	Binary	NMEA
VELE	Velocity - east	m/sec	n/a	n/a	103	n/a
VELN	Velocity - north	m/sec	n/a	n/a	103	n/a
VELU	Velocity - up	m/sec	n/a	n/a	103	n/a
VELX	ECEF velocity X	m/sec	1009	n/a	n/a	n/a
VELY	ECEF velocity Y	m/sec	1009	n/a	n/a	n/a
VELZ	ECEF velocity Z	m/sec	1009	n/a	n/a	n/a
WEEK	GPS week number	weeks	1000, 1002	n/a	102, 103, 104, 111	n/a
XSV	Excluded candidate SV	n/a	1012	n/a	n/a	n/a
ZCOUNT	DGPS modified zcount	counts	n/a	n/a	106	DGP

Note 1: When operating LABMON using delta positions, the LAT, LON, and ALT fields display the difference between the current and reference positions in meters.

Note 2: Speed units depends on the configuration data contained in the LABMON.CFG file (refer to paragraph 3.3.1.4 for additional information).

Note 3: UTC seconds uses data from binary message 1108 if available. Otherwise, data from binary message 1000 is used.

Table 3-2. Input Data Provided By Keyboard Keys (1 of 2)

Item Label	Description	Source			
		Zodiac		NAVCORE	
		Binary	NMEA	Binary	NMEA
Menu: GPS INPUT OPTIONS					
F1	Time initialization	1200	INIT	201	INIT
F2	Position and velocity initialization	1200	INIT	201	INIT
F3	Altitude input	1219	INIT	201	INIT
F4	Datum definition	1210	n/a	n/a	n/a
F5	Time Mark initialization (not implemented)	n/a	n/a	n/a	n/a
F6	Factory test (for factory use only)	1304	n/a	n/a	n/a
F7	DR initialization (for DR-enabled receiver)	1270	n/a	n/a	n/a
F8	Built-In Test	1300	IBIT	101	n/a
F9	Gyro factory test (for factory use only)	1305	n/a	n/a	n/a
F10	Send ASCII text to receiver	n/a	n/a	n/a	n/a
F11	Reset receiver	1303	INIT	201	INIT
F12	Reset counters	n/a	n/a	n/a	n/a
Menu: GPS I/O OPTIONS					
<Shift>F1	GPS I/O port settings	1330	n/a	217	ICOM
<Shift>F2	GPS message protocol type	1331	IPRO	n/a	n/a
<Shift>F3	Message log control (Note 1)	log	ILOG	n/a	LOG
<Shift>F4	Message query (Note 1)	query	Q	n/a	Q
<Shift>F5	NMEA generic message (Note 2)	n/a	n/a	n/a	n/a
<Shift>F6	NMEA typical message request (Note 3)	n/a	ILOG	n/a	LOG
<Shift>F7	Reserved	n/a	n/a	n/a	n/a
<Shift>F8	Store almanac UTC data	1040/1042	n/a	206	n/a
<Shift>F9	Request pseudoranges (Note 1)	n/a	n/a	213	n/a
<Shift>F10	Request ephemeris data	1041	n/a	n/a	n/a
<Shift>F11	Load ephemeris data	1241	n/a	n/a	n/a
<Shift>F12	Load almanac UTC data	1240/1242	n/a	205	n/a

Table 3-2. Input Data Provided By Keyboard Keys (2 of 2)

Item Label	Description	Source			
		Zodiac		NAVCORE	
		Binary	NMEA	Binary	NMEA
Menu: SOLUTION CONTROL					
<Ctrl>F1	Navigation validity criteria	1217	n/a	201	INIT
<Ctrl>F2	Platform type	1220	n/a	n/a	n/a
<Ctrl>F3	Navigation configuration	1221	n/a	201	n/a
<Ctrl>F4	Reserved	n/a	n/a	n/a	n/a
<Ctrl>F5	Cold start	1216	n/a	201	n/a
<Ctrl>F6	Datum select	1211	n/a	n/a	n/a
<Ctrl>F7	Antenna type	1218	n/a	n/a	n/a
<Ctrl>F8	Antenna elevation mask	1212	n/a	208	n/a
<Ctrl>F9	SV selection	1213	n/a	208	n/a
<Ctrl>F10	DGPS control	1214	n/a	209	IDGP
<Ctrl>F11	Power management	1317	n/a	211	n/a
Menu: LABMON CONFIGURATION OPTIONS					
<Alt>F1	LABMON I/O port settings	n/a	n/a	n/a	n/a
<Alt>F2	LABMON message protocol type	n/a	n/a	n/a	n/a
<Alt>F3	Reference position	n/a	n/a	n/a	n/a
<Alt>F4	Main display background color	n/a	n/a	n/a	n/a
<Alt>F5	Main display text color	n/a	n/a	n/a	n/a
<Alt>F6	Main display data color	n/a	n/a	n/a	n/a
<Alt>F7	Menu background color	n/a	n/a	n/a	n/a
<Alt>F8	Menu key color	n/a	n/a	n/a	n/a
<Alt>F9	Menu description color	n/a	n/a	n/a	n/a

Note 1: The Zodiac binary "log" and "query" messages inherit the numeric identifier of the message being requested.

Note 2: The <Shift>F5 keys are used to transmit a NMEA message entered by the user.

Note 3: The <Shift>F6 keys are used to send a series of log messages requesting a pre-defined set of output messages that can be used for receiver evaluation.

Table 3-3. LABMON Keyboard Key Functions (1 of 4)

Keyboard Key	Function	Action
KEYBOARD KEYS		
M	Menu change	Press the "M" key to cycle through the Function, <Shift>+Function, <Ctrl>+Function, and <Alt>+Function key menus.
N	No menu	Press the "N" key to toggle the display of the menu option portion of the main display screen on or off. This allows data to be viewed that is normally hidden behind the menu options.
R	Replay	Press the "R" key to replay a log file.
P	Pause	Press the "P" key to pause the receiver output data displayed on the screen. Press the "P" key again to resume data updates. The screen may also be paused by pressing the spacebar.
F	Filter	Press the "F" key to set the parameters used to "filter," or screen, data (refer to Section 3.3).
D	Delta (Note 1)	Press the "D" key to toggle LABMON between the current location (in degrees) and the delta position (in meters).
X	Extract data	Press the "X" key after starting to replay a log file (using the "R" key) to extract data from the file to a selected tab delimited file for plotting purposes.
+,-	Speed of replay	Press the "+" or "-" keys to increase or decrease the rate at which messages are processed during the replay of log files.
< >	Single step in replay	Press the "<" or ">" keys to step a single message backward or forward during replay of log files.
Q	Quit	Press the Q key to exit LABMON.
C	Clear screen	Press the "C" key to clear the LABMON screen outputs until they are refreshed at their normal time.
<Esc>	Exit prompt without changes	Press the <Esc> key to exit a prompt without sending the command.
FUNCTION KEYS		
F1	Time initialization	Press the F1 key to send the estimated user time and date. The time must be entered in 24-hour format and referenced to UTC or Greenwich Mean Time (GMT) rather than local time. The time input should be accurate to within an hour to acquire the first satellite when Cold Start is disabled. If Cold Start is enabled, the time and position do not need to be initialized.
F2	Position and velocity initialization	Press the F2 key to send latitude, longitude, speed, heading, and height to be used as the estimated user state. The latitude and longitude data must be referenced to the datum selected and entered in decimal degrees rather than degrees:minutes:seconds. South latitude and west longitude must be entered as negative numbers. The height is the altitude in meters above the datum ellipsoid. The WGS-84 datum is assumed if no datum is selected.
F3	Altitude input	Press the F3 key to send a value to be used as the estimated user altitude. Unless the force option is used, this value is only used while in 2-D navigation or acquisition modes.
F4	Datum definition	Press the F4 key to send datum definition parameters to be used.
F5	Time Mark initialization	Not implemented.

Table 3-3. LABMON Keyboard Key Functions (2 of 4)

Keyboard Key	Function	Action
FUNCTION KEYS (continued)		
F6	Factory test	For factory use only.
F7	DR initialization	Press the F7 key to initialize DR parameters.
F8	Built-In Test	Press the F8 key to send a Built-In Test (BIT) command. Navigation and tracking of satellites is interrupted during this test. When the BIT ends, the receiver is reset.
F9	Gyro factory test	Press F9 to perform a gyro test (for factory use only).
F10	Send ASCII characters to receiver	Sends a string of characters to the receiver.
F11	Reset receiver	Press the F11 key to send a reset command. This will reset certain receiver parameters. The message counters are reset at this time also.
F12	Reset counters	Press the F12 key to reset the message and error counters.
SHIFT + FUNCTION KEYS		
Shift + F1	GPS I/O port settings	Press the <Shift>F1 keys to send the receiver serial port settings for the baud rate, parity, number of data bits, and number of stop bits to be used by the receiver.
Shift + F2	GPS message protocol type	Press the <Shift>F2 keys to select the message protocol type used by the receiver.
Shift + F3	Message log control	Press the <Shift>F3 keys to send a log control message to request messages on a periodic basis or upon update. When using Zodiac binary protocol, the message timing may need to be modified to obtain message output. NOTE: The special values of "???" when using NMEA protocol, or "65535" when using Zodiac binary protocol, disables all messages. After this, no messages are output by the receiver unless a query message is sent, the receiver is reset, or messages are turned back on using the log control message. In binary mode, press the <Shift>F3 keys followed by "65535." Respond to the modify timing prompt with a "Y" (for yes).
Shift + F4	Message query	Press the <Shift>F4 keys to send a query message to request a one-time output of a message from the Zodiac receiver.
Shift + F5	NMEA generic message	Press the <Shift>F5 keys to enter the ASCII text for a non-supported generic NMEA message to send to the receiver. The entire message should be entered following the $ prompt; use null fields as required. The checksum will be computed and appended by LABMON before the message is transmitted.
Shift + F6	NMEA typical message request	Press the <Shift>F6 keys to send a series of NMEA log messages to enable the receiver to output a set of messages containing the typical data needed for performance evaluation.
Shift + F7	Reserved	None
Shift + F8	Store almanac UTC data	Press the <Shift>F8 keys to request raw almanac UTC data. LABMON receives the data and stores it in the files ALMANAC.GPS and UTC.GPS.
Shift + F9	Reserved	None
Shift + F10	Request ephemeris data	Press the <Shift>F10 keys to request output of all available ephemeris data or new ephemeris data when available.

Table 3-3. LABMON Keyboard Key Functions (3 of 4)

Keyboard Key	Function	Action
SHIFT + FUNCTION KEYS (continued)		
Shift + F11	Load ephemeris	Press the <Shift>F11 keys to upload raw ephemeris data from a selected ephemeris binary file to the receiver.
Shift + F12	Load almanac and UTC data	Press the <Shift>F12 keys to upload raw almanac and UTC data to the receiver from selected binary almanac and UTC data files.
CONTROL + FUNCTION KEYS		
Ctrl + F1	Navigation validity criteria	Press the <Ctrl>F1 keys to send navigation solution validity parameters (2-D navigation allowed, DGPS required, number of satellites used, and expected position errors).
Ctrl + F2	Platform type	Press the <Ctrl>F2 keys to select the type of application platform to be used.
Ctrl + F3	Navigation confirmation	Press the <Ctrl>F3 keys to send navigation configuration parameters (held altitude, ground track smoothing, position pinning, measurement filtering)
Ctrl + F4	Reserved	None
Ctrl + F5	Cold start	Press the <Ctrl>F5 keys to send a Cold Start command. When Cold Start is enabled, the receiver will only enter Cold Start after failing to acquire satellites that should be visible based on the current receiver position and time. The receiver automatically searches the entire sky for satellites in Cold Start.
Ctrl + F6	Datum select	Press the <Ctrl>F6 keys to send a datum number to the Zodiac receiver or to set the datum used by LABMON to transform NavCore receiver outputs. Out of range numbers default to zero which corresponds to WGS-84. Refer to Appendix E for datum names and numbers.
Ctrl + F7	Antenna type	Press the <Ctrl>F7 keys to select between a passive and active antenna.
Ctrl + F8	Antenna elevation mask	Press the <Ctrl>F8 keys to send the elevation mask angle to be used. Angles below the horizon must be entered as negative numbers. The default value for the Zodiac receiver is +10 degrees.
Ctrl + F9	SV selection	Press the <Ctrl>F9 keys to send satellite selection commands to enable or disable the use of selected satellites by the receiver. Enter a satellite's SV number to toggle between enabled and disabled. Enter zero to enable all satellites. Disabled satellites are displayed after XSV beneath the satellite visiblity list on the main display.
Ctrl + F10	DGPS control	Press the <Ctrl>F10 keys to send a Differential GPS Control command.
Ctrl + F11	Power management	Press the <Ctrl>F11 keys to send power management parameters to be used for power conservation. Valid NavCore update rates must be from one to five seconds

Table 3-3. LABMON Keyboard Key Functions (4 of 4)

Keyboard Key	Function	Action
ALT + FUNCTION KEYS		
Alt + F1	LABMON I/O port settings	Press the <Alt>F1 keys to change the parameters associated with the PC serial ports. These include the PC COM port number, the PC IRQ interrupt number, baud rate, parity, number of data bits, and number of stop bits (refer to Section 3.3 for additional information about these settings). After these values have all been entered, LABMON displays the selected COM port, the PC interrupt number, and the port address at the bottom of the screen.
Alt + F2	LABMON message protocol type	Press the <Alt>F2 keys to set the LABMON message processing protocol to Zodiac binary, Zodiac NMEA, NavCore binary, or NavCore NMEA.
Alt + F3	Reference position	Press the <Alt>F3 keys to set the reference position as a default for the position initialization function (using the F2 key) and as a reference for computing delta position.
Alt + F4	Main display background color	Press the <Alt>F4 keys to change the background color of the data portion of the main display screen.
Alt + F5	Main display text color	Press the <Alt>F5 keys to change the color of the field titles in the data portion of the main display screen.
Alt + F6	Main display data color	Press the <Alt>F6 keys to change the color of the data shown in the data portion of the main display screen.
Alt + F7	Menu background color	Press the <Alt>F7 keys to change the background color of the menu options portion of the main display screen.
Alt + F8	Menu key color	Press the <Alt>F8 keys to change the color of the function key designations in the menu options portion of the main display screen.
Alt + F9	Menu description color	Press the <Alt>F9 keys to change the color of the function key descriptions in the menu options portion of the main display screen.
Note 1: LABMON's delta position is useful to monitor changes in position relative to the reference position. The "D" key is used to toggle between the current location, in degrees, and the distance, in meters, from the reference position (set using the <Alt>F3 keys).		

3.11 Receiver Evaluation Using LABMON _____

There are a number of powerful features in LABMON that are useful to evaluate receiver performance. The features are described below along with other useful information related to receiver configuration and operation.

3.11.1 Message Set. The Zodiac Family and NavCore Series receivers have a very extensive message set that can provide a great deal of information from the receiver. When operating the receiver for evaluation purposes, it is likely that the user will require a different message set than the default set. The default set is chosen to provide typically needed data for use in the OEM product, without extra data needed for detailed evaluation or analysis.

Requesting too much data from the receiver on a periodic basis may result in processing problems by an OEM processor or the receiver. If too many output messages are created, a data checksum error may occur on a receiver output message during receipt of a new input message. This is an indication that a large number of periodic messages are being output.

3.11.2 Baud Rates. The user must ensure that the baud rates chosen will support the number and size of the messages requested. It is possible to request enough messages to prevent the receiver from keeping up at rates lower than 9600, for example. In this case, some of the messages cannot be output until the number is decreased or the baud rate is increased.

3.11.3. Message Logging. The user should turn off unneeded messages that occur at a high periodic rate if others are to be turned on. The default Zodiac message output timing prompt in LABMON is Time, but the Update option for data output should be used where appropriate. The NavCore Series supports message output based on time only.

To obtain a one time output of a message, use a query message. This avoids loading down the receiver with periodic output of fixed data. To obtain message output only when the data has changed or new data is available, use a log message with the Update output option. This will result in a message output upon change of the data only. To obtain periodic output use a log message with the Time output option. To turn off all messages in NMEA mode, use a log message with '???' as the message identifier. To turn off all messages in Zodiac binary mode, use a log message with '65535', which corresponds to FFFF Hex, as the message identifier; then, respond to the modify timing prompt by entering "Y" (for yes).

For Zodiac receiver evaluation, the following changes to the default message configuration are recommended:

- Turn on message 1012 for output on update.

- Message 1005 should also be turned on for output at a rate of once per second for DGPS evaluation. For NavCore receiver evaluation, the 106 message should be turned on for output at a rate of once per second for DGPS evaluation.

Use the message counters to monitor the number and rate at which messages are output from the receiver and to keep track of which input messages have been sent. It is often useful to reset these after changing the output messages to verify the desired configuration has been achieved. If the list of messages sent or received grows long enough to begin blocking other data, the message counters should also be reset.

3.11.4 Screen Clearing. Clearing the screen after the output message configuration has changed is recommended to clear data which will become stale if it is no longer being updated. This also makes it easy to see if data that is no longer requested has been turned off.

3.11.5 Data Logging. To review data carefully, the data should be logged and then replayed using LABMON. During replay, the user can single step through messages forward and backward to examine events or time periods of interest.

3.11.6 Data Reduction. The Extract function can be used to extract data from a log file, decode it if necessary, and write it into a tab-delimited file for plotting or data reduction using spreadsheet programs.

The Filter parameters are used to control which data points are written to the file. Using different settings for these and plotting the resultant ground tracks may help determine what criteria should be used in the OEM application to obtain the best performance of the operating environment. The Filter parameters are also used during normal receiver monitoring to indicate at a glance whether the navigation solution is meeting the current Filter criteria.

3.11.7. Post Processing Of Logged Data. LABMON has the capability to post-process previously logged data and to extract certain information that has been written to a text file.

3.11.7.1 Data Extraction. When the "X" key is pressed after starting to replay a log file (using the "R" key), a prompt is displayed requesting the operator to enter an extraction type: LLA. Only one extraction type is offered in the current version of LABMON, the LLA extraction.

The LLA extraction command extracts the longitude, latitude, and altitude into a tab-delimited text file. This file may be directly imported into a spreadsheet and plotted, producing a "bread crumb" ground track. Once selected, the LLA extraction offers the option of removing the sign of the extracted data, thereby recording only the absolute values of the data. The delta locations, in meters, from the reference position are also recorded.

Format: `GPSTIMESECS LON LAT ALT`
`ΔLON ΔLAT ΔALT`

Message 1000 must be enabled while logging this data.

3.11.7.2 Logging A Data File. To log a data file, type "LABMON <filename.ext>," where <filename.ext> is any legal DOS filename and extension (see paragraph 3.5). This action causes all data on the Host port to be written to the specified file. The full path and drive designation must also be included if logging to a specific location is desired.

When logging data to a file, be sure that the message that contains the data to be post-processed has been enabled and is being output by the receiver.

3.11.7.3 Extracting Data From A Log File. To extract data from a previously recorded log file, do the following:

a.   Start LABMON as described in Section 3.5 for no data recording.

b.   Press the "R" key for replay.

c.   Enter Log <filename.ext>. This must be the exact filename and extension including any drive and path designations.

d.   Press the "X" key for extract.

e.   Enter "LLA" (paragraph 3.11.7.1).

f.   Enter a <filename.ext> that will contain the extracted data.

g.   Press <spacebar> to start playback and extraction.

h.   When finished, quit LABMON and edit the extraction file using any text editor.

3.11.8 DGPS Operation. When evaluating DGPS operation, it is recommended to use the LABMON logging function. RTCM SC-104 data should also be gathered so that its format and integrity may be verified with the RTCMCHK utility program provided on the LABMON software diskette.

Some DGPS reference station equipment may be configured in such a way as to output data which is non-compliant with the RTCM standard. Conexant GPS receivers are designed to be tolerant of these format errors where possible, but in some circumstances, intermittent loss of DGPS operation may result. There may also be excessive latency or problems in the data links which can be observed and corrected by examination of this raw input data to the receiver.

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4 HARDWARE INTERFACE

Details of the specific Zodiac GPS receiver's electrical interface are contained in the applicable Data Sheet for the receiver. Copies of the applicable Data Sheets are provided with this *Designer's Guide*. Besides the pinout descriptions for the interface, the Data Sheet also contains a product overview, a technical description and specification, and a brief description of the Conexant binary and NMEA data messages applicable to the specific GPS receiver.

Information about the 2x10 pin field connector is contained in Appendix F. RF connector information is provided in Appendix G.

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5 SERIAL DATA I/O INTERFACE

This Section describes the formats of the two types of messages that can be communicated across the serial data interface for the Zodiac Global Positioning System (GPS) receiver engine. The structure and contents of each binary message is described in Section 5.2. The structure and contents of each National Marine Electronics Association (NMEA) message is described in Section 5.3.

5.1   Binary Message Format And Word Structure _____

5.1.1 Binary Message Format. The input/output binary data stream format is a low byte/high byte pattern. Each byte is output with its Least Significant Bit (LSB) first, followed by its higher order bits, ending with the Most Significant Bit (MSB) of the data byte.

The binary message format is nearly identical to that used by the previous NavCore/MicroTracker series of receivers, except that all floating point values are now represented as fixed-point integer numbers with explicit or implied scale factors.

Each binary message consists of a header portion and a data portion, each with its own checksum. Each message will have a header, but some messages may not have data. Message acknowledgements are in the form of a header, and message requests are made using headers as well. Table 5-1 shows the data types used to define the elements of the binary interface messages.

5.1.2 Word Structure. An integer is defined as 16 bits. While offsets are incorporated in the message description tables, the most convenient specification of memory layout in application implementation is likely to be a structure definition.

If the item is a fixed point quantity, the value of the LSB of the integer is given. To convert a fixed point item to a floating point variable, the integer representation is floated and multiplied by the resolution. When converting to float, consideration must be given to the range and resolution of the item to ensure that the type of float selected for the conversion has an adequate mantissa length to preserve the accuracy of the data item. Triple word items may require scaling portions of the variable separately and then adding them in floating point form.

Table 5-1. Binary Message Data Types

Type	Abbreviation	Words (Note 1)	Bits	Maximum Range
Bit (Note 2)	Bit	N/A	0 to 15	0 to 1
Character (Note 3)	C	N/A	8	ASCII 0 to 255
Integer	I	1	16	-32768 to +32767
Double Integer	DI	2	32	-2147483648 to +2147483647
Triple Integer	TI	3	48	-140737488355328 to +140737488355327
Unsigned Integer	UI	1	16	0 to 65535
Unsigned Double Integer	UDI	2	32	0 to 4294967295
Unsigned Triple Integer	UTI	3	48	0 to 281474976710656

Note 1: The term "word" is used throughout this document to specify a quantity which occupies 16 bits of storage.

Note 2: Data items using bit storage are specified with a format of w.b, where w is the word number and b is the bit number (0-15, 0 LSB) within the word. Multiple-bit items (bit fields) are indicated by a range of 'word.bit' values (e.g., 8.4-8.7).

Note 3: Although the AAMP2 processor and C compiler use 16-bit character representations, this data interface will use the more common 8-bit representation. The Zodiac receiver software will pack/unpack the character data internally as needed.

High Byte		Low Byte		
1000	0001	1111	1111	Word 1
MSB	LSB	MSB	LSB	
Message ID				Word 2
Data Word Count				Word 3
DCL0 QRAN 00XX XXXX				Word 4
Header Checksum				Word 5

Figure 5-1. Binary Message Header Format

Composite words may have independent definitions for each bit field in the word. Flag bits are either zero (false) or one (true). All bits that are designated as reserved within the bit descriptions of binary data have undefined values for outputs and must be set to zero for inputs.

5.2   Binary Message Header_____

The binary message header format has been modifed slightly from the NavCore V format to accommodate message logging requests. The format of the new message header is shown in Figure 5-1.

5.2.1 Message Header Word 1. Each input/output message starts with a synchronization word of the form $0x81FF_{HEX}$ with DEL (255 decimal) occupying the first eight bits followed by the Start Of Header (SOH) (129 decimal) occupying the second eight bits of the synchronization word.

5.2.2 Message Header Word 2. Word 2 contains the numeric message ID. For example, word 2 for Message ID 1000 would be:

High Byte		Low Byte	
0000	0011	1110	1000
MSB	LSB	MSB	LSB

Or $0x03E8_{HEX}$.

5.2.3 Message Header Word 3. Word 3 contains the word count for the data portion of the message. The word count does not include the data checksum word. A zero data word count indicates a "header-only" message.

5.2.4 Message Header Word 4. The fourth word of the message header is a 16-bit field allocated to protocol and message related flags. These flag bits extend control over ACK/NAK requests and implement message logging requests. The zeroes represented in the word 4 field shown in Figure 5-1 are reserved bits and should be set to zero within this word.

The ACK/NAK control mechanism gives the user the ability to request either ACK or NAK, or both, independently for each message request. The user sets the request (R) bit and either the acknowledge (A) bit or negative acknowledge (N) bit, or both, to select the proper acknowledge behavior. With this approach, the user can configure requests only to be NAKed, alerting the user when a problem arises without incurring the overhead necessary to continuously process ACKs.

The lower six bits of the flags word can be used as an additional input identifier. This identifier is not explicitly processed by the receiver; it is echoed back, in the same location, as part of the header in ACK/NAK responses. This feature allows the user to uniquely distinguish which input message an acknowledgement corresponds to when multiple input messages with the same message ID were processed during a particular period of time.

The flags word now supports message logging requests. The connect (C) and disconnect (D) bits are used to enable and disable, respectively, message outputs, and can be used either independently or in conjunction with the log request bits. A header-only message, with a Message ID and the connect bit set, enables the specified message with existing timing characteristics. Likewise, a header-only message, with Message ID and the disconnect bit set, disables the specified message. A

Trigger (on time, on update)	Word 6
Interval (sec)	Word 7
Offset (sec)	Word 8
Data Checksum	Word 9

Figure 5-2. Standard Log Request Message Format (Data Portion)

message with both connect and disconnect bits is ignored. Note that enabling and disabling a message does not modify its timing characteristics (trigger, interval, or offset). A log request with the connect bit set will set up the message's timing characteristics and then enable the message. Similarly, for a combined log and disable request, the message will be disabled after the timing characteristics are set. To disable all messages, set the message ID to FFFF$_{HEX}$ (all bits set) and set the disconnect (D) bit.

Setting the query (Q) request bit will output the message specified by the message ID one time during the next output interval. Standard log requests will be accepted if the log (L) bit is set and if the required data parameters are present in the data portion of the request message.

5.2.5 Message Header Word 5. Word 5 of the message header is the data checksum, used to validate the header portion of the message. It is computed by summing (modulo 2^{16}) all words (including the word containing DEL and SOH) contained in the header and then performing a two's complement on the sum.

The computation of the header checksum may be expressed mathematically as:

$$SUM = Mod\ 2^{16} \sum_{i=1}^{4} Word(i)$$

If sum = - 32768, Header Checksum = SUM; else Header Checksum = - SUM

where:

a.   Unary negation is computed as the two's complement of a 16-bit data word.

b.   Mod 2^{16} indicates the least 16 bits of an arithmetic process. That is, carry bits from bit position 16 are ignored.

c.   The summation is the algebraic binary sum of the words indicated by the subscript i.

d.   The -32768 sum value must be treated as a special case since it cannot be negated.

5.2.6 Log Request Messages. Figure 5-2 shows the format of the data portion of standard log request messages. The ranges for words 6, 7, and 8 of these messages are as follows:

Trigger   0 = on time, 1 = on update

Interval   0 to 65535 seconds (an interval of zero produces a query as if the query bit [Q] in word 4 of the message header has been set).

Offset   0 to 60 seconds (an offset of zero specifies an initial output relative to the current time. An offset of 60 specifies an initial output relative to the next even minute [zero seconds into the next minute]).

When the Trigger field is set to "on time" (integer value 0), the first output will occur at the next Offset seconds into the minute, and will repeat every Interval seconds thereafter. When the trigger field is set to "on update," the specified message will be output only when the data is updated (e.g., when satellite almanac is collected).

5.3   Binary Message Data _____

The data portion of a binary message, if it exists, can be variable in length, as specified by the data word count found in the header. The Data Checksum follows the data and is not included in the data word count.

The Data Checksum is a 16-bit word used to validate the data portion of the message. It is transmitted as the last word of any message containing data (see Figure 5-2).

When the Word Count field is zero, the Data Checksum does not exist. It is computed by summing (modulo 2^{16}) all words in the data portion of the message and then complementing that sum. The mathematical expression for the Data Checksum is:

$$SUM = Mod\, 2^{16} \sum_{i=6}^{5+N} Word(i)$$

If sum = - 32768, Data Checksum = SUM; else Data Checksum = - SUM

where:

a.   Unary negation is computed as the two's complement of a 16-bit data word.

b.   Mod 2^{16} indicates the least 16 bits of an arithmetic process. That is, carry bits from bit position 16 are ignored.

c.   The summation is the algebraic binary sum of the words indicated by the subscript (i).

d.   The -32768 sum value must be treated as a special case since it cannot be negated.

Data elements identified as "Reserved" must be set to zero for input messages and are undefined for output messages. All data storage which is not explicitly defined should be handled as if it were marked "Reserved."

Unless otherwise stated, the resolution of each numeric data item is one integer unit, as specified by that item in the "Units" field.

5.4   NMEA Messages, Format, And Sentence Structure _____

NMEA messages are output in response to standard Q (Query) or proprietary ILOG (Log Control) messages as described in Section 5.6. The timing of output messages is synchronized with the Time Mark output event.

5.4.1 NMEA Output Messages. The following supported NMEA output messages comply with the NMEA-0183 version 2.01 standard:

- GGA: GPS Fix Data
- GSA: GPS DOP and Active Satellites
- GSV: GPS Satellites in View
- RMC: Recommended Minimum Specific GPS Data

The Zodiac receiver also supports the following Conexant proprietary output messages:

- BIT: Conexant Proprietary Built-In Test Results
- ERR: Conexant Proprietary Error/Status
- RID: Conexant Proprietary Receiver ID
- ZCH: Conexant Proprietary Zodiac Channel Status

These proprietary messages conform to the message format described below.

5.4.2 NMEA Input Messages. The Zodiac receiver supports the following proprietary input messages:

- IBIT: Conexant Proprietary Built-In Test Command
- ILOG: Conexant Proprietary Log Control
- INIT: Conexant Proprietary Receiver Initialization
- IPRO: Conexant Proprietary Protocol

The INIT message is used to command initialization of the receiver and the IPRO message is used to change the message protocol. The first character of the message sentence is "P," followed by a three-character mnemonic code for Conexant Systems Inc. (RWI) according to Appendix III of the NMEA-0183 standard.

5.4.3 NMEA Message Format. All NMEA-0183 data messages are in ASCII form. Each message begins with ASCII $ (24$_{HEX}$) and ends with ASCII <CR><LF> (0D$_{HEX}$ and 0A$_{HEX}$). The valid character set consists of

all printable ASCII characters, 20_{HEX} to $7E_{HEX}$, except for the reserved characters listed in Table 5-2.

Each NMEA message, or sentence, consists of a set of fields separated by a comma delimiter character. Each field can contain either a string of valid characters or no characters (null field). Valid characters must conform with the formats described in Table 5-3.

The maximum number of characters in a sentence is 82, consisting of a maximum of 79 characters between the starting delimiter "$" and the terminating <CR> and <LF>.

Since the number of data fields can vary from sentence to sentence, it is important that the "listener" (or application software) locate fields by counting delimiters rather than counting the total number of characters received from the start of the sentence.

5.4.4 NMEA-0183 Approved Sentences. An approved NMEA-0183 sentence contains the following elements, in the order shown:

" $ "	Start of the sentence (24_{HEX})
<address field>	Talker identifier and sentence formatter.

[","<data field>]	Zero or more data fields.
	.
	.
	.
[","<data field>]	
["*"<checksum field>]	Optional checksum field.
<CR><LF>	End of sentence delimiter ($0D$ $0A_{HEX}$).

NOTE: Since the Zodiac receiver is a GPS device, the "talker" identifier is always "GP."

5.4.5 Proprietary Sentences. Proprietary sentences allow OEMs to transfer data that does not fall within the scope of approved NMEA sentences.

A proprietary sentence contains the following elements, in the order shown:

" $ "	Start of the sentence (24_{HEX})
" P "	Proprietary sentence ID (50_{HEX}).
<aaa>	OEM's mnemonic code.
[<valid characters, OEM's data>]	
["*"<checksum field>]	Optional checksum field.
<CR><LF>	End of sentence delimiter ($0D$ $0A_{HEX}$).

Table 5-2. NMEA Reserved Characters

Character	Hex Value	Decimal Value	Description
<CR>	0D	13	Carriage return (end of sentence delimiter)
<LF>	0A	10	Line feed (end of sentence delimiter)
$	24	36	Start of sentence delimiter
*	2A	42	Checksum field delimiter
,	2C	44	Field delimiter
!	21	33	Reserved
\	5C	92	Reserved
^	5E	94	Reserved
~	7E	126	Reserved

Table 5-3. NMEA Field Type Summary

Field Type	Symbol	Definition
**Special Format Fields**		

Status	A	Single character field:
		    A = Yes, Data Valid, Warning Flag Clear
		    V = No, Data Invalid, Warning Flag Set

Latitude	llll.ll	Fixed/variable length field: Degrees/minutes.decimal -- two fixed digits of degrees, two 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.yy	Fixed/variable length field: Degrees/minutes.decimal -- three fixed digits of degrees, two fixed digits of minutes and a <u>variable</u> 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: Hours/minutes/seconds.decimal -- two fixed digits of hours, two fixed digits of minutes, two fixed digits of seconds and a <u>variable</u> 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 field		Some fields are specified to contain pre-defined constants, most often alpha characters. Such a field is indicated in the NMEA-0183 standard by the presence of one or more valid characters. The following characters and character strings used to indicate field types are excluded from the list of allowable characters: "A," "a," "c," "hh," "hhmmss.ss," "llll.ll," "x," and "yyyyy.yy."
**Numeric Value Fields**		
Variable numbers	x.x	Variable length integer or floating point numeric field: Optional leading and trailing zeros. The decimal point and associated decimal-franction are optional if full resolution is not required (e.g., 73.10 = 73.1 = 073.1 = 73).
Fixed HEX field	hh_ _	Fixed length HEX numbers only, most significant bit on the left.
**Information Fields**		
Variable text	c- - c	Variable length valid character field.
Fixed alpha field	aa_ _	Fixed length field of uppercase or lowercase alpha characters.
Fixed number field	xx_ _	Fixed length field of numeric characters.
Fixed text field	cc_ _	Fixed length field of valid characters.

NOTES:

1. Spaces may only be used in variable text fields.

2. A negative sign ("-" or 2DHEX) is the first character in a field if the value is negative. The sign is omitted if the value is positive.

3. All data fields are delimited by a comma (",").

4. Null fields are indicated by no data between two delimiters.

Table 5-4. Zodiac Binary Data Messages

Output Message Name	Message ID	Input Message Name	Message ID
Geodetic Position Status Output (*)	1000	Geodetic Position and Velocity Initialization	1200
Channel Summary (*)	1002	User-Defined Datum Definition	1210
Visible Satellites (*)	1003	Map Datum Select	1211
Differential GPS Status	1005	Satellite Elevation Mask Control	1212
Channel Measurement	1007	Satellite Candidate Select	1213
ECEF Position Output	1009	Differential GPS Control	1214
Receiver ID (**)	1011	Cold Start Control	1216
User-Settings Output	1012	Solution Validity Criteria	1217
Built-In Test Results	1100	User-Entered Altitude Input	1219
UTC Time Mark Pulse Output (*)	1108	Application Platform Control	1220
Frequency Standard Parameters In Use	1110	Nav Configuration	1221
Power Management Duty Cycle In Use	1117	Perform Built-In Test Command	1300
Serial Port Communication Parameters In Use	1130	Restart Command	1303
EEPROM Update	1135	Frequency Standard Input Parameters	1310
EEPROM Status	1136	Power Management Control	1317
Frequency Standard Table Output Data	1160	Serial Port Communications Parameters	1330
Boot Status	1180	Factory Calibration Input	1350
Error/Status	1190	Frequency Standard Table Input Data	1360
		Message Protocol Control	1331
		Raw DGPS RTCM SC-104 Data	1351
		Flash Reprogram Request	1380

(*) Enable by default at power-up
(**) Once at power-up/reset

5.4.6 Checksum. The checksum is the 8-bit exclusive OR (no start or stop bits) of all characters in the sentence, including delimiters (except for the $ and the optional * delimiters). The hexadecimal value of the most significant and least significant four bits of the result are converted to two ASCII characters (0 to 9, A to F) for transmission. The most significant character is transmitted first.

