Oncore GPS User's Guide

MOTOROLA

ONCORE

USER'S GUIDE

May, 1996

68P41117U01
Revision 7.0
For Use with Oncore Receiver

MOTOROLA

ONCORE

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

LIST OF ILLUSTRATIONS

Chapter 2
GPS Principles

Chapter 3
Production Description

Chapter 4
Hardware Installation

Chapter 5
System Integration

LIST OF TABLES

ONCORE

ABOUT THIS MANUAL

This manual provides complete information detailing description, installation and integration of your Motorola Oncore Receiver. To help you find the information you need, we have provided a brief overview of each chapter.

Chapter 1 Introduction

This chapter introduces you to the Oncore family of products and familiarizes you with the Global Positioning System (GPS) environment.

Chapter 2 GPS Principles

This chapter describes the functions and operating environment of GPS.

Chapter 3 Product Description

This chapter describes features and technical characteristics of the family of Oncore products.

Chapter 4 Hardware Installation

This chapter describes equipment for installation, installation considerations and procedures for configuring hardware.

Chapter 5 System Integration

This chapter describes message formats and system integration requirements.

Chapter 6 I/O Software Commands

This chapter provides a complete list and description of all of the Oncore Input/Output (I/O) commands.

Appendices

Appendix A: Datums

Appendix B: Ellipsoids

ONCORE

CHAPTER 1 INTRODUCTION

CHAPTER CONTENT

Refer to this chapter for the following:

- An introduction to GPS and the Oncore receiver.
- A limited warranty for the LC Oncore receiver.
- A glossary defining common GPS terminology and acronyms.

About your Oncore Receiver

OVERVIEW

Nearly a decade of Global Positioning System (GPS) experience, combined with worldclass expertise in semiconductor products and communication development, has led Motorola to production of a new generation of GPS receiver modules, more compact and lightweight than ever before. Each channel of this versatile, 6- or 8-channel receiver independently tracks both code and carrier phases for the superior performance required in today's GPS user environment. Time recovery and differential GPS features are also inherent in the design. Specifically designed for embedded applications, the Oncore product line, when combined with its new, low-profile, active microstrip patch antenna, affords the engineer new freedom in bringing GPS technology to the most demanding Original Equipment Manufacturer (OEM) applications. The Oncore receiver is offered in three versions: the Basic Oncore receiver, the XT Oncore receiver, and the VP Oncore receiver. The three versions make Oncore technology available to support a wide array of customers' needs.

The Motorola GPS receiver transmits autonomous position, velocity, heading, satellite tracking status, and time information in three different, user selectable I/O protocols: Motorola Binary Format, National Marine Electronics Association (NMEA)-0183 Format, and LORAN Emulation Format. In addition, the basic GPS receiver may be configured to include 1PPS (one pulse per second) timing output, real-time differential GPS capabilities (both master and remote stations), and raw pseudorange/carrier phase observation data output.

Helpful Hints for using this Manual

USER'S GUIDE ORGANIZATION/CONTENT

This User's Guide contains six chapters and two. Chapter 1 Introduction is provided to introduce you to the Oncore family of products and familiarize you with the Global Positioning System (GPS) environment. Chapter 2, GPS Principles describes the functions and operating environment of GPS. Chapter 3, Product Description, describes features and technical characteristics of the family of Oncore products. Chapter 4, Hardware Installation, describes equipment for installation, installation considerations and procedures for different hardware configurations. Chapter 5, System Integration, describes message formats and system integration requirements. Chapter 6 I/O Software Commands provides a complete list and description of all of the Oncore Input/Output (I/O) commands. The appendices consists of Appendix A, Datums and Appendix B, Ellipsoids.

PRODUCT HIGHLIGHTS

Applications

Considering that 24-hour, worldwide coverage is fundamental to GPS positioning and navigation, it is easy to envision a broad range of applications and a large community of GPS users. Applications include the following:

- Automobile Navigation,
- Aircraft Navigation,
- Land Navigation,
- Marine Navigation,
- Fleet Tracking,
- Differential Systems,
- Routing Systems,
- Rail Management,
- Asset Management,
- Emergency Search and Rescue,
- Utility Services,
- Precise Time Measurement,
- Surveying and Mapping,
- Exploration, and
- Space.

Features

Features unique to the Motorola Oncore product line include the following:

- Six- or eight-channel parallel receiver,
- Code plus carrier tracking (carrier-aided tracking),
- Forty-nine available coordinate datums; two user-defined datums,
- Selectable idle mode of operation,
- Weather-resistant microstrip patch antenna,
- Operates from +5 Vdc regulated or +12 Vdc unregulated (internal +5V regulator conforms to Automotive Specification SAE J113),
- RS-232C/TTL interface to host equipment,
- NMEA and LORAN emulation interface capabilities,
- Three-dimensional positioning within 25 meters, SEP (without Selective Availability [SA]),
- Latitude, longitude, height, velocity, heading, time, and satellite status information output either continuously (once per second) or polled,
- RTCM SC-104 Type 1 and 9 interface capability,
- Optional lithium backup battery mounted on the board,
- Optional real-time-differential (RTD) GPS capabilities are now a standard feature,
- Optional 1 PPS output for special time applications, and
- Optional satellite pseudorange/carrier phase data output.

LIMITED WARRANTY
MOTOROLA GPS PRODUCTS

What This Warranty Covers and for How Long

MOTOROLA, INC. ("MOTOROLA") warrants its Global Positioning System (GPS) Products ("Product") against defects on material and workmanship under normal use and service for a period of twelve (12) months from Product's in-service date, but in no event longer than eighteen (18) months from initial shipment of the Product.

MOTOROLA, at its option, will at no charge either repair, exchange, or replace this Product during the warranty period provided it is returned in accordance with the terms of this warranty. Replaced parts or boards are warranted for the balance of the original applicable warranty period. All replaced parts or Product shall become the property of MOTOROLA. Any repairs not covered by this warranty will be charged at the cost of replaced parts plus the MOTOROLA hourly labor rate current at that time.

This express limited warranty is extended by MOTOROLA to the original end user purchaser only and is not assignable or transferable to any other party. This is the complete warranty for Products manufactured by MOTOROLA. MOTOROLA does not warrant the installation, maintenance or service of the Product.

MOTOROLA cannot be responsible in any way for any ancillary equipment not furnished by MOTOROLA which is attached to or used in connection with MOTOROLA's GPS Products, or for operation of the Product with any ancillary equipment and all such equipment is expressly excluded from this warranty. The Global Positioning System is operated and supported by the U.S. Department of Defense and is made available for civilian use solely at its discretion. The Global Positioning System is subject to degradation of position and velocity accuracies by the Department of Defense. MOTOROLA does not warrant or control Global Positioning System availability or performance.

This warranty applies within the fifty (50) United States and the District of Columbia.

What This Warranty Does Not Cover

(a) Defects or damage resulting from use of the Product in other than its normal and customary manner. (b) Defects or damage from misuse, accident or neglect. (c) Defects or damage from improper testing, operation, maintenance, installation, alteration, modification or adjustment. (d) Defects or damage due to lightning or other electrical discharge. (e) Product disassembled or repaired in such a manner as to adversely affect performance or prevent adequate inspection and testing to verify any warranty claim. (f) Product which has had the serial number removed or made illegible. (g) Freight costs to the repair depot.

How to Get Warranty Service

To receive warranty service, deliver or send the Product, transportation and insurance prepaid, along with your proof of purchase and receiver serial number to MOTOROLA. Call 847-714-7201 or FAX 847-714-7325 for return authorization and the shipping address.

General Provisions

This warranty sets forth the full extent of MOTOROLA's responsibility regarding the Product. Repair, replacement, or refund of the purchase price, at MOTOROLA's option, is the exclusive remedy. THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER EXPRESS WARRANTIES. IMPLIED WARRANTIES, INCLUDING WITHOUT LIMITATION IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THIS LIMITED WARRANTY. IN NO EVENT SHALL MOTOROLA BE LIABLE FOR DAMAGES IN EXCESS OF THE PURCHASE PRICE OF THE PRODUCT, FOR ANY LOSS OF USE, LOSS OF TIME, INCONVENIENCE, COMMERCIAL LOSS, LOST PROFITS OR SAVINGS OR OTHER INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE INSTALLATION, USE, OR INABILITY TO USE SUCH PRODUCT, TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW.

GLOSSARY

Almanac

Data transmitted by a GPS satellite which includes orbital information on all the satellites, clock correction, and atmospheric delay parameters. These data are used to facilitate rapid satellite acquisition. The orbital information in the almanac is less accurate than the ephemeris, but valid for a longer time (one to two years).

Ambiguity

The unknown integer number of cycles of the reconstructed carrier phase contained in an unbroken set of measurements from a single satellite pass at a single receiver.

Argument of Latitude

The sum of the true anomaly and the argument of perigee.

Argument of Perigee

The angle or arc from the ascending node to the closest approach of the orbiting body to the focus or perigee point, as measured at the focus of an elliptical orbit, in the orbital plane in the direction of motion of the orbiting body.

Ascending Node

The point at which an object's orbit crosses the reference plane (ie., the equatorial plane) from south to north.

Azimuth

A horizontal direction expressed as the angular distance between a fixed direction, such as north, and the direction of the object.

Bandwidth

A measure of the information-carrying capacity of a signal, expressed as the width of the spectrum of that signal (frequency domain representation) in Hertz (Hz).

Baseline

The three-dimensional (3D) vector distance between a pair of stations for which simultaneous GPS data has been collected and processed with differential techniques.

Beat Frequency

Either of two additional frequencies obtained when signals of two frequencies are mixed. The beat frequencies are equal to the sum or difference of the original frequencies.

Bias

See Integer Bias Terms.

Binary Biphase Modulation

Phase changes of either zero or 180 degrees (representing a binary zero or one, respectively) on a constant frequency carrier . GPS signals are biphase modulated.

Binary Pulse Code Modulation

Pulse modulation using a string of binary numbers (codes). This coding is usually represented by ones and zeros with definite meanings assigned to them, such as changes in phase or direction of a wave.

Bluebook

A slang term derived from a blue NGS reference book. The book contains information and formats required by NGS for survey data that is submitted to be considered for use in the national network.

C/A Code

The Coarse/Acquisition (or Clear/Acquisition) code modulated onto the GPS L1 signal. This code is a sequence of 1023 pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 1.023 MHz, thus having a code repetition period of one millisecond. This code was selected to provide good acquisition properties.

Carrier

A radio wave having at least one characteristic (such as frequency, amplitude, phase) that may be varied from a known reference value by modulation.

Carrier Beat Phase

The phase of the signal that remains when the incoming Doppler-shifted satellite carrier signal is beat (the difference frequency signal is generated) with the nominally constant reference frequency generated in the receiver.

Carrier Frequency

The frequency of the unmodulated fundamental output of a radio transmitter. The GPS L1 carrier frequency is 1575.42 MHz.

Celestial Equator

The great circle that is the projection of the earth's geographical equator of rotation onto the celestial sphere. Its poles are the north and south celestial poles.

Celestial Meridian

The vertical great circle on the celestial sphere that passes through the celestial poles, the astronomical zenith, and the nadir.

Glossary (Continued)

Chip

The length of time required to transmit either a one or a zero in binary pulse code. One chip of the C/A code is about 977 ns long, which corresponds to a distance of 293 m.

Chip Rate

Number of chips per second (e.g., the C/A code chip rate = 1.023 MHz).

Clock Offset

Constant difference in time readings between two clocks.

Code Division Multiple Access (CDMA)

A method of frequency reuse whereby many radios use the same frequency but with each one having a separate and unique code. GPS uses CDMA techniques with Gold's codes for their unique cross-correlation properties.

Conventional International Origin (CIO)

Average position of the earth's rotation axis during the years 1900-1905.

Correlation-Type Channel

A GPS receiver channel that uses a delay-lock-loop (DLL) to maintain an alignment (correlation peak) between the replica of the GPS code generated in the receiver and the received code from the satellite.

Deflection of the Vertical

The angle between the normal to the ellipsoid and the vertical (true plumbline). Since this angle has both a magnitude and a direction, it is usually resolved into two components: one in the meridian and the other perpendicular to it in the prime vertical.

Delay-Lock-Loop

The technique whereby the received code (generated by the satellite clock) is compared with the internal code generated by the receiver clock. The latter is shifted in time until the two codes match. Delay-lock-loops can be implemented in several ways, including tau dither and early-minus-late gating.

Delta Pseudorange

See Reconstructed Carrier Phase.

Differential Processing

GPS measurements can be differenced between receivers, satellites, and epochs. Although many combinations are possible, the present convention for differential processing of GPS measurements ar eto first take differences between receivers (single difference), then between satellites (double difference), then between measurement epochs (triple difference).

A single-difference measurement between receivers is the instantaneous difference in phase of the signal from the same satellite, measured by two receivers simultaneously.