5.5   Zodiac Binary Data Messages_____

This section describes the binary data messages of the Zodiac GPS receiver. All of the output and input binary messages are listed in Table 5-4 together with their corresponding message IDs. Power-up default messages are also identified.

Binary mode is selected according to the logic described in the "Jupiter" Data Sheet that accompanies this Designer's Guide. Binary messages are transmitted and received across the host port serial I/O interface

(RS-232) with the following default communications parameters:

- 9600 bps
- 8 data bits

- no parity
- 1 stop bit

5.5.1 Binary Output Message Descriptions. This section provides details for each of the output binary messages.

5.5.1.1 Geodetic Position Status Output (Message 1000). This message outputs the receiver's estimate of position, ground speed, course over ground, climb rate, and map datum. A solution status indicates whether or not the solution is valid (based on the solution validity criteria) and also the type of solution. The number of measurements used to compute the solution is also included.

The Polar Navigation flag is used to indicate that the solution estimate is too close to the North or South Pole to estimate longitude. When this flag is true, the longitude and true course outputs are invalid and are not updated. Users operating near the poles should use the ECEF Position Status Output message.

The contents of the Geodetic Position Status Output Message are described in Table 5-5.

Table 5-5. Message 1000: Geodetic Position Status Output Message (1 of 3)

Message ID:	1000				
Rate:	Variable; defaults to 1 Hz				
Message Length:	55 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	Satellite Measurement Sequence Number (Note 3)	I		0 to 32767	
Navigation Solution Validity (10.0-10.15)					
10.0	Solution Invalid - Altitude Used (Note 4)	Bit		1 = true	
10.1	Solution Invalid - No Differential GPS (Note 4)	Bit		1 = true	
10.2	Solution Invalid - Not Enough Satellites in Track (Note 4)	Bit		1 = true	
10.3	Solution Invalid - Exceeded Maximum EHPE (Note 4)	Bit		1 = true	
10.4	Solution Invalid - Exceeded Maximum EVPE (Note 4)	Bit		1 = true	
10.5	Solution Invalid - No DR Measurements (Note 5)	Bit		1 = true	
10.6	Solution Invalid - No DR Calibration (Note 6)	Bit		1 = true	
10.7	Solution Invalid - No Concurrent DR Calibration by GPS (Note 7)	Bit		1 = true	
10.8-10.15	Reserved				
Navigation Solution Type (11.0-11.15)					
11.0	Solution Type - Propagated Solution (Note 8)	Bit		1 = propagated	
11.1	Solution Type - Altitude Used	Bit		1 = altitude used	
11.2	Solution Type -Differential	Bit		1 = differential	
11.3	Solution Type - PM	Bit		1 = RF off	
11.4	Solution Type - GPS (Note 9)	Bit		1 = true	
11.5	Solution Type - Concurrent GPS Calibrated DR (Note 10)	Bit		1 = true	
11.6	Solution Type - Stored Calibration DR (Note 11)	Bit		1 = true	
11.7-11.15	Reserved				
12	Number of Measurements Used in Solution	UI		0 to 12	

Table 5-5. Message 1000: Geodetic Position Status Output Message (2 of 3)

Word No.:	Name:	Type:	Units:	Range:	Resolution:

13	Non-DR Link: Polar Navigation
	   DR Navigation Link:
	     Bit 0 = Polar Navigation
	     Bit 15 to 1 = Hading Uncertainty Standard Deviation (Note 12)
		Bit
		
		Bit
		UI
			
			degrees
				1 = true
				
				1 = true
				0 to 300
					
					0.01

14	GPS Week Number	UI	weeks	0 to 32767	
15-16	GPS Seconds From Epoch	UDI	seconds	0 to 604799	
17-18	GPS Nanoseconds From Epoch	UDI	nanosec	0 to 999999999	
19	UTC Day	UI	days	1 to 31	
20	UTC Month	UI	months	1 to 12	
21	UTC Year	UI	year	1980 to 2079	
22	UTC Hours	UI	hours	0 to 23	
23	UTC Minutes	UI	minutes	0 to 59	
24	UTC Seconds	UI	seconds	0 to 59	
25-26	UTC Nanoseconds From Epoch	UDI	nanosec	0 to 999999999	
27-28	Latitude	DI	radians	±0 to $\pi/2$	10^{-8}
29-30	Longitude	DI	radians	±0 to π	10^{-8}
31-32	Height	DI	meters	±0 to 50000	10^{-2}
33	Geoidal Separation	I	meters	±0 to 200	10^{-2}
34-35	Ground Speed	UDI	meters/sec	0 to 1000	10^{-2}
36	True Course	UI	radians	0 to 2π	10^{-3}
37	Magnetic Variation	I	radians	±0 to $\pi/4$	10^{-4}
38	Climb Rate	I	meters/sec	±300	10^{-2}
39	Map Datum (Note 13)	UI		0 to 188 and 300 to 304	
40-41	Expected Horizontal Position Error (Note 14)	UDI	meters	0 to 320000000	10^{-2}
42-43	Expected Vertical Position Error (Note 14)	UDI	meters	0 to 250000	10^{-2}
44-45	Expected Time Error (Note 14)	UDI	meters	0 to 300000000	10^{-2}
46	Expected Horizontal Velocity Error (Note 14)	UI	meters/sec	0 to 10000	10^{-2}
47-48	Clock Bias (Note 14)	DI	meters	±0 to 9000000	10^{-2}
49-50	Clock Bias Standard Deviation (Note 14)	DI	meters	±0 to 9000000	10^{-2}
51-52	Clock Drift (Note 14)	DI	m/sec	±0 to 1000	10^{-2}
53-54	Clock Drift Standard Deviation (Note 14)	DI	m/sec	±0 to 1000	10^{-2}
55	Data Checksum				

Table 5-5. Message 1000: Geodetic Position Status Output Message (3 of 3)

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

The satellite measurement sequence number relates the position solution data to a particular set of satellite measurements found in binary messages 1002 and 1007 (Channel Summary Message and Channel Measurement Message, respectively).

Note 4:

The value of this data item was initially set using the Solution Validity Criteria Message (Message 1217).

Note 5:

Either no DR messages are being received or data has been detected as inconsistent with GPS.

Note 6:

No calibration is available for DR measurements from concurrent GPS or from stored values.

Note 7:

No calibration is available for DR measurements from concurrent GPS.

Note 8:

It should be noted that bit zero of word 11 does **not** refer to a solution propagated by the navigation software. This bit is used to indicate if the solution was propagated by the serial I/O manager to generate a 1 Hz output message when no new navigation state data was available. This is an error condition potentially caused by a shortage of throughput in one cycle. It is unlikely to occur and is self correcting. Normal state propagation which occurs within the navigation software with or without measurements available for processing does not cause this bit to be set.

Note 9:

Navigation is based on GPS alone. Current systsem or GPS/DR with no DR measurements available.

Note 10:

DR is running with concurrent calibration by GPS.

Note 11:

DR is running with calibration from stored values from prior operating session.

Note 12:

An uncertainty value of 0x7FFF indicates unknown heading. A message value 0x000D indicates Polar Navigation equals true and heading uncertainty SD equals 0.06 (hex value 0x000C).

Note 13:

The table in Appendix B contains map datum codes from 0 to 188. Codes 300 to 304 are user-defined.

Note 14:

The data displayed by this field is not valid until the receiver is in navigation mode.

5.5.1.2 Channel Summary (Message 1002). This message provides a summary form of the satellite range measurements and signal tracking information on a per- channel basis. The contents of the Channel Summary Message are described in Table 5-6.

Table 5-6. Message 1002: Channel Summary Message

Message ID:	1002				
Rate:	Variable; defaults to 1 Hz				
Message Length:	51 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	Satellite Measurement Sequence Number (Note 3)	I		0 to 32767	
10	GPS Week Number	UI	weeks	0 to 32767	
11-12	GPS Seconds Into Week	UDI	sec	0 to 604799	
13-14	GPS Nanoseconds From Epoch	UDI	nanosec	0 to 999999999	
Channel Summary Data					
15.0+(3*n)	Measurement Used (Note 4)	Bit		1 = used	
15.1+(3*n)	Ephemeris Available	Bit		1 = available	
15.2+(3*n)	Measurement Valid	Bit		1 = valid	
15.3+(3*n)	DGPS Corrections Available	Bit		1 = available	
16+(3*n)	Satellite PRN	UI		0 to 32	
17+(3*n)	C/No	UI	dBHz	0 to 60	
51	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

The satellite measurement sequence number relates the position solution data to a particular set of satellite measurements found in binary messages 1002 and 1007 (Channel Summary Message and Channel Measurement Message, respectively).

Note 4:

n = 0 to 11

5.5.1.3 Visible Satellites (Message 1003). This message outputs the list of satellites visible to the receiver and their corresponding elevations and azimuths. The best possible DOPs, calculated from this visible list, are also provided. The contents of the Visible Satellites Message are described in Table 5-7.

Table 5-7. Message 1003: Visible Satellites Message

Message ID:	1003					
Rate:	Variable; default on update					
Message Length:	51 words					
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**	
1-4	Message Header					
5	Header Checksum					
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295		
8	Sequence Number (Note 2)	I		0 to 32767		
9	Best Possible GDOP	I		0 to 99	10^{-2}	
10	Best Possible PDOP	I		0 to 99	10^{-2}	
11	Best Possible HDOP	I		0 to 99	10^{-2}	
12	Best Possible VDOP	I		0 to 99	10^{-2}	
13	Best Possible TDOP	I		0 to 99	10^{-2}	
14	Number of Visible Satellites	UI		1 to 12		
VISIBLE SATELLITE SET (Note 3)						
15 + (3*j)	Satellite PRN (Note 4)	UI		0 to 32		
16 + (3*j)	Satellite Azimuth	I	radians	$\pm\pi$	10^{-4}	
17 + (3*j)	Satellite Elevation	I	radians	$\pm\pi/2$	10^{-4}	
51	Data Checksum					

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

Only the satellite sets for the number of satellites reported in word 14 of this message are valid.

Note 4:

j = the number of visible satellites minus one when the number of visible satellites is greater than zero.

5.5.1.4 Differential GPS Status (Message 1005). This message contains DGPS status information derived from the last set of differential corrections processed by the receiver. The contents of the Differential GPS Status Message are described in Table 5-8.

Table 5-8. Message 1005: Differential GPS Status Message (1 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
Message ID:	1005				
Rate:	Variable				
Message Length:	25 words				
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
Status (9.0-9.15)					
9.0	Station Health	Bit		1 = station bad	
9.1	User Disabled	Bit		1 = user disabled	
9.2-9.15	Reserved				
10	Station ID	UI		0 to 1023	
11	Age of Last Correction	UI	seconds	0 to 999	
12	Number of Available Corrections	UI		0 to 12	
CORRECTION STATUS PER SATELLITE (Note 3)					
j.0-j.5	Satellite PRN (Note 4)	UI		1 to 32	
j.6	Local Ephemeris	Bit		1 = ephemeris not available	
j.7	RTCM Corrections	Bit		1 = corrections not available	
j.8	RTCM UDRE	Bit		1 = UDRE too high	
j.9	Satellite Health	Bit		1 = satellite data indicates bad health	

Table 5-8. Message 1005: Differential GPS Status Message (2 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
j.10	RTCM Satellite Health	Bit		1 = RTCM source declares satellite bad	
j.11	Corrections Stale	Bit		1 = received stale corrections	
j.12	IODE Mismatch	Bit		1 = IODE mismatch	
j.13-j.15	Reserved				
25	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

Only the correction status words for the number of available corrections reported in word 12 of this message are valid.

Note 4:

The word number, j, ranges from 13 to 24.

5.5.1.5 Channel Measurement (Message 1007). This message provides measurement and associated data for each of the receiver's 12 channels. The contents of the Channel Measurement Message are described in Table 5-9.

Table 5-9. Message 1007: Channel Measurement Message

Word No.:	Name:	Type:	Units:	Range:	Resolution:
Message ID:	1007				
Rate:	Variable				
Message Length:	154 words				
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	Satellite Measurement Sequence Number (Note 3)	I		0 to 32767	
	CHANNEL MEASUREMENT DATA				
10 + 12*j	Pseudorange (Note 4)	TI	meters	$\pm 1.4^{14}$	10^{-3}
13 + 12*j	Pseudorange Rate	DI	meters/sec	± 21474836	10^{-3}
15 + 12*j	Carrier Phase	TI	meters	$\pm 1.4^{14}$	10^{-3}
18 + 12*j	Carrier Phase Bias	TI	meters	$\pm 1.4^{14}$	10^{-3}
21 + 12*j	Phase Bias Count	UI		0 to 65535	
154	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

The satellite measurement sequence number relates the position solution data to a particular set of satellite measurements found in binary messages 1002 and 1007 (Channel Summary Message and Channel Measurement Message, respectively).

Note 4:

j = 0 to 11

5.5.1.6 Reduced ECEF Position Status Output (Message 1009). This message provides measurement and associated data for each of the receiver's 12 channels. The contents of the Channel Measurement Message are described in Table 5-10.

Table 5-10. Message 1009: ECEF Position Output Message

Message ID:	1009					
Rate:	Variable					
Message Length:	22 words					
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**	
1-4	Message Header					
5	Header Checksum					
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295		
8	Sequence Number (Note 2)	I		0 to 32767		
9	Satellite Measurement Sequence Number (Note 3)	I		0 to 32767		
ECEF Navigation Solution						
10-11	ECEF Position - X (Note 4)	DI	meters	±0 to 9000000	10^{-2}	
12-13	ECEF Position - Y (Note 4)	DI	meters	±0 to 9000000	10^{-2}	
14-15	ECEF Position - Z (Note 4)	DI	meters	±0 to 9000000	10^{-2}	
16-17	ECEF Velocity - X (Note 4)	DI	meters/sec	±0 to 1000	10^{-2}	
18-19	ECEF Velocity - Y (Note 4)	DI	meters/sec	±0 to 1000	10^{-2}	
20-21	ECEF Velocity - Z (Note 4)	DI	meters/sec	±0 to 1000	10^{-2}	
22	Data Checksum	UI				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. The set time indicated is at the time the message is submitted to the output queue.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

The satellite measurement sequence number relates the position solution data to a particular set of satellite measurements found in binary messages 1002 and 1007 (Channel Summary Message and Channel Measurement Message, respectively).

Note 4:

The data displayed by this field is not valid until the receiver is in navigation mode.

5.5.1.7 Receiver ID (Message 1011). This message is output automatically at startup after the receiver has completed its initialization. It can be used to determine when the receiver is ready to accept serial input. Manual requests for this message are also honored. This message consists of five 20-byte (two characters per word), null-padded ASCII data fields. The contents of the Receiver ID Message are described in Table 5-11.

Table 5-11. Message 1011: Receiver ID Message

Message ID:	1011				
Rate:	Variable (see above)				
Message Length:	59 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9-18	Number of Channels	C			
19-28	Software Version	C			
29-38	Software Date	C			
39-48	Options List (Note 3)	C			
49-58	Reserved	UI			
59	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

The options list is a bit-encoded configuration word represented as an ASCII four-digit hexadecimal number:

        bit 0   minimize ROM usage
        bit 1   minimize RAM usage
        bits 2-15   reserved

5.5.1.8 User Settings Output (Message 1012). This message provides a summary of the settings for many of the user-definable parameters which were set either to default values or to values supplied by the user in input messages. The contents of the User Settings Output Message are described in Table 5-12.

Table 5-12. Message 1012: User-Settings Output Message (1 of 2)

Message ID:	1012				
Rate:	Variable				
Message Length:	22 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 2147483647	
8	Sequence Number (Note 2)	I		0 to 32767	
Operational Status (9.0-9.15)					
9.0	Power Management Enabled	Bit		1 = enabled	
9.1	Cold Start Disabled	Bit		1 = disabled	
9.2	DGPS Disabled	Bit		1 = disabled	
9.3	Held Altitude Disabled	Bit		1 = disabled	
9.4	Ground Track Smoothing Disabled	Bit		1 = disabled	
9.5	Position Pinning Disabled	Bit		1 = disabled	
9.6	Low Quality Measurement Disabled (Note 3)	Bit		1 = disabled	
9.7	Jamming Detection Enabled	Bit		1 = enabled	
9.8	Active Antenna	Bit		1 = active 0 = passive	
9.9-9.15	CNo Threshold		dBHz	0 to 50	
10	Cold Start Time-Out	UI	seconds	0 to 32767	
11	DGPS Correction Time-Out	UI	seconds	0 to 32767	
12	Elevation Mask	I	radians	0 to $\pm\pi/2$	10^{-3}
SELECTED CANDIDATES:					
13.0-14.15	Selected Candidate (Note 4)	Bit		1 = included candidate	
SOLUTION VALIDITY CRITERIA (15-20)					
15.0	Attitude Not Used	Bit		1 = required	
15.1	Differential GPS	Bit		1 = required	
15.2	DR Measurement	Bit		1 = required	
15.3	GPS Calibration	Bit		1 = required	
15.4	GPS Only	Bit		1 = required	
155-15.15	Reserved				
16	Number of Satellites in Track Required	UI		0 to 12	

Table 5-12. Message 1012: User Settings Output Message (2 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
17-18	Minimum Expected Horizontal Error	UDI	meters	0 to 1000	10^{-2}
19-20	Minimum Expected Vertical Error	UDI	meters	0 to 1000	10^{-2}
21	Application Platform	UI		0 = default 1 = static 2 = pedestrian 3 = marine (lakes) 4 = marine (sea level) 5 = land (auto) 6 = air	
22	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

When this bit is set, the receiver will only use "perfect" measurements (i.e., measurements without any errors in tracking status or data). If the bit is not set, the system uses measurements that, while not perfect, are still good enough to use under SPS conditions.

Note 4:

The selected candidate list is a 32-bit flag, each bit representing candidate selection status for one satellite (i.e., bit 0 = SV1 status, bit 1 = SV2 status...bit 31 = SV32 status).

5.5.1.9 Built-In Test (BIT) Results (Message 1100).
This message provides detailed test results of the last BIT commanded since power-up. It is output automatically after the completion of a commanded BIT, but may also be queried manually as needed. Non-

zero device failure status indicates failure. The contents of the Built-In Test (BIT) Results Message are described in Table 5-13.

Table 5-13. Message 1100: Built-In Test Results Message

Message ID:	1100				
Rate:	Variable				
Message Length:	20 words				

Word No.:	Name:	Type:	Units:	Range:	Resolution:
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	ROM Failure (Note 3)	UI			
10	RAM Failure (Note 3)	UI			
11	EEPROM Failure (Note 3)	UI			
12	Dual Port RAM Failure (Note 3)	UI			
13	Digital Signal Processor (DSP) Failure (Note 3)	UI			
14	Real-Time Clock (RTC) Failure (Note 3)	UI			
15	Serial Port 1 Receive Error Count	UI		0 to 65535	
16	Serial Port 2 Receive Error Count	UI		0 to 65535	
17	Serial Port 1 Receive Byte Count	UI		0 to 65535	
18	Serial Port 2 Receive Byte Count	UI		0 to 65535	
19	Software Version	UI		0.00 to 655.35	0.01
20	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

A value of zero indicates a test has passed. A non-zero value indicates a device failure. Missing devices will be reported as failures. Therefore, the OEM's BIT pass/fail should ignore words for components that are not in the system under test.

Note that the Dual Port RAM Failure test is currently not implemented. Therefore, word 12 will report a value of zero.

5.5.1.10 UTC Time Mark Pulse Output (Message 1108). This message provides the UTC seconds into week associated with the UTC synchronized Time Mark pulse. This message is output approximately 400 milliseconds before the Time Mark pulse strobe signal. The contents of the UTC Time Mark Pulse Output Message are described in Table 5-14.

Table 5-14. Message 1108: UTC Time Mark Pulse Output Message

Message ID:	1108				
Rate:	1 Hz				
Message Length:	20 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
UTC TIME					
9-13	Reserved				
14-15	UTC Seconds Of Week	UDI	seconds	0 to 604799	1 second
16	GPS to UTC Time Offset (integer part)	I	seconds	-32768 to +32767	1 second
17-18	GPS to UTC Time Offset (fractional part)	UDI	nanoseconds	0 to 999999999	1 nanosecond
UTC TIME VALIDITY (19.0-19.15)					
19.0	Time Mark Validity	Bit		1 = true	
19.1	GPS/UTC Sync	Bit		0 = GPS 1 = UTC	
19.2-19.15	Reserved				
20	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

5.5.1.11 Frequency Standard Parameters In Use (Message 1110). This message outputs the parameters used to support the receiver's uncompensated crystal oscillator. The contents of the Frequency Standard Parameters In Use Message are described in Table 5-15.

NOTE: Message 1110 is primarily used to output key parameters to GPS systems without non-volatile storage. This is why the format of input message 1310 is exactly the same -- the output message is used to capture data, while the input message is used to restore data.

Table 5-15. Message 1110: Frequency Standard Parameters In Use Message (1 of 2)

Message ID:	1110				
Rate:	Variable				
Message Length:	22 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	Frequency Standard Issue Number (Note 3)	UI		0 to 65535	
	TEMPERATURE CHARACTERISTIC:				
10	C_0 (Aging and Calibration Offset) (Note 4)	I	sec/sec	0 to $\pm 2^{-14}$	2^{-29}
11	C_1 (Linear Term) (Note 4)	I	sec/sec/°C	0 to $\pm 2^{-20}$	2^{-35}
12	C_2 (Second Order Term) (Note 4)	I	sec/sec/(°C)^2	0 to $\pm 2^{-26}$	2^{-41}
13	C_3 (Third Order Term) (Note 4)	I	sec/sec/(°C)^3	0 to $\pm 2^{-32}$	2^{-47}
14	T_{INF} (Inflection Point) (Note 4)	I	°C	0 to ± 100	0.01
	TEMPERATURE DYNAMICS:				
15	D_0 (Note 5)	I			
16	D_1 (Note 5)	I			
	TEMPERATURE SENSOR CALIBRATION:				
17	T_{REF} (Calibration ReferenceTemperature) (Note 6)	I	°C	0 to ± 100	0.01
18	T_0 (Temperature Sensor Reading at T_{REF}) (Note 6)	UI	counts	0 to 65535	1
19	S_0 (Temperature Sensor Scale Factor) (Note 6)	I	°C/count	0 to $\pm 2^{-3}$	2^{-18}

Table 5-15. Message 1110: Frequency Standard Input Parameters In Use Message (2 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
UNCERTAINTY COEFFICIENTS:					
20	U_0 (Note 7)	I	sec/sec	0 to $\pm 2^{-14}$	2^{-29}
21	U_1 (Note 7)	I	sec/sec/°C	0 to $\pm 2^{-20}$	2^{-35}
22	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

Unique identification of each update. This allows a different set of data to be in use while newer data are only stored to EEPROM. The issue number is preserved from run to run if non-volatile storage is available.

Note 4:

Defines a cubic in $(T - T_{INF})$. Over a range of $T_{INF} \pm 65$ degrees C, each term can produce from 0.002 to 60 ppm, approximately.

Note 5:

Unused.

Note 6:

These parameters define the temperature sensor scaling according to the equation:

$$T = T_{REF} + (T_{FILT} - T_0)S_0$$

Note 7:

Defines a linear equation in $(T - T_{INF})$. Over a range of $T_{INF} \pm 65°C$, each term can produce from 0.002 to 60 ppm, approximately.

5.5.1.12 Power Management Duty Cycle In Use (Message 1117). This message controls the use of power management in the receiver. The contents of the

Power Management Duty Cycle In Use Message are described in Table 5-16.

Table 5-16. Message 1117: Power Management Duty Cycle In Use Message

Message ID:	1117				
Rate:	Variable				
Message Length:	10 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	Power Management On Duty Cycle (Note 3)	I	seconds	0 = off 1-4 = on	
10	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

In power management mode, the RF power may be switched off to reduce power consumption. The digital circuitry may be gated off and the processor idled when not needed. This field gives the Measurement Engine permission to turn off the RF for the minimum off time in seconds.

5.5.1.13 Serial Port Communication Parameters In Use (Message 1130). This message contains the communication parameters for the receiver's two serial ports. The contents of the Serial Port Communication Parameters In Use Message are described in Table 5-17.

Table 5-17. Message 1130: Serial Port Communication Parameters In Use Message (1 of 2)

Message ID:	1130				
Rate:	Variable				
Message Length:	21 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
Port 1 Communication Parameters (9.0-11)					
9	Port 1 Character Width	Bit		0 = 7 bits 1 = 8 bits	
10	Port 1 Stop BIts	Bit		0 = 1 1 = 2	
11	Port 1 Parity	Bit		0 = no parity 1 = odd parity 2 = even parity	
12	Port 1 bps Rate (Note 3)	Bit		0 = custom 1 = 300 2 = 600 3 = 1200 4 = 2400 5 = 4800 6 = 9600 7 = 19200 8 = 38400 9 = 57600 10 = 76800 11 = 115200	
13	Port 1 Pre-Scale (Note 3)	UI		0 to 255	
14	Port 1 Post-Scale (Note 3)	UI		0 to 7	

Table 5-17. Message 1130: Serial Port Communication Parameters In Use Message (2 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
Port 2 Communication Parameters (12.0-14)					
15	Port 2 Character Width	Bit		0 = 7 bits 1 = 8 bits	
16	Port 2 Stop BIts	Bit		0 = 1 1 = 2	
17	Port 2 Parity	Bit		0 = no parity 1 = odd parity 2 = even parity	
18	Port 2 bps Rate (Note 3)	Bit		0 = custom 1 = 300 2 = 600 3 = 1200 4 = 2400 5 = 4800 6 = 9600 7 = 19200 8 = 38400 9 = 57600 10 = 76800 11 = 115200	
19	Port 2 Pre-Scale (Note 3)	UI		0 to 255	
20	Port 2 Post-Scale (Note 3)	UI		0 to 7	
21	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

When a custom bits-per-second (bps) rate is selected, the bps rate is equal to:

CPU clock / (16 x pre-scale x $2^{post-scale}$)

5.5.1.14 EEPROM Update (Message 1135). This message provides dynamic status notification for EEPROM writes. It contains the data block ID for the last set of data which was written to EEPROM. This message is most useful when configured for output on update (the default), as it will provide a notification of

all stored configuration changes as they occur. The contents of the EEPROM Update Message are described in Table 5-18.

Table 5-18. Message 1135: EEPROM Update Message

Message ID:	1135				
Rate:	Variable; default on update				
Message Length:	10 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9.0-9.7	Data ID (Note 3)	Bit		0 to 27	
9.8-9.15	Satellite PRN (Note 4)	Bit		0 to 32	
10	Data Checksum				

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

0 =	Status	14 =	Antenna selection
1 =	Position	15 =	User entered altitude
2 =	UTC/Iono	16 =	DGPS control
3 =	Frequency standard cubic parameters	17 =	Host port protocol selection
4 =	Host port communication configuration	18 =	Auxiliary port protocol selection
5 =	Auxiliary port communication configuration	19 =	Host port enabled messages
6 =	Memory options	20 =	Reserved (auxiliary port enabled messages)
7 =	Solution validity criteria	21 =	User datums
8 =	Power management selections	22 =	Frequency/temperature table
9 =	Selected datum	23 =	Almanac
10 =	Platform class	24 =	Frequency standard calibration data
11 =	Cold start control	25 =	Nav configuration data
12 =	Elevation mask angle	26 =	DR navigation parameters
13 =	Satellite candidate list	27 =	Gyro temperature table

Note 4:

This field is only valid when the Data ID = 23 (Almanac).

5.5.1.15 EEPROM Status (Message 1136). This message provides failure and storage status information for the EEPROM. Bits set in the failure words represent write failures during attempts to update the corresponding blocks of data. Bits set in the status words indicate that those data blocks have been updated at least once in the EEPROM. The contents of the EEPROM Status Message are described in Table 5-19.

Table 5-19. Message 1136: EEPROM Status Message

Message ID:	1136					
Rate:	Variable					
Message Length:	18 words					
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**	
1-4	Message Header					
5	Header Checksum					
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295		
8	Sequence Number (Note 2)	I		0 to 32767		
9.0	Device Not Present	Bit		1 = not present		
9.1-9.15	Reserved					
10-11	Almanac Failure (Note3)	Bit				
12-13	Failure (Note 4)	Bit		0 to 31		
14-15	Almanac Status (Note 3)	Bit				
16-17	Status (Note 4)	Bit		0 to 31		
18	Data Checksum					

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

The Almanac Failure and Almanac Status words are 32-bit bit maps where the LSB = PRN 1 and the MSB = PRN 32.

Note 4:

The Failure and Status words are bit maps with values as follows:

0 =	Status	16 =	DGPS control
1 =	Position	17 =	Host port protocol selection
2 =	UTC/Iono	18 =	Auxiliary port protocol selection
3 =	Frequency standard cubic parameters	19 =	Host port enabled messages
4 =	Host port communication configuration	20 =	Reserved (auxiliary port enabled messages)
5 =	Auxiliary port communication configuration	21 =	User datums
6 =	Memory options	22 =	Frequency/temperature table
7 =	Solution validity criteria	23 =	Reserved
8 =	Power management selections	24 =	Frequency standard calibration data
9 =	Selected datum	25 =	Nav configuration data
10 =	Platform class	26 =	DR navigation parameters
11 =	Cold start control	27 =	Gyro temperature table
12 =	Elevation mask angle	28 =	Reserved
13 =	Satellite candidate list	29 =	Reserved
14 =	Antenna selection	30 =	Reserved
15 =	User entered altitude	31 =	Data is being updated

5.5.1.16 Frequency Standard Table Output Data (Message 1160). This message contains parameters and table data used in the receiver's frequency standard compensation model. It is intended that this message will be used in conjunction with message 1360 to retrieve and restore this information for external storage. The contents of the Frequency Standard Table Output Data Message are described in Table 5-20.

Table 5-20. Message 1160: Frequency Standard Table Output Data Message (1 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
Message ID:	1160				
Rate:	Variable				
Message Length:	270 words				
1-4	Message Header				
5	Header Checksum				
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295	
8	Sequence Number (Note 2)	I		0 to 32767	
9	Table Frequency Offset (Note 3)	I	ppm	0 to ±51	0.15
10.0	Table Frequency Offset Valid (Note 4)	Bit		1 = valid	
10.1-10.15	Reserved				
11	Offset Error Estimate (Note 5)	I	ppm	0 to ±51	0.002
12	Aging Rate Estimate (Note 6)	I	ppm/yr	0 to ±5	0.0002
13	Last Rate Update Week (Note 7)	I	weeks	0 to 32767	1

14-269	Frequency Standard Table (Note 8):
	    LSB
	    MSB
		I	
			weeks
			ppm
				
				0 to 1023
				0 to ±19.05
					
					4
					0.15

270	Data Checksum				

Table 5-20. Message 1160: Frequency Standard Table Output Data Message (2 of 2)

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

Each value of frequency error in the table shares this common offset value.

Note 4:

Flag to indicate that the offset has been established.

Note 5:

Filtered estimate of accumulated error in the table offset value.

Note 6:

Filtered estimate of the current aging rate.

Note 7:

Whole week number of the last update of the aging rate.

Note 8:

LSB = the approximate time of last table entry update. MSB = the frequency error at each table temperature, less the table offset.

5.5.1.17 Boot Status (Message 1180). This message is output in the Jupiter Flash board receiver only at start-up to control the flash download process and to report the results of the flash ROM checksum validation test. The contents of the Boot Status Message are described in Table 5-21.

Table 5-21. Message 1180: Boot Status Message

Message ID:	1180				
Rate:	As required				
Message Length:	7 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Boot Status (Note 1)	IU short			
7	Data Checksum				
Note 1:					
0: Checksum = Pass 1: Checksum = Fail 2: Copying Header 3: Waiting for a Command					

5.5.1.18 Error/Status (Message 1190). This message provides diagnostic information if the receiver encounters an error during execution of its firmware.

The contents of the Error/Status Message are described in Table 5-22.

Table 5-22. Message 1190: Error/Status Message

Message ID:	1190					
Rate:	Variable					
Message Length:	13 words					
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**	
1-4	Message Header					
5	Header Checksum					
6-7	Set Time (Note 1)	UDI	10 msec ticks	0 to 4294967295		
8	Sequence Number (Note 2)	I		0 to 32767		
9	Class (Note 3)	UI		0 to 5		
10	Number	I				
11	Code Environment (CENV)	UI				
12	Program Counter (PC)	UI				
13	Data Checksum					

Note 1:

Set time is an internal 10 millisecond (T10) count since power-on initialization enabled the processor interrupts. It is not used to derive GPS time, but only serves to provide a sequence of events knowledge. The set time or T10 count references the receiver's internal time at which the message was created for output. The T10 range is approximately 71 weeks.

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message output.

Note 3:

0 =   User mode exception
1 =   Exec mode exception
2 =   Trap
3 =   Executive error
4 =   Executive Service Routine error
5 =   User error

5.5.2 Binary Input Message Descriptions. This section provides details for each of the input binary messages.

5.5.2.1 Geodetic Position and Velocity Initialization (Message 1200). This message allows the user to initialize the receiver with the specified geodetic position, ground speed, course over ground, and climb

rate. The course may be either true or magnetic, as indicated by the Magnetic Course field.

The GPS/UTC time represents the time at which the solution was computed and, if present, will be used to propagate the solution to the current time. The contents of the Geodetic Position and Velocity Initialization Message are described in Table 5-23.

Table 5-23. Message 1200: Geodetic Position and Velocity Initialization Message (1 of 2)

Message ID:	1200				
Rate:	As required - maximum rate is 1 Hz				
Message Length:	27 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
Initialization Control (7.0-7.15)					
7.0	Force Time	Bit		0 = normal 1 = forced	
7.1	GPS Time Valid	Bit		1 = valid	
7.2	UTC Time Valid	Bit		1 = valid	
7.3	Lat/Lon Valid	Bit		1 = valid	
7.4	Altitude Valid	Bit		1 = valid	
7.5	Speed/Course Valid	Bit		1 = valid	
7.6	Magnetic Course	Bit		1 = magnetic	
7.7	Climb Rate Valid	Bit		1 = valid	
7.8-7.15	Reserved				
8	GPS Week Number	UI	weeks	0 to 32767	
9-10	GPS Seconds Into Week	UDI	seconds	0 to 604799	
11	UTC Day	UI	days	1 to 31	

Table 5-23. Message 1200: Geodetic Position and Velocity Initialization Message (2 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
12	UTC Month	UI	months	1 to 12	
13	UTC Year	UI	year	1980 to 2079	
14	UTC Hours	UI	hours	0 to 23	
15	UTC Minutes	UI	minutes	0 to 59	
16	UTC Seconds	UI	seconds	0 to 59	
17-18	Latitude	DI	radians	±0 to $\pi/2$	10^{-9}
19-20	Longitude	DI	radians	±0 to π	10^{-9}
21-22	Altitude	DI	meters	±0 to 50000	10^{-2}
23-24	Ground Speed	UI	meters/sec	0 to 1000	10^{-2}
25	Course	UI	radians	0 to 2π	10^{-3}
26	Climb Rate	I	meters/sec	±300	10^{-2}
27	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.2 User-Defined Datum Definition (Message 1210). This message allows the user to define a datum to be used by the receiver to transform its position solution. Up to five user-defined datums may be stored. Storage of these parameters requires EEPROM. The contents of the User-Defined Datum Definition Message are described in Table 5-24.

Note that datum definition does not imply datum use. Message 1211 is used to specify the "Datum In Use" for the navigation function. Also, any Message 1210 that contains an undefined datum code is ignored.

Table 5-24. Message 1210: User-Defined Datum Definition Message

Message ID:	1210				
Rate:	As required - maximum rate is 1 Hz				
Message Length:	20 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	User Datum ID	UI		300-304	
8-9	Semi-Major Axis - Integer Part	UDI	meters	6300000 to 6400000	
10	Semi-Major Axis - Fractional Part	UI	meters	0 to 9999	10^{-4}
11	Inverse Flattening - Integer Part	UI		280 to 320	
12-13	Inverse Flattening - Fractional Part	UDI		0 to 999999999	10^{-9}
14-15	WGS-84 Datum Offset - dX	DI	meters	0 to ±9000000	10^{-2}
16-17	WGS-84 Datum Offset - dY	DI	meters	0 to ±9000000	10^{-2}
18-19	WGS-84 Datum Offset - dZ	DI	meters	0 to ±9000000	10^{-2}
20	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.3 Map Datum Select (Message 1211). This message allows the user to select a datum to be used by the receiver to transform its position solution. The contents of the Map Datum Select Message are described in Table 5-25.

Table 5-25. Message 1211: Map Datum Select Message

Message ID:	1211				
Rate:	As required - maximum rate 1 Hz				
Message Length:	8 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Datum ID (Note 2)	UI		0 to 188 and 300 to 304	
8	Data Checksum				
Note 1:					
The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					
Note 2:					
The table in Appendix B contains map datum codes from 0 to 188. Codes 300 to 304 are user-defined.					

5.5.2.4 Satellite Elevation Mask Control (Message 1212). This message allows the user to set the elevation mask angle used by the receiver to select visible satellites. Storage of the Elevation Mask Angle

parameter requires EEPROM. The contents of the Satellite Elevation Mask Control Message are described in Table 5-26.

Table 5-26. Message 1212: Satellite Elevation Mask Control Message

Message ID:	1212				
Rate:	As required - maximum rate 1 Hz				
Message Length:	8 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Elevation Mask Angle	UI	Radians	0 to $\pm\pi/2$	10^{-3}
8	Data Checksum				
Note 1:					
The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.5 Satellite Candidate Select (Message 1213).
This message allows the user to construct the list of satellites which will be considered for selection by the receiver. The contents of the Satellite Candidate Select Message are described in Table 5-27.

Table 5-27. Message 1213: Satellite Candidate Select Message

Message ID:	1213				
Rate:	As required - maximum rate 1 Hz				
Message Length:	10 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7.0	Satellite PRN #1	Bit		1 = included	
•					
•					
•					
7.15	Satellite PRN #16	Bit		1 = included	
8.0	Satellite PRN #17	Bit		1 = included	
•					
•					
•					
8.15	Satellite PRN #32	Bit		1 = included	
9.0	Non-Volatile Storage Select	Bit		1 = store in non-volatile memory	
9.1-9.15	Reserved				
10	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.6 Differential GPS Control (Message 1214).
This message allows the user to control the behavior of the receiver's differential capability. Storage of this message's parameters requires EEPROM. The contents of the Differential GPS Control Message are described in Table 5-28.

Table 5-28. Message 1214: Differential GPS Control Message

Word No.:	Name:	Type:	Units:	Range:	Resolution:
Message ID:	1214				
Rate:	As required - maximum rate 1 Hz				
Message Length:	9 words				
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7.0	DGPS Disable	Bit		1 = disable	
7.1	Correction Data Base Reset	Bit		1 = reset	
7.2-7.15	Reserved				
8	Correction Time-Out	UI		0 to 32767	
9	Data Checksum				

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

5.5.2.7 Cold Start Control (Message 1216). This message allows the user to disable the Cold Start acquisition mode of the receiver. When Cold Start is enabled at power-on, the Cold Start timer is set to 0. If a satellite is not acquired before the Cold Start time-out is exceeded, the Cold Start acquisition mode starts. If a satellite is acquired, the Cold Start timer is reset to 0, the receiver is re-positioned under the satellite, and the search continues until either the receiver navigates or the timer is exceeded.

Cold Start acquisition mode does not use the initial conditions of position, time, and almanac. This causes the receiver to look at a wider range of frequencies and satellites. The default Cold Start timer is 5 minutes.

Normal operation is to leave cold start enabled. However, in certain enclosed situations (e.g., parking garages, houses, office buildings, etc.), faster acquisitions may be achieved with cold start disabled. Storage of the Cold Start Disable parameter requires EEPROM. The contents of the Cold Start Control Message are described in Table 5-29.

Table 5-29. Message 1216: Cold Start Control Message

Message ID:	1216				
Rate:	As required - maximum rate 1 Hz				
Message Length:	9 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Reserved (Sequence Number)	I		0 to 32767	
7.0	Cold Start Disable	Bit		1 = disable	
7.1-7.15	Reserved				
8	Cold Start Time-Out	UI	sec	0 to 32767	
9	Data Checksum				
Note 1:					
The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.8 Solution Validity Input (Message 1217). The receiver will always output the best position solution it can attain, depending on the number and quality of available measurements. The Solution Validity Input Message allows the user to define the criteria for setting the position validity status specified in the position output messages. The status will be set to 'invalid' if any of the specified requirements are not met. Storage of this message's parameters requires EEPROM. The contents of the Solution Validity Input Message are described in Table 5-30.

Table 5-30. Message 1217: Solution Validity Input Message

Message ID:	1217				
Rate:	As required - maximum rate is 1 Hz				
Message Length:	13 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7.0	Altitude Not Used	Bit		1 = required	
7.1	Differential GPS	Bit		1 = required	
7.2	DR Measurements Required (Note 2)	Bit		1 = required	
7.3	Concurrent GPS Calibration of DR Required (Note 3)	Bit		1 = required	
7.4	GPS Only Solution Required (Note 4)	Bit		1 = required	
7.5-7.15	Reserved				
8	Minimum Number of Satellites Used	UI		0 to 12	
9-10	Maximum Expected Horizontal Position Error	UDI	meters	0 to 1000	10^{-2}
11-12	Maximum Expected Vertical Position Error	UDI	meters	0 to 1000	10^{-2}
13	Data Checksum				

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 2:

Must operate with DR. Standalone GPS not acceptable.

Note 3:

DR must be calibrated by concurrent GPS. Stored calibration from past sessions not acceptable.

Note 4:

DR must **NOT** be used, even if available.

5.5.2.9 User-Entered Altitude Input (Message 1219). This message allows the user to enter an altitude to be used for altitude hold during 2-D navigation. If the Force Use field is not set, the receiver may ignore the altitude input if it thinks it has a better estimate. Setting the Clear field will clear out the last estimate of altitude which the receiver uses for altitude hold. Setting the MSL Select field allows entry of mean-sea-

level altitude. A standard deviation can be specified to indicate the uncertainty associated with the entered altitude. The receiver will weight the altitude measurement according to this uncertainty. As a special case, a zero standard deviation indicates that the quality of the altitude is not known. The contents of the User-Entered Altitude Input Message are described in Table 5-31.

Table 5-31. Message 1219: User-Entered Altitude Input Message

Message ID:	1219				
Rate:	As required - maximum rate is 1 Hz				
Message Length:	12 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
Altitude Input Control (7.0-7.15)					
7.0	Force Use	Bit		1 = force	
7.1	MSL Select	Bit		1 = MSL	
7.2	Store (RAM) (Note 2)	Bit		1 = store	
7.3	Store (EEPROM) (Note 2)	Bit		1 = store	
7.4	Clear (RAM)	Bit		1 = clear	
7.5	Clear (EEPROM)	Bit		1 = clear	
7.6-7.15	Reserved				
8-9	Altitude	DI	meters	$\pm$0 to 50000	10^{-2}
10	Altitude Standard Deviation	UDI	meters	0 to 10000	10^{-2}
11	Data Checksum				
Note 1:					
The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					
Note 2:					
For an altitude sensor that is supplying data in real-time, the OEM must ensure that bits 7.2 and 7.3 are set to zero so the altitude value will not be stored continuously in memory (RAM or EEPROM).					

5.5.2.10 Application Platform Control (Message 1220). This message allows the user to adjust the receiver's dynamics based on the type of application in which the receiver is being used. Storage for the

Platform parameter requires EEPROM. The contents of the Application Platform Control Message are described in Table 5-32.

Table 5-32. Message 1220: Application Platform Control Message

Message ID:	1220				
Rate:	As required - maximum rate is 1 Hz				
Message Length:	8 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Platform	UI		0 = default 1 = static 2 = pedestrian 3 = marine (lakes) 4 = marine (sea level) 5 = land (auto) 6 = air	
8	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.11 Nav Configuration (Message 1221). This message allows the user to control various features in the navigation processing. The held altitude disable bit controls the use of stored GPS-based altitude to aid the receiver when the vertical geometry deteriorates. The ground track smoothing bit controls the use of satellite range bias estimates to minimize the position shifts resulting from SA and constellation changes. The position pinning bit controls the use of a horizontal speed test to pin the position reported by the receiver and eliminate the wander associated with SA when static. Ground track smoothing and position pinning are not used when DGPS corrections are in use. The contents of the Nav Configuration Message are described in Table 5-33.

Table 5-33. Message 1221: Nav Configuration Message

Message ID:	1221				
Rate:	As required - maximum rate is 1 Hz				
Message Length:	15 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
Nav Configuration Word (7.0-7.15)					
7.0	Held Altitude Disable (default = enabled)	Bit		0 = enabled 1 = disabled	
7.1	Ground Track Smoothing Disable (default = enabled)	Bit		0 = enabled 1 = disabled	
7.2	Position Pinning Disable (default = enabled)	Bit		0 = enabled 1 = disabled	
7.3	Disable Low Quality Measurements (Note 2)	Bit		0 = enabled 1 = disabled	
7.4	Enable Jamming Detect	Bit		0 = enabled 1 = disabled	
7.5-7.15	Reserved (must be zeroed out)	Bit		0	
8-14	Reserved (must be zeroed out)				
15	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					
Note 2: When this bit is set, the receiver will only use "perfect" measurements (i.e., measurements without any errors in tracking status or data). If the bit is not set, the system uses measurements that, while not perfect, are still good enough to use under SPS conditions.					

5.5.2.12 Perform Built-In Test Command (Message 1300). This message instructs the receiver to immediately execute its Built-In Test (BIT). Results of the BIT are available in the Built-In Test Results message. The contents of the Perform Built-In Test Command Message are described in Table 5-34.

Table 5-34. Message 1300: Perform Built-In Test Command Message

Message ID:	1300				
Rate:	As required - maximum rate approximately 0.1 Hz				
Message Length:	8 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Reserved				
8	Data Checksum				
Note 1:					
The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					

5.5.2.13 Restart Command (Message 1303). This message commands a full restart each time it is received. The contents of the Restart Command Message are described in Table 5-35.

Table 5-35. Message 1303: Restart Command Message

Message ID:	1303				
Rate:	As required - maximum rate approximately 0.2 Hz				
Message Length:	8 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
Invalidation Control (7.0-7.15)					
7.0	Invalidate RAM (Note 2)	Bit		0 to 1	
7.1	Invalidate EEPROM (Note 3)	Bit		0 to 1	
7.2	Invalidate RTC (Note 4)	Bit		0 to 1	
7.3-7.14	Reserved				
7.15	Force Cold Start (Note 5)	Bit		0 to 1	
8	Data Checksum				

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 2:

1 = invalidate all RAM address space before restart

Note 3:

1 = invalidate all data in the EEPROM device (if present) before restart

Note 4:

1 = invalidate all data in the RTC device (if present) before restart

Note 5:

1 = Force a cold start reset by clearing RAM and ignoring, but not clearing, the stored position in EEPROM. This provides cold start testing with the valid time. If cold start testing without time is desired, then the invalidate RTC bit (7.2) should also be set.

5.5.2.14 Frequency Standard Input Parameters (Message 1310). This message defines the temperature polynomial, coefficients, and scale factors used by the receiver's frequency standard compensation model. The contents of the Frequency Standard Input Parameters Message are described in Table 5-36.

NOTE: Message 1310 is primarily used to input key parameters from GPS systems without non-volatile storage. This is why the format of output message 1110 is exactly the same. In other words, the output message is used to capture data while the input message is used to restore data.

Table 5-36. Message 1310: Frequency Standard Input Parameters Message (1 of 2)

Message ID:	1310				
Rate:	As required - maximum rate 1 Hz				
Message Length:	20 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Frequency Standard Issue Number (Note 2)	UI		0 to 65535	
TEMPERATURE CHARACTERISTIC:					
8	C_0 (Aging and Calibration Offset) (Note 3)	I	sec/sec	0 to $\pm 2^{-14}$	2^{-29}
9	C_1 (Linear Term) (Note 3)	I	sec/sec/°C	0 to $\pm 2^{-20}$	2^{-35}
10	C_2 (Second Order Term) (Note 3)	I	sec/sec/(°C)^2	0 to $\pm 2^{-26}$	2^{-41}
11	C_3 (Third Order Term) (Note 3)	I	sec/sec/(°C)^3	0 to $\pm 2^{-32}$	2^{-47}
12	T_{INF} (Inflection Point) (Note 3)	I	°C	0 to ± 100	0.01
TEMPERATURE DYNAMICS:					
13	D_0 (Note 4)	I			
14	D_1 (Note 4)	I			
TEMPERATURE SENSOR CALIBRATION:					
15	T_{REF} (Calibration ReferenceTemperature) (Note 5)	I	°C	0 to ± 100	0.01
16	T_0 (Temperature Sensor Reading at T_{REF}) (Note 5)	UI	counts	0 to 65535	1
17	S_0 (Temperature Sensor Scale Factor) (Note 5)	I	°C/count	0 to $\pm 2^{-3}$	2^{-18}
UNCERTAINTY COEFFICIENTS:					
18	U_0 (Note 6)	I	sec/sec	0 to $\pm 2^{-14}$	2^{-29}
19	U_1 (Note 6)	I	sec/sec/°C	0 to $\pm 2^{-20}$	2^{-35}
20	Data Checksum				

Table 5-36. Message 1310: Frequency Standard Input Parameters Message (2 of 2)

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 2:

Unique identification of each update. This allows a different set of data to be in use while newer data are only stored to EEPROM. The issue number is preserved from run to run if non-volatile storage is available.

Note 3:

Defines a cubic in $(T - T_{INF})$. Over a range of $T_{INF} \pm 65$ degrees C, each term can produce from 0.002 to 60 ppm, approximately.

Note 4:

*** TBD ***. These parameters will be used to compensate temperature dynamics transients.

Note 5:

These parameters define the temperature sensor scaling according to the equation:

$$T = T_{REF} + (T_{FILT} - T_0)S_0$$

Note 6:

Defines a linear equation in $(T - T_{INF})$. Over a range of $T_{INF} \pm 65°C$, each term can produce from 0.002 to 60 ppm, approximately.

5.5.2.15 Power Management Control (Message 1317). This message controls the use of power management in the receiver. The contents of the Power Management Control Message are described in Table 5-37.

NOTE: Message 1317 is primarily used to input key parameters from GPS systems without non-volatile storage. This is why the format of output message 1117 is exactly the same. In other words, the output message is used to capture data while the input message is used to restore data.

Table 5-37. Message 1317: Power Management Control Message

Message ID:	1317				
Rate:	As required - maximum rate 1 Hz				
Message Length:	8 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Power Management On Duty Cycle (Note 2)	I	seconds	0 = off 1-4 = on	
8	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					
Note 2: In power management mode, the RF power may be switched off to reduce power consumption. The digital circuitry may be gated off and the processor idled when not needed. This field gives the Measurement Engine permission to turn off the RF for the minimum off time in seconds.					

5.5.2.16 Serial Port Communication Parameters (Message 1330). This message allows the user to set the communication parameters for the receiver's two serial ports. The contents of the Serial Port Communication Parameters Message are described in Table 5-38.

Table 5-38. Message 1330: Serial Port Communication Parameters Message (1 of 2)

Message ID:	1330				
Rate:	As required - maximum rate 1 Hz				
Message Length:	20 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
PORT CONTROL/VALIDITY DATA					
7.0	Port 1 Data Valid	Bit		1 = data valid	
7.1	Port 2 Data Valid	Bit		1 = data valid	
7.2-7.15	Reserved				
8	Port 1 Character Width	UI		0 = 7 bits 1 = 8 bits	
9	Port 1 Stop BIts	UI		0 = 1 1 = 2	
10	Port 1 Parity	UI		0 = no parity 1 = odd parity 2 = even parity	
11	Port 1 Bits Per Second (bps) Rate	UI		0 = custom 1 = 300 2 = 600 3 = 1200 4 = 2400 5 = 4800 6 = 9600 7 = 19200 8 = 38400 9 = 57600 10 = 76800 11 = 115200	
12	Port 1 Pre-Scale (Note 2)	UI		0 to 255	
13	Port 1 Post-Scale (Note 2)	UI		0 to 7	
14	Port 2 Character Width	Bit		0 = 7 bits 1 = 8 bits	
15	Port 2 Stop BIts	Bit		0 = 1 1 = 2	

Table 5-38. Message 1330: Serial Port Communication Parameters Message (2 of 2)

Word No.:	Name:	Type:	Units:	Range:	Resolution:
16	Port 2 Parity	Bit		0 = no parity 1 = odd parity 2 = even parity	
17	Port 2 bps Rate	Bit		0 = custom 1 = 300 2 = 600 3 = 1200 4 = 2400 5 = 4800 6 = 9600 7 = 19200 8 = 38400 9 = 57600 10 = 76800 11 = 115200	
18	Port 2 Pre-Scale (Note 2)	UI		0 to 255	
19	Port 2 Post-Scale (Note 2)	UI		0 to 7	
20	Data Checksum				

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 2:

Pre-scale and post-scale parameters are used to establish custom bps rates. The bps rate is equal to:

$$\text{CPU clock} / (16 \times \text{pre-scale} \times 2^{\text{post-scale}})$$

5.5.2.17 Message Protocol Control (Message 1331).
This message allows the user to set the message format protocol which will be used to communicate information to and from the receiver through the host serial I/O port. Currently, the available protocols are binary (with fixed-point numbers) and NMEA-0183. Storage for the Protocol Type parameter requires EEPROM. The contents of the Message Protocol Control Message are described in Table 5-39.

Table 5-39. Message 1331: Message Protocol Control Message

Message ID:	1331				
Rate:	As required - maximum rate 1 Hz				
Message Length:	9 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Reserved (must be zeroed out)	I			
8	Protocol Type (Note 2)	I		0 = binary 1 = NMEA 2 = RTCM SC-104	
9	Data Checksum				
Note 1: The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.					
Note 2: RTCM SC-104 is not a valid protocol for the host data stream.					

5.5.2.18 Factory Calibration Input (Message 1350).
This message is used to inform the system about the quality of the frequency standard being used. The contents of the Factory Calibration Input Message are described in Table 5-40.

Table 5-40. Message 1350: Factory Calibration Input Message

Message ID:	1350				
Rate:	As required - maximum rate 1 Hz				
Message Length:	10				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Oscillator Temperature (Note 2)	I	degrees C	-40 to +85	0.01
8-9	Oscillator Frequency Error	I	ppm	0 to ±51	0.01
10	Data Checksum				

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 2:

Externally supplied temperature measurement. An external temperature input causes the internal temperature sensor to be ignored as a source of temperature data.

5.5.2.19 Raw DGPS RTCM SC-104 Data (Message 1351). This input message contains DGPS RTCM SC-104 data. The message is provided for backwards compatibility with the earlier MicroTracker GPS receiver and may be used in lieu of the auxiliary port data.

The contents of the Raw DGPS RTCM SC-104 Data Message are described in Table 5-41.

Table 5-41. Message 1351: Raw DGPS RTCM SC-104 Data Message

Message ID:	1351				
Rate:	As required. The maximum allowable rate is once every 100 msec (Note 1)				
Message Length:	Varies with message				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 2)	I		0 to 32767	
7 to n-1	*Any valid RTCM-104 raw data in multiples of 16 bits, not to exceed 32 16-bit words (Note 3)*				
n	Data Checksum (Note 1)				

Note 1:

n must be less than or equal to 39. No more than 32 receiver 16-bit words of RTCM data should be delivered to the receiver with any one message.

Word Description	Number of Words
Header	4
Header Checksum	1
Reserved (Sequence Number)	1
RTCM Data	≤32
Data Checksum	1

Max Number of words	≤39

Note 2:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 3:

Raw demodulated data must conform to the "6 of 8" format described in the RTCM SC-104 standard. The data must also be packed into one or more 16-bit words and should be ordered chronologically from earliest to latest. Specifically, Word 7 should represent the earliest data and Word n-1 should represent the latest.

Within each word, the most significant bit (bit 15) should represent the latest received bit and the least significant bit (bit 0) should represent the earliest received bit. (Note that according to RTCM "6 of 8" format, bits 6 and 14 should be set marking (1) and bits 7 and 15 should be set spacing (0) for each word.) The intent of this bit ordering is to allow the user to pass on the raw RTCM data without modification.

5.5.2.20 Frequency Standard Table Input Data (Message 1360). This message allows the user to input the parameters and table data used in the receiver's frequency standard compensation model. It is intended that this message will be used in conjunction with

Message 1160 to retrieve and restore this information for external storage. The contents of the Frequency Standard Table Input Data Message are described in Table 5-42.

Table 5-42. Message 1360: Frequency Standard Table Input Data Message

Word No.:	Name:	Type:	Units:	Range:	Resolution:
Message ID:	1360				
Rate:	As required - maximum rate 1 Hz				
Message Length:	268 words				
1-4	Message Header				
5	Header Checksum				
6	Sequence Number (Note 1)	I		0 to 32767	
7	Table Frequency Offset (Note 2)	I	ppm	0 to ±51	0.15
8.0	Table Frequency Offset Valid (Note 3)	Bit		1 = valid	
8.1-8.15	Reserved				
9	Offset Error Estimate (Note 4)	I	ppm	0 to ±51	0.002
10	Aging Rate Estimate (Note 5)	I	ppm/yr	0 to ±5	0.0002
11	Last Rate Update Week (Note 6)	I	weeks	0 to 32767	1

12-267	Frequency Standard Table (Note 7):
	    LSB
	    MSB
		UI	
			weeks
			ppm
				
				0 to 1023
				0 to ±19.05
					
					4
					0.15

268	Data Checksum				

Note 1:

The sequence number is a count that indicates whether the data in a particular binary message has been updated or changed since the last message input.

Note 2:

Each value of frequency error in the table shares this common offset value.

Note 3:

Flag to indicate that the offset has not been established.

Note 4:

Filtered estimate of accumulated error in the table offset value.

Note 5:

Filtered estimate of the current aging rate.

Note 6:

Whole week number of the last update of the aging rate.

Note 7:

LSB = the approximate time of last table entry update. MSB = the frequency error at each table temperature, less the table offset.

5.5.2.21 Flash Reprogram (Message 1380). This message is used only in the Jupiter Flash board to force the receiver into the Reprogram Flash mode. The contents of the Flash Reprogram Message are described in Table 5-43.

Table 5-43. Message 1380: Flash Reprogram Message

Message ID:	1380				
Rate:	As required				
Message Length:	7 words				
Word No.:	**Name:**	**Type:**	**Units:**	**Range:**	**Resolution:**
1-4	Message Header				
5	Header Checksum				
6	Request Flag	Boolean		0 = false nonzero = true	
7	Data Checksum				
Note: This message does not provide the Sequence Number as Word 6.					

5.6   Zodiac NMEA Data Messages_____

This section describes the National Marine Electronics Association (NMEA) data messages of the Zodiac GPS receiver. All of the output and input NMEA messages are listed in Table 5-44 together with their corresponding message IDs. Power-up default messages are also identified.

NMEA mode is selected according to the logic described in the "Jupiter" Data Sheet that accompanies this Designer's Guide. NMEA messages are transmitted and received across the host port serial I/O interface (RS-232) with the following default communications parameters:

- 4800 bps
- 8 data bits
- no parity
- 1 stop bit

This interface conforms with the NMEA-0183, version 2.01, specification.

5.6.1 NMEA Output Message Descriptions. This section provides details for each of the output NMEA messages.

Table 5-44. Zodiac NMEA Data Messages

Output Message Name	Message ID
Conexant Proprietary Built-In Test Results	BIT
Conexant Proprietary Error/Status	ERR
GPS Fix Data (*)	GGA
GPS DOP and Active Satellites (*)	GSA
GPS Satellites in View (*)	GSV
Conexant Proprietary Receiver ID	RID
Recommended Minimum Specific GPS Data (*)	RMC
Course Over Ground and Ground Speed	VTG
Conexant Proprietary Zodiac Channel Status (**)	ZCH

Input Message Name	Message ID
Conexant Proprietary Built-In Test Command	IBIT
Conexant Proprietary Log Control Message	ILOG
Conexant Proprietary Receiver Initialization	INIT
Conexant Proprietary Protocol Message	IPRO
Standard Query Message	Q
(*) Enable by default at power-up	
(**) Once at power-up/reset	

5.6.1.1 Conexant Proprietary Built-In Test (BIT) Results (BIT). This proprietary message provides detailed test results when a BIT is commanded. Non-zero device failure status indicates failure.

The contents of the BIT Message are described in Table 5-45.

Table 5-45. BIT Message: Conexant Proprietary Built-In Test (BIT) Results Message

Message ID:	BIT			
Rate:	Variable			
Fields:	11			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$PRWIBIT	Start of sentence and address field (Note 1)		$PRWIBIT
1	ROM_FAIL	ROM failure (Note 2)	hhhh	0001
2	RAM_FAIL	RAM failure (Note 2)	hhhh	0000
3	EEP_FAIL	EEPROM failure (Note 2)	hhhh	0000
4	DPR_FAIL	Dual Port RAM failure (Note 2)	hhhh	0000
5	DSP_FAIL	Digital Signal Processor (DSP) failure (Note 2)	hhhh	0000
6	RTC_FAIL	Real-Time Clock (RTC) failure (Note 2)	hhhh	0000
7	SP1-ERR	Serial Port 1 Receive Error Count	x.x	0
8	SP2_ERR	Serial Port 2 Receive Error Count	x.x	0
9	SP1_RCV	Serial Port 1 Receive Character Count	x.x	15
10	SP2_RCV	Serial Port 2 Receive Character Count	x.x	640
11	SW_VER	Software Version	x.x	01.02
	CKSUM	Checksum	*hh	*75
	<CR><LF>	Sentence terminator		<CR><LF>

Note 1:

$ = NMEA message prefix.
P   = Proprietary message indicator.
RWI = Conexant Systems Inc. mnemonic.
BIT   = BIT Results message ID.

Note 2:

A value of zero indicates a test has passed. A non-zero value indicates a device failure. Missing devices will be reported as failures. Therefore, the OEM's BIT pass/fail should ignore words for components that are not in the system under test. Note that the Dual Port RAM failure test is currently not implemented. Therefore, field 4 will report a value of zero.

Sample Message:

```
$PRWIBIT,0001,0000,0000,0000,0000,0000,0,0,15,640,01.02*75
```

5.6.1.2 Conexant Proprietary Error/Status (ERR).
This message provides diagnostic information if the
receiver encounters an error during execution of its
firmware.

The contents of the ERR Message are described in
Table 5-46.

Table 5-46. ERR Message: Conexant Proprietary Error/Status Message

Message ID:	ERR			
Rate:	Variable			
Fields:	3			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_{\_\_\_\_}$ERR	Start of sentence and address field		$PRWIERR
1		Class:　0　= User mode exception 　　　　1　= Executive mode exception 　　　　2　= Trap 　　　　3　= Executive error 　　　　4　= ESR error 　　　　5　= User error	x.x	0
2		Exception, Trap, or Error Number	x.x	0
3		Word Address of Condition	hhhhhh	005BC9
	CKSUM	Checksum	*hh	*01
	<CR><LF>	Sentence terminator		<CR><LF>

Sample Message:

```
$PRWIERR,0,0,005BC9*01
```

5.6.1.3 GPS Fix Data (GGA). This message contains time, position, and fix related data for the Zodiac receiver. When a navigation solution passes all of the validity criteria (set using the binary Solution Validity Criteria message), a GGA message is generated automatically. Otherwise, if any of the validity criteria are invalid for the solution, a GGA message is not generated.

The contents of the GGA Message are described in Table 5-47.

Table 5-47. GGA Message: GPS Fix Data Message (1 of 2)

Message ID:	GGA (while receiver is in Navigation Mode -- Note 1)			
Rate:	Variable; defaults to 1 Hz			
Fields:	14			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_ _GGA	Start of sentence and address field		$GPGGA
1	POS_UTC	UTC of position (hours, minutes, seconds, decimal seconds)	hhmmss.ss	222435
2	LAT	Latitude	llll.ll	3339.7334
3	LAT_REF	Latitude direction (N = north, S = south)	a	N
4	LON	Longitude	yyyyy.yy	11751.7598
5	LON_REF	Longitude direction (E = east, W = west)	a	W
6	GPS_QUAL	GPS quality indicator (Note 2)	x	2
7	NUM_SATS	Number of satellites in use, 00 to 12 (may be different from the number in view)	xx	06
8	HDOP	Horizontal Dilution of Precision (HDOP)	x.x	1.33
9	ALT_MSL	Antenna altitude above/below mean sea level (geoid) (Note 3)	x.x	27.0
10	M	Units of antenna altitude (meters)	M	M
11	GEOID_SEP	Geoidal separation (Note 4)	x.x	-34.4
12	M	Units of geoidal separation (meters)	M	M
13	DGPS_AGE	Age of differential GPS data (Note 5)	x.x	7
14	STA_ID	Differential reference station ID (0000 to 1023) (Note 6)	xxxx	0000
	CKSUM	Checksum	*hh	*41
	<CR><LF>	Sentence terminator		<CR><LF>

Table 5-47. GGA Message: GPS Fix Data Message (2 of 2)

Note 1:

When the the navigation solution is invalid, fields 1 through 5 and 8 through 14 are null. Field 7 also has special meaning (see Note 3).

Note 2:

GPS quality indicator:

0 = Fix not available or invalid.
1 = GPS fix.
2 = Differential GPS fix.

Note 3:

The geodetic altitude can be computed from the mean sea level altitude by adding the geoidal separation (word 11).

Note 4:

Geoidal separation is the difference between the WGS-84 Earth ellipsoid and mean sea level (geoid).

Note 5:

Time in seconds since the last SC104 Type 1 or Type 9 update; null field when DGPS is not used.

Note 6:

This field is null when DGPS is not used.

Sample Message:

```
$GPGGA,222435,3339.7334,N,11751.7598,W,2,06,1.33,27.0,M,-34.4,M,7,0000*41
```

5.6.1.4 GPS DOP and Active Satellites (GSA). This message contains the Zodiac receiver's operating mode, satellites used for navigation, and DOP values.

The contents of the GSA Message are described in Table 5-48.

Table 5-48. GSA Message: GPS DOP and Active Satellites Message

Message ID:	GSA			
Rate:	Variable			
Fields:	17			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_ _GSA	Start of sentence and address field		$GPGSA
1	OP_MODE	Mode (Note 1)	a	A
2	FIX_MODE	Mode (Note 2)	x	3
3-14	SATN	PRNs of satellites used in solution (null for unused fields)	xx,xx,....	04, 16, 09, 24, ...
15	PDOP	Position Dilution of Precision (PDOP) (Note 3)	x.x	3.33
16	HDOP	Horizontal Dilution of Precision (HDOP) (Note 3)	x.x	1.96
17	VDOP	Vertical Dilution of Precision (VDOP) (Note 3)	x.x	2.70
	CKSUM	Checksum	*hh	*06
	<CR><LF>	Sentence terminator		<CR><LF>

Note 1:

Mode (operating):

M = Manual, forced to operate in 3-D mode.
A = Automatic, allowed to automatically switch between 2-D and 3-D.

Note 2:

Mode (fix):

1 = Fix not available
2 = 2-D
3 = 3-D

Note 3:

DOPs are based on the set of satellites above the elevation mask angle, which may not be the same set as that used for navigation.

Sample Message:

```
$GPGSA,A,3,04,16,09,24,,,,,,,,,3.33,1.96,2.70*06
```

5.6.1.5 GPS Satellites in View (GSV). This message contains the number of satellites in view, PRN numbers, elevation, azimuth, and Signal-to-Noise Ratio (SNR) values. Each transmission identifies up to four satellites maximum; additional satellite data is sent in a second or third message. The total number of messages being transmitted and the number of the message being transmitted is indicated in the first two fields.

The contents of the GSV Message are described in Table 5-49.

Table 5-49. GSV Message: GPS Satellites in View Message

Message ID:	GSV			
Rate:	Variable; defaults to 0.5 Hz			
Fields:	19			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_ _GSV	Start of sentence and address field		$GPGSV
1	MAX_MSG	Total number of messages (1 to 3)	x	2
2	NUM_MSG	Message number (1 to 3)	x	1
3	NUM_SATS	Total number of satellites in view	xx	07
4	SAT_PRN	Satellite PRN number (Note 1)	xx	24
5	ELEV	Elevation in degrees (90 degrees maximum) (Note 2)	xx	60
6	AZ	Azimuth in True degrees (000 to 359) (Note 2)	xxx	216
7	SNR	SNR (C/No) 00 to 99 dB, null when not tracking	xx	50
8-11	...	2nd satellite PRN number, elevation, azimuth, SNR (Note 1)	xx, xx, xxx, xx	...
12-15	...	3rd satellite PRN number, elevation, azimuth, SNR (Note 1)	xx, xx, xxx, xx	...
16-19	...	4th satellite PRN number, elevation, azimuth, SNR (Note 1)	xx, xx, xxx, xx	...
	CKSUM	Checksum	*hh	*75
	<CR><LF>	Sentence terminator		<CR><LF>

Note 1:

    The visible satellites may include one or more that are below the horizon. Since NMEA does not account for negative elevation angles, the elevation field will be null for these satellites.

Note 2:

    Azimuth and elevation are null when the satellite is in track, but a visible list is not available.

Sample Message:

```
$GPGSV,2,1,07,24,60,216,50,20,47,135,47,12,40,020,47,16,36,319,46*75
```

5.6.1.6 Conexant Proprietary Receiver ID (RID).
This message is output automatically at startup after the receiver has completed its initialization. It can be used to determine when the receiver is ready to accept serial

input. Manual requests for this message are also honored.

The contents of the RID Message are described in Table 5-50.

Table 5-50. RID Message: Conexant Proprietary Receiver ID Message

Message ID:	RID			
Rate:	Variable (see above)			
Fields:	5			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_ _ _ _RID	Start of sentence and address field		$PRWIRID
1	NUM_CHN	Number of Channels	xx	12
2	SW_VER	Software Version	x.x	00.90
3	SW_DATE	Software Date	cccccccc	12/25/95
4	OPT_LST	Options List (Note 1)	hhhh	0003
5	RES	Reserved		
	CKSUM	Checksum	*hh	*40
	<CR><LF>	Sentence terminator		<CR><LF>

Note 1:

The options list is a bit-encoded configuration word represented as a four-digit hexadecimal number:

bit 0   minimize ROM usage
bit 1   minimize RAM usage
bits 2-15 reserved

Sample Message:

```
$PRWIRID,12,00.90,12/25/95,0003,*40
```

5.6.1.7 Recommended Minimum Specific GPS Data (RMC). This message contains time, date, position, course, and speed data. The fields in this message will always contain data even when the receiver is not navigating. This allows user-initialized, stored, or default values to be displayed before a solution is obtained.

The contents of the RMC Message are described in Table 5-51.

Table 5-51. RMC Message: Recommended Minimum Specific GPS Data Message

Message ID:		RMC			
Rate:		Variable; defaults to 1 Hz			
Fields:		11			
Field No.:	**Symbol:**	**Field Description:**		**Field Type:**	**Example:**
	$_ _RMC	Start of sentence and address field			$GPRMC
1	POS_UTC	UTC of position (hours, minutes, seconds, decimal seconds)		hhmmss.ss	185203
2	POS_STAT	Position status (A = Data valid, V = Data invalid) (Note 1)		a	A
3	LAT	Latitude		llll.ll	3339.7332
4	LAT_REF	Latitude direction (N = north, S = south)		a	N
5	LON	Longitude		yyyyy.yy	11751.7598
6	LON_REF	Longitude direction (E = east, W = west)		a	W
7	SPD	Speed over ground (knots)		x.x	0.000
8	HDG	Heading/track made good (degrees True)		x.x	121.7
9	DATE	Date (dd/mm/yy)		xxxxxx	160496
10	MAG_VAR	Magnetic variation (degrees)		x.x	13.8
11	MAG_REF	Magnetic variation (E = east, W = west) (Note 2)		a	E
	CKSUM	Checksum		*hh	*55
	<CR><LF>	Sentence terminator			<CR><LF>

Note 1:

The position status flag will be set to "V" (data invalid) until the receiver is navigating. At that time, the flag is changed to "A" (data valid) and the information provided in the RMC message will reflect a navigation solution.