A double-difference measurement is obtained by differencing the single difference for one satellite with respect to the corresponding single difference for a chosen reference satellite.

A triple-difference measurement is the difference between a double difference at one epoch of time and the same double difference at the previous epoch of time.

Differential GPS solutions can be computed using either code phase or carrier phase measurements. In differential carrier phase solutions, the integer ambiguities must be resolved.

Differential (Relative) Positioning

Determination of relative coordinates of two or more receivers that are simultaneously tracking the same satellites. Dynamic differential positioning is a real-time technique achieved by sending code corrections to the roving receiver from one or more monitor stations. Static differential GPS involves determining baseline vectors between pairs of receivers.

Dilution of Precision

A description of the geometrical contribution to the uncertainty in a position fix, given by the expression DOP = SQRT TRACE (A^TA), where A is the design matrix for the instantaneous position solution (dependent on satellite-receiver geometry). The type of DOP factor depends on the parameters of the position fix solution. Standard terms for GPS applications include the following:

GDOP	Geometric DOP - three coordinates plus clock offset in the solution.
PDOP	Position DOP - three coordinates.
HDOP	Horizontal DOP - two horizontal coordinates.
VDOP	Vertical DOP - height only.
TDOP	Time DOP - clock offset only.
RDOP	Relative DOP - normalized to 60 seconds.

DoD

United States Department of Defense. The government agency that led the development, deployment, and operation of GPS.

Glossary (Continued)

Doppler Aiding

The use of Doppler carrier-phase measurements to smooth the code-phase measurements. Also referred to as carrier aided smoothing or carrier-aided tracking.

Doppler Shift

The apparent change in frequency of a received signal due to the rate of change of the range between the transmitter and receiver. See Reconstructed Carrier Phase.

Double-Difference Ambiguity Resolution

A method to determine the set of ambiguity values which minimizes the variance of the solution for a receiver pair baseline vector.

Dynamic Positioning

Determination of a timed series of sets of coordinates for a moving receiver, each set of coordinates being determined from a single data sample, and usually computed in real time.

Earth-Centered Earth-Fixed (ECEF)

Usually refers to a coordinate system centered at the center of the earth that rotates with the earth. Cartesian coordinate system where the X direction is the intersection of the prime meridian (Greenwich) with the equator. The X and Y vectors rotate with the earth. Z is the direction of the spin axis.

Eccentric Anomaly E

The regularizing variable in the two-body problem. E is related to the mean anomaly M by Kepler's equation. $M = E - e \cdot \sin(E)$, where e is the eccentricity.

Eccentricity

The ratio of the distance from the center of an ellipse to its focus to the semimajor axis. $e = (1 - b^2/a^2) - 1/2$, where a and b are the semimajor and semiminor axes of the ellipse.

Ecliptic

The earth-sun orbital plane. North is the direction of the system's angular momentum. Also called the ecliptic pole.

Elevation

Height above mean sea level or vertical distance above the geoid.

Elevation Mask Angle

The elevation angle below which satellites are ignored. Normally set to ten degrees to avoid interference problems caused by buildings, trees, multipath, and atmospheric errors.

Glossary (Continued)

Ellipsoid Height

The measure of vertical distance above the ellipsoid. Not the same as elevation above sea level, because the ellipsoid does not agree exactly with the geoid. GPS receivers output position fix height referenced to the WGS-84 datum.

Ephemeris

A list of orbital parameters of a celestial object that can be used to compute accurate positions as a function of time. Available as broadcast ephemeris or as postprocessed precise ephemeris.

Epoch

Measurement interval or data frequency. For example, if measurements are made and reported every five seconds, then we have five second epochs.

Fast Switching Channel

A switching channel with a sequence time short enough to recover (through software prediction) the integer part of the carrier beat phase.

Flattening

A parameter used to define the shape of an ellipsoid.

$f = (a - b)/a = 1 - (1 - e^2)^{1/2}$, where

a = semimajor axis

b = semiminor axis

e = eccentricity

Frequency Band

A range of frequencies in a particular region of the electromagnetic spectrum.

Frequency Spectrum

The distribution of amplitudes as a function of frequency of the constituent waves in a signal.

Fundamental Frequency

The fundamental frequency used in GPS is 10.23 MHz. The carrier frequencies L1 and L2 are integer multiples of this fundamental frequency.

L1 = 154F = 1575.42 MHz

L2 = 120F = 1227.60 MHz

GDOP

Geometric dilution of precision. See Dilution of Precision.

$GDOP^2 = PDOP^2 + TDOP^2$

Geocenter

The center of mass of the earth.

Glossary (Continued)

Geodetic Datum

A mathematical model designed to best fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. The relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude, and height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line from the origin to some other point.

Geoid

The particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is perpendicular to the force of gravity at all points.

Geoid Height

The height above the geoid is often called elevation above mean sea level.

GPS

Global Positioning System, consisting of the space segment (up to 24 NAVSTAR satellites in six different orbital planes), the control segment (five monitor stations, one master control station and three uplink stations), and the user segment (GPS receivers).

NAVSTAR satellites carry extremely accurate atomic clocks and broadcast coherent simultaneous signals.

GPS ICD-200

The GPS Interface Control Document is a government document that contains the full technical description of the interface between the satellites and the user. GPS receivers must comply with this specification if they are to receive and process GPS signals properly.

Gravitational Constant

The proportionality constant in Newton's Law of Gravitation. $G = 6.672 \times 10^{-11}\ Nm^2/Kg^2$.

Greenwich Mean Time (GMT)

See Universal Time.

HDOP

Horizontal dilution of precision. See Dilution of Precision.

HOW

Handover Word. The word in the GPS message that contains time synchronization information for the transfer from the C/A code to the P code.

Inclination

The angle between the orbital plane of a body and some reference plane (e.g. equatorial plane).

INS

Inertial Navigation System, which contains an Inertial Measurement Unit (IMU).

Integer Bias Terms

The receiver counts the radio waves from the satellite, as they pass its antenna, to a high degree of accuracy. However, it has no information on the number of waves to the satellite at the time it started counting. This unknown number of wavelengths between the satellite and the antenna is the integer bias term.

Integrated Doppler

A measurement of Doppler shift frequency or phase over time.

Ionospheric Delay

A wave experiences delay while propagating through the ionosphere, which is non-homogeneous in space and time and is a dispersive medium. Phase delay depends on electron content and affects carrier signals. Group delay depends on dispersion in the ionosphere as well, and affects signal modulation (codes). The phase and group delay are of the same magnitude, but opposite sign.

JPO

Joint Program Office for GPS located at the USAF Space Division at El Segundo, California. The JPO consists of the USAF Program Manager and Deputy Program Managers representing the Army, Navy, Marine Corps, Coast Guard, Defense Mapping Agency, and NATO.

Kalman Filter

A numerical method used to track a time-varying signal in the presence of noise. If the signal can be characterized by some number of parameters that vary slowly with time, then Kalman filtering can be used to tell how incoming raw measurements should be processed to best estimate those parameters as a function of time.

Kinematic Surveying

A form of continuous differential carrier-phase surveying requiring only short periods of data observations. Operational constants include starting from or determining a known baseline, and tracking a minimum of four satellites. One receiver is statically located at a control point, while others are moved between points to be measured.

Keplerian Orbital Elements

Allow description of any astronomical orbit. The six Keplerian orbital elements are as follows:

a = semimajor axis

e = eccentricity

w = argument of perigee

Ω = right ascension of ascending node

i = inclination of orbital plane

To = epoch of perigee passage.

L1, L2

The L-band signals radiated by each NAVSTAR satellite. The L1 signal is a 1575.42-MHz carrier modulated with both the C/A and P codes and with the NAV message. The L2 signal is a 1227.60-MHz carrier modulated with the P code and the NAV message. Under anti-spoofing, the P code becomes the encrypted Y code for authorized users only.

Lane

The area (or volume) enclosed by adjacent lines (or surfaces) of zero phase of either the carrier beat phase signal, or of the difference between two carrier beat phase signals. On the earth's surface, a line of zero phase is the focus of all points for which the observed value would have an exact integer value for the complete instantaneous phase measurement. In three dimensions, this lane becomes a surface.

L Band

The radio frequency band extending from 390 MHz (nominally) to 1550 MHz.

Mean Anomaly

M = n(t - T), where n is the mean motion, t is the time, and T is the instant of perigee passage.

Mean Motion

n = 2/P, where P is the period of revolution.

Microstrip Antenna

A two-dimensional, flat, precisely-cut piece of metal foil glued to a substrate.

Glossary (Continued)

Monitor Station

Any of a worldwide group of stations used in the GPS control segment to monitor satellite clock and orbital parameters. Data collected at these sites are linked to a master station where corrections are calculated and controlled. These data are uploaded to each satellite at least once per day from an uplink station.

Multichannel Receiver

A receiver containing many independent channels. Such a receiver offers the highest signal-to-noise ratio (SNR) because each channel tracks one satellite continuously.

Multipath

Interference similar to ghosts on a television screen, which occurs when multiple signals arrive at an antenna having traversed different paths. In GPS, the signal traversing the longer path will yield a larger pseudorange estimate and increase the error. Multiple paths may arise from reflections from structures near the antenna or from the ground.

Multipath Error

A positioning error resulting from interference between radio waves that have traveled between the transmitter and the receiver by paths of different electrical lengths.

Multiplexing Channel

A receiver channel that is sequenced through several satellite channels (each from a specific satellite and at a specific frequency) at a rate which is synchronous with the satellite message bit rate (50 bits per second, or 20 milliseconds per bit). Thus, one complete sequence is completed in a multiple of 20 milliseconds.

NAD-83

North American Datum, 1983

NAVDATA

The 1500-bit navigation message broadcast by each satellite at 50 bps on both the L1 and L2 signals. The message contains system time, clock correction parameters, ionospheric delay model parameters, and the satellite's ephemeris and health. This information is used by the GPS receiver in processing GPS signals to obtain user position, velocity, and time.

NAVSTAR

The name given to GPS satellites, which stands for NAVigation Satellite Timing and Ranging.

Observation Session

The period of time over which simultaneous GPS data is collected by two or more receivers.

Outage

A point in time and space that the GPS receiver is unable to compute a position fix. This may be due to satellite signal blockage, unhealthy satellites, or a dilution of precision (DOP) value that exceeds a specified limit.

P Code

The protected or precise code modulated on both the L1 and L2 GPS signals. The P code is a very long (about 10^{14} bits) sequence of pseudorandom binary biphase modulations on the GPS carrier at a chipping rate of 10.23 MHz that does not repeat itself for about 38 weeks. Each satellite uses its own unique one-week segment of this code, which is reset each week. Under anti-spoofing, the P code is encrypted to form Y code. The Y code is only accessible by authorized users, as controlled by the U.S. DoD.

PDOP

Position dilution of precision, a unitless figure of merit expressing the relationship between the error in user position and the error in satellite ranges. Geometrically, PDOP is proportional to the inverse of the volume of the pyramid formed by lines running from the receiver to four observed satellites. Values considered good for positioning are small, such as 3. Values greater than 7 are considered poor. Small PDOP is associated with many or widely separated satellites, and large PDOP is associated with bunched up or few satellites. See Dilution of Precision

Parity Error

A digital message consists of ones and zeros. Parity is an exclusive-or sum of these bits in a word unit. A parity error results when a bit (or bits) is changed during transmission, so that the parity calculated at reception is not the same as it was when the message was transmitted.

Perigee

That point in a geocentric orbit when the geometric distance is a minimum. The closest approach of the orbiting body.

Phase-Lock-Loop

The technique of making the phase of an oscillator signal follow exactly the phase of a reference signal. This is accomplished by first comparing the phases of the two signals, and then using the resulting phase difference signal to adjust the reference oscillator frequency to eliminate phase difference when the two signals are next compared.

Glossary (Continued)

Phase Observable

See Reconstructed Carrier Phase.

Point Positioning

Geographic positions produced from one receiver in stand-alone mode. At best, position accuracy obtained from a stand-alone receiver is 15 to 25 meters (without SA), depending on the geometry of the satellites.

Polar Motion

Motion of the instantaneous axis of the rotation of the earth with respect to the solid body of the earth. This motion is irregular but more or less circular with an amplitude of about 15 miles and a main period of about 430 days (also called Chandler Wobble).

Precise Positioning Service (PPS)

The highest level of military dynamic positioning accuracy provided by GPS, based on the dual frequency P code and having high anti-jam and anti-spoof qualities.

Prime Vertical

The vertical circle perpendicular to the celestial meridian.

PRN

Pseudorandom noise, a sequence of digital ones and zeros that appear to be randomly distributed like noise, but which can be exactly reproduced. The most significant property of PRN codes is that they have a low autocorrelation value for all delays or lags except when they are exactly coincident. Each NAVSTAR satellite has its own unique C/A and P pseudorandom noise codes.

Pseudolite

A ground-based GPS transmitter station that broadcasts a signal with a structure similar to that of an actual GPS satellite. Pseudolites are designed to improve the accuracy and integrity of GPS, particularly near airports.