Note 2:

Easterly variation (E) subtracts from True course.

Westerly variation (W) adds to True course.

Sample Message:

```
$GPRMC,185203,A,3339.7332,N,11751.7598,W,0.000,121.7,160496,13.8,E*55
```

5.6.1.8 Course Over Ground and Ground Speed (VTG). This message contains the course over ground (true and magnetic) and speed relative to the ground.

The contents of the VTG Message are described in Table 5-52.

Table 5-52. VTG Message: Course Over Ground and Ground Speed Message

Message ID:	VTG (while receiver is in Navigation Mode -- Note 1)			
Rate:	Variable			
Fields:	8			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_ _VTG	Start of sentence and address field		$GPVTG
1	TRU_CRS	Course over ground, degrees True	x.x	291.3
2	T	True course indicator	T	T
3	MAG_CRS	Course over ground, degrees magnetic	x.x	277.3
4	M	Magnetic course indicator	M	M
5	SPD_N	Speed over the ground (knots)	x.x	0.784
6	N	Nautical speed indicator (N = knots)	N	N
7	SPD_K	Speed (kilometers)	x.x	1.452
8	K	Speed indicator (K = km/hr)	K	K
	CKSUM	Checksum	*hh	*4F
	<CR><LF>	Sentence terminator		<CR><LF>
Note 1: Output of this message is temporarily suppressed while the receiver is in Acquisition Mode.				

Sample Message:

```
$GPVTG,291.3,T,277.3,M,0.784,N,1.452,K*4F
```

5.6.1.9 Conexant Proprietary Zodiac Channel Status (ZCH). This message complements the GSV message by providing satellite-to-channel mapping and a status indication for each channel.

The contents of the ZCH Message are described in Table 5-53.

Table 5-53. ZCH Message: Conexant Proprietary Zodiac Channel Status Message

Field No.:	Symbol:	Field Description:	Field Type:	Example:
Message ID:	ZCH			
Rate:	Variable; defaults to 1 Hz			
Fields:	24			
	$_ _ _ _ZCH	Start of sentence and address field		$PRWIZCH
1-2	SAT_PRN	Channel 1 satellite PRN number (Note 1)	xx	05
2	STATUS	Channel 1 status indication (Note 1)	hh_ _	F
3-4	...	Channel 2 satellite PRN number and status indication	xx,hh_ _	...
5-6	...	Channel 3 satellite PRN number and status indication	xx,hh_ _	...
7-8	...	Channel 4 satellite PRN number and status indication	xx,hh_ _	...
9-10	...	Channel 5 satellite PRN number and status indication	xx,hh_ _	...
11-12	...	Channel 6 satellite PRN number and status indication	xx,hh_ _	...
13-14	...	Channel 7 satellite PRN number and status indication	xx,hh_ _	...
15-16	...	Channel 8 satellite PRN number and status indication	xx,hh_ _	...
17-18	...	Channel 9 satellite PRN number and status indication	xx,hh_ _	...
19-20	...	Channel 10 satellite PRN number and status indication	xx,hh_ _	...
21-22	...	Channel 11 satellite PRN number and status indication	xx,hh_ _	...
23-24	...	Channel 12 satellite PRN number and status indication	xx,hh_ _	...
	CKSUM	Checksum	*hh	*37
	<CR><LF>	Sentence terminator		

Note 1:

Channel number (xx) is implied by position in message. Data for all 12 channels is always provided in this message. If a channel is unused, a value of 0 will appear for both channel fields. The status indication (hh_ _) is a one-digit, hexadecimal value which represents four bits as follows:

<y.0> Measurement of the satellite on this channel used in navigation solution.
<y.1> Ephemeris available for the satellite on this channel.
<y.2> Satellite on this channel is in track.
<y.3> DGPS corrections available for the satellite on this channel (NOTE: this bit will never be set whenever the configuration of a particular Zodiac GPS receiver does not support DGPS).

Sample Message:

```
$PRWIZCH,05,F,20,F,04,F,09,F,16,F,06,F,07,6,00,0,24,F,00,0,00,0,00,0*37
```

5.6.2 NMEA Input Message Descriptions. This section provides details for each of the input NMEA messages.

5.6.2.1 Conexant Proprietary Built-In Test (BIT) Command Message (IBIT). This proprietary message instructs the receiver to immediately execute its BIT. Results of the BIT are available in the Conexant Proprietary Built-In Test Results message. The data field is reserved and should be left null.

The contents of the IBIT Message are described in Table 5-54.

Table 5-54. IBIT Message: Conexant Proprietary Built-In Test (BIT) Command Message

Message ID:	IBIT			
Rate:	As required			
Fields:	1			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$PRWIIBIT	Start of sentence and address field (Note 1)		$PRWIIBIT
1	RES	Reserved		
	CKSUM	Checksum (optional)	*hh	
	<CR><LF>	Sentence terminator		<CR><LF>
Note 1:				

Note 1:

$ = NMEA message prefix.
P = Proprietary message indicator.
RWI = Conexant Systems Inc. mnemonic.
ILOG = BIT command message ID.

Sample Message:

$PRWIIBIT,

5.6.2.2 Conexant Proprietary Log Control Message (ILOG). This proprietary message controls the output of the Zodiac receiver's NMEA messages.

The contents of the ILOG Message are described in Table 5-55.

Table 5-55. ILOG Message: Conexant Proprietary Log Control Message

Message ID:	ILOG			
Rate:	As required			
Fields:	5			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$PRWIILOG	Start of sentence and address field (Note 1)		$PRWIILOG
1	MSG_ID	Approved sentence formatter of the data being requested (Note 2)	ccc	RMC
2	ENABLE	Output enable flag (A = enable, V = disable) (Note 3)	a	A
3	TRIG	Output trigger (t = on time, u = on update) (Note 4)	a	T
4	INTERVAL	Output interval (seconds, 0 = once) (Note 4)	x.x	5
5	OFFSET	Initial output offset (seconds from minute mark) (Note 4)	x.x	0
	CKSUM	Checksum (optional)	*hh	
	<CR><LF>	Sentence terminator		<CR><LF>

Note 1:

  $ = NMEA message prefix.
  P   = Proprietary message indicator.
  RWI   = Conexant Systems Inc. mnemonic.
  ILOG = Log control message ID.

Note 2:

  A special form of this field disables all output messages. Use "???" as the message ID as in the following example:

          $PRWIILOG,???,V,,,

Note 3:

  This field may be null to indicate that the previous setting should be left unchanged.

Note 4:

  The TRIG, INTERVAL, and OFFSET fields may be null to indicate that the previous setting should be left unchanged.

Sample Message:

  $PRWIILOG,RMC,A,T,5,0

5.6.2.3 Conexant Proprietary Receiver Initialization Message (INIT). This proprietary message commands the Zodiac receiver to perform a reset, modify its operating mode, or reinitialize itself using specified parameters.

The contents of the INIT Message are described in Table 5-56.

Table 5-56. INIT Message: Conexant Proprietary Receiver Initialization Message (1 of 2)

Message ID:	INIT			
Rate:	As required			
Fields:	14			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$PRWIINIT	Start of sentence and address field (Note 1)		$PRWIINIT
1	RESET	Software reset flag (A = reset, V = don't reset) (Note 2)	a	V
2	RES_1	Reserved		
3	RES_2	Reserved		
4	LAT	Latitude (Note 2)	llll.lll	3339.650
5	LAT_REF	Latitude direction (N = north, S = south) (Note 2)	a	N
6	LON	Longitude (Note 2)	yyyyy.yy	11751.680
7	LON_REF	Longitude direction (E = east, W = west) (Note 2)	a	W
8	ALT	Altitude (meters) (Note 2)	x.x	64.131
9	SPD	Ground speed (Note 2)	x.x	0.0
10	SPD_TYP	Ground speed units (M = m/sec, N = knots, K = km/hr) (Note 2)	a	M
11	HDG	Heading (0.0 to 360.0 degrees north) (Note 2)	x.x	0.0
12	HDG_TYP	Heading type (T = true, M = magnetic) (Note 2)	a	T
13	TIME	UTC time (hours, minutes, seconds) (Note 2)	hhmmss	162338
14	DATE	UTC date (Note 2)	ddmmyy	190594
	CKSUM	Checksum (optional)	*hh	
	<CR><LF>	Sentence terminator		<CR><LF>

Table 5-56. INIT Message: Conexant Proprietary Receiver Initialization Message (2 of 2)

Note 1:

$	=	NMEA message prefix.
P	=	Proprietary message indicator.
RWI	=	Conexant Systems Inc. mnemonic.
INIT	=	Initialization message ID.

Note 2:

This function is enabled by default.

Each of the fields 1 through 14 may be null to indicate that the previous setting for the data item should be left unchanged. For example, reset may be commanded without specifying the other parameters by issuing the following command:

```
$PRWIINIT,A, , , , , , , , , , , , ,<CR><LF>
```

When using null fields, the following restrictions apply:

- If a supplied parameter has a corresponding unit specifier or reference indicator, it must also be supplied.

- Both latitude and longitude must be provided to specify a valid horizontal position.

- Both ground speed and heading must be provided to specify a valid horizontal velocity.

- If a magnetic heading is specified, horizontal position (lat/lon), and UTC time and date must also be provided.

- UTC time and date must be provided together.

Sample Message:

```
$PRWIINIT,V,,,3339.650,N,11751.680,W,64.131,0.0,M,0.0,T,162338,190594
```

5.6.2.4 Conexant Proprietary Protocol Message (IPRO). This proprietary message allows the user to set the message format protocol which will be used to communicate information to and from the receiver through the host serial I/O port. Currently, the available protocols are binary (with fixed-point numbers) and NMEA-0183. Storage for the Protocol Type parameter requires EEPROM.

The contents of the IPRO Message are described in Table 5-57.

Table 5-57. IPRO Message: Conexant Proprietary Protocol Message

Message ID:		IPRO		
Rate:		As required		
Fields:		2		
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$PRWIIPRO	Start of sentence and address field (Note 1)		$PRWIIPRO
1	RES	Reserved		
2	PRO_TYPE	Protocol Type (RBIN = Conexant binary))	cccc	RBIN
	CKSUM	Checksum (optional)	*hh	
	<CR><LF>	Sentence terminator		<CR><LF>
Note 1:				

Note 1:

$ = NMEA message prefix.
P = Proprietary message indicator.
RWI = Conexant Systems Inc. mnemonic.
INIT = Initialization message ID.

Sample Message:

```
$PRWIIPRO,,RBIN
```

5.6.2.5 Standard Query Message (Q). This message is used to request a one-time output of any of the approved NMEA messages from the Zodiac receiver. The typical response time between receipt of a query and the transmission of the requested message is approximately one second.

The contents of the Q Message are described in Table 5-58.

Table 5-58. Q Message: Standard Query Message

Message ID:	Q			
Rate:	As required			
Fields:	1			
Field No.:	**Symbol:**	**Field Description:**	**Field Type:**	**Example:**
	$_ _ _ _ Q	Start of sentence and address field (Note 1)		$LCGPQ
1	MSG_ID	Approved sentence formatter of the data being requested	ccc	GSV
	CKSUM	Checksum (optional)	*hh	
	<CR><LF>	Sentence terminator		<CR><LF>
Note 1:				
The identifier of the device from which data is being requested (refer to paragraph 5.4.4 of this chapter) must be "GP" (GPS device) for the "Zodiac" receiver to recognize the message; otherwise, the message will be ignored.				

Sample Message:

$LCGPQ,GSV

6 ZODIAC GPS RECEIVER OPERATION

This section presents a detailed operational description of the Zodiac™ family of GPS receivers. An overview is provided for the navigation and receiver support functions. Each of the receiver's internal storage devices are described as well as how each one is initialized and used to control operational configurations. This section also provides a description of start-up modes and satellite management.

6.1 Internal (Onboard) Data Sources_____

Internal data sources are the "built-in" information storage capabilities of the GPS receiver. The onboard receiver firmware maintains these data sources for use on a continuing basis.

6.1.1 Static RAM (SRAM). SRAM is used to store all firmware variables manipulated by the GPS receiver. If external power has been supplied to SRAM during the "idle" state, this data will be available to the initialization functions at start-up. Satellite ephemeris, last position, and frequency standard parameters are important data that helps to minimuze Time-To-First-Fix (TTFF) if the data is available in SRAM.

6.1.2 Real-Time Clock (RTC). Along with SRAM, an onboard RTC is a valuable source of data at system start-up. If external power has been applied to the RTC during the "idle" state, time/date information will be available to the initialization functions at start-up.

Valid time/date is a key component used to compute satellite visibility and to minimize TTFF. Note that a value of "last known time" is available in SRAM. On

the Jupiter board, the RTC is powered whenever SRAM is powered (refer to section 6.7 for more information about the RTC).

6.1.3 Electrically Erasable Programmable Read-Only Memory (EEPROM). Onboard EEPROM is useful for long-term storage of data that varies somewhat over time but is, in general, fairly constant over short periods of time (weeks). Unlike SRAM and the RTC, power is not required to maintain data during "idle" states. Important data in EEPROM that helps to minimize TTFF includes satellite almanac, last known position, and frequency standard parameters. Note that EEPROM is used only if the required data is not available from SRAM (refer to section 6.7 for more information about the EEPROM).

6.1.4 Read-Only Memory (ROM). Onboard ROM is only used as a data source if SRAM and EEPROM are unavailable. Satellite almanac and frequency standard parameters can be obtained from ROM with limited usefulness.

6.2 Initialization _____

6.2.1 Definition. Initialization is defined as the set of data and/or actions that provide time varying information for use by the GPS receiver at start-up. The most common example is Position, Velocity, and Time (PVT) initialization. For a GPS receiver installed in an automobile, this information is constantly changing as time progresses and the vehicle moves from location to location.

Initialization data is required when the onboard data sources are old or invalid. Serial input messages are prepared by the user and transmitted to the GPS receiver. In general, the GPS receiver is capable of "bootstrapping" itself without any valid data sources, but TTFF times are extended.

6.2.2 Position, Velocity, Time (PVT) Data. The most common form of user supplied initialization data is position and time (velocity is normally included in

this group, but is only required for higher dynamic operations). Accurate PVT and valid almanac/ephemeris data are required to generate the current satellite visibility list and appropriate acquisition uncertainties, resulting in optimal TTFF performance.

6.2.3 Satellite Ephemeris. Unlike user PVT information, satellite ephemeris data is available from every satellite that is continuously tracked (18 seconds minimum collection time). The ephemeris is maintained in SRAM. This "over-the-air" availability means that the user does not normally have to supply ephemeris data.

6.2.4 Satellite Almanac. Almanac information for all satellites is available from each tracked satellite (12.5 minute collection time for the complete set) and is maintained in the onboard EEPROM and SRAM. Like ephemeris data, "over-the-air" availability means that

the user does not normally have to supply almanac data.

6.2.5 Universal Time Coordinated (UTC) And Ionospheric Parameters. UTC and ionospheric correction parameters are available from every tracked

satellite (broadcast once every 12.5 minutes) and are maintained in the onboard EEPROM and SRAM. Like almanac and ephemeris data, "over-the-air" availability means that the user does not normally have to supply UTC and ionospheric data.

6.3   Configuration _____

6.3.1 Definition. Configuration is defined as the set of data and/or actions that provide information that is fairly constant and usually connected with installation, environmental, or user preferences. Common examples are map datums or satellite elevation mask angle. Configuration data customizes and/or optimizes the GPS receiver for use in a particular situation. In general, this data is held constant until the user decides to change it. Table 6-1 provides a brief description of all default configuration parameters.

Configuration data controls the "personality" of the receiver. Stated another way, configuration data controls how the receiver works on a daily basis. Typically, this information is stored in EEPROM, accessed at the time of initialization, and updated whenever the user dictates a change.

The obvious benefit of this feature is that the board can be configured to work in a customized way.

Each of the various types of configuration data is briefly described in the following paragraphs.

6.3.2 Geodetic Datums. Zodiac GPS receivers provide two configuration features related to datums: datum selection and datum definition. Datum selection controls the transformation used for all navigation outputs and inputs. Over 180 predefined datums are available for user configuration.

Datum definition allows the user to specify a custom datum that can be used in the same way as an element of the predefined set. A maximum of five user-defined datums is supported. Refer to section 6.6 (Navigation) for more details.

6.3.3 Satellite Selection. Zodiac GPS receivers provide two configuration features related to satellite selection: elevation mask angle and candidate satellite specification. Satellite elevation mask angle defines the elevation angle that is used to screen satellites for inclusion in the navigation solution and Dilution of Precision (DOP) calculations. Satellites that fall between the elevation mask angle and the horizon (0 degree mask) are tracked, when possible, to gather their

ephemeris data so they are ready to be used when they rise above the elevation mask.

Satellite candidate specification is used to explicitly control inclusion in the visible list (satellites above horizon). By default, a satellite is a candidate until it is excluded, at which point it must be re-selected to be a candidate again. Refer to sections 6.6 and 6.7 (Navigation and Support Functions, respectively) for more details.

6.3.4 Differential GPS (DGPS) Control. Zodiac GPS receivers provide two configuration features related to DGPS operation: disable and correction timeout. When DGPS disable is asserted, the navigation solution is computed without the benefit of differential corrections even if they are available.

The DGPS timeout parameter is used to specify the maximum allowable time difference between current time and the validity time of the DGPS corrections. If the timeout is exceeded, DGPS navigation solutions are unavailable until the correction time delta becomes less than the timeout. Refer to sections 6.6 and 6.7 (Navigation and Support Functions, respectively) for more details.

6.3.5 Cold Start Control. A simple control that enables or disables this feature and sets the timeout for automatic transition to cold start is available. Refer to section 6.4 for a description of this feature.

6.3.6 Solution Validity Criteria. This configuration feature allows the user to specify a set of conditions that must be met for a navigation solution to be reported as "valid." Constraints that can be imposed on solution validity include:

- Use of DGPS corrections.
- Use of altitude.
- Minimum number of satellites.
- Maximum expected position errors (EHPE and EVPE).

Refer to section 6.6 (Navigation) for a description of this feature.

Table 6-1. Default Configuration Data

Parameter	Value/Description
Datum	WGS-84
Mask angle	10 degrees
Cold start control	Enabled
Timeout	300 seconds
Platform class	Automotive
Altitude measurement validity	Mark altitude solutions valid
Maximum Expected Horizontal Position Error (EHPE) validity	100 meters (*)
Maximum Expected Vertical Position Error (EVPE) validity	150 meters (*)
Criterion for the minimum number of satellites used for a solution	Zero (*) (**)
DGPS validity	Not required for a valid solution (*)
Held altitude	Enabled
Position pinning	Enabled (automatically disabled when DGPS corrections are available)
Ground track smoothing	Enabled (only when DGPS is not available)
DGPS disable	"false" (i.e., DGPS is active if corrections are available)
Host port communication parameters (Conexant binary)	9600-N-8-1
Host port communication parameters (NMEA)	4800-N-8-1
Auxiliary port communication parameters (RTCM input only)	9600-N-8-1

(*) Solution validity criteria.
(**) After a "fully determined" or successful transition to navigation.

6.3.7 User-Entered Altitude. This configuration feature allows the user to supply a known value of altitude that can be used to improve the overall quality of the navigation solution. The most common application of this feature is to provide a mean sea level value for a boat that is used exclusively on an ocean. Refer to section 6.6 (Navigation) for more details.

6.3.8 Vehicle Platform Select. This configuration feature allows the user to specify the type of vehicle in which the Zodiac receiver has been installed. Refer to section 6.6 (Navigation) for more details.

6.3.9 Navigation Control. Several navigation control features are provided by the Zodiac GPS receivers. These features are:

- Groundtrack smoothing.
- Position pinning.

- Validity criteria.

Refer to section 6.6 for more details on these features.

6.3.10 Configuration Straps. Configuration straps control the use of available configuration data at the time of initialization. These straps act as metacommands that can override or complement an existing set of configuration data. Note that these straps are only read once at initialization time, so a power cycle or software reset must be executed after any strap changes are made.

6.3.10.1 National Marine Electronics Association (NMEA) Select. When asserted, the host serial communication interface is configured for NMEA operation (4800-8-N-1). Configuration data related to the host port that may be available from other sources is not used. When de-asserted, operation of the host port is controlled by any available configuration data

sources (SRAM, EEPROM, etc.). Details of the NMEA message set are contained in Section 5 of this Designer's Guide.

6.3.10.2 ROM Defaults. When asserted, all configuration and initialization data is obtained from ROM defaults. In addition, SRAM is cleared to

guarantee that the receiver is started in a known operational state. The host serial communication interface is configured for Conexant binary operation (9600-8-N-1). When de-asserted (the normal operational state), configuration and initialization data are obtained from all valid sources (SRAM, EEPROM, RTC, etc.).

6.4   Start-Up Modes_____

Zodiac GPS receivers have four types of start-up modes (Warm, Initialized, Cold, and Frozen) based on the availability and source of initialization data. Each of these modes are briefly described in the following paragraphs.

6.4.1 Warm Start. This state is present when all key data (PVT, ephemeris, and frequency standard parameters) is valid and available in SRAM. Two common conditions that result in this state are a software reset ("hot" start) after continuous navigation or a return from an "idle" period (power cycle) of a few minutes that was preceded by a period of continuous navigation.

6.4.2 Initialized Start. This state is similar to Warm Start except that ephemeris data is not available at start-up, implying that SRAM was not powered during the "idle" state or that the data time validity has expired. Common conditions that result in this state are user-

supplied PVT initialization or continuous RTC operation with an accurate last known position available from EEPROM.

6.4.3 Cold Start. This state occurs as a result of unknown position and/or time, either of which causes an unreliable satellite visibility list. Almanac information is used to identify previously healthy satellites and to generate "working" visible satellite lists, while frequency standard data minimizes satellite acquisition uncertainties.

6.4.4 Frozen Start. This state is entered if there are no valid data sources available (SRAM, RTC, EEPROM). This is considered to be a recovery mode because EEPROM should always contain valid information. An "out-of-the-box" board or a unit that has not operated for a significant amount of time (months) may approximate this state because the data in EEPROM may be valid but expired or partially complete.

6.5   Satellite Management_____

This section describes the satellite management functions of the Zodiac family of GPS receivers.

6.5.1 Visible List Generation. A list of satellites visible to the receiver antenna is maintained whenever possible. A satellite is considered visible if its elevation in the sky is known to be above the horizon, if its almanac and ephemeris data indicate it is healthy, and if it has not been excluded by manual candidate satellite specification. Note that although a satellite is visible, its measurement is only available for use if the satellite is above the elevation mask angle.

The receiver's channel resources are directed toward acquiring only those satellites which appear in this list except when the receiver is in cold start mode. Satellites within the list are ordered from highest to lowest elevation which, for sequential acquisition, also dictates the order in which acquisition attempts are made.

Receiver position and current time are required to compute satellite positions from orbital data. If position

and/or time is not considered to be well known (i.e., their expected errors are large), then the list is extended below the horizon and is filled to the maximum of 12 satellites. If DGPS corrections are available, the satellites represented in the corrections are used to set the list membership instead, since they also represent satellites visible to a nearby transmitting DGPS base station.

New visible satellite lists are generated by events that could cause a change in satellite list membership or could indicate a significant change in a satellite position relative to the antenna. These events include receipt of an elevation mask angle or candidate satellite specification command, downloading of a new satellite almanac, and changes in satellite health status reflected in new almanac or ephemeris data.

In the case where DGPS corrections are used to establish list membership, a change in the set of satellites reflected in the corrections also causes a new list to be generated.

During initial acquisition, a new list is generated when the receiver makes step adjustments to position and time. In the absence of these events, the visible satellite list is updated every 30 seconds. The visible satellite list is output in the Visible Satellites message (binary Message 1003).

6.5.1.1 DOPs. Geometric Dilution of Precision (GDOP) is a measure of the quality of a satellite constellation geometry. GDOP reflects the influence of satellite geometry on the accuracy of user position and time estimates. The best geometry is that which produces the lowest GDOP value. GDOP acts as a multiplier of the error in position and time estimates due to other sources.

GDOP is a composite measure. It can be separated into Position Dilution of Precision (PDOP), which reflects the effects of geometry on three-dimensional position estimates, and Time Dilution of Precision (TDOP), which reflects geometric effects on time estimates. The relationship can be expressed as:

$$\text{GDOP} = \sqrt{(\text{PDOP})^2 + (\text{TDOP})^2}$$

In turn, PDOP can be separated into horizontal and vertical components: Horizontal Dilution of Precision (HDOP) and Vertical Dilution of Precision (VDOP). These components represent the effects of satellite geometry on two-dimensional horizontal position and on vertical position (altitude) estimates, respectively. This relationship can be expressed as:

$$\text{PDOP} = \sqrt{(\text{HDOP})^2 + (\text{VDOP})^2}$$

The receiver computes the best available GDOP and each of its components in the Visible Satellites message (binary Message 1003). The best available GDOP is that associated with the satellite constellation consisting of all visible satellites above the mask angle (satellites whose measurements may be used).

At least four satellites are required to estimate position and time, and therefore to compute a GDOP. The DOP fields in Message 1003 are set to maximum values when GDOP cannot be computed.

6.5.2 Acquisition Modes. Two methods of satellite acquisition are used by the Zodiac GPS receiver: sequential acquisition and parallel acquisition.

6.5.2.1 Sequential Acquisition. Sequential acquisition describes the acquisition of a satellite with all non-tracking channels. An example of this acquisition mode is Cold Start, in which individual satellite acquisitions

are attempted one at a time using all available channels to cover the wide doppler uncertainty.

As satellites are acquired, they stay in track on one channel with the remaining channels available for the next acquisition. Sequential acquisition is always used to acquire the first satellite. The receiver will automatically transition to parallel acquisition after the first satellite is acquired during a Warm Start or an Initialized Start.

6.5.2.2 Parallel Acquisition. Parallel acquisition describes the acquisition of a satellite with a single non-tracking channel. An example of this acquisition mode occurs after the first satellite is acquired in Warm Start, in which all of the visible satellites are assigned a channel and acquisitions are attempted simultaneously. Note that even though a single channel is being used, a large doppler uncertainty can still be covered with extended search time.

6.5.2.3 Adaptive Threshold-Based Signal Detection. To extend the weak signal reception capability of the receiver, an adaptive noise threshold-based detection scheme has been implemented in the receiver software. With this approach, a variable detection threshold is computed from the average cross-correlation value of the received signal with a Pseudo-Random Noise (PRN) code. This PRN code is similar in structure to the GPS satellite PRN codes but uses a PRN ID that is not assigned to any of the GPS satellites. The computation of the received C/No power is also based on the cross-correlation value as determined above.

This scheme lowers the average detection threshold for weak signals, thus improving the receiver's ability to acquire and track satellites under these conditions. Conversely, this scheme sets a higher threshold when strong signals are received. This method results in more reliable acquisition of satellites and a corresponding reduction in TTFF over a wider variation of GPS signal strength conditions.

6.5.2.4 Overall Search Process. Figure 6-1 depicts the overall search process as it interacts with the visible satellite list generation described in section 6.5.1. Sequential or parallel acquisition is selected based on channel availability and the required frequency search range (the number of doppler bins) for each satellite.

6.5.3 Data Collection. Subframe data collection is a continuous process once a satellite is in track. This technique guarantees that current ephemeris and almanac information are always available to an operating GPS receiver (making identification of unhealthy satellites easy).

```
                          ┌──────────────────┐
                          │   Start Search   │
                          └──────────────────┘
                                   │
              ┌────────────────────────────────────────┐
              │   Compute Visible Satellite List Ordered│
              │   From Highest to Lowest Elevation Angle│
              │           SV(1) --> SV(n)               │
              └────────────────────────────────────────┘
                                   │
                          ┌──────────────────┐
                          │      i = 1        │
                          └──────────────────┘
                                   │
              ┌────────────────────────────────────────┐
              │   Estimate Oscillator Frequency Uncertainty │
              └────────────────────────────────────────┘
                                   │
              ┌────────────────────────────────────────┐
              │   Determine Required Doppler Bins For SV(i) │
              └────────────────────────────────────────┘
                                   │
                     N    ◇ Hardware Channel ◇
                    ◄──────  Available?
                                   │ Y
              ┌────────────────────────────────────────┐
              │   Assign Hardware Channel to Search     │
              │         Specific Doppler Bin            │
              └────────────────────────────────────────┘
                                   │
                     N    ◇ SV(i) Doppler Bins ◇
                    ◄──────  Fully Assigned?
                                   │ Y
                          ┌──────────────────┐
                          │    i = i + 1     │
                          └──────────────────┘
                                   │
                     N    ◇     i > n?     ◇
                    ◄──────
                                   │ Y
                     N    ◇ All Visible Satellites ◇   Y
                    ◄──────   In Track?          ──────►  End Search Process
```
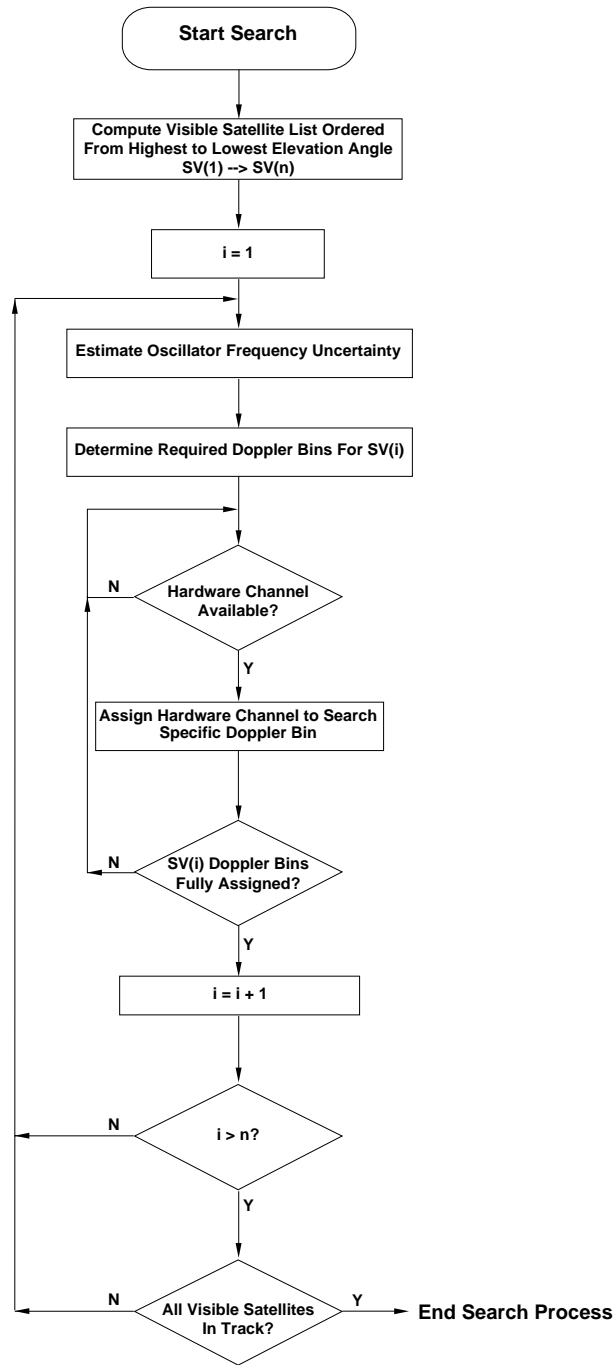
Figure 6-1. Zodiac Search Process

6.5.3.1 Ephemeris. Ephemeris data is gathered and maintained on a per satellite basis. For continuously tracked satellites (no blockage), it will take between 18 and 36 seconds to gather the data set. Once gathered, it is used to compute high accuracy satellite position, velocity, and acceleration (PVA) states for navigation and reacquisition processes. Note that this data is not maintained in EEPROM due to its limited time validity.

6.5.3.2 Almanac. Almanac data is gathered and maintained on a per satellite basis. For continuously tracked satellites (no blockage), it will take a minimum of 12.5 minutes to gather the complete data set for all satellites. The primary function of almanac data is to provide approximate satellite PVA states for the acquisition process. Note that this data is maintained in

EEPROM due to its validity over an extended time range (weeks).

6.5.3.3 UTC And Ionospheric Corrections. This data is gathered and maintained independently of the satellite from which it was obtained (one set is used for all). For continuously tracked satellites (no blockage), it will take a minimum of 12.5 minutes to gather an updated data set.

UTC corrections are used to compute the exact time offset between GPS and UTC time. Ionospheric corrections are used by the navigation process to compensate for the effects of the satellite signal passing through the Earth's ionosphere. Note that this data is maintained in EEPROM due to its validity over an extended time range (weeks).

6.6   Navigation _____

This section describes the operation of the navigation software in the GPS receiver. This software initializes and maintains a state vector which is used to report time, position, and velocity to the user.

The navigation software uses pseudorange, integrated carrier phase, and doppler measurements from the satellites, and external altitude inputs if available. An eight-state Kalman filter estimates position, velocity, and clock errors.

The OEM has substantial control over the operation of the navigation system to customize it for a specific application. This section defines many of the features of the navigation system with emphasis on those that the OEM can control.

6.6.1 Geodetic Datums. Geodetic parameters are used in both input and output messages. The receiver reports position as a set of geodetic parameters (latitude, longitude, and altitude) in the Geodetic Position Status Output message (binary Message 1000). Geodetic parameters are also reported in the GPS Fix Data message (NMEA Message GGA), with the substitution of Mean Sea Level (MSL) altitude for geodetic altitude, and in the Recommended Minimum Specific GPS Data message (NMEA Message RMC) as latitude and longitude. The receiver expects geodetic parameters as part of the Geodetic Position and Velocity Initialization input message (binary Message 1200).

Whether geodetic parameters are used as input or output data, they are always referenced to the currently selected geodetic datum. Each geodetic datum is defined by five parameters:

- The semi-major axis
- Flattening of the reference ellipsoid
- Delta X component of the WGS-84 datum origin offset.
- Delta Y component of the WGS-84 datum origin offset.
- Delta Z component of the WGS-84 datum origin offset.

The receiver has 189 pre-defined user datums selectable by the OEM. These datums, together with their identification codes, are listed in Appendix E of this Designer's Guide. All of the pre-defined datums are taken from the U.S. Government document, *Department of Defense World Geodetic System 1984*.

6.6.1.1 User Selection of Geodetic Datums. The default datum is WGS-84 (defined as datum code zero for the receiver). Other datums are selected using the Map Datum Select message (binary Message 1211). The selected code is reported back in the position status output message 1000 or 1001.

For example, if the receiver was in Conexant binary mode and the OEM wanted to use a previously recorded position to initialize the receiver, and then get reported positions in WGS-84, the OEM would send three messages to the receiver as follows:

1. Send a Map Datum Select message (binary Message 1211) with the desired datum code (the new datum code is reported back in Message 1000 and/or 1001 if either or both messages have been enabled).

2. Send a Geodetic Position and Velocity Initialization message (binary Message 1200) with the correct latitude, longitude, and altitude.

3. Finally, send another Message 1211 with the datum code 0 to set the datum back to WGS-84.

The selected datum is always stored in EEPROM, so that it is saved during power-off and reset cycles.

The Conexant binary Map Datum Select message must be used to change the geodetic datum; the datum cannot be changed when in NMEA mode. NMEA outputs will use the last datum selected in binary mode or WGS-84 if a datum selection has never been made.

6.6.1.2 User Defined Datums. Besides the 189 pre-defined datums, the OEM can define five custom datums for a specific application. Each datum is defined by the five parameters described in section 6.6.1 and the new datum definition is sent to the receiver using the User-Defined Datum Definition message (binary Message 1210).

There are five custom datum codes to choose from, 300 to 304. All user-defined datums are stored in EEPROM. Once the datum is stored, it is selected using the Conexant binary Map Datum Select message in the same manner as the pre-defined datums. If a custom datum is stored and later re-defined, the existing datum will be overwritten.

6.6.2 Platform Class. The Zodiac GPS receiver supports three platform classes:

*   Pedestrian (low dynamics)
*   Automotive (medium dynamics)
*   Aircraft (high dynamics)

The platform class is set by the OEM to optimize navigation processing for the dynamics of the specific platform that is carrying the receiver. The class is used to set process noise parameters, velocity decay time constants, and speed and altitude limits.

The default platform class is automotive. The OEM sets the platform class using the Application Platform Control message (binary Message 1220). The platform class is stored in EEPROM, so it is retained when power is turned off.

6.6.2.1 Pedestrian. This platform class is used when the receiver is mobile in a low dynamic environment. An example would be a handheld GPS receiver used for hiking.

6.6.2.2 Automotive. This platform class is for moderate dynamic environments where altitude is not constant. A common example would be a car or truck, although motorcycles and touring bicycles also fall into this category.

6.6.2.3 Aircraft. This platform class is for high dynamic environments where altitude may change rapidly. Examples are airplanes and helicopters.

6.6.3 Navigation Cycle. The navigation software nominally executes once per second. During each execution, the navigation state is propagated forward in time to the current time and updated with any available measurements. The navigation solution is then provided to the serial interface for output in the selected message set (either Conexant binary or NMEA).

6.6.3.1 State Propagation. User state propagation over the measurement update interval, nominally one second, is by dead reckoning with constant tangent plane velocity. The tangent plane is defined by the current position and the selected datum. This means that if the vertical velocity is zero, the state propagation will be at constant altitude in the user-selected datum. For Pedestrian, Automotive, and Aircraft platforms, user state propagation is in three dimensions.

Once the receiver has been navigating and a velocity has been established by the Kalman filter, it will be used to propagate the state forward in the absence of further measurements for a limited time period, until the estimated errors in the propagated velocity have reached certain limits. Once these limits are reached, the velocity estimate is considered less reliable and is decayed exponentially with platform class dependent time constants.

6.6.3.2 Measurement Processing. Once four satellites are available above the elevation mask angle with ephemeris data and sufficiently good geometry, the Kalman filter begins to process the measurements. The Kalman filter processes two measurements for each satellite, the integrated carrier phase measurement (also known as carrier-smoothed pseudo-range) and the doppler, or range rate, measurement.

6.6.3.3 Altitude Processing. The receiver uses altitude aiding if a source is available and the Expected Vertical Position Error (EVPE) exceeds a threshold. The sources available for aiding, in the order of preference for use, are:

1. User-Entered Altitude.
2. Held Altitude.

3.   ROM Altitude (Acquisition Only).

User-Entered Altitude. The User-Entered Altitude Input message (binary Message 1219) is used to supply an altitude to the receiver. The altitude can be specified as instantaneous, valid until cleared from RAM, or valid until cleared from EEPROM.

Instantaneous altitude is valid for one navigation cycle only. This altitude input type is used when there is a continuous source of external altitude data.

Held Altitude. Held altitude is stored in the receiver when the navigation solution is valid. The held altitude is stored with a variance that grows from the last time it was updated to reflect the age and growing uncertainty of the altitude estimate.

Use of held altitude is normally a significant performance boost in an urban environment with heavy blockage and it is enabled by default. A held altitude value is discarded if the estimated climb rate magnitude exceeds 1 m/sec. The OEM can disable the use of held altitude using the Nav Configuration message (binary Message 1221).

6.6.3.4 Position Pinning. When the receiver is not using DGPS, satellite measurements include time varying range errors. These errors induce velocities in the receiver's state estimate even if the receiver is motionless. The magnitude of these velocities depends on the geometry and number of satellites in track. Typical values are between one-half and two meters per second. The position estimate of the receiver will wander around inside a circle of approximately 100 meters (the 2-Drms position error specified in the *GPS SPS Signal Specification*).

This wandering of the position estimate while the receiver is static is undesirable for users who display their position on a map or for those with similar applications. The receiver's proprietary navigation software is capable of "pinning" the position output when the estimated velocity is low and the navigation solution is of good quality. This prevents the wandering behavior of the solution in static situations, but introduces some risk that actual platform motion will be mistaken for SA induced wandering.

By default, the position pinning feature of the Zodiac GPS receiver is enabled. The OEM can turn it off using the Nav Configuration message (binary Message 1221). Users who expect to see the effects of SA in their solutions should turn it off to prevent the possibility of mistaking platform motion as SA wander. The configuration word which controls this feature is

stored in EEPROM and the user setting will be retained through power-off and reset cycles.

6.6.3.5 Ground Track Smoothing. Without the use of DGPS, satellite measurements are corrupted by SA and do not generate a consistent estimate for receiver position. Typical range errors are on the order of 30 meters. The receiver processes all satellites above the mask angle to minimize the effects of the range error.

Changes occur in the set of satellites being processed because of blockage, and the rising and setting of satellites. When a change occurs, the position estimate formed from averaging these errors is shifted. These shifts can be substantial, typically 10 to 20 meters, but up to 100 or more in bad geometry.

The receiver has a proprietary compensation technique for these constellation switch effects which maintains a smooth estimate of the platform's groundtrack and altitude. This smoothing is accomplished without any loss of dynamic response.

However, this method is not required and is automatically disabled when DGPS is available. Without DGPS, the method is enabled by default. Most users should leave it enabled. One reason for disabling it would be to compare the solution with a point solution from another receiver or a solution calculated off-line.

Ground track smoothing can be disabled using the Nav Configuration message (binary Message 1221). The configuration word is stored in EEPROM, so the setting for groundtrack smoothing will be retained through power-off and reset cycles.

6.6.4 Solution Validity. The validity of navigation solution outputs is determined by user-defined criteria. The OEM can specify which criteria to apply for the particular application. There are five possible criteria used to validate a solution:

1.   Was an altitude measurement used?
2.   Was DGPS used?
3.   How many satellite measurements were used?
4.   What is the Expected Horizontal Position Error (EHPE)?
5.   What is the Expected Vertical Position Error (EVPE)?

The OEM cannot change the validity criteria in NMEA mode. These criteria can be set using only the binary Solution Validity Criteria message (Message 1217) and they are retained through power-off and reset cycles in EEPROM.

6.6.4.1 Altitude Measurement Validity Criterion. The altitude measurement validity criterion allows the OEM to specify if solutions that make use of an altitude measurement should be marked valid. Altitude is not used in the solution unless it is necessary because of deteriorating EVPE or untracked satellites. When it is required, the OEM may wish this to be an indication that the solution is invalid for purposes of the specific application. The default is that solutions using altitude measurements may be marked valid.

6.6.4.2 DGPS Used Validity Criterion. The DGPS used validity criterion indicates an invalid navigation solution if DGPS is unavailable after it has been required. The system default is that DGPS is not required for a valid solution.

6.6.4.3 Number of Satellites Used Validity Criterion. The number of satellites used validity criterion indicates an invalid navigation solution if the minimum number of satellites required to be in the solution is not met. The default for this test is zero.

A solution may be reported as valid with no measurements used so long as the EHPE and EVPE criteria pass and a Kalman filter solution has been previously computed. The reason the default is set to zero is to allow the receiver to coast through brief outages without declaring the solution invalid (e.g., for example, under a freeway overpass).

If the measurements are lost for a long time, the EHPE and EVPE will grow until they surpass their thresholds and the solution fails the validity test for that reason. Some applications require a solution to be marked invalid unless it uses three, four, or more satellites. The OEM can set any of these thresholds by sending a binary Solution Validity Criteria message (Message 1217) with the number of satellites required.

6.6.4.4. Maximum EHPE Validity Criterion. The EHPE is the one sigma horizontal position error estimate for the solution. The validity criterion default is 10 meters. The meaning of the reported EHPE depends on whether or not DGPS is in use. If DGPS is in use the EHPE is the estimated one-sigma error in <u>absolute</u> position accuracy. When DGPS is not in use, the EHPE and EVPE are reported with the effects of the satellite User Equivalent Range Error (UERE) excluded. This excludes SA induced error from the EHPE and EVPE.

So in SPS navigation, the EHPE and EVPE serve as convergence indicators for the Kalman filter, not as absolute accuracy limits for the reported position. The EHPE validity threshold can be set by the OEM in the binary Solution Validity Criteria message (Message 1217).

6.6.4.5 Maximum EVPE Validity Criterion. The EVPE is the one sigma vertical position error estimate for the solution. The default is 25 meters. The operation and meaning of this criterion is analogous to the EHPE criterion in section 6.6.4.4. The threshold can be set in the binary Solution Validity Criteria message (Message 1217).

6.6.5 Mean Sea Level (MSL). MSL is a geoid, or a surface of equal gravitational potential. The height of the MSL geoid above or below the reference ellipsoid (WGS-84 by default) is called the geoidal separation. A positive geoidal separation means that the geoid is above the ellipsoid.

Values for the geoidal separation are computed at any receiver position by interpolating on the table of geoidal separation values provided in the U.S. Government document, *Department of Defense World Geodetic System 1984*.

Altitude or height computation is referenced to the ellipsoid (WGS-84 by default) and is referred to as geodetic altitude. Altitude referenced to the geoid (usually referred to as altitude MSL) can be computed as the geodetic altitude minus the geoid separation.

6.6.6 Magnetic Variation. The magnetic variation model used in the receiver is derived from the full International Geomagnetic Reference Field (IGRF) 95 magnetic model. Documentation, tabular data, and test programs for the IGRF 95 magnetic model can be obtained from the National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC) web site (http://julius.ngdc.noaa.gov/seg/potfld/geomag.html).

The magnetic variation is used to convert true heading to magnetic heading. It is output in binary Message 1000. To convert the true course provided in binary Message 1000 to magnetic heading, the magnetic variation is added to the true course.

6.7   Support Functions _____

This section describes the support functions of the GPS receiver.

6.7.1 Serial Communication Interfaces. Zodiac GPS receivers provide two bi-directional serial communication interfaces: the Host and Auxiliary ports. More information on these interfaces is provided in Section 5 of this Designer's Guide.

6.7.1.1 The Host Port. The Host port is the primary interface to the controlling application and provides all the services for initializing and configuring the system as well as for the reporting of the navigation solution and receiver status.

By default, the Host port is configured for 9600 baud, no parity, 8 data bits, and 1 stop bit. The Conexant binary communications protocol is the default selection for the Host port.

The default settings (configuration and protocol) can be overridden with the use of the NMEA Select control line of the interface. When this line is asserted, the configuration defaults to 4800 baud, no parity, 8 data bits, and 1 stop bit, and the communications protocol defaults to NMEA. Note that the NMEA Select line will override any previously stored selections for the Host port configuration and communication settings.

While using the Conexant binary communications protocol on the Host port, a number of application specific parameters can be configured to customize the receiver for a specific application. The ability to freely switch between Conexant binary and NMEA modes provides full capability to all users.

Host port output messages can be configured using the log control messages supported in both Conexant binary and NMEA message protocols. Changes to the port configuration settings, communications protocol, and message controls are stored in non-volatile EEPROM.

6.7.1.2 The Auxiliary Port. The Auxiliary port is used exclusively for the receipt of differential corrections in RTCM SC-104 serial message format.

By default, the Auxiliary port is configured for 9600 baud, no parity, 8 data bits, and 1 stop bit.

6.7.2 EEPROM Services. The EEPROM services provide for the non-volatile storage and retrieval of system configuration parameters and data that vary

somewhat by time but are, in general, fairly constant for short periods of time (weeks).

The configuration and operational data stored in EEPROM is only read during system intialization if the complimentary SRAM data is invalid. When data is stored in EEPROM, a checksum is stored with it to validate the data when it is read. If the data read from EEPROM during initialization is invalid, default values from ROM will be used to initialize the system.

EEPROM data blocks are updated/refreshed when the corresponding system data changes significantly. The qualification of a significant change varies for each data block. In the case of user configurable data items (datum selection, user-defined datums, platform class, communication parameters, etc.), simply receiving new inputs is all that is required for the data to be refreshed in the EEPROM.

In the case of slowly changing data (position, almanac, frequency standard data, etc.), additional constraints of distance moved, change in value, and/or elapsed time are imposed on the EEPROM update.

The various parameters and data maintained in the Zodiac receiver's EEPROM are listed in Table 6-2.

6.7.3 RTC Services. The RTC services provide for the storage of time/date data, maintained while the system is in an "idle" state. As long as external power is provided to the RTC device, it will keep the time/date data current, providing the system with accurate time initialization as needed.

The time/date data is only read from the RTC during system initialization. When the time/date data is stored in the RTC, a snapshot of the data is stored with a checksum in the RAM space of the RTC device (RTC-RAM). The snapshot data in the RTC-RAM is used to determine if the RTC was kept alive, and therefore if the time/date data is valid. If the clock data is not valid at system initialization, the "last known time" stored in SRAM will be used if it is available, otherwise time will be invalid.

The time/date data is updated in the RTC periodically while the system is in its Kalman filter navigation mode.

6.7.4 Differential GPS (DGPS). DGPS techniques can be used to eliminate errors introduced by Selective Availability (SA) and other error sources. DGPS requires one GPS receiver to be located at a precisely surveyed location. This receiver, often referred to as a

"base station" or "reference station," calculates corrections to the measured pseudorange and delta-range measurements from each of the satellites it is tracking.

These corrections are then broadcast over a communications link to remote GPS receivers in the field which apply these corrections to their measurements before computing a position solution. This technique effectively eliminates much of the error due to SA as well as errors due to unmodeled satellite clock errors, satellite ephemeris errors, and atmospheric delays. This "improved" solution is present in all output messages.

With a few minor exceptions outlined below, DGPS is enabled by default, but may be disabled by the OEM. Because SA changes with time, the corrections deteriorate with time as well. Therefore, DGPS operation will only occur when enough current DGPS corrections are available.

The Zodiac receiver accepts RTCM SC-104 format DGPS correction messages directly on the auxiliary serial port.

The receiver also accepts DGPS corrections data formatted as a binary data input message (Message 1351) over its primary serial port. More detailed information on the format of this message is provided in Section 5 of this Designer's Guide.

6.7.4.1 The RTCM Protocol. The Zodiac will accept 6-of-8 RTCM SC-104 data directly from the auxiliary serial port. No external formatting is required and the receiver handles all parsing and verification of the data. The user needs only to verify the integrity of the data sent to the receiver to ensure that high bit errors are not present in the detected RTCM raw data stream.

The user should be aware that RTCM SC-104 data will be used only if, for every 30-bit word, the syndrome (6-bit parity) exactly matches the one which should occur on the basis of the 24-bit data seen in each word. No attempt will be made to correct single bit errors; any syndrome mismatch will cause rejection of that data word and rejection of the message in which it exists.

The receiver will parse the incoming data bits and decode all of the RTCM SC-104 messages. Those messages required for DGPS operation will be used to fill in the DGPS database within the receiver. Those messages which are not used will be discarded.

6.7.4.2 The RTCM Message Types. The receiver accepts DGPS correction data as a subset of the 64 RTCM SC-104 messages found in Table 4-2 of the RTCM SC-104 Version 2.1 standard. Though the receiver will accept and decode all RTCM messages, not all messages are necessary for DGPS operation.

The Data Sheet for each of the Zodiac GPS receivers (Jupiter, Pluto, etc.) shows which of the messages defined in the RTCM standard are used by the receiver to form a DGPS position solution. Refer to the standard for more detailed descriptions of these and other RTCM SC-104 messages. (The user should be aware that RTCM SC-104 is still an evolving standard, and that future releases of Zodiac software may be modified to accommodate its revision.)

Type 1 Message. Type 1 messages contain pseudorange and pseudorange rate corrections for a complete set of visible satellites. Currently, this is the most common type of message transmitted by commercial RTCM providers and base stations.

Type 2 Message. Type 2 messages contain delta corrections and are transmitted by reference stations to help receivers during ephemeris cutovers. These

Table 6-2. Parameters And Data Maintained In EEPROM

Configuration Data	Satellite Management Parameters	Navigation Data
Serial Port Configuration (both ports)	UTC and Ionosphere Model Parameters	Last Known Position
Solution Validity Criteria	Frequency Standard Data	User-Entered Altitude
Selected Datum	Almanac Data	
Platform Class		
Cold Start Control		
Satellite Elevation Mask Angle		
Satellite Candidate List		
Differential GPS Control		
Default Serial Output Messages		
User Defined Datums		
Navigation Control		

messages are used by the field receiver in conjunction with Type 1 or Type 9 messages until both the reference station and field receiver are operating with the same set of ephemeris.

Type 9 Message. Type 9 messages have the same format as Type 1 messages, but usually only contain corrections for a subset of the visible constellation. These messages are typically transmitted at a higher rate than the Type 1 messages. Beacons, such as those operated by the U.S. Coast Guard, are currently the primary source for these corrections, but they are also available from some commercial service providers and base stations.

6.7.4.3 Compliance With RTCM SC-104 Requirements. The Radio Technical Commission for Maritime Services (RTCM) has a special committee numbered 104 (SC-104). Its charter is to create recommended standards for the transmission of DGPS correction data. The Zodiac family of receivers complies with the current version of this standard (version 2.1) with the exception of the serial data hardware implementation.

The specification for the serial data interface will be as described in Section 5 of this Designer's Guide. The Zodiac is not configured as "terminal equipment" as specified in paragraph 5.3.4 of the RTCM SC-104 standard.

6.7.4.4 DGPS Initialization And Configuration. At power-on, the receiver initializes its internal DGPS database to indicate that no valid DGPS data is available. If the user requests the Differential GPS Status message (binary Message 1005), the message will indicate that no corrections have been processed. Some of the position status messages (binary messages 1000 and 1001, and NMEA message GGA) will also indicate that the receiver is not computing a DGPS solution.

As sufficient valid RTCM data is passed to the receiver, it will automatically produce DGPS solutions. Other than supplying RTCM data and ensuring that DGPS operation is not disabled, no action is required on the part of the user to cause DGPS operation.

The receiver will compute DGPS solutions whenever all of the following conditions are satisfied:

- Ephemeris data has been collected by the receiver for at least four satellites.
- DGPS corrections have been received for at least the same four satellites, and these corrections are not older than the time limit specified in the

Differential GPS Control message (binary Message 1214).

- The "Issue Of Data Ephemeris" (IODE) is the same for both the receiver-collected ephemeris and the RTCM SC-104 corrections.
- All of the applicable satellites have good health or have been declared healthy for DGPS purposes by the RTCM SC-104 source.
- The User Differential Range Error (UDRE) reported by the RTCM SC-104 source is equal to or less than eight meters for all four satellites.
- The RTCM SC-104 source declares itself to be in good health.
- The user has not turned DGPS operation off.

6.7.4.5 Disabling DGPS Operation. The user may disable DGPS operation through the Differential GPS Control message (binary Message 1214). When disabled, the receiver will not use DGPS information to compute a position solution nor will the information be erased.

During the time that DGPS operation is disabled, and DGPS solutions are not being computed, RTCM processing continues as long as RTCM messages are being sent to the receiver. The data contained within these messages will be used to update the receiver's internal DGPS database. As soon as the DGPS function is enabled, the most current data will be used to compute a position solution.

6.7.4.6 DGPS Reset. The user may also "reset" the DGPS process at any time using the Differential GPS Control message (binary Message 1214). When this is done, the DGPS data currently stored in the receiver is invalidated or replaced by its default values. This discontinues DGPS service until new RTCM SC-104 and ephemeris data is collected.

A DGPS reset is different from the type of reset initiated by power-on or an initialization message system reset. During a DGPS reset, "DGPS Disable" and "Correction Timeout" are unaffected. If values have been previously entered for these words, these same values will be in effect both before and after the DGPS reset. If new valid entries for these words are received within a Differential GPS Control message that also contains a reset, then the new values will be in effect after the reset. However, after a DGPS reset all other DGPS parameters will be set to their default values.

6.7.4.7 DGPS Status Request. The user may request that the status of DGPS operation be provided. When requested, the Differential GPS Status message (binary Message 1005) provides information on the state of

each of the corrections being processed. In the event that DGPS solutions are not available, the status message also provides enough diagnostic data for the user to determine why they are not being computed.

6.7.5 Built-In Test (BIT). The receiver can be commanded to execute a BIT at any time while in Conexant binary mode. The receiver performs the test and returns the results in the corresponding output message.

A BIT is commanded by sending a binary Perform Built-In Test Command message (Message 1300). Such a command will interrupt normal receiver operations and result in a system reset.

Output messages that are processed by the serial I/O hardware when the BIT command is received are output, but subsequent output messages are suspended until after the BIT cycle is complete. When the BIT is complete, the receiver is reset and normal operation resumes. This means that the BIT results may not be the first received output message after a BIT command.

6.7.5.1 Interpreting BIT Results. A device failure indicator in the BIT Results Message is valid for all devices installed on the board. The failure words defined in Message 1100 will be zero if the device is working as expected and non-zero if an error was detected.

ROM Failure. The ROM Failure word in Message 1100 indicates the result of a ROM (program memory) checksum test. A failed status means that the ROM chip may be defective.

RAM Failure. The RAM Failure word in Message 1100 indicates the results of a non-destructive pattern test and an address line integrity test. A failed status means that the RAM chip(s) may be defective.

EEPROM Failure. There are no explicit tests of the EEPROM device in response to Message 1100. However, the receiver maintains and reports a status of what parameters have been written to EEPROM. When a data block has been written and cannot be successfully read back from the device, a failure will be reported. A failure will also be reported if the device does not respond to an attempt to access it. A failed status means that the EEPROM chip may be defective.

Digital Signal Processor (DSP). The DSP Failure word in Message 1100 indicates the results of the DSP tests. A failed status indicates that one or more of the DSP tests failed and that the DSP chip may be defective.

RTC. The RTC Failure word in Message 1100 indicates the results of a time rollover test of the RTC. A failed status indicates that the RTC test failed and that the RTC chip may be defective.

PORT 1 (Host Port) and PORT 2 (Aux Port) Error and Received Byte Counts. There are no explicit tests for the two serial communications ports. However, a count of bytes received with error and a count of bytes received without error for each port are maintained and reported in Message 1100. These words provide a measure of the reliability of the communications interface. If the count of bytes received with error is large, the interface may be defective or the port configuration may be incorrect.

APPENDIX A: Acronyms, Abbreviations, and Glossary

This appendix provides a list of all acronyms, abbreviations, and selected terms used in this document, together with their associated meaning.

2-D	Two dimensional
2-Drms	Two-dimensional root mean square
3-D	Three dimensional
3-Drms	Three-dimensional root mean square
AAMP	Advanced Architecture Microprocessor
A/D	Analog/Digital
Almanac	A set of orbital parameters that allows calculation of approximate GPS satellite positions and velocities. The almanac is used by a GPS receiver to determine satellite visibility and as an aid during acquisition of GPS satellite signals. The almanac is a subset of satellite ephemeris data and is updated weekly by GPS Control.
Altitude Hold	A technique which allows navigation using measurements from three GPS satellites plus an independent value of altitude.
Altitude Hold Enable Command	This message allows the application processor to enable or disable the Altitude Hold feature.
Altitude Hold Mode	A Navigation Mode during which a value of altitude is processed by the Kalman Filter as if it were a range measurement from a satellite at the Earth's center (WGS-84 reference ellipsoid center).
AP	Application Processor. The processor connected to the Zodiac GPS receiver port which controls the receiver with command messages and uses data from output messages.
ASCII	American Standard Code for Information Interchange
ATO	Acquisition Time-Out
Auto Hold	The receiver will use the last altitude calculated in 3-D navigation as the current value of Held Altitude when entering Altitude Hold 2-D navigation. It will continue to use this value throughout this Altitude Hold event unless an Amended Altitude is received from the application processor. The 3-D calculated altitude used in this way is called an Auto Hold altitude.
B	Boolean
Baud	(see bps)
BIT	Built-In Test

Block I Satellite	Satellites designed and built to support GPS development and testing. A total of 10 Block I satellites were successfully launched between February 1978 and October 1989.
Block II Satellite	Satellites designed and built to support GPS Space Segment operation. A total of 28 Block II satellites have been built and launched as of August 1995. Twenty-Four of these have been successfully orbited.
Block IIR Satellite	Satellites being designed to eventually replace Block II satellites. The first Block IIR satellite is scheduled to be ready for launch in 1995.
bps	bits per second (sometimes referred to as baud rate)
C	Celsius
C/A Code	Coarse/Acquisition Code. A spread spectrum direct sequence code that is used primarily by commercial GPS receivers to determine the range to the transmitting GPS satellite.
CEP	Circular Error Probable. The radius of a circle, centered at the user's true location, that contains 50 percent of the individual position measurements made using a particular navigation system.
Clock Error	The uncompensated difference between synchronous GPS system time and time best known within the GPS receiver.
CMOS	Complimentary Metal Oxide Semiconductor
C/No	Carrier-to-Noise density ratio. Also, Channel Signal-To-Noise.
COG	Course Over Ground
Cold Start	A condition in which the GPS receiver can arrive at a navigation solution without initial position, time, current ephermeris, and almanac data.
Control Segment	The Master Control Station and the globally dispersed Monitor Stations used to manage the GPS satellites, determine their precise orbital parameters, and synchronize their clocks.
dB	Decibel
DB-9	9-pin D-Subminiature Connector
DB-25	25-pin D-Subminiature Connector
dBiC	Decibel-Isometric-Circular (measure of power relative to an isometric antenna with circular polarization)
dBm	Decibels per milliwatt
dBW	Decibel-Watt (measure of power relative to one watt)
DC	Direct Current

DGPS	Differential GPS. A technique to improve GPS accuracy that uses pseudorange errors recorded at a known location to improve the measurements made by other GPS receivers within the same general geographic area.
DI	Double Precision Integer
Doppler Aiding	A signal processing strategy, which uses a measured doppler shift to help a receiver smoothly track the GPS signal to allow a more precise velocity and position measurement.
DoD	Department of Defense
DOP	Dilution of Precision (see GDOP, HDOP, PDOP, TDOP, and VDOP).
DOS	Disk Operating System
DSP	Digital Signal Processor
DTR	Data Terminal Ready
ECEF	Earth-Centered Earth-Fixed. A Cartesian coordinate system with its origin located at the center of the Earth. The coordinate system used by GPS to describe three-dimensional location. For the WGS-84 reference ellipsoid, ECEF coordinates have the Z-axis aligned with the Earth's spin axis, the X-axis through the intersection of the Prime Meridian and the Equator and the Y -axis is rotated 90 degrees East of the X-axis about the Z-axis.
EEPROM	Electrically Erasable Programmable Read-Only Memory
EFP	Extended Floating Point
EHPE	Expected Horizontal Position Error
EMC	Electromagnetic Compatibiity
EMI	Electromagnetic Interference
Ephemeris	A set of satellite orbital parameters that is used by a GPS receiver to calculate precise GPS satellite positions and velocities. The ephemeris is used to determine the navigation solution and is updated frequently to maintain the accuracy of GPS receivers.
EPROM	Erasable Programmable Read Only Memory
ESD	Electrostatic Discharge
EVPE	Expected Vertical Position Error
FFC	Flex cable
FOM	Figure Of Merit
FP	Floating Point

FRP	Federal Radionavigation Plan. The U.S. Government document which contains the official policy on the commercial use of GPS.
GaAs	Gallium Arsenide
GDOP	Geometric Dilution of Precision. A factor used to describe the effect of the satellite geometry on the position and time accuracy of the GPS receiver solution. The lower the value of the GDOP parameter, the less the error in the position solution. Related indicators include PDOP, HDOP, TDOP, and VDOP.
GMT	Greenwich Mean Time
GPS	Global Positioning System. A space-based radio positioning system which provides suitably equipped users with accurate position, velocity, and time data. When fully operational, GPS will provide this data free of direct user charge worldwide, continuously, and under all weather conditions. The GPS constellation will consist of 24 orbiting satellites, four equally spaced around each of six different orbital planes.
GPSRE	GPS Receiver Engine
GPS Time	The number of seconds since Saturday/Sunday Midnight UTC, with time zero being this midnight. Used with GPS Week to determine a specific point in GPS time.
GPS Week	The number of weeks since January 6, 1980, with week zero being the week of January 6, 1980. Used with GPS Time to determine a specific point in GPS time.
HDOP	Horizontal Dilution of Precision. A measure of how much the geometry of the satellites affects the position estimate (computed from the satellite range measurements) in the horizontal (East, North) plane.
Held Altitude	The altitude value that will be sent to the Kalman filter as a measurement when in Altitude Hold Mode. It is an Auto Hold Altitude unless an Amended Altitude is supplied by the application processor.
Horizontal Dilution of Precision	(see HDOP)
Hz	Hertz
I/O	Input/output
I	Integer
IF	Intermediate Frequency
IGRF	International Geomagnetic Reference Field
I/O	Input/Output
IODE	Issue of Data Ephemeris

JPO	Joint Program Office. An office within the U.S. Air Force Systems Command, Space Systems Division. The JPO is responsible for managing the development and production aspects of the GPS system and is staffed by representatives from each branch of the U.S. military, the U.S. Department of Transportation, Defense Mapping Agency, NATO member nations, and Australia.
Kalman Filter	Sequential estimation filter which combines measurements of satellite range and range rate to determine the position, velocity, and time at the GPS receiver antenna.
km	kilometer
L1 Band	The 1575.42 MHz GPS carrier frequency which contains the C/A code, P-code, and navigation messages used by commercial GPS receivers.
L2 Band	A secondary GPS carrier, containing only P-code, used primarily to calculate signal delays caused by the atmosphere. The L2 frequency is 1227.60 MHz.
LD/LR	Line Driver/Line Receiver
LED	Light Emitting Diode
LPTS	Low Power Time Source
LSB	Least Significant Bit
m/sec	Meters per second (units of velocity)
m/sec/sec	Meters per second per second (units of acceleration)
m/sec/sec/sec	Meters per second per second per second (units of impulse or "jerk")
Mask Angle	The minimum GPS satellite elevation angle permitted by a particular GPS receiver design.
Measurement Error Variance	The square of the standard deviation of a measurement quantity. The standard deviation is representative of the error typically expected in a measured value of that quantity.
MFI	Multi-Function Interface
MHz	Megahertz
MR	Master Reset
MSB	Most Significant Bit
MSL	Mean Sea Level
MTBF	Mean Time Between Failure
Multipath Errors	GPS positioning errors caused by the interaction of the GPS satellite signal and its reflections.

mV   Millivolt

mW   Milliwatt

NF   Noise Factor

NMEA   National Marine Electronics Association

Obscuration   Term used to describe periods of time when a GPS receiver's line-of-sight to GPS satellites is blocked by natural or man-made objects.

OEM   Original Equipment Manufacturer

Overdetermined Solution   The solution of a system of equations containing more equations than unknowns. The GPS receiver computes, when possible, an overdetermined solution using the measurements from all GPS satellites it can track, instead of the four necessary for a three-dimensional position solution.

P-Code   Precision Code. A spread spectrum direct sequence code that is used primarily by military GPS receivers to determine the range to the transmitting GPS satellite.

Parallel Receiver   A receiver that monitors four or more satellites simultaneously.

PC   Personal Computer

PCMCIA   Personal Computer Memory Card International Association

PDOP   Position Dilution of Precision. A measure of how much the error in the position estimate produced from satellite range measurements is amplified by a poor arrangement of the satellites with respect to the receiver antenna.

Pi (or π)   The mathematical constant having a value of approximately 3.14159.

P-P   Peak-to-Peak

PPS   Pulse Per Second.

                                            Also: Precise Positioning Service. The GPS positioning, velocity, and time service which will be available on a continuous, worldwide basis to users authorized by the DoD.

PRN   Pseudorandom Noise Number. The identity of the GPS satellites as determined by a GPS receiver. Since all GPS satellites must transmit on the same frequency, they are distinguished by their pseudorandom noise codes.

PRR   Pseudo-Range Rate

Pseudorange   The calculated range from the GPS receiver to the satellite determined by measuring the phase shift of the PRN code received from the satellite with the internally generated PRN code from the receiver. Because of atmospheric and timing effects, this time is not exact. Therefore, it is called a pseudorange instead of a true range.

PSF   Post Select Filter

PVT   Position, velocity, and time

PWB   Printed Wiring Board

RAM   Random Access Memory

Receiver Channels   A GPS receiver specification which indicates the number of independent
                                           hardware signal processing channels included in the receiver design.

RF   Radio Frequency

RFI   Radio Frequency Interference

ROM   Read-Only Memory

RTC   Real-Time Clock

RTCA   Radio Technical Commission for Aeronautics

RTCM   Radio Technical Commission for Maritime Services

SA   Selective Availability. The method used by the DoD to control access to
                                           the full accuracy achievable with the C/A code.

Satellite Elevation   The angle of the satellite above the horizon.

SEP   Spherical Error Probable. The radius of a sphere, centered at the user's
                                           true location, that contains 50 percent of the individual three-dimensional
                                           position measurements made using a particular navigation system.

Sequential Receiver   A GPS receiver in which the number of satellite signals to be tracked
                                           exceeds the number of available hardware channels. Sequential receivers
                                           periodically reassign hardware channels to particular satellite signals in a
                                           predetermined sequence.

SNR   Signal-To-Noise Ratio (expressed in decibels).

SOG   Speed Over Ground

SPS   Standard Positioning Service. A positioning service available to all GPS
                                           users on a continuous, worldwide basis with no direct charge. SPS uses
                                           the C/A code to provide a minimum dynamic and static positioning
                                           capability.

Standby SRAM   Portion of the SRAM that is powered by a "keep-alive" power supply
                                           when prime power is removed to preserve important data and allow faster
                                           entry into the Navigation Mode when prime power is restored. All of the
                                           SRAM in the receiver is "keep-alive" SRAM.

SRAM   Static Random Access Memory

SV   Space Vehicle. Also Satellite Vehicle.

TDOP	Time Dilution of Precision. A measure of how much the geometry of the satellites affects the time estimate computed from the satellite range measurements.
Three-Dimensional Coverage (Hours)	The number of hours-per-day with four or more satellites visible. Four visible satellites are required to determine location and altitude.
Three-Dimensional (3-D) Navigation	Navigation Mode in which altitude and horizontal position are determined from satellite range measurements.
Time Mark Pulse	A one pulse per second (1PPS) output synchronized to UTC when the receiver is in its Navigation Mode.
TOW	Time Of Week
TTFF	Time-To-First-Fix. The actual time required by a GPS receiver to achieve a position solution. This specification will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design.
TTL	Transistor-Transistor Logic
Two-Dimensional Coverage (Hours)	The number of hours-per-day with three or more satellites visible. Three visible satellites can be used to determine location if the GPS receiver is designed to accept an external altitude input (Altitude Hold).
Two-Dimensional (2-D) Navigation	Navigation Mode in which a fixed value of altitude is used for one or more position calculations while horizontal (2-D) position can vary freely based on satellite range measurements.
UDRE	User Differential Range Error. A measure of error in range measurement to each satellite as seen by the receiver.
UERE	User Equivalent Range Error
Update Rate	The GPS receiver specification which indicates the solution rate provided by the receiver when operating normally.
U.S. Air Force Space Command	The U.S. Air Force agency responsible for the operation of the GPS Space and Control Segments.
UTC	Universal Time Coordinated. This time system uses the second defined true angular rotation of the Earth measured as if the Earth rotated about its Conventional Terrestrial Pole. However, UTC is adjusted only in increments of one second. The time zone of UTC is that of Greenwich Mean Time (GMT).
VCO	Voltage Controlled Oscillator
VDOP	Vertical Dilution of Precision. A measure of how much the geometry of the satellites affects the position estimate (computed from the satellite range measurements) in the vertical (perpendicular to the plane of the user) direction.
VSWR	Voltage Standing Wave Ratio

WGS-84

World Geodetic System (1984). A mathematical ellipsoid designed to fit the shape of the entire Earth. It is often used as a reference on a worldwide basis, while other ellipsoids are used locally to provide a better fit to the Earth in a local region. GPS uses the center of the WGS-84 ellipsoid as the center of the GPS ECEF reference frame.

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APPENDIX B: References

This appendix provides a list of documents that may help a user of Conexant's GPS receivers learn more about the way the GPS can be used. Not all of these documents have been referenced in the text of this Designer's Guide.

1. *Global Positioning System Standard Positioning Service Signal Specification,* United States Department of Defense, 5 November 1993.

2. *Standard For Interfacing Marine Electronic Devices, NMEA 0183, Version 2.00,* National Marine Electronics Association, January 1992

3. *RTCM Recommended Standards for Differential NAVSTAR GPS Service, Version 2.1,* Radio Technical Commission for Maritime Services, January 1994.

4. *Principle of Operation of NAVSTAR and System Characteristics,* Milliken and Zoller, Global Positioning System, Vol. 1, 1980, pp. 3-14.

5. *Department of Defense World Geodetic System 1984*, DMA TR 8350.2 2nd Edition, 1 September 1991.