Pseudorange

A measure of the apparent propagation time from satellite to receiver antenna, expressed as a distance. A pseudorange is obtained by multiplying the apparent signal propagation time by the speed of light. Pseudoranges differ from actual geometric ranges due to the satellite/receiver clock offset, propagation delays, and other errors. The apparent propagation time is determined from the time shift required to align (correlate) a replica of the GPS code generated in the receiver with the received GPS code. The time shift is the difference between the time of signal reception (measured in the receiver time frame) and the time of signal emission (measured in the satellite time frame).

Glossary (Continued)

Range Rate

The rate of change of range between the satellite and the receiver. The range to a satellite changes due to both satellite and receiver motion. Range rate (or pseudorange rate) is determined by measuring the Doppler shift of the satellite signal's carrier frequency.

RDOP

Relative dilution of precision. See Dilution of Precision.

Reconstructed Carrier Phase

The difference between the phase of the incoming Doppler-shifted GPS carrier and the phase of a nominally constant reference frequency generated in the receiver. For static positioning, the reconstructed carrier phase is sampled at epochs determined by a clock in the receiver. The reconstructed carrier phase changes according to the continuously integrated Doppler shift of the incoming signal, biased by the integral of the frequency offset between the satellite and receiver reference oscillators. The reconstructed carrier phase can be related to the satellite-to-receiver range, once the initial range (or phase ambiguity) has been determined. A change in the satellite-to-receiver range of one wavelength of the GPS carrier (19 cm for L1) will result in a one-cycle change in the phase of the reconstructed carrier.

Relative Navigation

A technique similar to relative positioning except that one or both of the points may be moving. The pilot of a ship or an aircraft may need to know the vehicle's position relative to a harbor or runway. A data link is used to relay the error terms to the moving vessel to allow real-time navigation.

Right Ascension

The angular distance measured from the vernal equinox, positive to the east, along the celestial equator to the ascending node. Typically denoted by a capital omega (Ω). Used to discriminate between orbital planes.

RTCM

Radio Technical Commission for Maritime Services Commission set up to define a differential data link to relay GPS correction messages from a monitor station to a field user. RTCM SC-104 recommendations define the correction message format and 16 different correction message types.

SATNAV

A local term referring to use of the older TRANSIT system for satellite navigation. One major difference between TRANSIT and GPS is that the TRANSIT satellites are in low-altitude polar orbits with a 90-minute period.

Glossary (Continued)

Selective Availability (SA)

A DoD program to control the accuracy of pseudorange measurements, whereby the user receives a false pseudorange which is in error by a controlled amount. Differential GPS techniques can reduce these effects for local applications. Under SA, the DoD guarantees unauthorized users an accuracy of 100 m 2DRMS at a 95% confidence level.

Semi-major Axis

One half of the major axis of an ellipse.

SEP

Spherical Error Probable, a statistical measure of precision defined as the 50th percentile value of the three-dimensional position error statistics. Thus, half of the results are within the 3D SEP value.

Sidereal Day

Time between two successive upper transits of the vernal equinox. One sideral day is just under four minutes shorter than one solar day.

Simultaneous Measurements

Measurements referenced to time-frame epochs that are either exactly equal or so closely spaced in time that the time misalignment can be accommodated by correction terms in the observation equation rather than by parameter estimation.

Slope Distance

The three-dimensional vector distance from station one to station two. The shortest distance (a chord) between two points.

Slow Switching Channel

A switching channel with a sequencing period that is too long to allow recovery of the integer part of the carrier beat phase.

Solar Day

Time between two successive upper transits of the sun.

Spheroid

See Ellipsoid.

Spread Spectrum

The received GPS signal is a wide bandwidth low-power signal (-160 dBW). This property results from modulating the L-band signal with a PRN code in order to spread the signal energy over a bandwidth that is much greater than the signal information bandwidth. This is done to provide the ability to receive all satellites unambiguously and to provide some resistance to noise and multipath.

Glossary (Continued)

Spread Spectrum System

A system in which the transmitted signal is spread over a frequency band much wider than the minimum bandwidth needed to transmit the information being sent.

SPS

Standard Positioning Service, uses the C/A code to provide a minimum level of dynamic or static positioning capability. The accuracy of this service is set at a level consistent with national security. See Selective Availability.

Squaring-Type Channel

A GPS receiver that multiplies the received signal by itself to obtain a second harmonic of the carrier that does not contain the code modulation. Used in codeless receiver designs to obtain dual frequency measurements.

Static Positioning

Positioning applications in which the positions of static or near-static points are determined.

SV

Satellite vehicle or space vehicle.

Switching Channel

A receiver channel that is sequenced through a number of satellite signals (each from a specific satellite and at a specific frequency) at a rate which is slower than, and asynchronous with, the message data rate.

TDOP

Time dilution of precision. See Dilution of Precision.

TOW

Time of week, in seconds from midnight Saturday UTC.

Translocation

A version of relative positioning that makes use of a known position, such as a JSGS survey mark, to aid in accurately positioning a desired point. The position of the mark, determined using GPS, is compared with the accepted value. The three-dimensional differences are then used in the calculations for the second point.

Tropospheric correction

The correction applied to the measurement to account for tropospheric delay. This value is normally obtained from the modified Hopfield model, the parameters of which are broadcast by the satellites.

Glossary (Continued)

True Anomaly

The angular distance, measured in the orbital plane from the earth's center (occupied focus) from the perigee to the current location of the satellite (orbital body).

Universal Time

Local solar mean time at Greenwich Meridian. Some commonly used versions of universal time follow:

UT0	Universal time as deduced directly from observations of stars and the fixed numerical relationship between universal and sidereal time (3 minutes, 56.555 seconds).
UT1	UT0 corrected for polar motion.
UT2	UT0 corrected for seasonal variations in the earth's rotational rate.
UTC	Universal time coordinated; uniform atomic time system kept very close to UT2 by offsets. Maintained by the U.S. Naval Observatory (USNO)

GPS time is directly related to UTC by the following:

UTC - GPS = UTC offset (11 seconds in 1996)

User Range Accuracy (URA)

The contribution to the range measurement error from an individual error source (apparent clock and ephemeris prediction accuracies) converted into range units, assuming that the error source is uncorrelated with all other error sources.

UTM

Universal transverse mercator conformal map projection. A special case of the transverse mercator projection. Abbreviated as the UTM grid, it consists of 60 north-south zones, each six degrees wide in longitude.

VDOP

Vertical dilution of precision. See Dilution of Precision.

Vernal Equinox

One of two dates per year when the equator and ecliptic intersect along the line between the earth and sun. On these days, the day and night are each 12 hours long everywhere on earth, hence the term equinox, or "equal nights". The vernal equinox corresponds to the spring equinox in the Northern Hemisphere.

Vertical

The line perpendicular to the geoid at any point, which is the direction of the force of gravity at that point. Aslo known as the plumbline.

Glossary (Continued)

WGS-72

World Geodetic System (1972). The mathematical reference ellipsoid previously used by GPS, having a semimajor axis of 6378.135 km and a flattening of 1/298.26.

WGS-84

World Geodetic System (1984). The mathematical ellipsoid used by GPS since January 1984, having a semimajor axis of 6378.137 km and a flattening of 1/298.257223563.

Z-Count

The GPS satellite clock time at the leading edge of the next data subframe of the transmitted GPS message (usually expressed as an integer number of six seconds).

ONCORE

CHAPTER 2 GPS PRINCIPLES

CHAPTER CONTENT

Refer to this chapter for the following:

- A description of the NAVSTAR GPS segments.
- An explanation of the GPS navigation message.
- Available public GPS information services.

About NAVSTAR GPS

OVERVIEW

The NAVigation Satellite Timing and Ranging (NAVSTAR) GPS is an all weather, radio based, satellite navigation system that enables users to accurately determine three-dimensional position, velocity, and time. The overall system consists of three major segments: the space segment, the ground control segment, and the user segment.

Space Segment

The space segment is a constellation of satellites operating in 12-hour orbits at an altitude of 20,183 km (10,898 nmi). When completed, this constellation will contain 21 satellites (plus three spares) in six orbits, each orbital plane equally spaced about the equator and inclined at 55 degrees.

Ground Control Segment

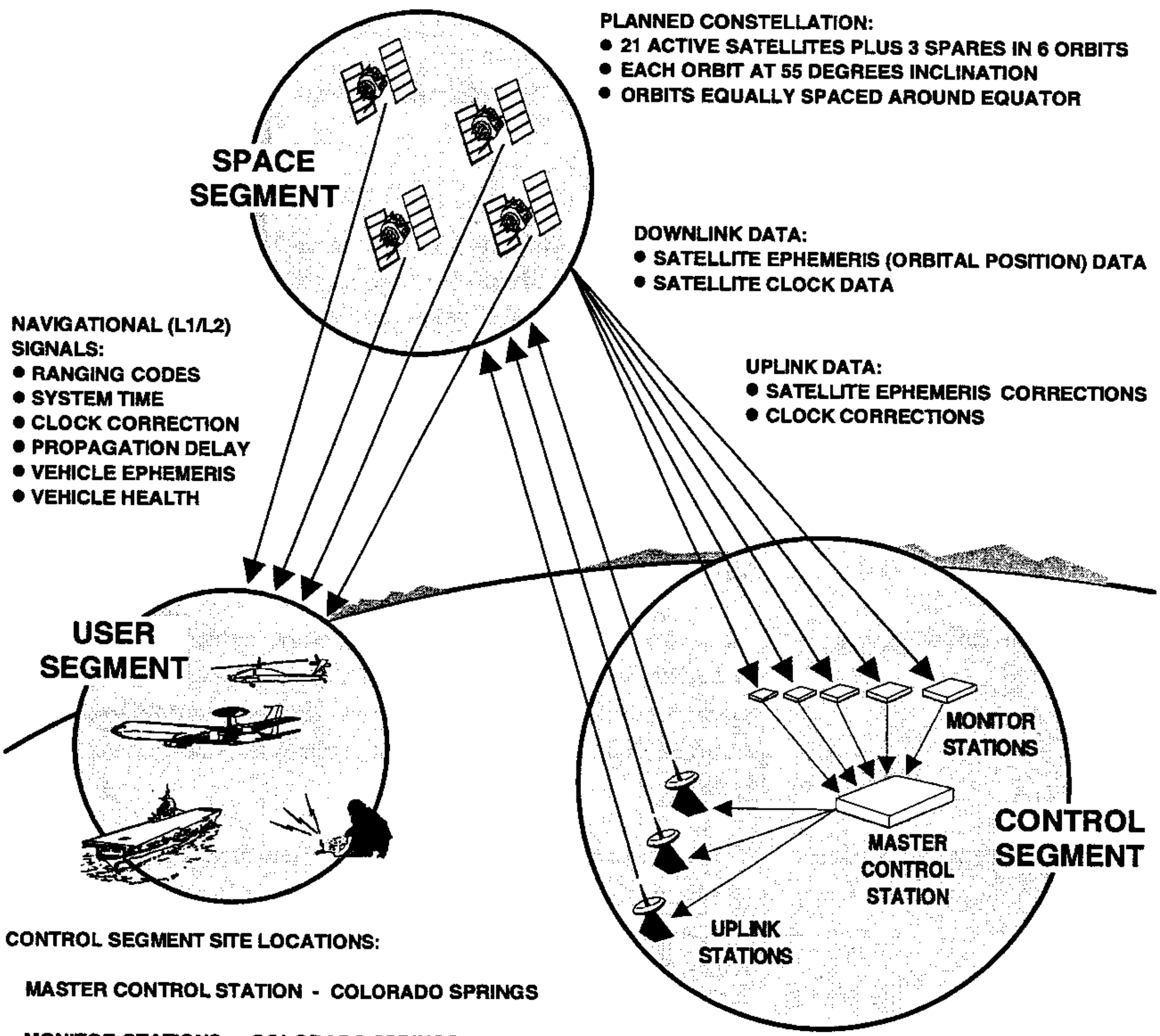
The ground control segment consists of a master control center and a number of widely separated monitoring stations. The ground control network tracks the satellites, precisely determines their orbits, and periodically uploads ephemeris correction and other system data to all satellites for retransmission to the user segment.

User Segment

The user segment is the collection of all GPS user receivers (such as your Motorola GPS Receiver) and their support equipment. Navigation with the receiver is accomplished by passive multilateration. More simply, the GPS Receiver's position is determined by the geometric intersection of several simultaneously observed ranges (satellite to receiver distances) from satellites with known coordinates in space. The receiver measures the transmission time required for a satellite signal to reach the receiver. Transit time is determined using code correlation techniques. The actual measurement is a unique time shift for which the code sequence transmitted by the satellite correlates with an identical code generated in the tracking

User Segment (Continued)

receiver. The receiver code is shifted until maximum correlation between the two codes is achieved. This time shift multiplied by the speed of light is the receiver's measure of the range to the satellite. Because this measurement includes various propagation delays, as well as satellite and receiver clock errors, it is not a true geometric range and so is called a pseudorange. The receiver processes these pseudorange measurements along with the received ephemeris data (satellite orbit data) to determine the user's three-dimensional position. A minimum of four pseudorange observations are required to mathematically solve for four unknown receiver parameters (i.e., latitude, longitude, altitude, time). If one of these parameters is known (for example, altitude fixed) then only three satellite pseudorange observations are required and thus only three satellites need to be tracked in these cases.