6. Internet web site for the National Geophysical Data Center (NGDC): "http://julius.ngdc.noaa.gov/seg/potfld/ geomag.html"

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APPENDIX C: NAVSTAR GPS Operation

The NAVSTAR GPS is a space-based satellite radio navigation system developed by the U.S. Department of Defense (DoD). GPS receivers provide land, marine, and airborne users with continuous three-dimensional position, velocity, and time data. This information is available free of direct charge to an unlimited number of users. The system operates under all weather conditions, 24 hours a day, anywhere on Earth.

The GPS system consists of three major segments: Space, Control, and User as illustrated in Figure C-1.

GPS System Design

The Space Segment. This segment consists of a nominal constellation of 24 operational satellites (including 3 spares). These satellites have been placed in 6 orbital planes (as shown in Figure C-2) about 10,900 miles (20,200 km) above the Earth's surface.

The satellites are in circular orbits with a 12-hour orbital period and inclination angle of 55 degrees. This orientation normally provides a GPS user with a minimum of 5 satellites in view from any point on Earth at any one time.

Each satellite continuously broadcasts an RF signal at a center frequency of 1575.42 MHz (L1 band). This signal is modulated by a 10.23 MHz clock rate precise ranging signal and by a 1.023 MHz clock rate coarse acquisition (C/A) code ranging signal.

Each of these two binary signals has been formed by a precision code (P-code) or a C/A code which is modulo-2 added to 50 bits per second (bps) navigation data. This navigation data, which is computed and controlled by the GPS Control Segment, includes the satellite's time, its clock correction and ephemeris parameters, almanacs, and health status for all GPS satellites. From this information, the user computes the satellite's precise position and clock offset.

Currently, the DoD encrypts the P-code ranging signal and thus denies access to the Precise Positioning

Space Segment

Control Segment
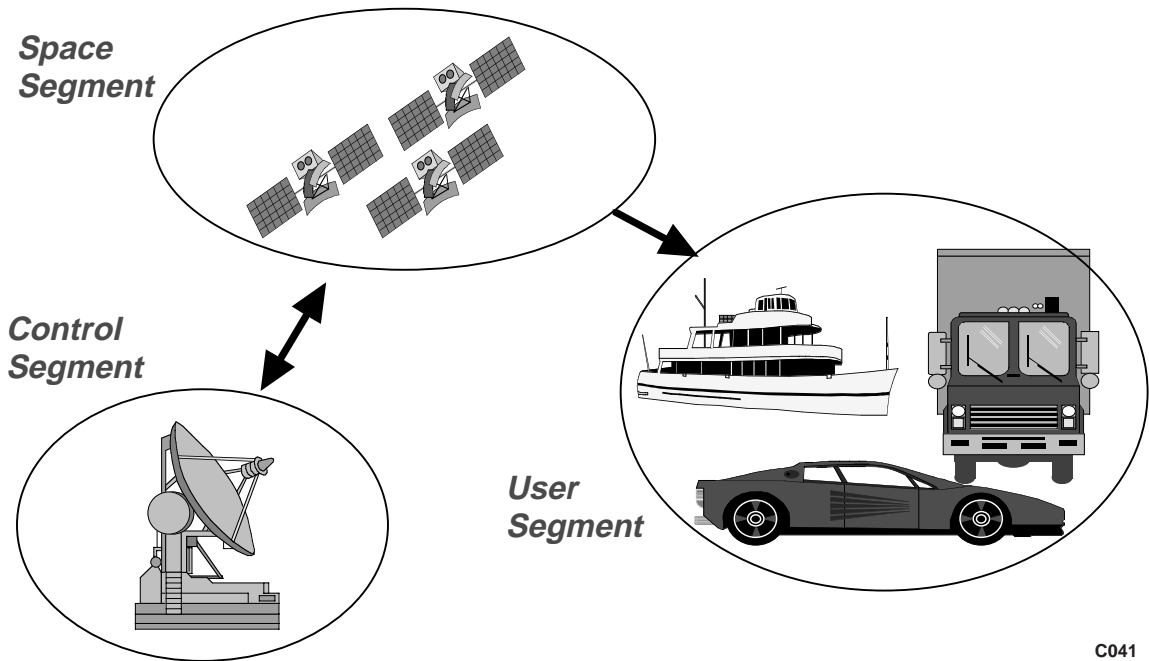
User Segment

C041

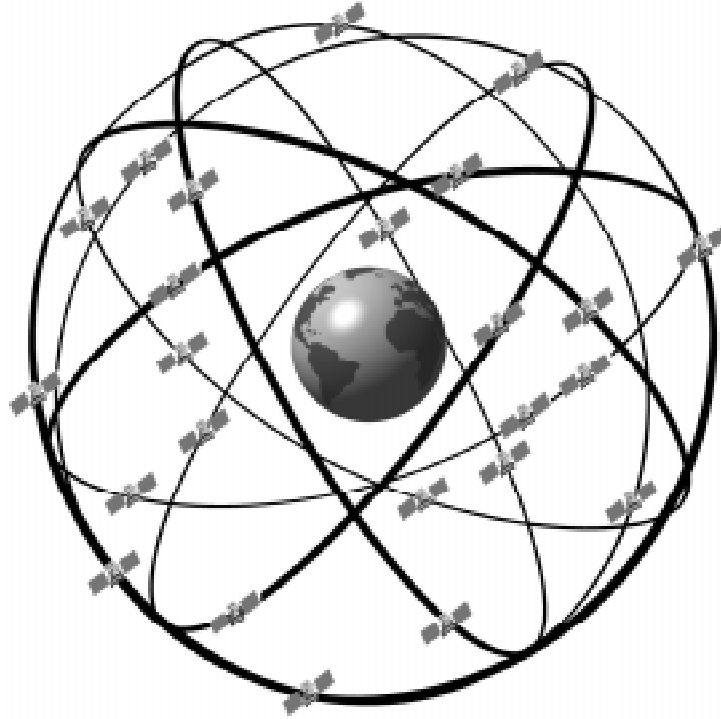**Figure C-1. Major Segments of the NAVSTAR GPS System**

Figure C-2. NAVSTAR GPS Operational Satellite Constellation

Service (PPS) by unauthorized users. The Standard Positioning Service (SPS) uses the C/A code ranging signal and is intended for general public use.

The Control Segment. This segment consists of a Master Control Station, located in Colorado Springs, and a number of monitor stations at various locations around the world.

Each monitor station tracks all the GPS satellites in view and passes the signal measurement data back to the Master Control Station. There, computations are performed to determine precise satellite ephemeris and satellite clock errors. The Master Control Station generates the upload of user navigation data for each

satellite. This data is subsequently rebroadcast by the satellite as part of its navigation data message.

The User Segment. This segment is the collection of all GPS receivers and their application support equipment such as antennas and processors. This equipment allows users to receive, decode, and process the information necessary to obtain accurate position, velocity, and timing measurements. This data is used by the receiver's support equipment for specific application requirements.

GPS supports a wide variety of applications including navigation, surveying, and time transfer. Receivers may be used in a standalone mode or integrated with other systems to enhance the overall system performance.
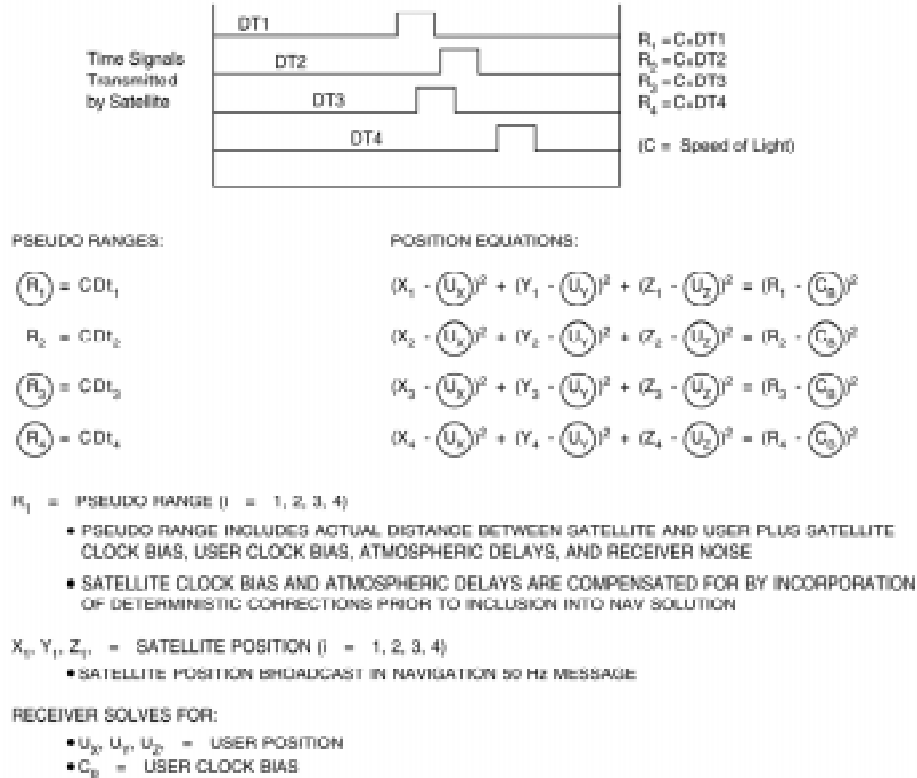
Figure C-3. Range Processing Equations

GPS System Operation_____

How A GPS Receiver Determines Position. A GPS receiver determines its geographic position by measuring the ranges (the distance between a satellite with known coordinates in space and the receiver's antenna) of several satellites and computing the geometric intersection of these ranges.

To determine a range, the receiver measures the time required for the GPS signal to travel from the satellite to the receiver antenna. The timing code generated by each satellite is compared to an identical code generated by the receiver. The receiver's code is shifted until it matches the satellite's code. The resulting time shift is multiplied by the speed of light to arrive at the apparent range measurement.

Since the resulting range measurement contains propagation delays due to atmospheric effects, and satellite and receiver clock errors, it is referred to as a "pseudorange." Changes in each of these pseudoranges over a short period of time are also measured and processed by the receiver. These measurements, referred to as "delta-pseudoranges," are used to compute velocity.

A minimum of four pseudorange measurements are required by the receiver to mathematically determine time and the three components of position (latitude, longitude, and altitude). The equations used for these calculations are shown in Figure C-3. The solution of these equations may be visualized as the geometric intersection of four ranges from four known satellite locations.

Figure C-4 illustrates "triangulation," one way to envision the navigation process. For ease of understanding, it is assumed that the user clock is synchronous.

After the four range equations are solved, the receiver has estimates of its position and time. Similar equations are then used to calculate velocity using relative velocities instead of pseudoranges. The position, velocity, and time data is generally computed once a second.

If one of these parameters, such as altitude, is known, only three satellite pseudorange measurements are needed for the receiver to determine its position and time. In this case, only three satellites need to be tracked.
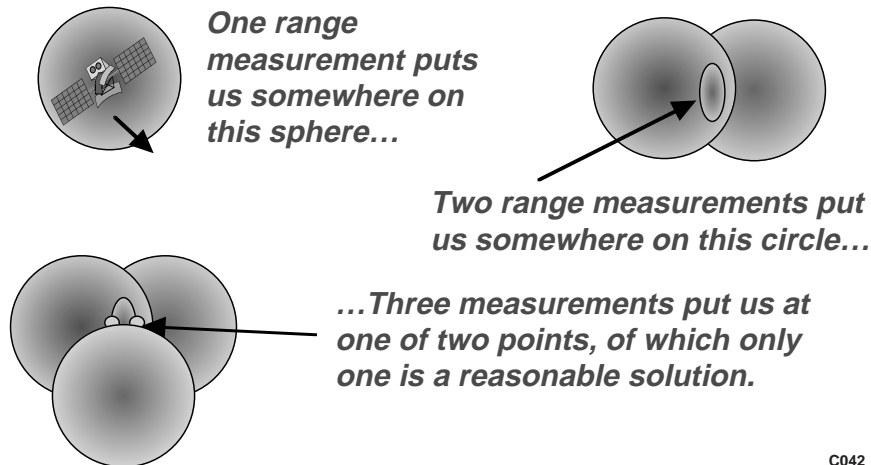
One range measurement puts us somewhere on this sphere…

Two range measurements put us somewhere on this circle…

…Three measurements put us at one of two points, of which only one is a reasonable solution.

C042

Figure C-4. Satellite Ranging Intersections

GPS Accuracy. GPS accuracy has a statistical distribution which is dependent on two important factors. The expected accuracy will vary with the error in the range measurements as well as the geometry or relative positions of the satellites and the user.

Dilution of Precision. The Geometric Dilution of Precision (GDOP) indicates how much the geometric relationship of the tracked satellites affects the estimate of the receiver's position, velocity, and time.

There are four other DOP components which indicate how the geometry specifically affects errors in horizontal position (HDOP), vertical position (VDOP), position (PDOP), and time (TDOP).

DOPs are computed based on the spatial relationships of the lines of sight between the satellites and the user. The motion of the satellites relative to each other and the user causes the DOPs to vary constantly. For the same range measurement errors, lower DOPs relate to more accurate estimates.

The errors in the range measurements used to solve for position may be magnified by poor geometry. The least amount of error results when the lines of sight have the greatest angular separation between them (see Figure C-5).

For example, if two lines of sight are necessary to establish a user position, the least amount of error is present when the lines cross at right angles.

Range Measurement Error. The error in the range measurement is dependent on one of two levels of GPS accuracy to which the user has access. PPS is the most accurate, but is reserved for use by the DoD and certain authorized users. SPS is less accurate and intended for general public use. This is the level of accuracy used by the Zodiac family of GPS receivers.

The SPS signal is intentionally degraded to a certain extent by a process known as Selective Availability (SA). SA is used to limit access to the full accuracy of SPS in the interest of U.S. national security.

*Differential GPS (DGPS)*_____

DGPS Description. The following general description of DGPS is excerpted from the document *RTCM Recommended Standards For Differential NAVSTAR GPS Service*. Refer to that document for more specific details of DGPS operations (see Appendix B).

Differential operation of the GPS offers the possibility of accuracies from 1 to 10 meters for dynamic, navigation applications. As illustrated by Figure C-6, DGPS operation requires a reference receiver to be placed at a known, surveyed-in point. By comparing the

known location with that predicted by the GPS, corrections are determined. These corrections are then broadcast to nearby users who use them to improve their position solutions.

Sources Of Bias Error. The differential technique works if the preponderant errors are bias errors due to causes outside the receiver. This is the case for GPS. The major sources of error are the following:
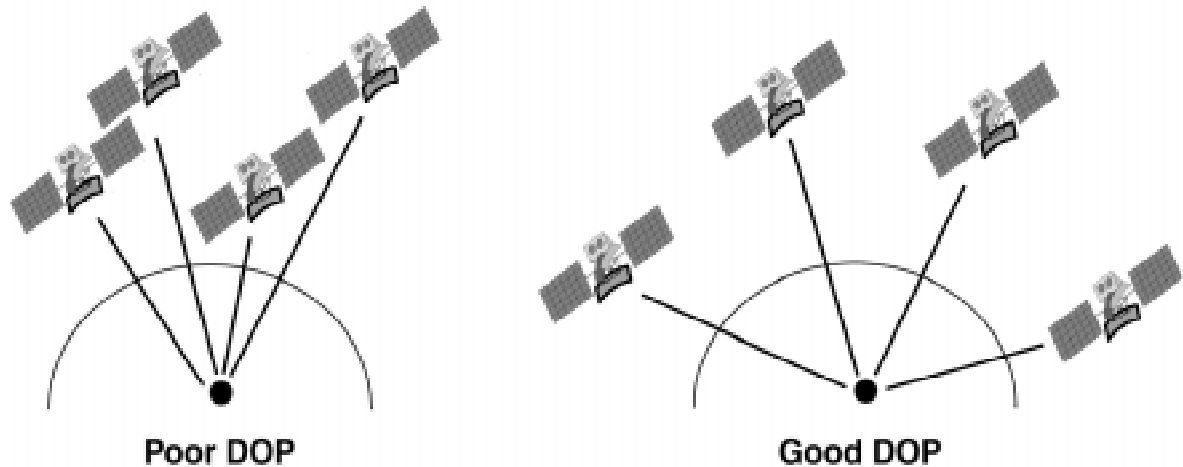
Figure C-5. Geometrical Dilution of Precision

1. SA errors: artificial errors introduced at the satellites for security reasons. Pseudorange errors of this type are about 30 meters, 1-sigma. PPS users have the capability to eliminate them entirely.
2. Ionospheric delays: signal propagation group delay which is typically 20 to 30 meters during the day and 3 to 6 meters at night.
3. Tropospheric delays: signal propagation delays caused by the lower atmosphere. While the delays are as much as 30 meters at low satellite elevation angles, they are quite consistent and modellable. Variations in the index of refraction can cause differences (between reference station and user) in signal delays from 1 to 3 meters for low-lying satellites.
4. Ephemeris error: differences between the actual satellite location and the location predicted by the satellite orbital data. Normally these are quite small, less than 3 meters, but they could be more than 30 meters under SA.
5. Satellite clock errors: differences between the satellite clock time and that predicted by the satellite data. The oscillator that times the satellite signal is free-running; the GPS ground control station monitors it and establishes corrections that are sent up to the satellite to set the data message. The user reads the data and adjusts the signal timing accordingly.

Satellite clock errors are completely compensated by differential operation as long as both reference and user receivers are employing the same satellite data. Ephemeris errors, unless they are quite large (30 meters or more) are similarly compensated by differential operation. SA errors that affect the timing of the signals are also compensated by differential operation, except

that the corrections lose their validity after a period of time.

For users near the reference station, the respective signal paths to the satellites are sufficiently close so that compensation is almost complete. As the user-reference station separation is increased, the different ionospheric and tropospheric paths to the satellites may be sufficiently far apart that the atmospheric inhomogeneities cause the delays to differ somewhat. To the extent they differ, they constitute an error in the DGPS measurement, called spatial decorrelation. This type of error will be greater at larger user-station separations.

Required DGPS Equipment. The equipment consists of a GPS receiver with antenna, a data processor, a data link receiver with antenna, and interfacing equipment as illustrated in Figure C-7. The data processor applies the corrections received from the reference station to the pseudoranges measured by the sensor.

Application of DGPS Corrections. For each satellite employed by the user's receiver, the correction obtained from the reference station (Message Type 1 or 9) is added to the pseudorange measurement. The correction itself is derived from the range and range-rate, adjusted to account for the time elapsed between the time of reception of the correction and the time of the user pseudorange measurement, as follows:

$$PRC(t) = PRC(t_0) + RRC \times [t - t_0]$$

where $PRC(t)$ is the correction to be applied, $PRC(t_0)$ is the range correction from the message, RRC is the range-rate correction from the message, t_0 is the time
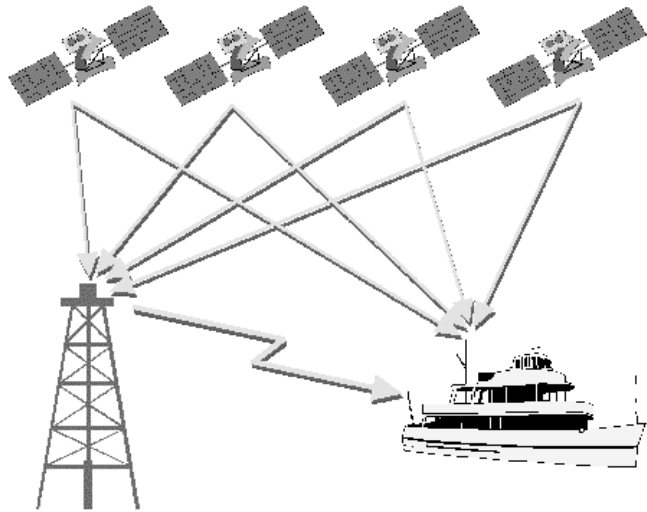
- **GPS receiver at fixed <u>surveyed</u> location**
  - — Calculates error in each satellite range
- **Correction factors are broadcast to all mobile units for all satellites**
- **Position accuracies of < 2m are achievable with good DGPS correction data**

Figure C-6. DGPS Operation

reference of the correction, and t is the time associated with the pseudorange measurement.

Occasionally a Type 2 message is sent interspersed among the correction messages, which provides a secondary correction. This is done to allow a user to operate with old (up to two hours) satellite ephemeris and satellite clock data while the reference station is operating with the most recent data. This correction, called the "delta correction," is added to the normal correction for that satellite. The reference station will usually decode the satellite data before the user does since it is constantly monitoring the data.

Data Link. The data link, which communicates the corrections from the reference station to the user receiver, can take a number of forms and operate at any of several frequencies. The chief requirement is that the messages be communicated reliably at a data rate of at least 50 bps (continuous transmission). Figure C-7 shows the user data link functions.

In its simplest form, the data link continuously carries the DGPS data message without interruption at a constant data rate of at least 50 bps. However, it is

transparent to the GPS receiver whether the data is transmitted continuously or in bursts, or whether protocol overhead is added. For example, each message (or multiple messages, or any fraction of a message) could be transmitted as a short burst at 2400 bps, along with a data link protocol preamble, parity, and even error correction bits. This would be stripped off at the receiver end and the differential correction bits would be stored in the buffer, to be transferred to the receiver at will.

DGPS broadcasts intended for general public use require that the data link be a standard, published design. For non-public use, however, the reference station, data link, and receivers could be part of an integrated DGPS system. In such a case, the data might be encrypted to limit the service to paying customers. The format allows for such operation.

At the minimum rate of 50 bps, there is considerable robustness in the data link. The corrections are broadcast frequently enough so that the loss of as many as three consecutive corrections can be tolerated and still provide five-meter accuracy.
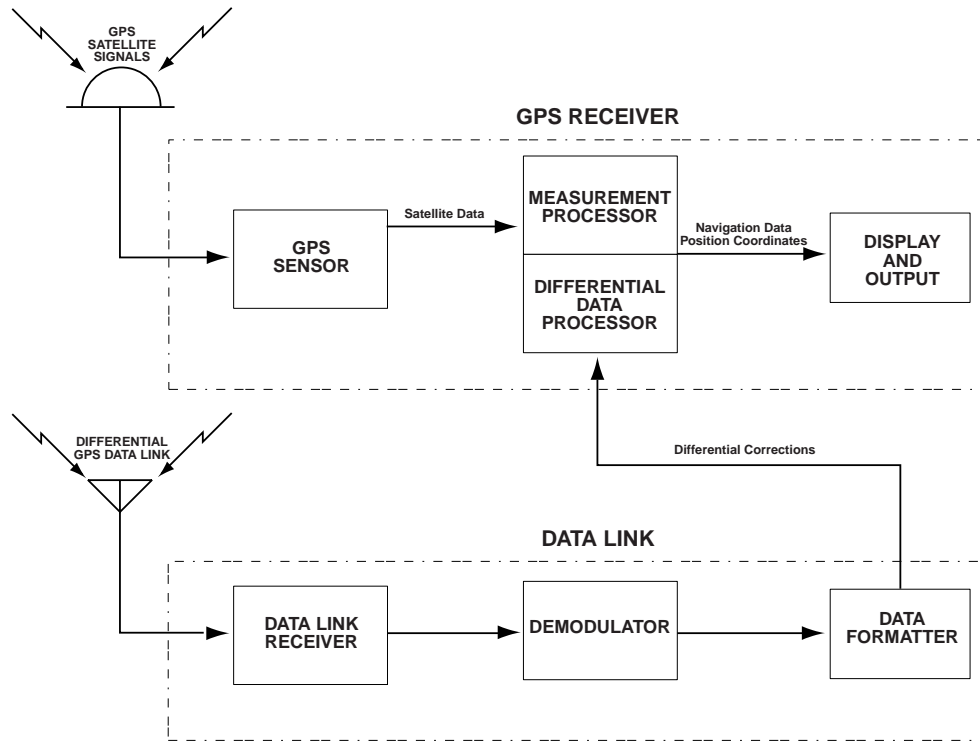
Figure C-7. User Equipment Block Diagram

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APPENDIX D: Frequently Asked Questions

This Appendix provides answers to frequently asked questions about GPS in general and about the Zodiac family of GPS receivers in particular. These questions are intended to supplement the operational description provided in Section 6 of this Designer's Guide.

1. **How far and under what conditions can a passive antenna track before it is necessary to change it to an active antenna?**

    There is no simple answer to this question. Conexant generally recommends limiting cable loss to 3 dB between the antenna and the receiver board. If attenuation exceeds this value there likely will be degraded signal acquisition and navigation accuracy performance. It is true that GPS satellites transmit more power than their specification requires, but that margin has been allocated to the 3 dB cable loss. The safest approach is to use an active antenna unless the antenna and receiver engine are co-located.

2. **Can the Zodiac receiver operate efficiently in an urban location with tall office structures and buildings?**

    The receiver operates efficiently in an urban environment because it contains 12 parallel channels and CityTracker^{TM} software which allows optimal performance in this setting. The parallel channels maintain continuous tracking of all satellites that are visible at any point in time and are used to produce an overdetermined solution that minimizes the effects of signal blockage. When these signals are momentarily lost due to blockage or attenuation, the navigation process typically has more than enough signals remaining to support continuous navigation. The CityTracker^{TM} software provides additional smoothing by minimizing the effects of selective availability on different combinations of GPS satellite signals.

3. **Is there any danger to the receiver when switching is done between active and passive antennas?**

    Yes. If preamp power is supplied to an active antenna and then connected to a passive antenna there is a high probability of damage since the passive antenna often presents a short circuit to ground at DC. This then shorts out the preamp power line and destroys the bias-tee network on the receiver.

4. **What is the criteria for choosing satellites for navigation if more than four are visible?**

    The Zodiac receiver continuously tracks all visible satellites. The measurements from these satellites are all used in an overdetermined solution to provide the most robust performance that is possible.

5. **What is the accuracy of GPS with selective availability turned on? How is the accuracy affected by DGPS?**

    The U.S. Government guarantees that horizontal accuracy will be less than 100 meters 95 percent of the time and less than 300 meters 99.99 percent of the time. Accuracy with DGPS is primarily a function of the quality and latency of the corrections used.

6. **What is the difference between the two models for position determination used in GPS: WGS 84 and Earth-Centered-Earth-Fixed (ECEF)?**

    ECEF refers to a Cartesian (rectangular) coordinate system (x,y,z,) whose center is at the middle of the Earth; one axis goes through the North Pole, one through the Greenwich meridian at the equator, and the third passes through the equator 90 degrees offset from the second. This system rotates with the Earth. GPS satellites broadcast their location in this coordinate system.

    WGS-84 contains a mathematical model of the Earth's surface (spheroid) which is a good, well-accepted model worldwide. The model does have some limitations that must be understood. For example, 0 meters altitude may

differ from sea level in this model by as much as ~100 meters. Position in WGS-84 is specified in latitude and longitude and by the altitude above the WGS-84 spheroid (Earth surface model).

7.   **What are the addresses for U.S. FM DGPS service providers?**

> ACCQPOINT Communications Corp.
> 2737 Campus Drive
> Irvine, CA 92715
> (800) 995-3477
>
> Differential Corrections Inc. (DCI)
> 10121 Miller Avenue
> Cupertino, CA 95014
> (408) 446-8350

8.   **Does the Zodiac receiver provide an overdetermined solution?**

The Zodiac provides all-in-view parallel tracking of all visible satellites. In SPS mode all valid measurements are used to produce an overdetermined navigation solution to minimize position excursions arising from selective availability and loss of signals. In DGPS all valid measurements with valid DGPS corrections are also used in an overdetermined solution. For example, if 8 satellites are in track, all are producing valid measurements, and DGPS corrections are available for 7 of the 8, then 7 DGPS corrected measurements will be used in the overdetermined DGPS solution.

9.   **How is heading data at low speeds derived? Shouldn't the heading be derived from Doppler data rather than position differences?**

The Zodiac and other Conexant receivers compute velocity from the carrier loop Doppler information. Heading angle is then computed from east and north velocity as the arctangent (Ve/Vn). Selective availability induces an error on the GPS clock and thus the carrier Doppler information is corrupted just as the pseudorange is corrupted. However, the carrier data is a much better source of velocity information than position differences.

The worst case heading error at 5 meters per second is 1.1 degrees when selective availability is off or DGPS is on. All heading determination techniques using GPS velocities have large uncertainties at small velocities when the velocity approaches the magnitude of the inherent noise.

APPENDIX E: Reference Ellipsoids And Datum Tables For Zodiac And NavCore Receivers

Reference Ellipsoids: The following data is taken from DoD World Geodetic System 1984, DMA TR 8350.2-B, 1 Dec 1987, Second Printing. Includes 1 Sept 1991 updates.

REFERENCE ELLIPSOIDS

No.:	Name:	Semi-Major Axis:	Inverse Flattening:
1	Airy	6377563.396000	299.324965
2	Modified Airy	6377340.189000	299.324965
3	Australian National	6378160.000000	298.250000
4	Bessel 1841	6377397.155000	299.152813
5	Clarke 1866	6378206.400000	294.978698
6	Clarke 1880	6378249.145000	293.465000
7	Everest 1830	6377276.345000	300.801700
8	Everest 1948	6377304.063000	300.801700
9	Fischer 1960	6378166.000000	298.300000
10	Modified Fischer 1960	6378155.000000	298.300000
11	Fischer 1968	6378150.000000	298.300000
12	GRS 1980	6378137.000000	298.257222
13	Helmert 1906	6378200.000000	298.300000
14	Hough	6378270.000000	297.000000
15	International	6378388.000000	297.000000
16	Krassovsky	6378245.000000	298.300000
17	South American 1969	6378160.000000	298.250000
18	WGS 60	6378165.000000	298.300000
19	WGS 66	6378145.000000	298.250000
20	WGS 72	6378135.000000	298.260000
21	WGS 84	6378137.000000	298.257224
22	Bessel 1841 (Namibia)	6377483.865000	299.152813
23	Everest 1956	6377301.243000	300.801700
24	Everest 1969	6377295.664000	300.801700
25	Everest (Sabah & Sarawak)	6377298.556000	300.801700
26	SGS 85	6378136.000000	298.257000

Zodiac Datum Table: The following list of datums, maintained and selectable through the LABMON evaluation software, applies to Conexant's Zodiac Family of GPS receivers.

	ROM Datums				
Code:	**Name:**	**Ell:**	**dx:**	**dy:**	**dz:**
0	WGS 84 - Default	21	0	0	0
1	Adindan - MEAN FOR Ethiopia, Sudan	6	-166	-15	204
2	Adindan - Burkina Faso	6	-118	-14	218
3	Adindan - Cameroon	6	-134	-2	210
4	Adindan - Ethiopia	6	-165	-11	206
5	Adindan - Mali	6	-123	-20	220
6	Adindan - Senegal	6	-128	-18	224
7	Adindan - Sudan	6	-161	-14	205
8	Afgooye - Somalia	16	-43	-163	45
9	Ain el Abd 1970 - Bahrain	15	-150	-251	-2
10	Ain el Abd 1970 - Saudi Arabia	15	-143	-236	7
11	Anna 1 Astro 1965 - Cocos Islands	3	-491	-22	435
12	Antigua Island Astro 1943 Antigua (Leeward Islands)	6	-270	13	62
13	Arc 1950 MEAN FOR Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe	6	-143	-90	-294
14	Arc 1950 - Botswana	6	-138	-105	-289
15	Arc 1950 - Burundi	6	-153	-5	-292
16	Arc 1950 - Lesotho	6	-125	-108	-295
17	Arc 1950 - Malawi	6	-161	-73	-317
18	Arc 1950 - Swaziland	6	-134	-105	-295

Code:	Name:	Ell:	dx:	dy:	dz:
19	Arc 1950 - Zaire	6	-169	-19	-278
20	Arc 1950 - Zambia	6	-147	-74	-283
21	Arc 1950 - Zimbabwe	6	-142	-96	-293
22	Arc 1960 - MEAN FOR Kenya, Tanzania	6	-160	-6	-302
23	Ascension Island 1958 Ascension Island	15	-191	103	51
24	Astro Beacon E 1945 - Iwo Jima	15	145	75	-272
25	Astro DOS 71/4 - St Helena Island	15	-320	550	-494
26	Astro Tern Island (FRIG) 1961 Tern Island	15	114	-116	-333
27	Astronomical Station 1952 Marcus Island	15	124	-234	-25
28	Australian Geodetic 1966 Australia & Tasmania	3	-133	-48	148
29	Australian Geodetic 1984 Australia & Tasmania	3	-134	-48	149
30	Ayabelle Lighthouse - Djibouti	6	-79	-129	145
31	Bellevue (IGN) Efate & Erromango Islands	15	-127	-769	472
32	Bermuda 1957 - Bermuda	5	-73	213	296
33	Bissau - Guinea-Bissau	15	-173	253	27
34	Bogota Observatory - Colombia	15	307	304	-318
35	Bukit Rimpah Indonesia (Bangka & Belitung Islands)	4	-384	664	-48
36	Camp Area Astro Antarctica (McMurdo Camp Area)	15	-104	-129	239
37	Campo Inchauspe - Argentina	15	-148	136	90

Code:	Name:	Ell:	dx:	dy:	dz:
38	Canton Astro 1966 - Phoenix Islands	15	298	304	-375
39	Cape - South Africa	6	-136	108	-292
40	Cape Canaveral - Bahamas, Florida	5	-2	151	181
41	Carthage - Tunisia	6	-263	6	431
42	Chatham Island Astro 1971 New Zealand (Chatham Island)	15	175	-38	113
43	Chua Astro - Paraguay	15	-134	229	-29
44	Corrego Alegre - Brazil	15	-206	172	-6
45	Dabola - Guinea	6	-83	37	124
46	Djakarta (Batavia) Indonesia (Sumatra)	4	-377	681	-50
47	DOS 1968 New Georgia Islands (Gizo Island)	15	230	-199	-752
48	Easter Island 1967 - Easter Island	15	211	147	111
49	European 1950 MEAN FOR Austria, Belgium, Denmark, Finland, France, West Germany, Gibralter, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland	15	-87	-98	-121
50	European 1950 MEAN FOR Austria, Denmark, France, West Germany, Netherlands, Switzerland	15	-87	-96	-120
51	European 1950 MEAN FOR Iraq, Israel, Jordan, Lebanon, Kuwait, Saudi Arabia, Syria	15	-103	-106	-141
52	European 1950 - Cyprus	15	-104	-101	-140
53	European 1950 - Egypt	15	-130	-117	-151
54	European 1950 England, Channel Islands, Ireland, Scotland, Shetland Islands	15	-86	-96	-120

Code:	Name:	Ell:	dx:	dy:	dz:
55	European 1950 - Finland, Norway	15	-87	-95	-120
56	European 1950 - Greece	15	-84	-95	-130
57	European 1950 - Iran	15	-117	-132	-164
58	European 1950 - Italy (Sardinia)	15	-97	-103	-120
59	European 1950 - Italy (Sicily)	15	-97	-88	-135
60	European 1950 - Malta	15	-107	-88	-149
61	European 1950 - Portugal, Spain	15	-84	-107	-120
62	European 1979 MEAN FOR Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland	15	-86	-98	-119
63	Fort Thomas 1955 Nevis, St. Kitts (Leeward Islands)	6	-7	215	225
64	Gan 1970 - Republic of Maldives	15	-133	-321	50
65	Geodetic Datum 1949 - New Zealand	15	84	-22	209
66	Graciosa Base SW 1948 Azores (Faial, Graciosa, Pico, Sao Jorge, Terceira)	15	-104	167	-38
67	Guam 1963 - Guam	5	-100	-248	259
68	Gunung Segara - Indonesia (Kalimantan)	4	-403	684	41
69	GUX 1 Astro - Guadalcanal Island	15	252	-209	-751
70	Herat North - Afghanistan	15	-333	-222	114
71	Hjorsey 1955 - Iceland	15	-73	46	-86
72	Hong Kong 1963 - Hong Kong	15	-156	-271	-189
73	Hu-Tzu-Shan - Taiwan	15	-637	-549	-203

Code:	Name:	Ell:	dx:	dy:	dz:
74	Indian - Bangladesh	7	282	726	254
75	Indian - India, Nepal	23	295	736	257
76	Indian 1954 - Thailand, Vietnam	7	218	816	297
77	Indian 1975 - Thailand	7	209	818	290
78	Ireland 1965 - Ireland	2	506	-122	611
79	ISTS 061 Astro 1968 South Georgia Islands	15	-794	119	-298
80	ISTS 073 Astro 1969 - Diego Garcia	15	208	-435	-229
81	Johnston Island 1961 - Johnston Island	15	189	-79	-202
82	Kandawala - Sri Lanka	7	-97	787	86
83	Kerguelen Island 1949 Kerguelen Island	15	145	-187	103
84	Kertau 1948 - West Malaysia & Singapore	8	-11	851	5
85	Kusaie Astro 1951 - Caroline Islands	15	647	1777	-1124
86	L. C. 5 Astro 1961 - Cayman Brac Island	5	42	124	147
87	Leigon - Ghana	6	-130	29	364
88	Liberia 1964 - Liberia	6	-90	40	88
89	Luzon Philippines (Excluding Mindanao)	5	-133	-77	-51
90	Luzon - Philippines (Mindanao)	5	-133	-79	-72
91	Mahe 1971 - Mahe Island	6	41	-220	-134
92	Massawa - Ethiopia (Eritrea)	4	639	405	60
93	Merchich - Morocco	6	31	146	47
94	Midway Astro 1961 - Midway Islands	15	912	-58	1227

Code:	Name:	Ell:	dx:	dy:	dz:
95	Minna - Cameroon	6	-81	-84	115
96	Minna - Nigeria	6	-92	-93	122
97	Montserrat Island Astro 1958 Montserrat (Leeward Islands)	6	174	359	365
98	M'Poraloko - Gabon	6	-74	-130	42
99	Nahrwan - Oman (Masirah Island)	6	-247	-148	369
100	Nahrwan - Saudi Arabia	6	-243	-192	477
101	Nahrwan - United Arab Emirates	6	-249	-156	381
102	Naparima BWI - Trinidad & Tobago	15	-10	375	165
103	North American 1927 MEAN FOR Antigua, Barbados, Barbuda, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Turks Islands	5	-3	142	183
104	North American 1927 MEAN FOR Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua	5	0	125	194
105	North American 1927 - MEAN FOR Canada	5	-10	158	187
106	North American 1927 - MEAN FOR CONUS	5	-8	160	176
107	North American 1927 MEAN FOR CONUS (East of Mississippi River) including Louisiana, Missouri, Minnesota	5	-9	161	179
108	North American 1927 MEAN FOR CONUS (West of Mississippi River)	5	-8	159	175
109	North American 1927 - Alaska	5	-5	135	172
110	North American 1927 Bahamas (Except San Salvador Island)	5	-4	154	178
111	North American 1927 Bahamas (San Salvador Island)	5	1	140	165

Code:	Name:	Ell	dx:	dy:	dz:
112	North American 1927 Canada (Alberta, British Columbia)	5	-7	162	188
113	North American 1927 Canada (Manitoba, Ontario)	5	-9	157	184
114	North American 1927 Canada (New Brunswick, Newfoundland, Nova Scotia, Quebec)	5	-22	160	190
115	North American 1927 Canada (Northwest Territories, Saskatchewan)	5	4	159	188
116	North American 1927 - Canada (Yukon)	5	-7	139	181
117	North American 1927 - Canal Zone	5	0	125	201
118	North American 1927 - Cuba	5	-9	152	178
119	North American 1927 Greenland (Hayes Peninsula)	5	11	114	195
120	North American 1927 - Mexico	5	-12	130	190
121	North American 1983 Alaska, Canada, CONUS	12	0	0	0
122	North American 1983 Central America, Mexico	12	0	0	0
123	Observatorio Metereo 1939 Azores (Corvo & Flores Islands)	15	-425	-169	81
124	Old Egyptian 1907 - Egypt	13	-130	110	-13
125	Old Hawaiian MEAN FOR Hawaii, Kauai, Maui, Oahu	5	61	-285	-181
126	Old Hawaiian - Hawaii	5	89	-279	-183
127	Old Hawaiian - Kauai	5	45	-290	-172

Code:	Name:	Ell:	dx:	dy:	dz:
128	Old Hawaiian - Maui	5	65	-290	-190
129	Old Hawaiian - Oahu	5	58	-283	-182
130	Oman - Oman	6	-346	-1	224
131	Ord. Survey G. Britain 1936 MEAN FOR England, Isle of Man, Scotland, Shetland Islands, Wales	1	375	-111	431
132	Ord. Survey G. Britain 1936 - England	1	371	-112	434
133	Ord. Survey G. Britain 1936 England, Isle of Man, Wales	1	371	-111	434
134	Ord. Survey G. Britain 1936 Scotland, Shetland Islands	1	384	-111	425
135	Ord. Survey G. Britain 1936 - Wales	1	370	-108	434
136	Pico de las Nieves - Canary Islands	15	-307	-92	127
137	Pitcairn Astro 1967 - Pitcairn Island	15	185	165	42
138	Point 58 MEAN FOR Burkina Faso & Niger	6	-106	-129	165
139	Pointe Noire 1948 - Congo	6	-148	51	-291
140	Porto Santo 1936 Porto Santo, Madeira Islands	15	-499	-249	314
141	Provisional S. American 1956 MEAN FOR Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela	15	-288	175	-376
142	Provisional S. American 1956 - Bolivia	15	-270	188	-388
143	Provisional S. American 1956 Chile (Northern, Near 19°S)	15	-270	183	-390
144	Provisional S. American 1956 Chile (Southern, Near 43°S)	15	-305	243	-442

Code:	Name:	Ell:	dx:	dy:	dz:
145	Provisional S. American 1956 - Colombia	15	-282	169	-371
146	Provisional S. American 1956 - Ecuador	15	-278	171	-367
147	Provisional S. American 1956 - Guyana	15	-298	159	-369
148	Provisional S. American 1956 - Peru	15	-279	175	-379
149	Provisional S. American 1956 Venezuela	15	-295	173	-371
150	Provisional S. Chilean 1963 Chile (South, Near 53°S) (Hito XVIII)	15	16	196	93
151	Puerto Rico Puerto Rico, Virgin Islands	5	11	72	-101
152	Qatar National - Qatar	15	-128	-283	22
153	Qornoq - Greenland (South)	15	164	138	-189
154	Reunion - Mascarene Islands	15	94	-948	-1262
155	Rome 1940 - Italy (Sardinia)	15	-225	-65	9
156	Santo (DOS) 1965 Espirito Santo Island	15	170	42	84
157	Sao Braz Azores (Sao Miguel, Santa Maria Islands)	15	-203	141	53
158	Sapper Hill 1943 - East Falkland Island	15	-355	21	72
159	Schwarzeck - Namibia	22	616	97	-251
160	Selvagem Grande - Salvage Islands	15	-289	-124	60
161	SGS 85 - Soviet Geodetic System 1985	26	3	9	-9
162	South American 1969 MEAN FOR Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Trinidad & Tobago, Venezuela	17	-57	1	-41

Code:	Name:	Ell:	dx:	dy:	dz:
163	South American 1969 - Argentina	17	-62	-1	-37
164	South American 1969 - Bolivia	17	-61	2	-48
165	South American 1969 - Brazil	17	-60	-2	-41
166	South American 1969 - Chile	17	-75	-1	-44
167	South American 1969 - Colombia	17	-44	6	-36
168	South American 1969 - Ecuador	17	-48	3	-44
169	South American 1969 Ecuador (Baltra, Galapagos)	17	-47	27	-42
170	South American 1969 - Guyana	17	-53	3	-47
171	South American 1969 - Paraguay	17	-61	2	-33
172	South American 1969 - Peru	17	-58	0	-44
173	South American 1969 - Trinidad & Tobago	17	-45	12	-33
174	South American 1969 - Venezuela	17	-45	8	-33
175	South Asia - Singapore	10	7	-10	-26
176	Tananarive Observatory 1925 Madagascar	15	-189	-242	-91
177	Timbalai 1948 Brunei, East Malaysia (Sabah, Sarawak)	25	-679	669	-48
178	Tokyo - MEAN FOR Japan, Korea, Okinawa	4	-148	507	685
179	Tokyo - Japan	4	-148	507	685
180	Tokyo - Korea	4	-146	507	687
181	Tokyo - Okinawa	4	-158	507	676

Code:	Name:	Ell:	dx:	dy:	dz:
182	Tristan Astro 1968 - Tristan da Cunha	15	-632	438	-609
183	Viti Levu 1916 Fiji (Viti Levu Island)	6	51	391	-36
184	Wake-Eniwetok 1960 - Marshall Islands	14	102	52	-38
185	Wake Island Astro 1952 - Wake Atoll	15	276	-57	149
186	WGS 1972 - Global Definition	20	0	0	0
187	Yacare - Uruguay	15	-155	171	37
188	Zanderij - Suriname	15	-265	120	-358

NavCore Datum Table: The following list of datums, maintained and selectable through the LABMON evaluation software, applies to Conexant's NavCore GPS receivers:

0	WGS-84 (Default)	49	Mahe 1971
1	Adindan	50	Marco Astro
2	AFG	51	Massawa
3	AIN EL ABD 1970	52	Merchich
4	Anna 1 Astro 1965	53	Midway Astro 1961
5	ARC 1950	54	Minna
6	ARC 1960	55	Nahrwan Masirah Island
7	Ascension Island 1958	56	Narhwan United Arab Emirates
8	Astro Beacon "E"	57	Nahrwan Saudia Arabia
9	Astro B4 SOR. ATOLL	58	Namibia
10	Astro POS 71/4	59	Naparima, BWI
11	Astronomic Station 1952	60	NAD-27 Conus
12	Australian Geodetic 1966	61	NAD-27 Alaska
13	Australian Geodetic 1984	62	NAD-27 Bahamas
14	Bellevue (IGN)	63	NAD-27 San Salvador Island
15	Bermuda 1957	64	NAD-27 Canada
16	Bogota Observatory	65	NAD-27 Canal Zone
17	Campo Inchauspe	66	NAD-27 Caribbean
18	Canton Island 1966	67	NAD-27 Central America
19	Cape	68	NAD-27 Cuba
20	Cape Canaveral	69	NAD-27 Greenland
21	Carthage	70	NAD-27 Mexico
22	Chatham 1971	71	North America 1983
23	Chua Astro	72	Observatorio 1966
24	Corrogo Alegre	73	Old Egyptian 1960
25	Djakarta (Batavia)	74	Old Hawaiian
26	DOS 1968	75	Oman
27	Easter Island 1967	76	Ordinance Survey of Great Britain
28	European 1950	77	Pico de las Nieves
29	European 1979	78	Pitcairn Astro 1967
30	Gandajika Base	79	Provisional South Chilean 1963
31	Geodetic Datum 1949	80	Provisional South American 1956
32	Guam 1963	81	Puerto Rico
33	GUX 1 Astro	82	Qatar National
34	Hjorsey 1955	83	Qornoq
35	Hong Kong 1963	84	Rome 1940
36	Indian Thailand	85	Santa Braz
37	Indian Bangladesh	86	Santo (DOS)
38	Ireland 1965	87	Sapper Hill
39	ISTS 073 Astro 1969	88	South American 1969
40	Johnston Island 1962	89	South Asia
41	Kandawala	90	Southeast Base
42	Kerguelen Island	91	Southwest Base
43	Kertau 1948	92	Timbalai 1948
44	La Reunion	93	Tokyo
45	L.C. 5 Astro	94	Tristan Astro 1968
46	Liberia 1964	95	Viti Levu 1916
47	Luzon	96	Wake-Eniwetok 1960
48	Mindanao Island	97	Zanderij

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APPENDIX F: 2x10 Pin Field Connector Information

This appendix contains specifications and ordering information for the 2x10 pin field connector (available from Elco, Inc.).

18.00 mm (0.7087 in)

PWB surface

2.00 mm (0.0787 in)

6.35 mm
(0.250 in)

0.508 mm
(0.02 in)

square pins
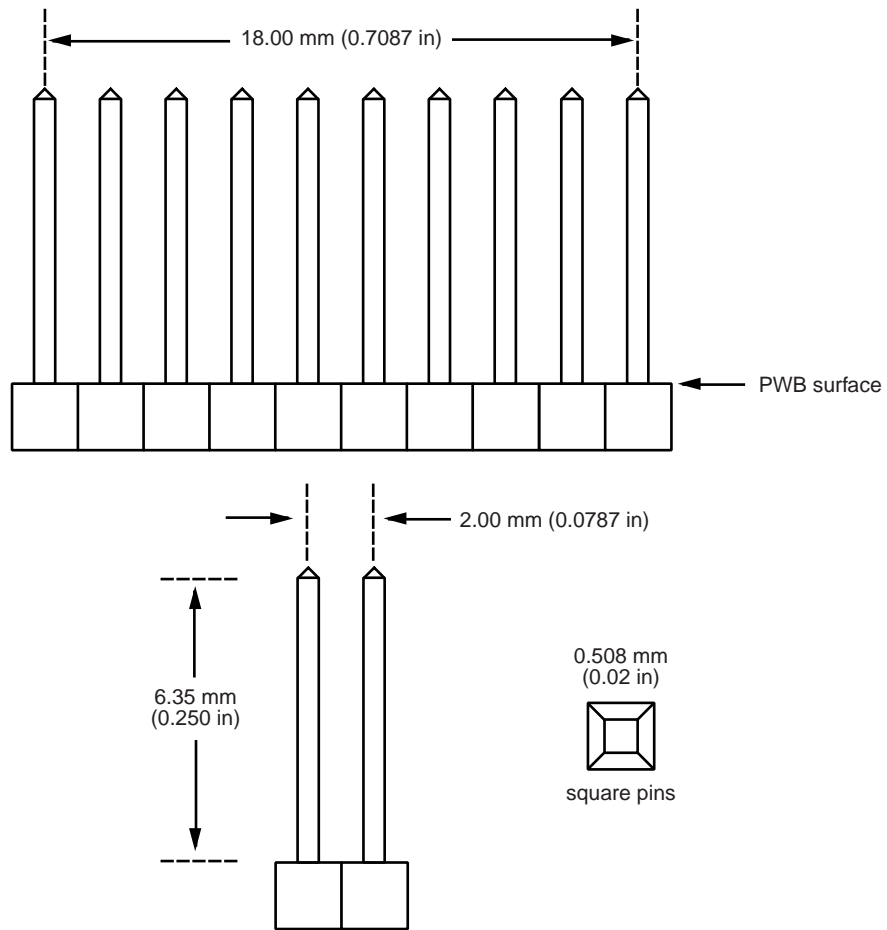
2x10 Pin Field Header Mechanical Detail   **C465**

ELCO
ELCO

IDC Receptacle

United States Japan Europe Korea Singapore

Vertical Receptacle

Right Angle Receptacle
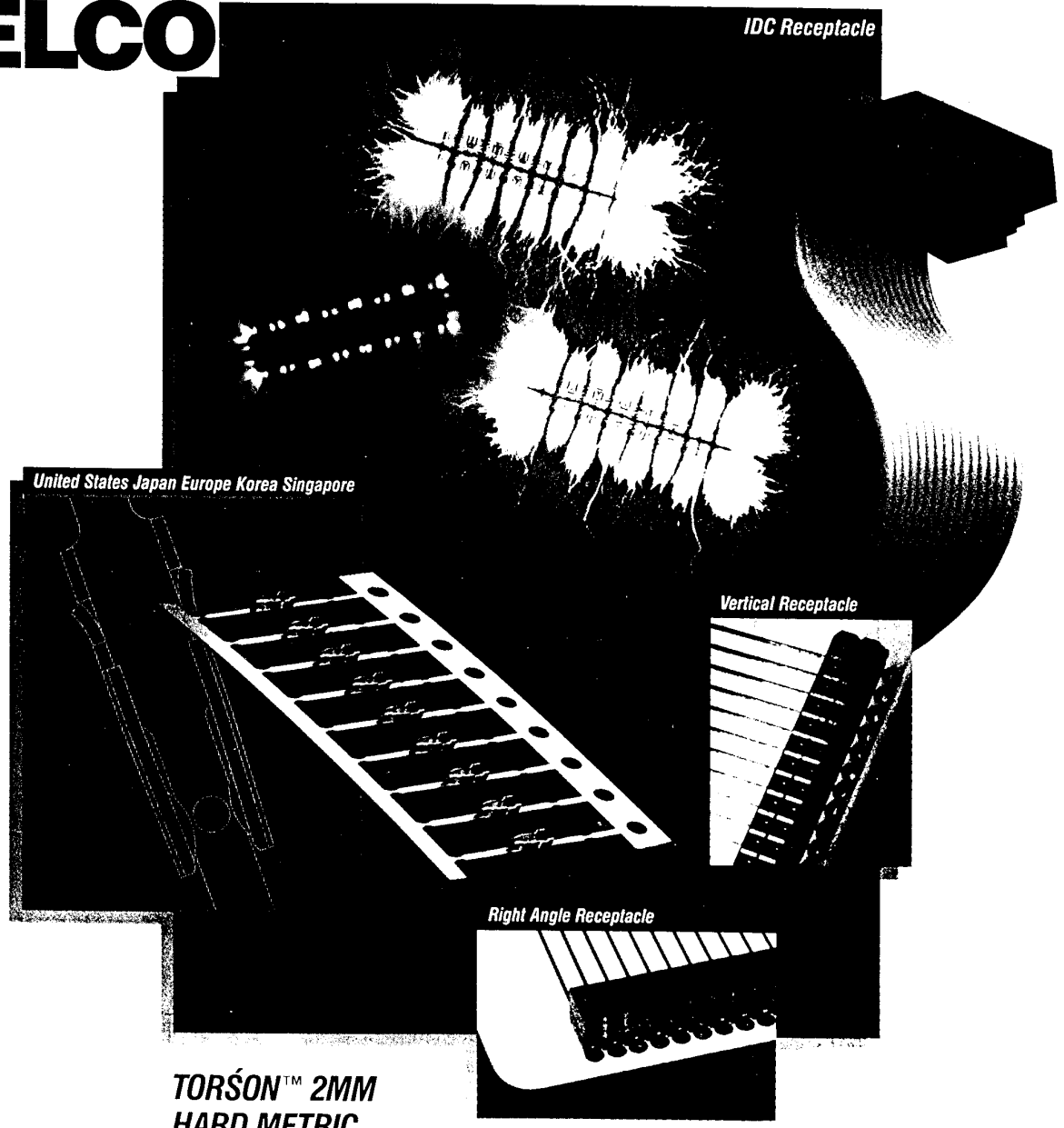
TORŚON™ 2MM
HARD METRIC
CONNECTION
SYSTEM
CATALOG

TORŚON™ 2MM HARD METRIC RECEPTACLE, HEADER AND IDC CONNECTION SYSTEM

The unique Torśon 2mm Hard Metric Receptacle and Header System uses a newly-patented breakthrough design feature that, for the first time, provides the torsion and flexibility in each beam needed to maintain continuous electrical contact, even under harsh conditions. Torśon connectors are configured so that Hertz risers extend from contact beams to provide excellent contact at all times. Versatile Torśon low-profile connectors are available in a wide selection of configurations: IDC receptacles, thru board and surface mount, vertical receptacles, right angle and vertical unshrouded and vertical shrouded headers with and without latches from six to fifty positions.
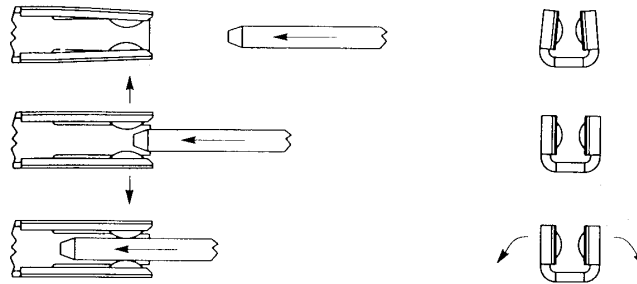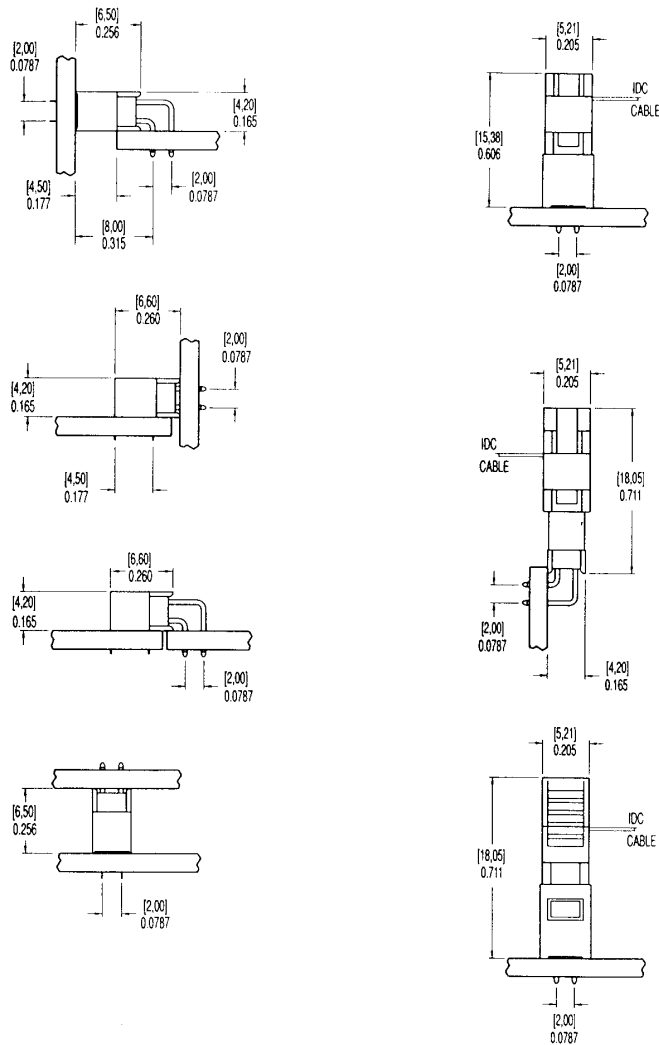
PRODUCT SPECIFICATIONS

- **Contact Stress — min. 150 KPSI**
- **Insertion Force — 6 oz max. [1.67 newtons]**
- **Withdrawal Force — .75 oz min. [.21 newtons]**
- **Contact Resistance — 20 milliohms initial**
- **Dielectric Withstanding Voltage — 1000 VAC**
- **Current Rating — 2 amps max.**
- **Durability — 50 cycles**
- **Operating Temperature — (−55°C to 105°C) — IDC (−55°C to +85°C)**
- **Insulation Resistance — 2500 megohms min.**

Other product features and benefits include:

- **Low profile.**
- **Plastic contact lead-in for ease of insertion.**
- **Early and long contact wipe.**
- **Two-piece interconnection system for high reliability.**
- **Low insertion force and high normal force contacts for large number of pin-outs and interface reliability.**
- **High temperature insulator material accommodates reflow soldering temperatures.**
- **15 μ inch (0,38 micrometers) gold plating on all mating surfaces.**

TYPICAL APPLICATIONS

Dimensions are for reference only. For precise calculations, product drawings are available. Specifications are subject to change without notice.

Vertical Receptacle   Surface Mount Vertical Receptacle   Right Angle Receptacle   Low Profile Vertical Receptacle
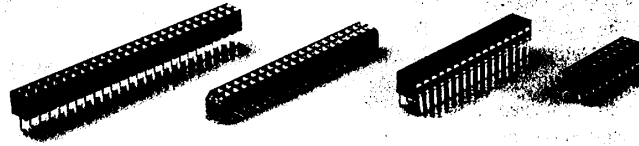
VERTICAL RECEPTACLES
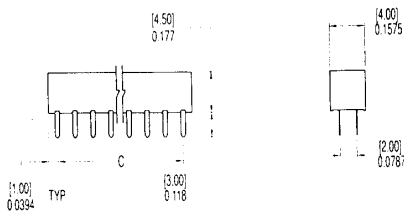
LOW PROFILE VERTICAL RECEPTACLES
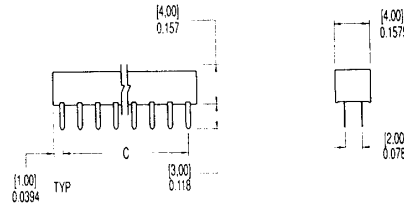
SURFACE MOUNT VERTICAL RECEPTACLES
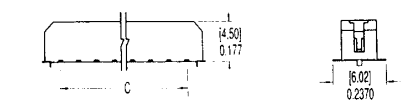
RIGHT ANGLE RECEPTACLES
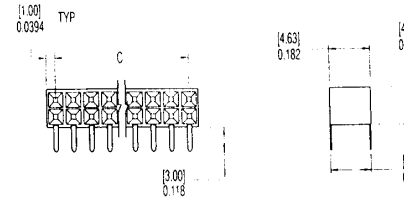
C	NO OF POS. DOUBLE ROW	VERTICAL RECEPTACLE PART NUMBER	LOW PROFILE RECEPTACLE PART NUMBER
4,00 /.1575	6	20 8390 2006 00 101	20 8390 2006 20 101
6,00 /.2362	8	20 8390 2008 00 101	20 8390 2008 20 101
8,00 /.3150	10	20 8390 2010 00 101	20 8390 2010 20 101
10,00 /.3937	12	20 8390 2012 00 101	20 8390 2012 20 101
12,00 /.4724	14	20 8390 2014 00 101	20 8390 2014 20 101
14,00 /.5512	16	20 8390 2016 00 101	20 8390 2016 20 101
16,00 /.6299	18	20 8390 2018 00 101	20 8390 2018 20 101
18,00 /.7087	20	20 8390 2020 00 101	20 8390 2020 20 101
20,00 /.7874	22	20 8390 2022 00 101	20 8390 2022 20 101
22,00 /.8661	24	20 8390 2024 00 101	20 8390 2024 20 101
24,00 /.9449	26	20 8390 2026 00 101	20 8390 2026 20 101
26,00 /1.0236	28	20 8390 2028 00 101	20 8390 2028 20 101
28,00 /1.1024	30	20 8390 2030 00 101	20 8390 2030 20 101
30,00 /1.1811	32	20 8390 2032 00 101	20 8390 2032 20 101
32,00 /1.2598	34	20 8390 2034 00 101	20 8390 2034 20 101
34,00 /1.3386	36	20 8390 2036 00 101	20 8390 2036 20 101
36,00 /1.4173	38	20 8390 2038 00 101	20 8390 2038 20 101
38,00 /1.4961	40	20 8390 2040 00 101	20 8390 2040 20 101
40,00 /1.5748	42	20 8390 2042 00 101	20 8390 2042 20 101
42,00 /1.6535	44	20 8390 2044 00 101	20 8390 2044 20 101
44,00 /1.7323	46	20 8390 2046 00 101	20 8390 2046 20 101
46,00 /1.8110	48	20 8390 2048 00 101	20 8390 2048 20 101
48,00 /1.8898	50	20 8390 2050 00 101	20 8390 2050 20 101

Variations in plating and/or tail lengths are available upon request.

C	NO OF POS. DOUBLE ROW	S/M VERTICAL RECEPTACLE PART NUMBER	RIGHT ANGLE RECEPTACLE PART NUMBER
4,00 /.1575	6	20 8390 2006 01 101	20 8391 2006 00 101
6,00 /.2362	8	20 8390 2008 01 101	20 8391 2008 00 101
8,00 /.3150	10	20 8390 2010 01 101	20 8391 2010 00 101
10,00 /.3937	12	20 8390 2012 01 101	20 8391 2012 00 101
12,00 /.4724	14	20 8390 2014 01 101	20 8391 2014 00 101
14,00 /.5512	16	20 8390 2016 01 101	20 8391 2016 00 101
16,00 /.6299	18	20 8390 2018 01 101	20 8391 2018 00 101
18,00 /.7087	20	20 8390 2020 01 101	20 8391 2020 00 101
20,00 /.7874	22	20 8390 2022 01 101	20 8391 2022 00 101
22,00 /.8661	24	20 8390 2024 01 101	20 8391 2024 00 101
24,00 /.9449	26	20 8390 2026 01 101	20 8391 2026 00 101
26,00 /1.0236	28	20 8390 2028 01 101	20 8391 2028 00 101
28,00 /1.1024	30	20 8390 2030 01 101	20 8391 2030 00 101
30,00 /1.1811	32	20 8390 2032 01 101	20 8391 2032 00 101
32,00 /1.2598	34	20 8390 2034 01 101	20 8391 2034 00 101
34,00 /1.3386	36	20 8390 2036 01 101	20 8391 2036 00 101
36,00 /1.4173	38	20 8390 2038 01 101	20 8391 2038 00 101
38,00 /1.4961	40	20 8390 2040 01 101	20 8391 2040 00 101
40,00 /1.5748	42	20 8390 2042 01 101	20 8391 2042 00 101
42,00 /1.6535	44	20 8390 2044 01 101	20 8391 2044 00 101
44,00 /1.7323	46	20 8390 2046 01 101	20 8391 2046 00 101
46,00 /1.8110	48	20 8390 2048 01 101	20 8391 2048 00 101
48,00 /1.8898	50	20 8390 2050 01 101	20 8391 2050 00 101

Variations in plating and/or tail lengths are available upon request.

Discrete Crimp-to-Wire Receptacles/Housings

2.00 x 2.00 mm (0.079 x 0.079 in.) Centerlines

Minitek™ Receptacles and Housings
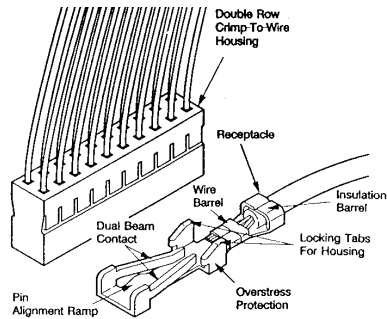
Features

Receptacle

- Applicable to wire sizes 26 through 36 AWG.
- Dual-beam design ensures reliable electrical performance.
- Gold plated contact area.
- Pin alignment ramp for precision mating.
- Overstress protection feature protects against damage during mating.
- Locking tabs ensure stability within the housing.

Housing

- 2 x 2 through 2 x 25 unkeyed housings.
- 2 x 2 through 2 x 17 and 1 x 3 through 1 x 17 keyed housings.

Options

- Center key polarization

- Latching when used with Minitek™ shrouded headers increases mating/unmating force by approximately 1 kg (2.2 lbs).
- Polarization through molded-in position or post inserted plug.

Mating Data

Mates with 0.50 mm (0.020 in.) square pin 4.00 mm (0.157 in.) long. Point of contact is 2.50 mm (0.098 in.) from the mating face of the housing.

Berg Electronics Products	Page
■ Minitek™ unshrouded headers	9-8 to 9-23
■ Minitek™ shrouded headers	9-40 to 9-43

Specifications

- JIS-5020
- MIL-STD-202

Approvals and Certifications

ЯU File no. E66906

SP· File no. LR46923

Application Equipment

Description	Page
■ Olympian Model 740 Semi-automatic two-ton bench press	9-49
■ HT-151 for 26–30 AWG	9-49
■ HT-152 for 32–36 AWG	9-49

Technical Data

Materials

- Housing . . . . Glass-filled thermoplastic (UL 94 V-0)
  - ► Color . . . . Black
- Receptacle . . . . Phosphor-bronze

Operating Environment

- Temperature range . . . . -40°C to +105°C

Plating

- Underplate . . . . 1.27 µm (50 µin.) min nickel
- Finish . . . . 0.20 µm (8 µin.) min gold
  or 0.76 µm (30 µin.) min gold

Electrical Performance

- Insulation resistance . . . . 1000 MΩ min
- Withstanding voltage . . . . 650 V rms

- Voltage rating . . . . 200 V ac/dc
- Current rating . . . . 2 amp continuous
- Contact resistance . . . . 20 mΩ max

Mechanical Performance

- Mating force per contact . . . . 1.77 N (180 gf) max
- Unmating force per contact . . . . 0.20 N (20 gf) min
- Terminal retention force . . . . 7.83 N (800 gf) min
- Durability (mating cycles) 100

Packaging

- Housings . . . . cartons
- Receptacles . . . . reels

Customer Support Materials

Description	Order No.	Description	Order No.
Customer Product Drawings	By Part No.	Product Bulletin	950522-001
Product Samples	By Part No.	Product Specifications	110-036
		■ Crimp Specification	100-006

Discrete Crimp-to-Wire Receptacles/Housings
2.00 x 2.00 mm (0.079 x 0.079 in.)

Description
Receptacle

PART NO. 77138

SECTION A-A   SECTION B-B

PART NO. 77139

SECTION A-A   SECTION B B

A163396-0468
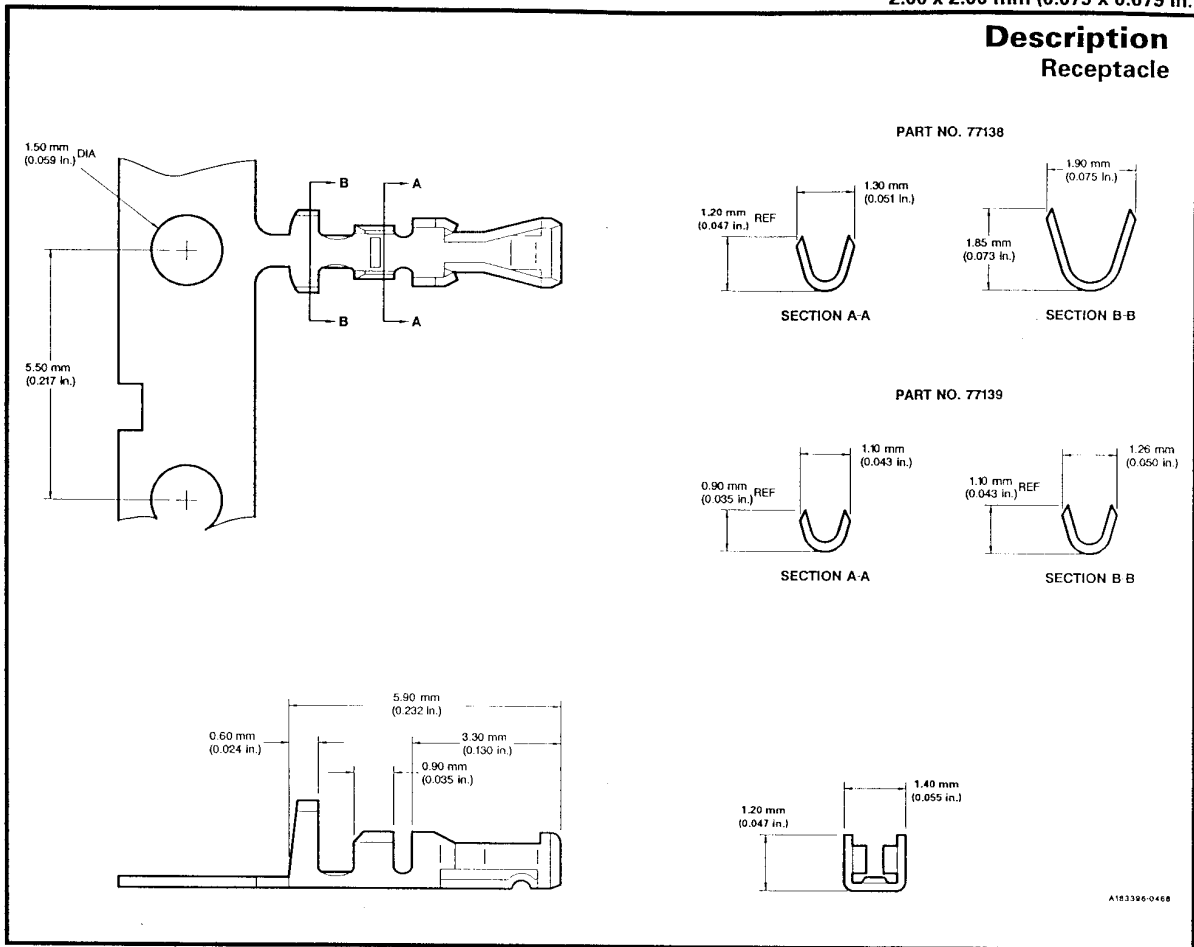
Ordering Data
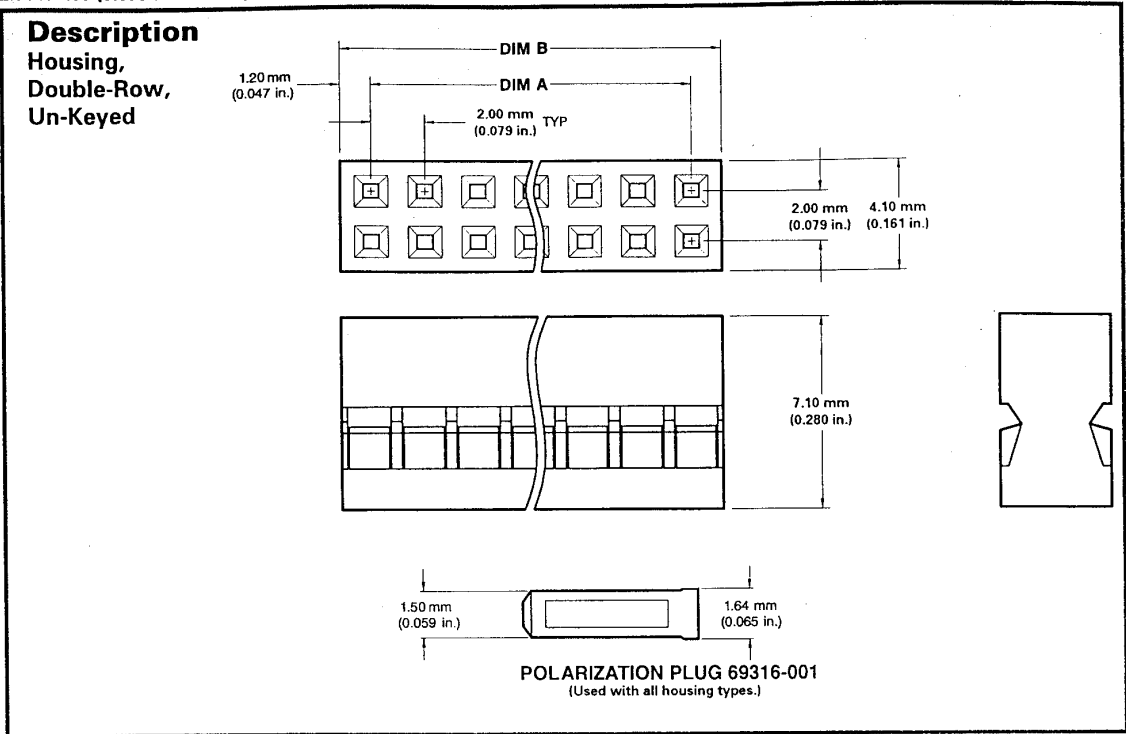### Receptacle

Base number specifies wire size AWG. ─────────┐   ┌───────── Dash number specifies plating.