CONTROL SEGMENT SITE LOCATIONS:

MASTER CONTROL STATION - COLORADO SPRINGS

MONITOR STATIONS - COLORADO SPRINGS
ASCENSION
DIEGO GARCIA
KWAJALEIN
HAWAII

UPLINK STATIONS - ASCENSION
DIEGO GARCIA
KWAJALEIN

About the GPS Navigation Message

GPS NAVIGATION MESSAGE

The GPS navigation message is the data supplied to the user from a satellite. Signals are transmitted at two L-band frequencies, L1 and L2, to permit corrections to be made for ionospheric delays in signal propagation time.

The L1 carrier is modulated with a 10.23 MHz precision ranging (P-code) signal and a 1.023 MHz clear acquisition (C/A code) ranging signal. These are pseudo random (PR) noise codes in phase quadrature. The L2 signal is modulated with the P-code only. Both the L1 and L2 signals also are continuously modulated with a data-bit stream at 50 bits per second. The P-code is a PR sequence with a period of 38(+) weeks. The C/A code is a shorter PR sequence of 1023 bits having a period of one millisecond. The P-code is intended for military use and ultimately will be available to authorized users only. Access to the GPS system by civilian users is provided through the C/A coded signals.

The navigation message consists of a 50 bit per second data stream containing information enabling the receiver to perform the computations required for successful navigation. Each satellite has its own unique C/A code that provides satellite identification for acquisition and tracking by the user.

PUBLIC INFORMATION SERVICES

Additional Information Sources

There are several sources from which to obtain further information about GPS and the current status of the satellites. Information about four public GPS Information Centers is provided below.

USCG GPS IC
Commanding Officer (GPSIC)
Omega Navigation System Center
7323 Telegraph Rd.
Alexandria, VA 22310-3998

The Civil GPS Service was established to provide civil GPS users with information on system status and a point of contact. As a part of this service, the U.S. Coast Guard has begun operations of the GPSIC on a test and evaluation basis. Current services include GPS operational advisory broadcasts (OAB) containing current constellation status, future scheduled outages, and an almanac suitable for making GPS coverage and satellite visibility predictions. The OABs are available 24 hours a day by computer bulletin board, or as a recorded telephone message (without almanac) at (703) 313-5907. The communications parameters for the bulletin board (703) 313-5910 are 8 data bits, 1 stop bit, no parity, and modem speeds of 300 to 14,400 bps.

For internet access, or to speak with a representative, call (703) 313-5900 or fax (703)-313-5920.

Additional Information Sources (Continued)

GPS Bulletin Board at Holloman

Formerly located at Yuma, Arizona, this bulletin board recently has been moved to Holloman Air Force Base. The bulletin board provides a daily almanac, observed range errors, comments on the satellite, and the OCS advisories. This service requires full duplex, 8-bit data words, no parity and 1 stop bit (preferred because it supports the X-modem and Y-modem error checking block transmission) or full duplex, 7-bit word, odd or even parity, and 1 stop bit.

1200 baud (preferred) or 300 baud	(505) 679-1525, 1526, 1527, 1528

To speak with a representative, call (505) 679-1784, 1787, or 1657.

GPS Satellite Clock Behavior and
Related GPS Information
U.S. Naval Observatory
Washington D.C. 20392-5100 USA

USNO Series 4 Weekly Bulletins. Received by mail, they contain information on the status of GPS and timing data.

To speak with a representative, call (202) 653-1525

Available telephone lines	(202) 653-0068, 0155, 1079
Baud rates	1200, 2400 or 9600
Comm parameters	8 data bits, 1 stop, no parity; terminate lines with CR/LF
Password	Call for password
Internet access (telnet)	tycho.usno.navy.mil (192.5.41.239) Login as ads

Comments to: adsmgr@tycho.usno.navy.mil

NOAA
National Geodetic Survey, N/CG174
SSMC 3, Station 09535
1315 E. West Highway
Silver Springs, MD 20910

Precise orbital positions and velocities based on post computations of tracking data collected from stations of the Cooperative International GPS Tracking Network (CIGNET) are available from NGS. Satellite orbital data are scheduled to be available two weeks after the tracking data are collected. For a description of formats, fee schedule, or to order data contact (301) 713-3242.

Additional Information Sources (Continued)

For detailed information about NMEA formats and specifications, contact:

NMEA - National Marine Electronics Association
P. O. Box 50040
Mobile, AL 36606
(205) 473-1793

For detailed information about RTCM formats and specifications, contact:

Radio Technical Commission for Maritime Services
Post Office Box 19087
Washington, D.C. 20036

There are several GPS related sites on the World Wide Web (WWW) that are excellent resources for learning more about GPS. To find a current listing of these sites, use any of the search engines to search for "GPS".

ONCORE

CHAPTER 3 PRODUCT DESCRIPTION

CHAPTER CONTENT

Refer to this chapter for the following:

• A simplified functional description of Oncore operation.

• Physical mounting and electrical connection of Oncore receivers.

• BASIC Oncore technical characteristics and operating features.

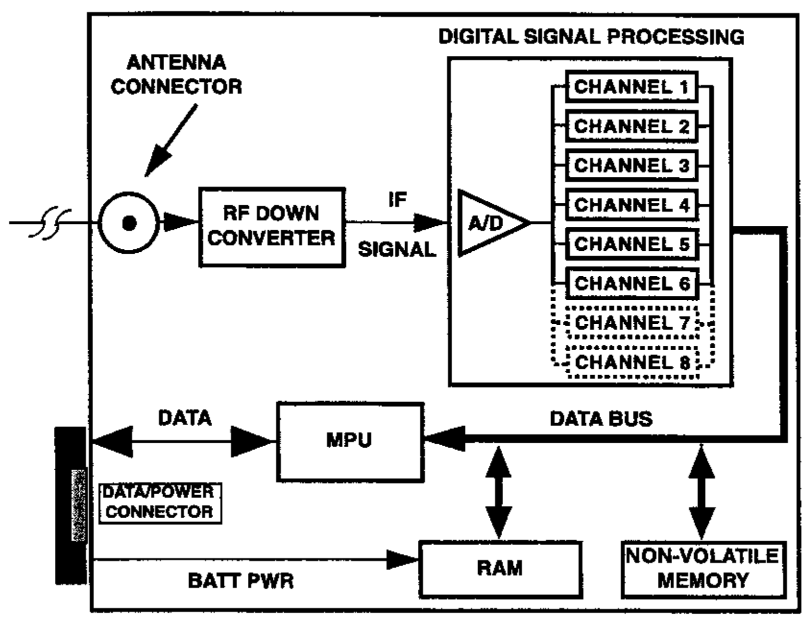
• XT Oncore technical characteristics and operating features.

• VP Oncore technical characteristics and operating features.

OVERVIEW

The Basic, XT and VP receivers provide position, velocity, time, and satellite tracking status.

A simplified functional block diagram of an Oncore receiver is shown in the following illustration.



Oncore Receiver Functional Block Diagram

OVERVIEW (CONTINUED)

Simplified Block Diagram Description

The Oncore receiver is a six (or eight) channel parallel design capable of tracking six or eight satellites simultaneously. The module receives the L1 GPS signal (1575.42 MHz) and operates off the clear/acquisition (C/A) carrier tracking. The code tracking is carrier aided. The BASIC and XT Oncore receivers can be powered with unregulated 12 Vdc or optionally with regulated 5 Vdc power. Differential GPS and time recovery capabilities are inherent in the architecture and available as options.

The L1 band signals transmitted from GPS satellites are collected by a low-profile, microstrip patch antenna, passed through a narrow band bandpass filter, and then amplified by a signal preamplifier contained within the Antenna Module. Filtered and amplified L1 band signals from the Antenna Module are then routed to the RF signal processing section of the Oncore receiver Module via a single coaxial interconnecting cable. This interconnecting cable also provides the required +5V for signal preamplification in the Antenna Module.

The RF signal processing section of the Oncore receiver printed circuit board (PCB) contains the required circuitry for downconverting the GPS signals received from the Antenna Module. The resulting intermediate frequency (IF) signal is then passed to the six (or eight) channel code and carrier correlator section of the GPS receiver PCB where a single, high-speed analog-to-digital (AD) converter converts the IF signal to a digital sequence prior to channel separation. This digitized IF signal is then routed to the digital signal processor (also contained within the six (or eight) channel code and carrier correlator section) where the signal is split into six (or eight) separate channels for code correlation, filtering, carrier tracking, code tracking, and signal detection.

The processed signals are synchronously routed to the position processor (microprocessor [MPU]) section. This section controls the GPS receiver PCB operating modes and decodes and processes satellite data and pseudorange and delta range measurements used to compute position and velocity. In addition, the position processor section contains the required interface to the RS232 port for the BASIC and XT Oncore receivers and a TTL interface for the VP Oncore receiver.

Keep-alive random access memory (RAM) is provided for retention of satellite ephemeris data. To prevent loss of this information when the Oncore receiver is powered off, an external +12V/+5V BATT source is required. Nonvolatile electrically erasable programmable read only memory (EEPROM) is used for storage of custom operating parameters, almanac information, and other information, as specified in Chapter 5.

Retention of the real-time-clock (RTC) value also requires the external +12V/+5V BATT source when the Oncore receiver is powered off.

ANTENNA MODULE

Description

The antenna module is housed in a custom styled, molded encasement that provides a rugged, durable protective cover, ready for exposure to the elements.

All of the antenna module's electrical circuitry and components are contained within the sealed antenna assembly. The major components include a low profile, microstrip patch antenna, a ceramic RF filter (i.e., preselector), and a signal preamplifier. The antenna module is designed and tuned to efficiently collect the L1 band signals transmitted from GPS satellites at a nominal frequency of 1575.42 MHz. Once collected, the signals are amplified and relayed to the Oncore receiver. Signal preamplification within the antenna module is made possible by external power supplied by the Oncore receiver. The antenna module nominally draws 22 mA of current (50 mA maximum) at 5 Vdc, directly from the antenna connector on the Oncore receiver.

Various antenna module mounting options and assembly instructions are detailed in Chapter 4. The dimensions of the Motorola GPS antenna are shown in Figure 3.2

Active Antenna Specifications

The GPS receiver supplies power (+5Vdc) to this active antenna.

Table 3.1 Active Antenna RF Interface Specifications

Amplification:	24 dB
Input impedance:	50 Ω
VSWR:	2:1 max at 1575.42 MHz ±1 MHz
Connector type:	OSX Jack, Straight
Preamplifier power:	+5 Vdc, 25 mA available at connector (max 50 mA)
Operating frequency :	1575.42 MHz
Bandwidth:	30 MHz typical
Polarization:	Right hand circular
Pattern :	Essentially hemispherical
Gain Characteristics:	+3 dBic minimum at 90° above horizon (zenith) 0 dBic minimum at 30° above horizon –6 dBic minimum at 0° above horizon
Preamplifier Gain:	18 dB minimum (including 6 dB cable loss)
Noise Figure:	2.5 dB maximum

ANTENNA MODULE (CONTINUED)

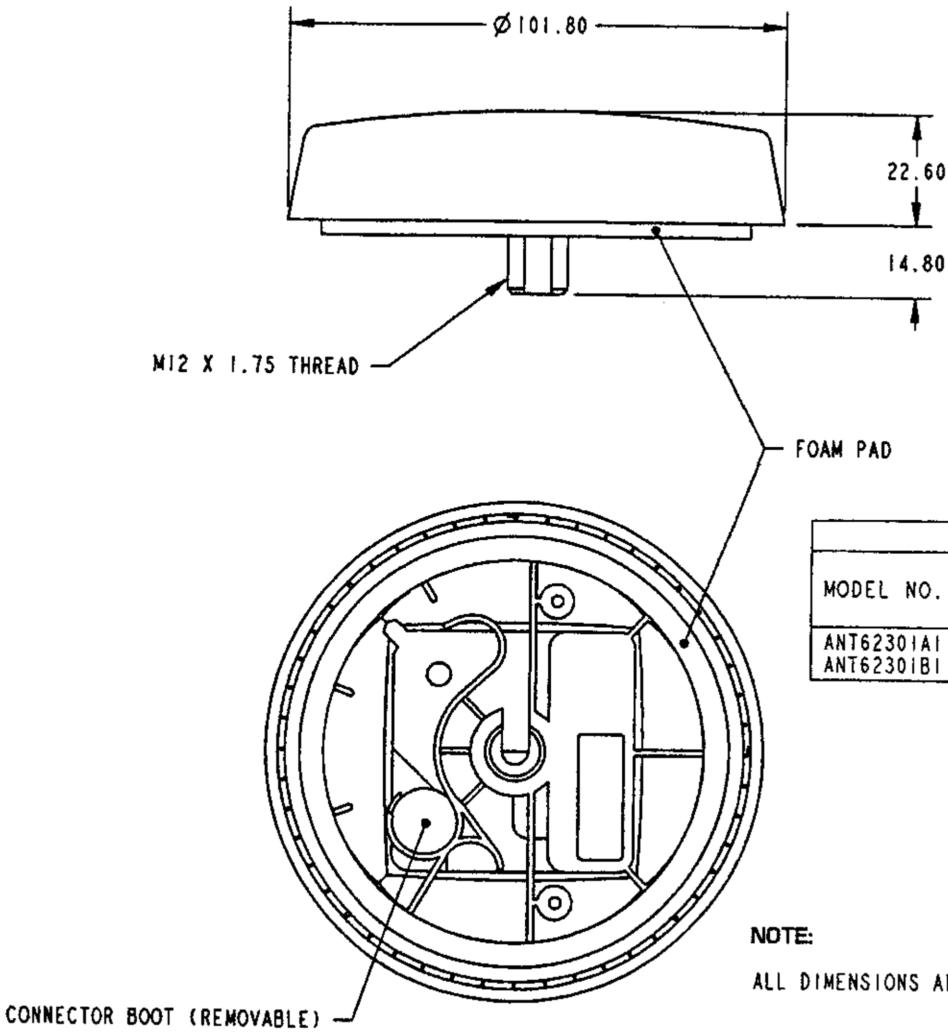


TABLE 1		
MODEL NO.	ASSEMBLY NO.	COLOR
ANT62301A1	01V43199T94	GRAY
ANT62301B1	01V41199U10	WHITE

NOTE:

ALL DIMENSIONS ARE FOR REFERENCE ONLY.

GPS Antenna Dimensions

Antenna Gain Pattern

The sensitivity of an antenna as a function of elevation angle is represented by the gain pattern. Some directions are much more appropriate for signal reception than others, so the gain characteristics of an antenna play a significant role in the antenna's overall performance.

A cross-sectional view of the antenna gain pattern along a fixed azimuth (in a vertical cut) is displayed in the following figure. The gain pattern clearly indicates that the antenna is designed for full, upper hemispherical coverage, with the gain diminishing at low elevations. This cross-section is representative of any vertical cross-section over a 0 to 360 degree azimuth range and thus, the 3-dimensional gain pattern is a symmetric spheroidal surface. It is important to note that this gain pattern varies in elevation angle, but not in horizontal azimuth. This design is well-suited for many GPS applications, accommodating full sky coverage above the local horizon and minimizing ground-reflected multipath effects.

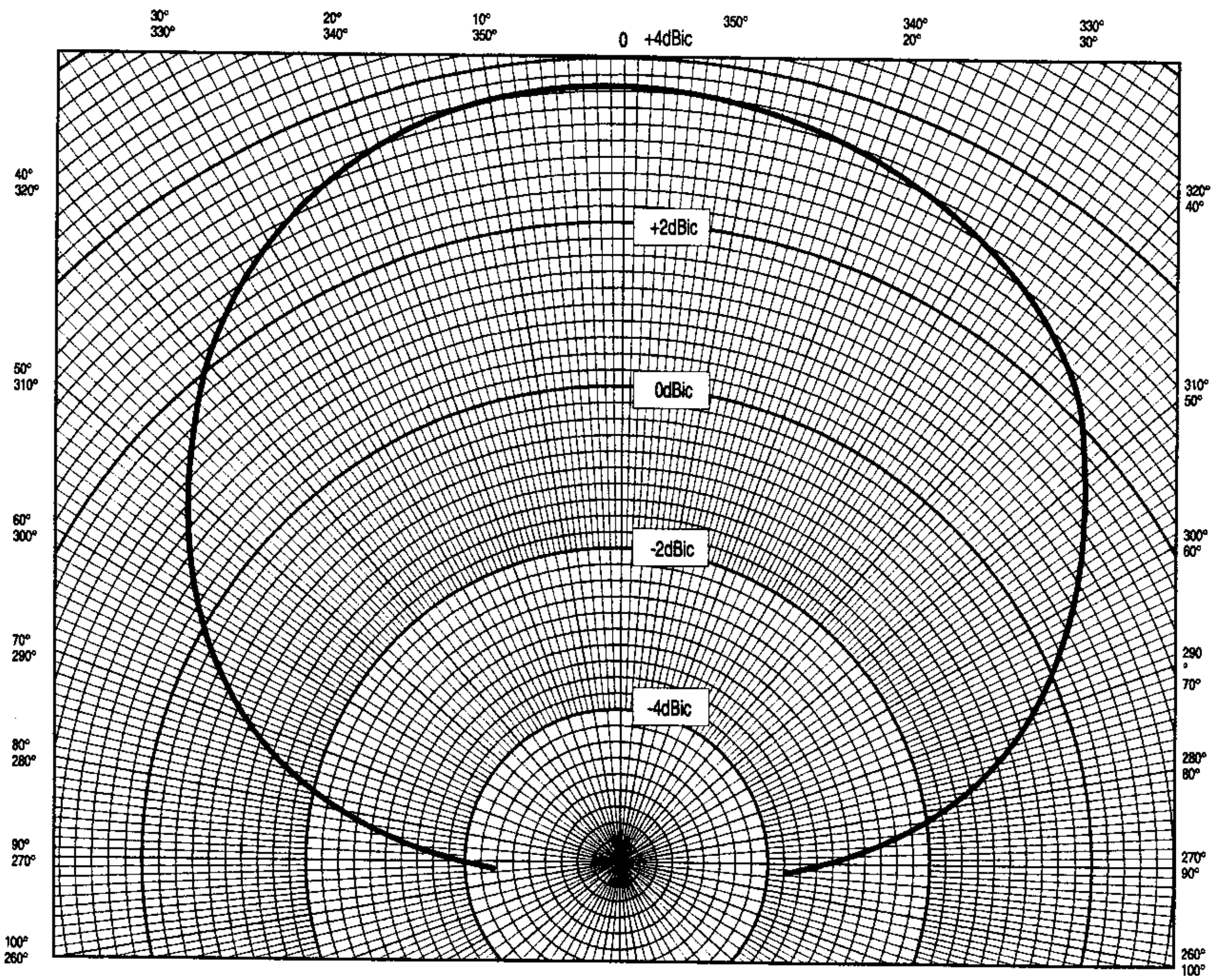


Figure 3.3: Typical Antenna Gain Pattern
For ANT 62301xx

ELECTRICAL CONNECTIONS

The BASIC, XT and VP Oncore receivers receive electrical power and receive/transmit ASCII signals through a connector (power/data connector) mounted on the Oncore receivers.

The following tables list assigned signal connections of the BASIC, XT and VP Oncore receivers' power/data connectors. Illustrations of connector and pin number orientation appear in the discussions for each of the receivers after printed circuit board mounting paragraphs.

BASIC Oncore Power/Data Connector Pin Assignments

Pin #	Signal Name	Description
1	+12V/+5V BATT	(Optional) +5 Vdc regulated or +12 Vdc unregulated for running Real Time Clock and retention of satellite ephemeris information stored in keep-alive RAM memory
2	+5V MAIN	(Optional) +5 Vdc regulated for power requirements of entire GPS receiver (+12 Vdc signal not used)
3	+12V/+5V RTN	Power supply (+5 V or +12 V) return
4	Vpp	Flash memory (EPROM) programming voltage
5	+12V MAIN	+12 Vdc unregulated for power requirements of entire GPS receiver
6	1 PPS	One pulse per second output
7	1 PPS RTN	One pulse per second return
8	RS232 TXD	Serial RS232 data output
9	RS232 RXD	Serial RS232 data input
10	RS232 RTN	Signal return for RS232 signals.

XT Oncore Power/Data Connector Pin Assignments

Pin #	Signal Name	Description
1	SHIELD TO CASE	Shield to case / EMI ground
2	RS232 RXD	Serial RS232 data input
3	RS232 TXD	Serial RS232 data output
4	Vpp	Flash memory (EPROM) Programming Voltage
5	ONEPPS RTN	One pulse per second return
6	+5V/+12V BATT	+5 Vdc regulated or +12 Vdc unregulated for running real-time-clock and retention of satellite ephemeris information stored in keep-alive RAM memory
7	+5V/+12 RTN AND RS232 RTN	Power supply (+5V or +12V) return and return for RS232 signal
8	+12V SW	+12 V switched
9	ONEPPS	One pulse per second signal

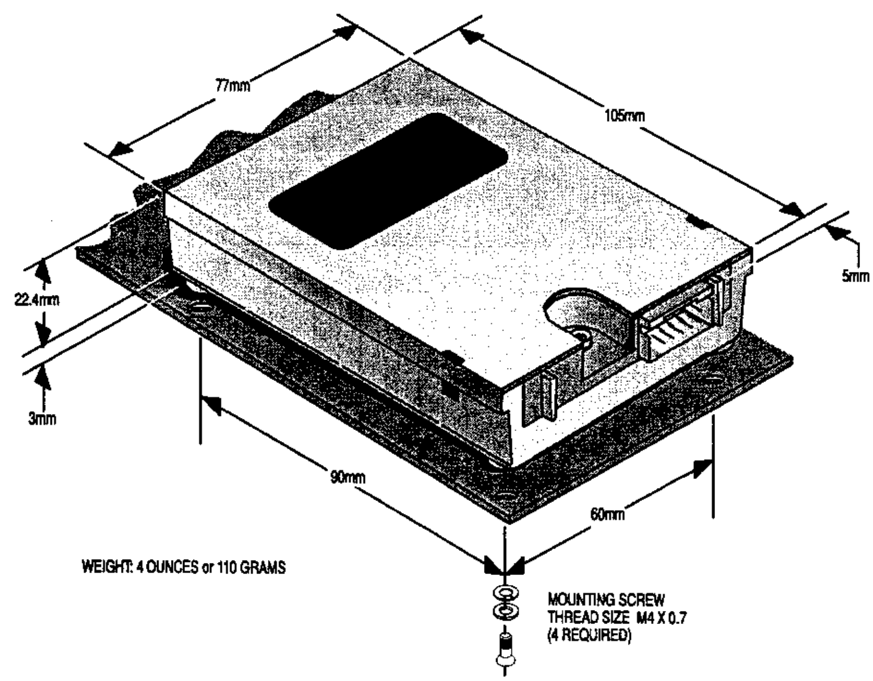
ELECTRICAL CONNECTIONS (CONT)

VP Oncore Power/Data Connector Pin Assignments

Pin #	Signal Name	Description
1	BATTERY	External applied back-up
2	+5V PWR	+5 Vdc regulated
3	GROUND	Ground (receiver)
4	Vpp	Flash memory (EPROM) Programming Voltage
5	–	N/A
6	ONEPPS	One pulse per second signal
7	ONEPPS RTN	One pulse per second return
8	TTL TXD	Transmit 5V logic
9	TTL RXD	Receive 5V logic
10	TTL RTN	Transmit/receive return

PRINTED CIRCUIT BOARD MOUNTING

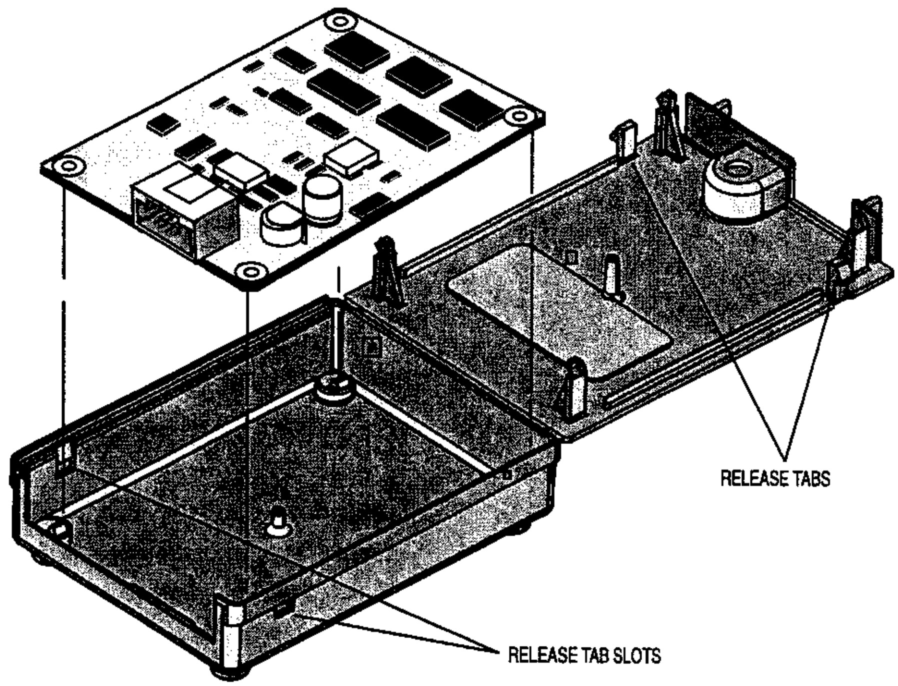
Boards shipped in a plastic housing to prevent inadvertent damage and to provide environmental protection may be installed in the plastic housing or free of the housing depending on your particular OEM application. The following illustrations show each mounting configuration.