□ □ □ □ □ - X X X

Base Number	Wire Gauge
77138	26 AWG to 30 AWG
77139	32 AWG to 36 AWG
Dash Number	**Plating**
-001	0.20 μm (8 μin.) min gold over nickel
-101	0.76 μm (30 μin.) min gold over nickel

Ordering data shown is for our standard product offering. For non-standard or custom products, contact your authorized Berg Electronics representative.

Discrete Crimp-to-Wire Receptacles/Housings
2.00 x 2.00 (0.079 x 0.079 in.)

Description

Housing,
Double-Row,
Un-Keyed

1.20 mm (0.047 in.)

DIM B

DIM A

2.00 mm (0.079 in.) TYP

2.00 mm (0.079 in.)   4.10 mm (0.161 in.)

7.10 mm (0.280 in.)

1.50 mm (0.059 in.)   1.64 mm (0.065 in.)

POLARIZATION PLUG 69316-001
(Used with all housing types.)

Ordering Data

Housing
Part No. 69307

69307-XXX

Dash number specifies number of positions.

Number of Positions	Dash Number	Dimension A		Dimension B	
		mm	in.	mm	in.
2 x 2	-004	2.00	0.079	4.40	0.173
2 x 3	-006	4.00	0.157	6.40	0.252
2 x 4	-008	6.00	0.236	8.40	0.331
2 x 5	-010	8.00	0.315	10.40	0.409
2 x 6	-012	10.00	0.394	12.40	0.488
2 x 7	-014	12.00	0.472	14.40	0.567
2 x 8	-016	14.00	0.551	16.40	0.646
2 x 9	-018	16.00	0.630	18.40	0.724
2 x 10	-020	18.00	0.709	20.40	0.803
2 x 11	-022	20.00	0.787	22.40	0.882
2 x 12	-024	22.00	0.866	24.40	0.961
2 x 13	-026	24.00	0.945	26.40	1.039
2 x 14	-028	26.00	1.024	28.40	1.118
2 x 15	-030	28.00	1.102	30.40	1.197
2 x 16	-032	30.00	1.181	32.40	1.276
2 x 17	-034	32.00	1.260	34.40	1.354
2 x 18	-036	34.00	1.339	36.40	1.433
2 x 19	-038	36.00	1.417	38.40	1.512
2 x 20	-040	38.00	1.496	40.40	1.591
2 x 21	-042	40.00	1.575	42.40	1.669
2 x 22	-044	42.00	1.654	44.40	1.748
2 x 23	-046	44.00	1.732	46.40	1.827
2 x 24	-048	46.00	1.811	48.40	1.906
2 x 25	-050	48.00	1.890	50.40	1.984

Ordering data shown is for our standard product offering. For non-standard or custom products, contact your authorized Berg Electronics representative.

Discrete Crimp-to-Wire Receptacles/Housings
2.00 x 2.00 (0.079 x 0.079 in.)

Description
Housing, Double-Row, Keyed

7.10 mm
(0.280 in.)

2.00 mm
(0.079 in.)

1.00 mm
(0.039 in.)

DIM C

4.10 mm
(0.161 in.)

2.00 mm
(0.079 in.)

2.00 mm TYP
(0.079 in.)

DIM A

DIM B
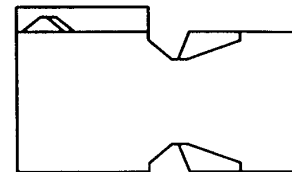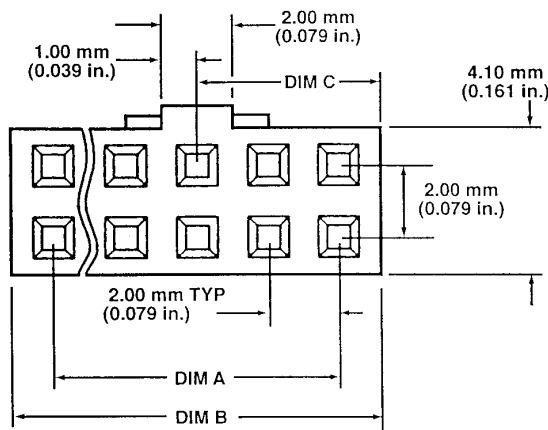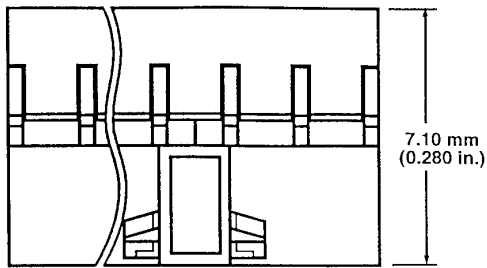
See page 9-46 for polarization plug.

Ordering Data
Housing
Part No. 90311

Dash number specifies number of positions.

9 0 3 1 1 - X X X

Number of Positions	Dash Number	Dimension A		Dimension B		Dimension C	
		mm	in.	mm	in.	mm	in.
2 x 2*	-004	2.00	0.079	4.40	0.173	2.20	0.087
2 x 3	-006	4.00	0.157	6.40	0.252	3.20	0.126
2 x 4	-008	6.00	0.236	8.40	0.331	4.20	0.165
2 x 5	-010	8.00	0.315	10.40	0.409	5.20	0.205
2 x 6	-012	10.00	0.394	12.40	0.488	6.20	0.244
2 x 7	-014	12.00	0.472	14.40	0.567	7.20	0.283
2 x 8	-016	14.00	0.551	16.40	0.646	8.20	0.323
2 x 9	-018	16.00	0.630	18.40	0.724	9.20	0.362
2 x 10	-020	18.00	0.709	20.40	0.803	10.20	0.402
2 x 11	-022	20.00	0.787	22.40	0.882	11.20	0.441
2 x 12	-024	22.00	0.866	24.40	0.961	12.20	0.480
2 x 13	-026	24.00	0.945	26.40	1.039	13.20	0.520
2 x 14	-028	26.00	1.024	28.40	1.118	14.20	0.559
2 x 15	-030	28.00	1.102	30.40	1.197	15.20	0.598
2 x 16	-032	30.00	1.181	32.40	1.276	16.20	0.638
2 x 17	-034	32.00	1.260	34.40	1.354	17.20	0.677

* Note: 2 x 2 housing has single latching tab and no center key.

Ordering data shown is for our standard product offering. For non-standard or custom products, contact your authorized Berg Electronics representative.

Discrete Crimp-to-Wire Receptacles/Housings
2.00 x 2.00 (0.079 x 0.079 in.)

Description
Housing, Single-Row, Keyed

7.10 mm
(0.280 in.)

2.00 mm
(0.079 in.)

1.00 mm
(0.039 in.)

DIM C

2.00 mm
(0.079 in.)

2.00 mm TYP
(0.079 in.)

DIM A

DIM B
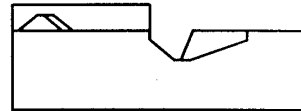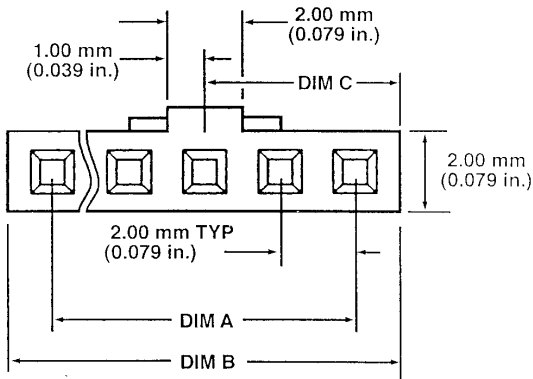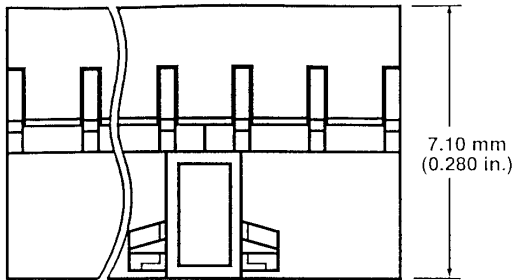
See page 9-46 for polarization plug.

Ordering Data
Housing
Part No. 90312

Dash number specifies number of positions.

9 0 3 1 2 - X X X

No. of Postions	Dash Number	Dimension A		Dimension B		Dimension C	
		mm	in.	mm	in.	mm	in.
1 x 3	-003	4.00	0.157	6.40	0.252	3.20	0.126
1 x 4	-004	6.00	0.236	8.40	0.331	4.20	0.165
1 x 5	-005	8.00	0.315	10.40	0.409	5.20	0.205
1 x 6	-006	10.00	0.394	12.40	0.488	6.20	0.244
1 x 7	-007	12.00	0.472	14.40	0.567	7.20	0.283
1 x 8	-008	14.00	0.551	16.40	0.646	8.20	0.323
1 x 9	-009	16.00	0.630	18.40	0.724	9.20	0.362
1 x 10	-010	18.00	0.709	20.40	0.803	10.20	0.402
1 x 11	-011	20.00	0.787	22.40	0.882	11.20	0.441
1 x 12	-012	22.00	0.866	24.40	0.961	12.20	0.480
1 x 13	-013	24.00	0.945	26.40	1.039	13.20	0.520
1 x 14	-014	26.00	1.024	28.40	1.118	14.20	0.559
1 x 15	-015	28.00	1.102	30.40	1.197	15.20	0.598
1 x 16	-016	30.00	1.181	32.40	1.276	16.20	0.638
1 x 17	-017	32.00	1.260	34.40	1.354	17.20	0.677

Ordering data shown is for our standard product offering. For non-standard or custom products, contact your authorized Berg Electronics representative.

Application Equipment for Crimp-to-Wire Minitek™ Receptacles
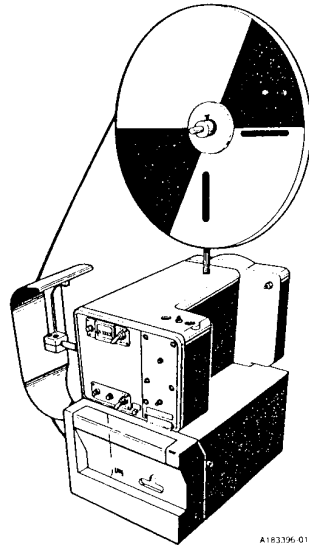
A183396-0100

OLYMPIAN Model 740 Semi-automatic Two-ton Bench Press

Features

- Ideal for medium-volume production requirements.
- Rugged construction, requires little maintenance.
- Electrically operated.
- Uses Precision Interchangeable Crimpers. These applicators allow quick tooling changeovers for various wire sizes and styles of terminals. Fine-tuning knobs allow fast, precise adjustment of the terminal's wire and insulation barrel crimp height.
- Easy to operate.

Technical Data

	OL-740
Application Rate (crimps/hour)	2400*
Electrical Requirements	115 V ac, 60 Hz, 10 amp
*Application rates given are approximate. Actual rates achieved depend on operator dexterity.	

Ordering Data

Machines (for strip-form receptacles)	Wire Size AWG	Identification Number
OLYMPIAN Model 740 (press only)	N/A	133911-002
OL-740 applicators	26-30	155250-001
	32-36	155250-002
OLYMPIAN MODEL 740 (press with applicator)	26-30	133911-527
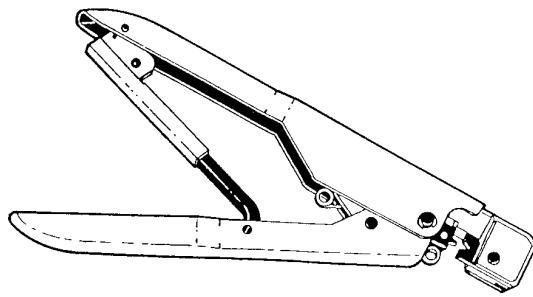
A183396-0103

Hand Tools

Features

- Lightweight.
- Rugged.
- Ratchet-action handle assures complete crimp cycle.
  - ► HT-151 for 26-30 AWG
  - ► HT-152 for 32-36 AWG

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APPENDIX G: RF Connector Information

This appendix contains specifications and ordering information for the RF connector.

![M/A-COM INTERCONNECT DIVISION logo]

OSX Subminiature Snap-On Connectors and Adapters
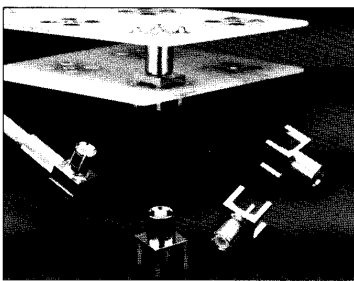
Board-to-Board
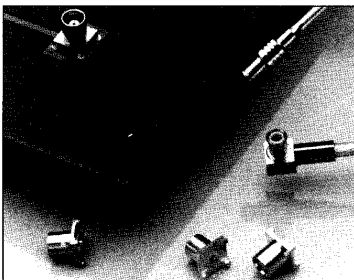
Surface Mount

OSX subminiature snap-on connectors from M/A-COM are an excellent blend of size, weight, durability and performance for applications such as GPS, automotive and wireless communications. OSX connectors are 30% smaller than standard SMB connectors and offer the user more densely packaged coaxial connections. While the overall diameter has been reduced, OSX connectors use center contacts and dielectrics dimensionally similar to field tested MIL-C-39012 SMB connectors yielding excellent performance and durability.

In addition to flexible and semi-rigid cable connectors, OSX is available as printed circuit board receptacles for both board-to-board and surface mount applications. A mated pair of board-to-board connectors yield 7.11 mm (0.28 inch) nominal separation between the printed circuit boards and still provide .254 mm (0.010 inch) stand-off per connector for optimum board cleaning. OSX surface mount connectors meet new requirements for denser PCB packaging and lower installed costs. These subminiature snap-on connectors withstand the harsh environment of infrared reflow, convection and vapor phase soldering and provide .254 mm (0.010 inch) stand-off.

By offering so many features in such a small connector, M/A-COM's OSX connectors are sure to fit most applications where space, weight, size, performance and ease of assembly are required. Contact the factory with your specific requirements.

.649 (16.5)   .376 (9.6)

CIRCUIT BOARD PLANE   **SMB**   **OSX**
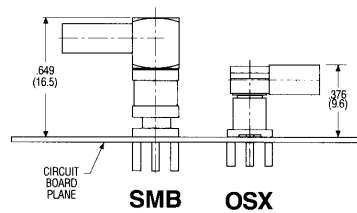
Typical Mated Height Comparison

PLUG

Letter	Millimeters (Inches)	
	Minimum	Maximum
A	0.48 (.0189)	0.53 (.0208)
B	2.00 (.0788)	2.07 (.0815)
C	3.66 (.144)	3.76 (.148)
D	0.00 (.000)	0.30 (.0118)
E	2.81 (.111)	3.19 (.125)
F	4.16 (.164)	-
G	2.81 (.111)	3.20 (.126)
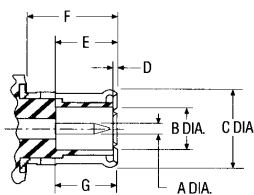
JACK

Letter	Millimeters (Inches)	
	Minimum	Maximum
H	1.80 (.071)	1.97 (.077)
I	3.43 (.135)	3.48 (.137)
J	3.61 (.142)	3.75 (.147)
K	2.31 (.091)	2.79 (.110)
L	2.61 (.103)	2.79 (.110)
M	4.00 (.158)	4.12 (.162)
N	0.75 (.0296)	0.85 (.0334)

M/A-COM Inc.   ■   140 Fourth Avenue, Waltham, MA 02254 USA   ■   Telephone: 800-366-2266
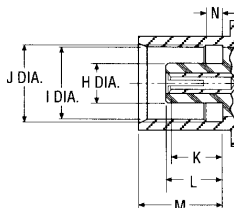
OSX   Specifications

Requirement	Detail

General

Materials	Brass per QQ-B626, Comp. 360, half hard. Beryllium copper per ASTM-B-196. PTFE fluorocarbon per ASTM-D-1457. Soft copper alloy.
Finish	Center Contacts: Gold-plated (MIL-G-45204) over nickel plate (QQ-N-290) over copper plate (MIL-C-14550) Outer Contacts: Gold plated (MIL-G-45204) over nickel plate (QQ-N-290) over copper plate (MIL-C-14550) Housings: Nickel plated (QQ-N-290) over copper plate (MIL-C-14550), or Gold plated (MIL-G-45204) over nickel plate (QQ-N-290) over copper plate (MIL-C-14550). All other metal parts shall be furnished so as to provide a connector which meets corrosion requirements. For different platings, contact the factory.
Design	The design shall be such that the outline and interface dimensions shown in this catalog are met.

Electrical

Frequency	dc-6 GHz
Nominal Impedance	50 ohms
Voltage Rating	335 Volts (VRMS Maximum) @ Sea Level
VSWR	1.25:1 Maximum @ 4 GHz 1.35:1 Maximum @ 6 GHz
Insulation Resistance	10,000 Megohms Minimum
Insertion Loss	.1 dB Maximum/1000 MHz
Dielectric Withstanding Voltage	1000 Volts (VRMS Minimum) @ Sea Level
Contact Resistance Center Contact Outer Contact Cable to Housing	 5.0 Milliohms Maximum 1.0 Milliohms Maximum 1.0 Milliohms Maximum
Corona 70,000 ft.	250 Volts (VRMS Minimum)
RF High Potential @ Sea Level Contact Current	670 Volts (VRMS Minimum) @ MHz 1.5 ADC Max

Mechanical

Force to Engage	3.4 lbs. Maximum (1.1 Typical)
Force to Disengage	4.5 lbs. Maximum
Contact Captivation	Designed to maintain OSX interface when mating.
Connector Durability	500 insertion and withdrawal cycles at 12 cycles per minute maximum.

Environmental

Temperature Rating	-65°C + 165°C
Vibration	MIL-STD-202, Method 204, Condition B
Shock	MIL-STD-202, Method 213, Condition A
Moisture Resistance	MIL-STD-202, Method 106
Corrosion	MIL-STD-202, Method 101, Condition B, 48 Hours
Thermal Shock	MIL-STD-202, Method 107, Condition B

Performance data typical of 5837-5003-10. Performance for other connectors will vary.
M/A-COM has design control and all data contained herein is subject to change without notice. Contact the factory for specifications on other connector types.

Flexible Cables

| Cable Type		RG-58/U	RG-174/U	RG-178/U	RG-188/U	RG-196/U	RG-316/U
Impedance (ohms)		50	50	50	50	50	50
(Dia.) (mm)	Jacket	5.05 Max	2.67 Max	1.91 Max	2.79 Max.	2.03 Max.	2.59 Max.
	Outer Conductor	3.81 Max.	2.24 Max.	1.37 Max.	2.06 Max.	1.37 Max.	2.06 Max.
	Dielectric Core	3.05 Max.	1.60 Max.	.86 ± .05	1.52±.08	.86± .05	1.52±.08
	Center Conductor	.81 Nom.	.51 Nom.	.31 Nom.	.51 Nom.	.31 Nom.	.31 Nom.
Cable Retention		20 lbs.	20 lbs.	10 lbs.	20 lbs.	10 lbs.	20lbs.

M/A-COM Inc.   ■   140 Fourth Avenue, Waltham, MA 02254 USA   ■   Telephone: 800-366-2266

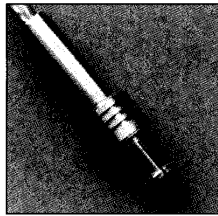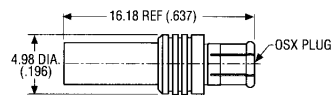# OSX   For Flexible Cable

Solder Attachment
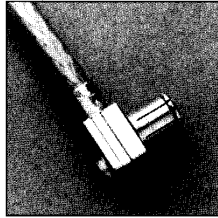
Right Angle Cable Plug
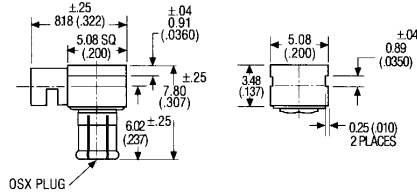
Captured Center Contact	
Part Number	**Cable**
5807-5001-09	RG-174/U, 188/U, 316/U

Finish: Gold plated
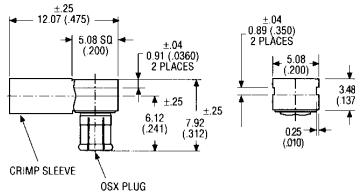
Full Crimp Attachment

Straight Cable Plug

Captured Center Contact	
Part Number	**Cable**
5831-5001-10	RG-174/U, 188/U, 316/U
Non-Captured Center Contact	
Part Number	**Cable**
5831-5002-10	RG-178/U, 196/U
5831-5003-10	RG-174/U, 188/U, 316/U

Finish: Nickel plated.
Crimp center contact and outer ferrute.
Econo-Crimp Tool Part Number 2598-5314-54 are
recommended for assembly.

Crimp Attachment
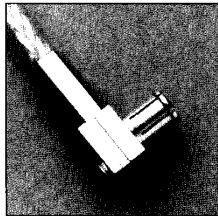
Right Angle Cable Plug

Captured Center Contact	
Part Number	**Cable**
5837-5002-10[1]	RG-178/U, 196/U
5831-5003-10[1]	RG-188/U, 316/U
5837-5006-10[1]	RG-58/U
5837-5010-63[2]	RD-316/U

[1]Finish: Nickel plated.
[2]Finish: Gold plated.

Crimp Attachment • Printed Circuit Board
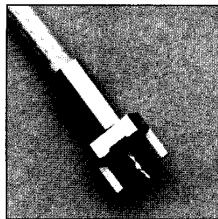
Straight Cable Terminal
Without Center Contact
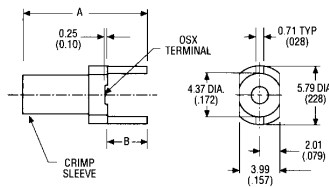
| Cable	RG-174/U, 188/U, 316/U		RG-178, 196/U	
Part Number	5818-5002-10	5818-5003-10	5818-5004-10	5818-5005-10
Dim. A	mm (Inches) 11.76 (.463)	mm (Inches) 10.74 (.423)	mm (Inches) 12.01 (.473)	mm (Inches) 11.00 (.433)
Dim. B	3.94 (.155)	2.92 (.115)	3.94 (.155)	2.92 (.115)

Finish: Nickel plated.

OSX   For Semi-Rigid Cable

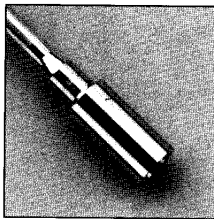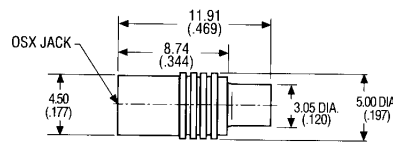## .085 Dia. • Direct Solder Attachment

Straight Cable Plug

OSX PLUG
11.48 REF.
(.452)
3.05 DIA.
(.120)
5.00 DIA.
(.197)
7.21 REF.
(.284)
CABLE REF
PLANE
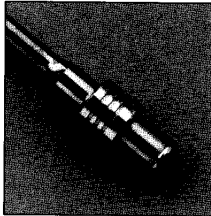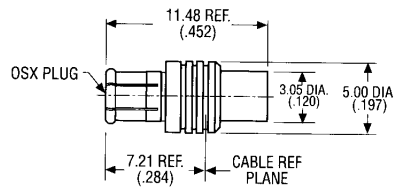
| With Contact	
Part Number	**Cable**
5801-7985-63	RG-405/U

Finish: Gold plated

Straight Cable Jack

OSX JACK
11.91
(.469)
8.74
(.344)
4.50
(.177)
3.05 DIA.
(.120)
5.00 DIA.
(.197)

Without Contact	
Part Number	**Cable**
5802-7985-63	RG-405/U

Finish: Gold plated

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OSX   Printed Circuit Board Receptacles

Straight Terminal • Printed Circuit Board
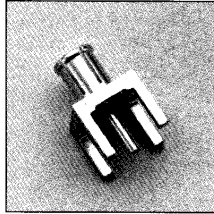
Straight Plug Receptacle
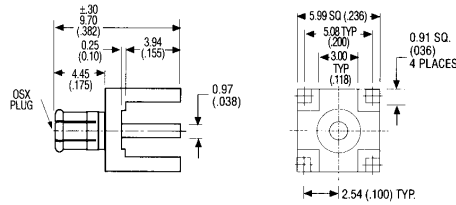
Part Number	5863-000-10

Finish: Gold plated
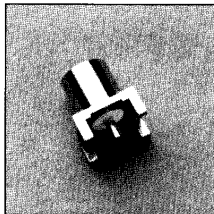
Straight Jack Receptacle
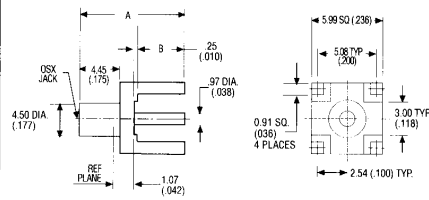
Part Number	Captured Center Contact					
	5862-5002-10		5862-5003-10		5862-5004-10	
	mm	(Inches)	mm	(Inches)	mm	(Inches)
Dim. A	8.28	(.326)	9.30	(.366)	7.09	(.279)
Dim. B	2.92	(.115)	3.94	(.155)	1.73	(.068)

Finish: Nickel plated.
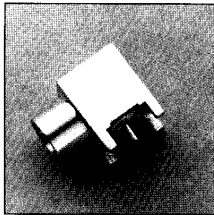
Right Angle Jack Receptacle
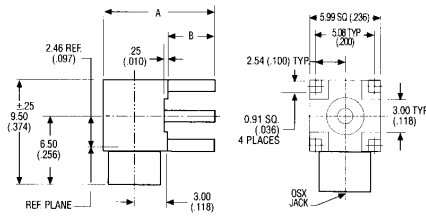
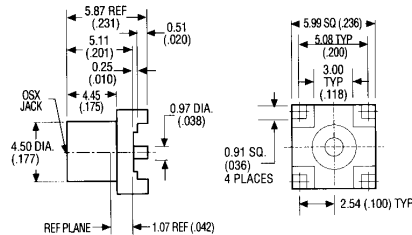| Part Number	Captured Center Contact					
	5864-5001-10		5864-5002-10		5864-5003-10	
	mm	(Inches)	mm	(Inches)	mm	(Inches)
Dim. A	9.93	(.391)	7.72	(.304)	8.92	(.351)
Dim. B	3.94	(.155)	1.73	(.068)	2.92	(.115)

Finish: Nickel plated.

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OSX   Printed Circuit Board Receptacles

Surface Mount • Straight Terminal
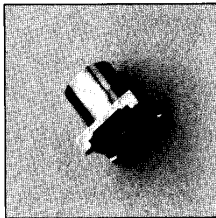
Straight Jack Receptacle

Part Number	5862-5007-13
Part Number	5899-5004-54[1]

Finish: Tin lead plated.
[1]Tape and Reel packaging. 900 conectors per
reel (carrier width 16mm, carrier pitch 12mm).

### Recommended Mounting Pattern for Microstrip Line
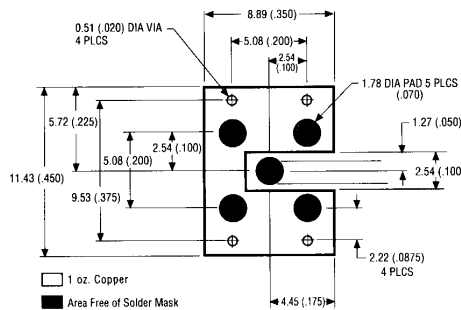
Notes:
1. Printed wiring board material: glass epoxy FR-4 or similar;
   relative permittivity: 4.8, 1 oz. copper clad both sides.
2. These dimensions valid for 1.58 (.062) board thickness.
3. Decimal inch equivalents are shown in parentheses for
   general information only.

Part number 5862-5007-13 is designed for surface mount-
ing using infrared and vapor phase solder techniques.
Connector materials used include brass housings and
teflon dielectric support bushings which are compatible
with infrared and vapor phase soldering limits of 215°C.

The infrared soldering method should employ a convection
heating feature because of the shrouded center contact
which is inherent to the OSX straight coaxial connector
design. (Manual soldering techniques are not recommended
because of the physical connector housing-to-board spacing
of 1.29mm (.051 inches).)

The solder paste selection for reflow soldering techniques
is generally a function of components used on printed wire
board assembly. The metal content of the paste, for
screening-stencil applications, is generally 85-90% by
weight. Nozzle dispensing techniques will have a slightly
lower content. Solder paste thickness of 0.15mm (.006
inches) to 0.25mm (.010 inches) is recommended. Standard
electrical grade solders such as 63/37 (183°C), 60/40
(190°C) and 62/36/2 (189°C) are used for most applica-
tions. These types of solder employ a mild rosin/resin flux.

Typical reflow temperature profiles:
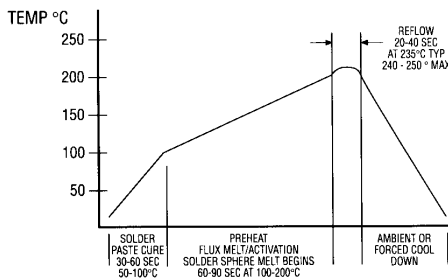
Typical Infrared and Convection Heating/Soldering Profile
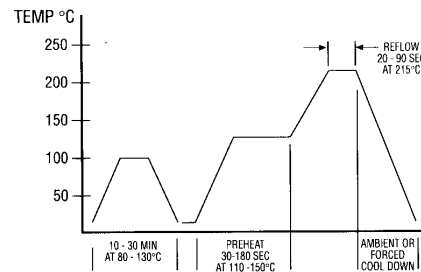
Typical Vapor Phase Heating/Soldering Profile

OSX   Between-Series Adapters and Tools

Between-Series Adapters

Part Number	Description
5880-2240-00	OSX Jack to SMA Jack
5881-2241-00	OSX Plug to SMA Plug
5882-2240-00	OSX Plug to SMA Jack
5882-2241-00	OSX Jack to SMA Plug

Consult factory for complete specifications.

Econo-Crimp Assembly Kit

Part Number **2598-5005-54**

The kit contains:

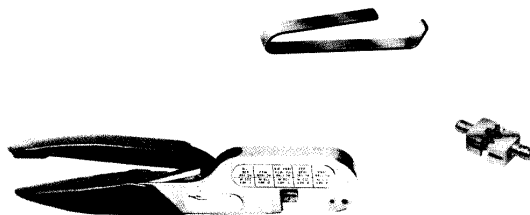| Description	Part Number
Crimp Tool	2598-5006-54
Crimp Die	2598-5007-54

All tools may be purchased separately.

Crimp Die Part Number	Die	Size	For Use With RG/U Cable
2598-5007-54	A	2.67±.08 Hex	178B & 196A
	C	3.25 ± .08 Hex	188A & 316

Optional Die for Full Crimp Cable Plug:

Crimp Die Part Number	Die	Size	For Use With RG/U Cable
2598-5314-54	A	2.67±.08 Hex	178B & 196A
	B	.75 ± .03 Sq.	178B,196A,188A & 316
	C	3.25 ± .08 Hex	174,188A & 316

MIL-C-22520/5-01 Type Hex Crimp Kit

Part Number **2098-0105-54**

The kit contains:

Description	Part Number
Crimp Tool	5698-5014-54
Die Change Tool	5698-5017-54
Crimp Die	5698-5015-54

All tools may be purchased separately.

Crimp Die Part Number	Die	Hex Size ±.08	For Use With RG/U Cable
5698-5015-54	A	2.67	178B & 196A
	C	3.25	174,188A & 316

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APPENDIX H: RG-142 and RG-316 Specifications

This appendix provides technical specifications for the RG-142 and RG-316 antenna cables used with the Zodiac GPS receiver.

Typical Specification for RG-142:

I.   Electrical Characteristics:

Nominal impedance	50 ohms
Nominal inductance	0.065 micro-h/ft
Nominal capacitance (conductor to shield)	29.0 pf/ft
Nominal velocity of propagation	69.5%
Nominal delay	1.48 pf/ft
Nominal attenuation	1500 Mhz
	32.0 dB/100 ft
Nominal shield dc resistance @ 20 degrees C	2.3 ohms/1000 ft
Nominal conductor dc resistance @ 20 degrees C	16.3 ohms/1000 ft
Continuous working voltage	1400 V RMS maximum

II.   Physical Characteristics:

Nominal weight	43 lbs/1000 ft
Minimum bending radius	2.0 inches
Temperature rating	-70 to +200 degrees C
Type shield and percent coverage	2 silver coated copper
	Inner braid, 96%
	Outer braid, 95%
Maximum pulling tension	146 lbs
Insulation material	TFE Teflon*
Jacket material	Brown tint FEP Teflon*
Conductor diameter	0.037 inches nominal
Core diameter	0.1155 inches nominal
Outside dimensions	0.195 inches nominal

*Teflon is a trademark of DuPont

Typical Specifcation for RG-316:

I.   Electrical Characteristics:

Nominal impedance   50 ohms
Nominal inductance   0.065 micro-h/ft
Nominal capacitance (conductor to shield)   29.0 pf/ft
Nominal velocity of propagation   69.5%
Nominal delay   1.48 pf/ft
Nominal attenuation   1500 Mhz
                                                         57.9 dB/100 ft
Nominal shield dc resistance @ 20 degrees C   6.5 ohms/1000 ft
Nominal conductor dc resistance @ 20 degrees C   33.0 ohms/1000 ft
Continuous working voltage   900 V RMS

II.   Physical Characteristics:

Nominal weight   10 lbs/1000 ft
Minimum bending radius   1.0 inch
Temperature rating   -70 to +200 degrees C
Type shield and percent coverage   Silver coated copper
                                                         Inner braid, 96%
                                                         Outer braid, 96%
Maximum pulling tension   21 lbs
Insulation material   TFE Teflon*
Jacket material   Brown tint FEP Teflon*
Conductor diameter   0.020 inches nominal
Core diameter   0.58 inches nominal
Outside dimensions   0.96 inches nominal
Applicable specifications   MIL-C-17F (M17/113-RG316)
*Teflon is a trademark of DuPont