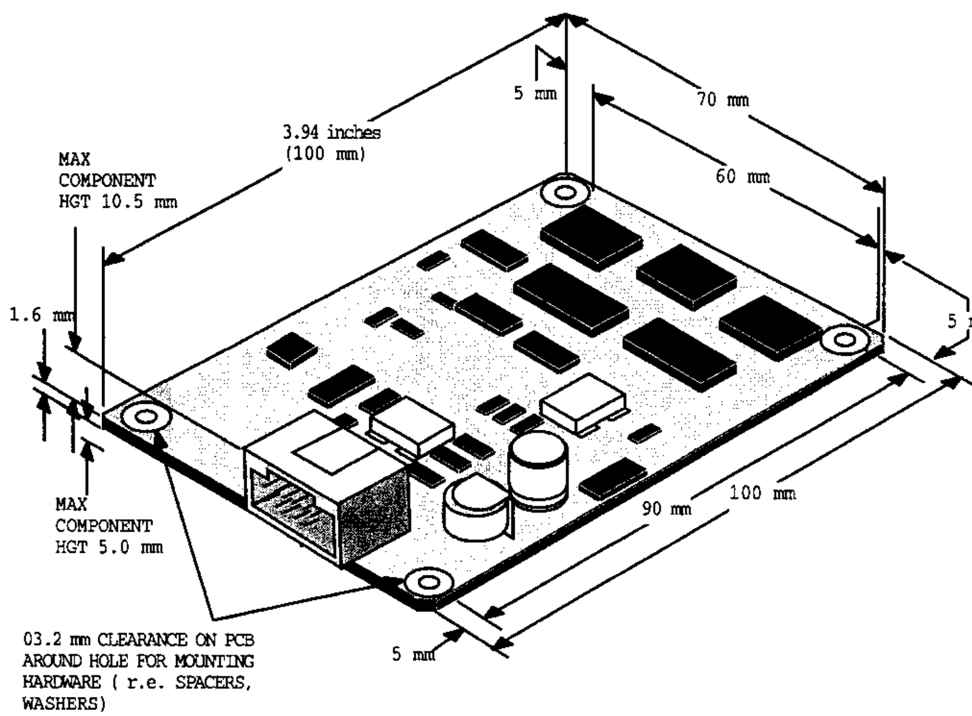
Plastic Encased Oncore Receiver Mounting

PRINTED CIRCUIT BOARD MOUNTING (CONTINUED)

CAUTION: The GPS receiver PCB contains parts and assemblies sensitive to damage by electrostatic discharge (ESD). Use ESD precautionary procedures when handling, removing or inserting the PCB.



Removal of Oncore Receiver from Plastic Housing



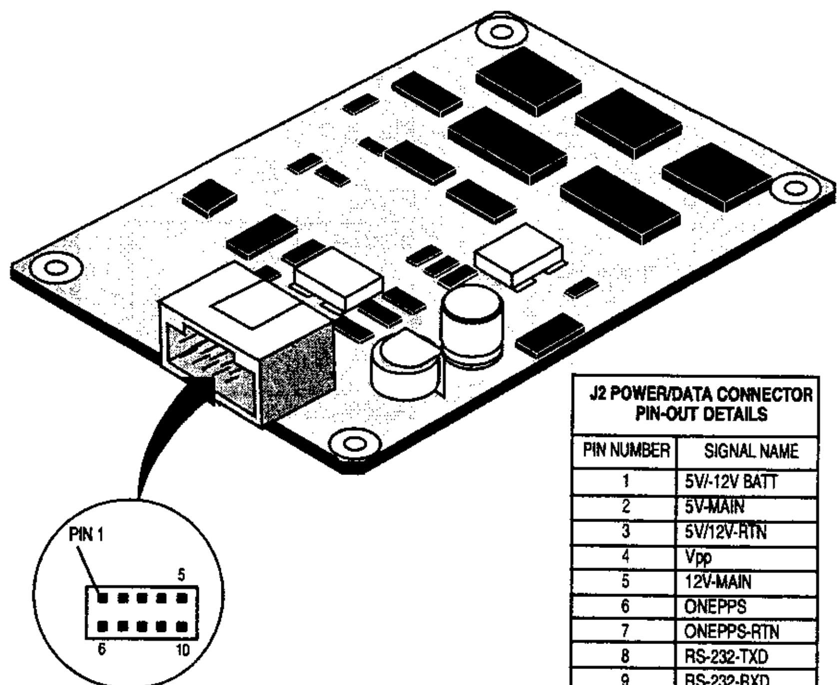
Mounting of Oncore Receiver PCB

BASIC ONCORE RECEIVER

The following discussion describes the operating features and technical characteristics for the BASIC Oncore receiver.

Operating Features

The BASIC Oncore receiver represents hardware version 1.5. It operates on +5 Vdc regulated or +12 Vdc unregulated power source. Its data port interface is RS232 compatible. It is shipped within a plastic housing. It has a 10-pin, rectangular data/power connector and a OSX RF connector for antenna signal connection.

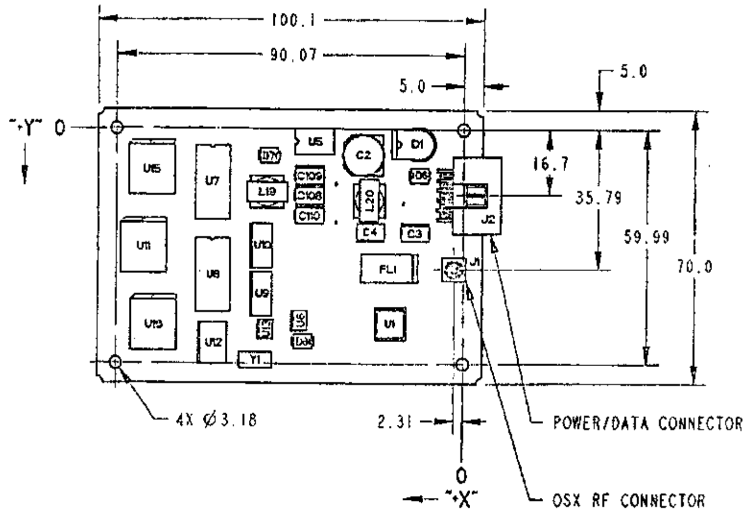


J2 POWER/DATA CONNECTOR PIN-OUT DETAILS	
PIN NUMBER	SIGNAL NAME
1	5V/-12V BATT
2	5V-MAIN
3	5V/12V-RTN
4	Vpp
5	12V-MAIN
6	ONEPPS
7	ONEPPS-RTN
8	RS-232-TXD
9	RS-232-RXD
10	RS-232-RTN

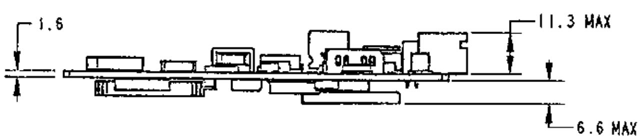
BASIC Oncore Receiver

BASIC Oncore GPS Receiver Technical Characteristics

General Characteristics	Receiver Architecture	• 6 (or 8) channel • L1 1575.42 MHz • C/A code (1.023 MHz chip rate) • Code plus carrier tracking (carrier aided tracking)
	Tracking Capability	• 6 (or 8) simultaneous satellite vehicles
Performance Characteristics	Dynamics	• Velocity: 1000 knots (515 m/s) > 1000 knots at altitudes < 60,000 ft. • Acceleration: 4 g • Jerk: 5 m/s^3
	Acquisition Time (Time To First Fix, TTFF)	• 23 s typical TTFF (with current almanac, position, time and ephemeris) • 45 s typical TTFF (with current almanac, position and time) • 2.5 s typical reacquire (<1 s internal)
	Positioning Accuracy	• Less than 25 m, SEP (without SA) [DoD may invoke Selective Availability (SA), potentially degrading accuracy to 100 m (2DRMS)] • DGPS accuracy 1-5 meters typical
	Timing Accuracy (1 Pulse Per	• 130 ns observed (1σ) with SA on • In position hold mode. < 50 ns observed (1σ) with SA on
	Antenna	• Active micro strip patch antenna module • Powered by receiver module (25mA @ 5Vdc)
	Datums	• 49 std. datums, 2 user defined, default WGS-84
Serial Communication	Output Messages	• Latitude, longitude, height, velocity, heading, time, satellite tracking status (Motorola binary protocol) • NMEA-0183 Version 2.00 (selected formats) available • Software selectable output rate (continuous or poll) • Broad list of command/control messages • RS-232C interface
Electrical Characteristics	Power Requirements	• 9 to 16 Vdc or 5 Vdc ± 0.25 V
	"Keep-Alive" BATT Power	• 4.75-16 Vdc; 0.3 mA (max) or • 3V on-board battery: 15μA (typ.) 60μA (max)
	Power Consumption	• 1.3 W @ 5 Vdc; 1.8 W @ 12 Vdc
Physical Characteristics	Dimensions	• Receiver board 3.94 x 2.76 x 0.7 in. (100 x 70 x 17.8 mm) • Plastic housing 4.13 x 3.03 x 1 in. (105 x 77 x 25.4 mm) • Active antenna module 4.01 (dia.) x 0.89 in. (102 (dia.) x 22.6 mm)
	Weight	• Receiver board 2.3 oz. (64 g) • Receiver in plastic housing 3.8 oz. (107 g) • Active antenna module 4.8 oz. (136.2 g)
	Connectors	• Data/power: 10 pin (2x5) shrouded header, RF: OSX (subminiature snap-on)
	Antenna to Receiver Interconnection	• Single coaxial cable (6 dB max loss at L1; 1575, 42 MHz)
Environmental Characteristics	Operating Temperature	• Receiver module -30°C to +85°C • Active antenna module -40°C to +100°C
	Humidity	• 95% noncondensing +30°C to +60°C
	Altitude	• 60,000 ft. (18 km) • > 60,000 ft. (18 km) for velocities < 1000 knots
Miscellaneous	Optional features	• 1 PPS timing output • Raw measurement data • On-board rechargeable lithium battery
	DGPS	• Differential GPS-standard software feature • RTCM SC-104 format (remote input) • Motorola custom format (master output and remote input)



TOP SIDE



BOTTOM SIDE

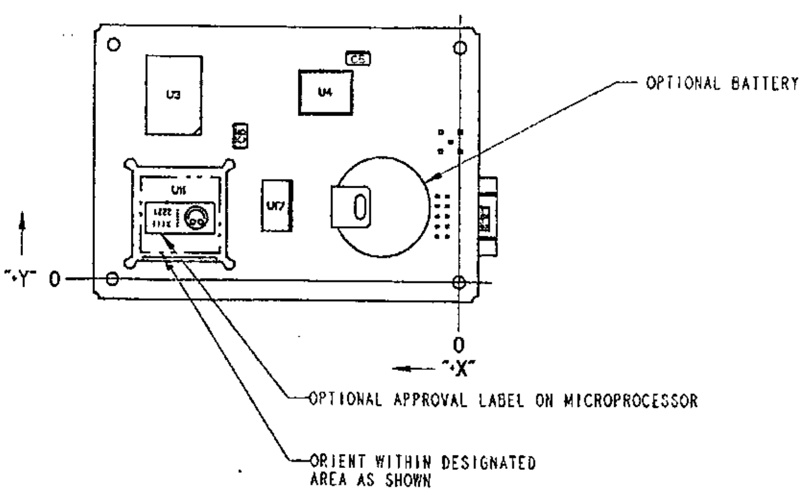


TABLE II

COMPONENT LEGEND

DESIGNATION	SIDE	LOCATION NOMINAL TO CENTER "X"	LOCATION "Y"	SIZE MAX IN RELATION TO BOARD "X"	SIZE "Y"	HEIGHT
C2	TOP	26.37	6.71	11.50	10.50	11.30
C3	TOP	12.52	26.39	7.60	4.60	3.35
C4	TOP	24.33	26.52	7.60	4.60	3.35
C5	BOTTOM	26.87	57.12	6.30	3.51	3.05
C6	BOTTOM	57.35	36.80	3.51	6.30	3.05
C108	TOP	40.34	16.87	7.60	4.60	3.35
C109	TOP	40.34	11.79	7.60	4.60	3.35
C110	TOP	40.34	21.95	7.60	4.60	3.35
D1	TOP	11.51	3.78	11.20	8.69	7.25
D6	TOP	11.38	11.79	5.59	3.81	2.81
D7	TOP	50.75	6.83	5.59	3.81	2.81
D8	TOP	41.99	54.33	5.59	3.81	2.81
FL1	TOP	19.38	35.53	15.01	7.37	6.09
L19	TOP	51.26	16.10	10.69	12.50	6.55
L20	TOP	24.71	18.26	12.50	10.69	6.55
U1	TOP	19.00	49.76	8.46	8.46	2.54
U3	BOTTOM	74.75	47.22	18.15	24.15	3.43
U4	BOTTOM	35.26	48.23	14.12	11.56	3.83
U5	TOP	43.00	7.21	10.16	7.62	4.45
U6	TOP	43.00	49.00	6.20	5.00	2.00
U7	TOP	65.61	13.82	12.10	18.90	2.95
U8	TOP	65.48	37.44	12.10	18.90	2.95
U9	TOP	52.78	42.27	8.00	11.30	2.45
U10	TOP	52.78	29.95	8.00	11.30	2.45
U11	BOTTOM	72.85	16.74	28.01	28.01	4.82
U12	TOP	65.48	54.84	10.55	10.45	2.90
U13	TOP	51.64	51.28	6.20	5.00	2.00
U14	TOP	83.13	29.95	12.60	15.10	3.81
U15	TOP	81.10	10.01	12.60	15.10	3.81
U16	TOP	80.59	49.63	12.60	15.10	3.81
U17	BOTTOM	47.70	16.74	10.55	12.95	2.90
Y1	TOP	54.18	59.16	8.51	4.06	2.54
BATTERY	BOTTOM	20.35	18.97	27.00	25.5	6.60

Basic Oncore Dimensions

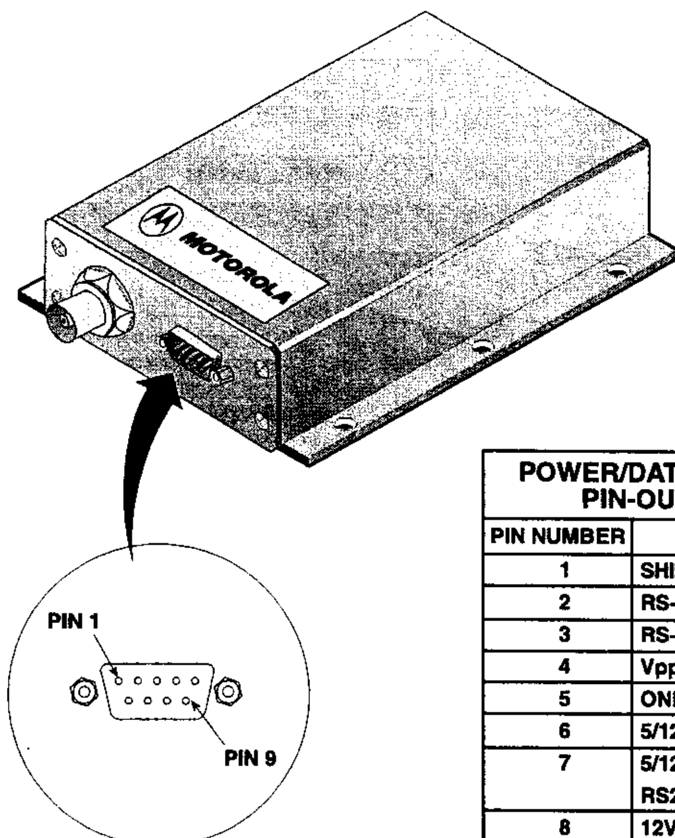
XT ONCORE RECEIVER

The following discussion describes the operating features and technical characteristics for the XT Oncore receiver.

Operating Features

The XT Oncore receiver represents hardware version 1.5. It operates on +5 Vdc regulated or +12 Vdc unregulated power source. Its data port interface is RS232 compatible. It is encased within an aluminum housing. It has a 9-pin, DB data/power connector and a BNC RF connector for antenna signal connection.

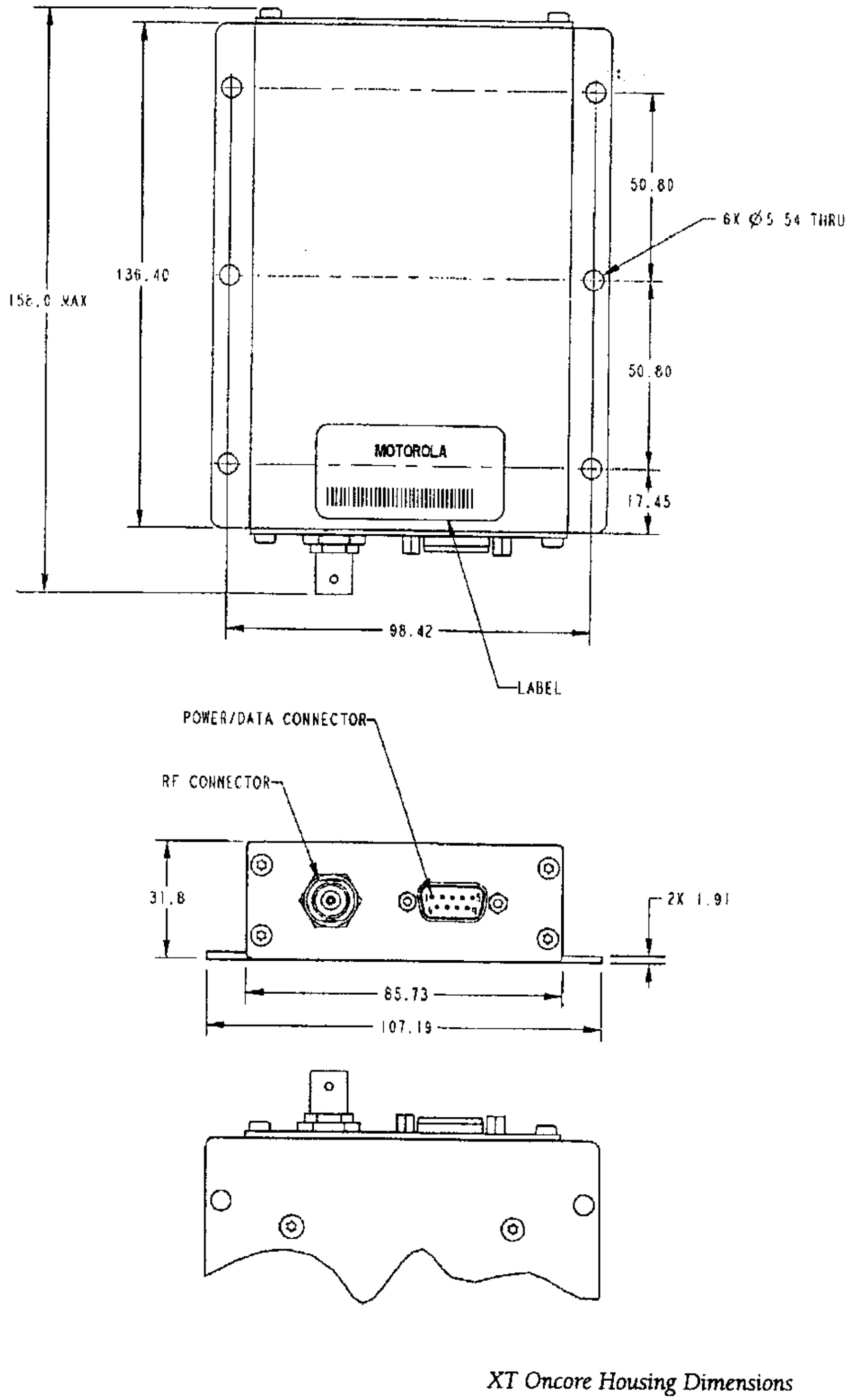
XT Oncore Receiver



POWER/DATA CONNECTOR PIN-OUT DETAILS	
PIN NUMBER	SIGNAL NAME
1	SHIELD TO CASE/EMI GND
2	RS-232-RXD
3	RS-232-TXD
4	Vpp
5	ONEPPS-RTN
6	5/12V-BAT
7	5/12-RTN AND RS232-RTN
8	12V-SW
9	ONEPPS

XT Oncore GPS Receiver Technical Characteristics

General Characteristics	Receiver Architecture	• 6 (or 8) channel • L1 1575.42 MHz • C/A code (1.023 MHz chip rate) • Code plus carrier tracking (carrier aided tracking)
	Tracking Capability	• 6 (or 8) simultaneous satellite vehicles
Performance Characteristics	Dynamics	• Velocity: 1000 knots (515 m/s) > 1000 knots at altitudes < 60,000 ft. • Acceleration: 4 g • Jerk: 5 m/s^3
	Acquisition Time (Time To First Fix, TTFF)	• 23 s typical TTFF (with current almanac, position, time and ephemeris) • 45 s typical TTFF (with current almanac, position and time) • 2.5 s typical reacquire (<1 s internal)
	Positioning Accuracy	• Less than 25 m, SEP (without SA) [DoD may invoke Selective Availability (SA), potentially degrading accuracy to 100 m (2DRMS)] • DGPS accuracy 1-5 meters typical
	Timing Accuracy (1 Pulse Per	• 130 ns observed (1σ) with SA on • In position hold mode. < 50 ns observed (1σ) with SA on
	Antenna	• Active micro strip patch antenna module • Powered by receiver module (25mA @ 5Vdc)
	Datums	• 49 std. datums, 2 user defined, default WGS-84
Serial Communication	Output Messages	• Latitude, longitude, height, velocity, heading, time, satellite tracking status (Motorola binary protocol) • NMEA-0183 Version 2.00 (selected formats) available • Software selectable output rate (continuous or poll) • Broad list of command/control messages • RS-232C interface
Electrical Characteristics	Power Requirements	• 9 to 16 Vdc or 5 Vdc ± 0.25 V
	"Keep-Alive" BATT Power	• 4.75-16 Vdc; 0.3 mA (max) or • 3V on-board battery: 15μA (typ.) 60μA (max)
	Power Consumption	• Receiver in metal housing 1.8 W @ 12 Vdc
Physical Characteristics	Dimensions	• Receiver 5.5 x 4.2 x 1.25 in. (140 x 107 x 32 mm) • Active antenna module 4.01 (dia.) x 0.89 in. (102 (dia.) x 22.6 mm)
	Weight	• Receiver in metal housing 13.9 oz. (393 g) • Active antenna module 4.8 oz. (136.2 g)
	Connectors	• Data/power: DB-9, RF:BNC
	Antenna to Receiver Interconnection	• Single coaxial cable (6 dB max loss at L1; 1575, 42 MHz)
Environmental Characteristics	Operating Temperature	• Receiver module -30°C to +85°C • Active antenna module -40°C to +100°C
	Humidity	• 95% noncondensing +30°C to +60°C
	Altitude	• 60,000 ft. (18 km) • > 60,000 ft. (18 km) for velocities < 1000 knots
Miscellaneous	Optional features	• 1 PPS timing output • Raw measurement data • On-board rechargeable lithium battery
	DGPS	• Differential GPS-standard software feature • RTCM SC-104 format (remote input) • Motorola custom format (master output and remote input)



XT Oncore Housing Dimensions

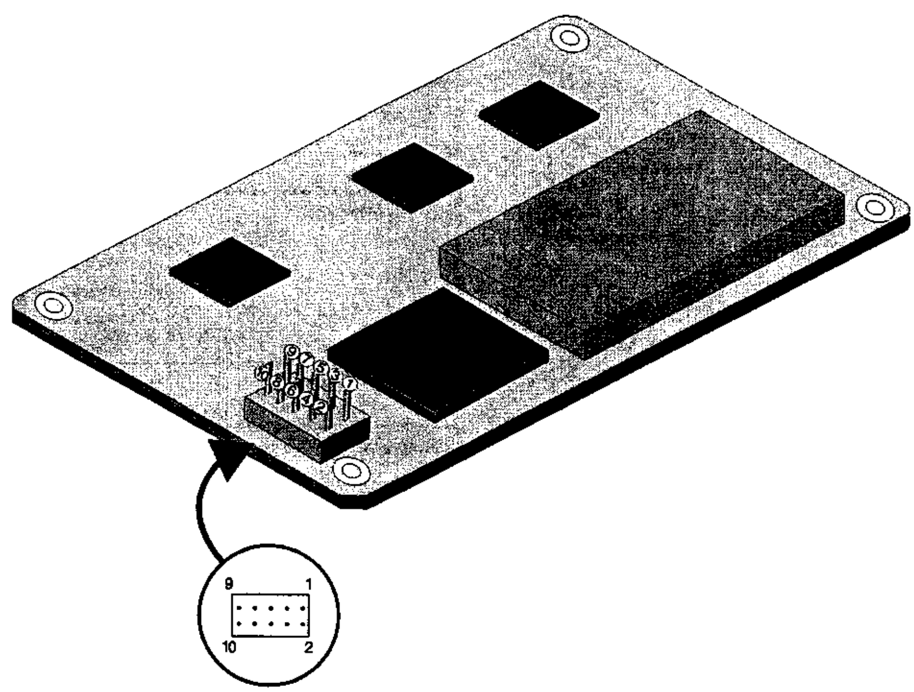
VP ONCORE RECEIVER

The following discussion describes the operating features and technical characteristics for the VP Oncore receiver.

Operating Features

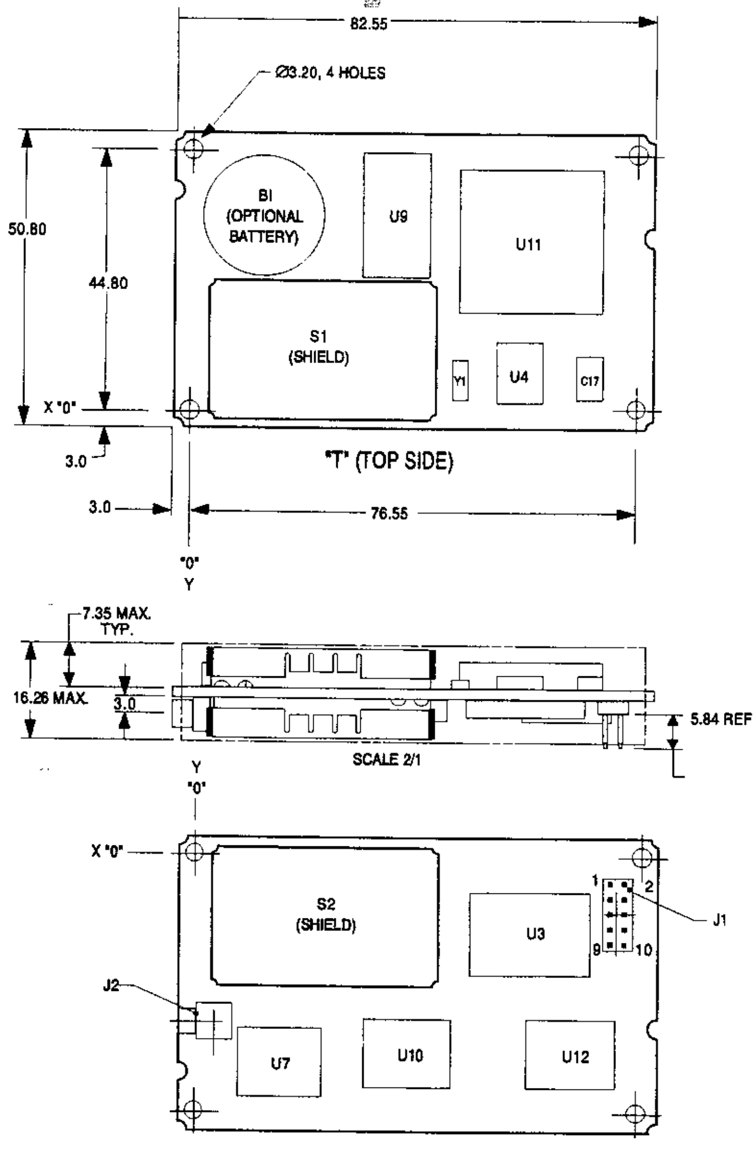
The VP Oncore receiver represents hardware version 1.5. It operates on +5 Vdc regulated power source. Its data port interface is inverted TTL compatible. It is shipped within protective packaging. It has a 10-pin, data/power connector and a OSX RF connector for antenna signal connection.

VP Oncore Receiver



VP Oncore GPS Receiver Technical Characteristics

General Characteristics	Receiver Architecture	• 6 (or 8) channel • L1 1575.42 MHz • C/A code (1.023 MHz chip rate) • Code plus carrier tracking (carrier aided tracking)
	Tracking Capability	• 6 (or 8) simultaneous satellite vehicles
Performance Characteristics	Dynamics	• Velocity: 1000 knots (515 m/s) > 1000 knots at altitudes < 60,000 ft. • Acceleration: 4 g • Jerk: 5 m/s^3
	Acquisition Time (Time To First Fix, TTFF)	• 23 s typical TTFF (with current almanac, position, time and ephemeris) • 45 s typical TTFF (with current almanac, position and time) • 2.5 s typical reacquire (< 1 s internal)
	Positioning Accuracy	• Less than 25 m, SEP (without SA) [DoD may invoke Selective Availability (SA), potentially degrading accuracy to 100 m (2DRMS)] • DGPS accuracy 1-5 meters typical
	Timing Accuracy (1 Pulse Per Second, 1 PPS)	• 130 ns observed (1σ) with SA on • In position hold mode. < 50 ns observed (1σ) with SA on
	Antenna	• Active micro strip patch antenna module • Powered by receiver module (25mA @ 5Vdc) • Passive antenna configuration (see optional features)
	Datums	• 49 std. datums, 2 user defined, default WGS-84
Serial Communication	Output Messages	• Latitude, longitude, height, velocity, heading, time, satellite tracking status (Motorola binary protocol) • NMEA-0183 Version 2.00 (selected formats) available • Software selectable output rate (continuous or poll) • Broad list of command/control messages • TTL Interface (inverted)
Electrical Characteristics	Power Requirements	• 5 ± 0.25 Vdc 50 mVpp ripple (max)
	"Keep-Alive" BATT Power	• External 2.5 V to 5.25 V 15µA (type 60µA (max) • 3V on-board battery: 15µA (typ.) 60µA (max)
	Power Consumption	• 1.1 W @ 5 V
Physical Characteristics	Dimensions	• Receiver 2.00 x 3.25 x 0.64 in. (50.8 x 82.6 x 16.3 mm)) • Active antenna module 4.01 (dia.) x 0.89 in. (102 (dia.) x 22.6 mm)
	Weight	• Receiver 1.8 oz. (51 g)) • Active antenna module 4.8 oz. (136.2 g)
	Connectors	• Data/power: 10 pin (2x5) unshrouded header on 0.100" centers • RF: right angle OSX (subminiature snap-on)
	Antenna to Receiver Interconnection	• Single coaxial cable (for active antenna – 6 dB max loss at L1; 1575.42 MHz)
Environmental Characteristics	Operating Temperature	• Receiver module -30°C to +85°C
	Humidity	• 95% noncondensing +30°C to +60°C
	Altitude	• 60,000 ft. (18 km) • > 60,000 ft. (18 km) for velocities < 1000 knots
Miscellaneous	Optional features	• 1 PPS timing output • Raw measurement data • On-board rechargeable Lithium battery • On-board LNA option for use with passive antenna
	DGPS	• Differential GPS-standard software feature • RTCM SC-104 format (remote input) • Motorola custom format (master output and remote input)



"B" (BOTTOM SIDE)

(J1) POWER/DATA LEGEND		
PIN#	SIGNAL NAME	DESCRIPTION
1	BATTERY	EXTERNAL APPLIED BACK-UP
2	5V PWR	+5Vdc REGULATED
3	GROUND	GROUND (RECEIVER)
4	VPP	FLASH EPROM PROGRAMMING
5	(NOT USED)	
6	ONEPPS	1 PULSE PER SECOND OUTPUT
7	ONEPPS-RTN	1 PULSE PER SECOND RETURN
8	TTL-TXD	TRANSMIT 5V LOGIC
9	TTL-RXD	RECEIVE 5V LOGIC
10	TTL-RTN	TRANSMIT/RECEIVE RETURN

COMPONENT LEGEND						
REF DESIG	PCB SIDE	LOCATION (NOMINAL TO CENTER)		SIZE (NOMINAL)		
		"X"	"Y"	WIDTH "X"	LENGTH "Y"	HEIGHT
B1	T	12.4	33.6	20.5	—	4.0
C17	T	67.1	6.4	4.3	7.3	2.8
J1	B	72.44	9.45	4.9	12.3	8.2
J2	B	3.35	28.75	6.0	6.0	6.0
S1	T	22.6	10.6	39.3	23.8	6.9
S2	B	22.6	10.6	39.3	23.8	6.9
U3	B	55.5	13.1	20.0	14.0	3.0
U4	T	56.8	7.2	7.5	10.3	2.5
U7	B	16.0	35.5	14.0	11.5	3.6
U9	T	34.1	35.5	11.7	21.0	3.2
U10	B	35.5	35.1	15.0	11.5	3.6
U11	T	60.0	33.7	24.2	24.2	4.6
U12	B	61.3	29.8	15.0	11.5	3.6
Y1	T	45.0	5.9	2.5	6.7	1.5

NOTE:

(J1) POWER/DATA CONNECTOR:
MFR: AMP #104326-06
HEADER, 10-PIN W/2.54 CENTERS

(J2) RF CONNECTOR:
MFR: MACOM #5864-5002-10
(OSX) SUB-MINIATURE SNAP-ON

VP Oncore Printed Circuit Board

CHAPTER 4 HARDWARE INSTALLATION

CHAPTER CONTENT

Refer to this chapter for the following:

- Installation precautions.
- Thermal considerations.
- GPS Antenna Module mounting.

Installation Overview

RECEIVER MODULE INSTALLATION

Your Oncore receiver has been carefully inspected and packaged to ensure optimum performance. As with any piece of electronic equipment, proper installation is essential before you can use the equipment.

You can mount the Oncore receiver board into your existing housing system.

CAUTION!

INSTALLATION PRECAUTIONS AND CONSIDERATIONS

Before you install an Oncore receiver, please review the following precautions and considerations.

Electrostatic Precautions

The Oncore receiver printed circuit boards (PCBs) contain parts and assemblies sensitive to damage by electrostatic discharge (ESD). Use ESD precautionary procedures when handling the PCB.

Electromagnetic Considerations

The Oncore receiver PCBs contain a very sensitive RF receiver; you must observe certain precautions to prevent possible interference from the host system. Because the electromagnetic environment will vary for each OEM application, it is not possible to define exact guidelines to assure electromagnetic compatibility.

RF Shielding

The RF circuitry sections on the Oncore GPS receiver board are protected with a tin plate shield to guard against potential interference from external sources. When a design calls for the Oncore to be near or around RF sources such as

Installer Caution (Continued)

RF Shielding (Continued)

radios, it is recommended that the Oncore be tested and tried in the target environment to identify potential interference issues prior to final design.

In worst case situations, the Oncore receiver PCB may require an additional enclosure in a metal shield to eliminate electromagnetic compatibility (EMC) problems.

Real-Time Clock (RTC)

When powered up, the RTC in the Oncore receiver will have an incorrect time unless it was previously set and maintained by external backup power. To ensure a faster time to first fix, the time, date, and GMT offset should be input if both the main power and battery backup power have been disconnected.

Thermal Considerations

The receiver operating temperature range is -30°C to +85°C, and the storage temperature range is -40°C to +125°C. The antenna operating range is -40°C to +100°C, and the storage temperature range is -40°C to +125°C. Before installation, you should perform a thermal analysis of the housing environment to ensure that temperatures do not exceed +85°C when operating (+125°C stored). This is particularly important if

- air circulation in the installation site is poor,
- other electronics are installed in the enclosure with the Oncore receiver PCB, or
- the Oncore receiver PCB is enclosed within a shielded container due to electromagnetic interference (EMI) requirements.

Grounding Considerations

The VP Oncore receiver is grounded through Pin 3 of the power/data connector. The four mounting holes in the receiver PCB are isolated from the PCB ground plane.

ONCORE RECEIVER ELECTRICAL CONNECTIONS AND MOUNTING INSTRUCTIONS

Refer to Chapter 3 for detailed electrical and mechanical specifications concerning your Oncore receiver.

PCB Mounting Hardware

Mounting Hardware

For all the design validation and process validation tests that were conducted and completed successfully by Motorola, the VP Oncore PCBs were mounted on round or hex female threaded metal standoffs and screwed/tightened down with metal english or metric screws. The mounting standoffs are also available with english or metric threads.

One of the key points in selecting the four standoffs that will mechanically hold and secure the VP Oncore PCB to the application PCB directly or indirectly is the diameter of the standoffs. Obviously the height of the standoff will be determined by the customers application. Recommended nominal diameter of the standoffs should be around 0.165 in. or 4.16 mm (See Figure 4.1.)

These standoff should give ample space and clearance between

- the outside diameter of the standoff and the outside edge of the RF shields of the VP Oncore, and
- the outside diameter of the standoff and the outside edge of the 10 pin header of the VP Oncore.

If the recommended diameters of the standoff are not available, one can probably go higher with the next available diameter. See Table 1 for a suggested list of companies that carry standoffs equal or close to the recommended diameters. The maximum limit is around 0.212 in. or 5.38 mm diameter; at this point the standoffs are literally touching the RF shields.

Another important point to consider is the mating 10-pin receptacle on the application PCB. When choosing this mating connector, one must be aware that the outer diameter of the standoffs should not come too close to this connector.

Obviously the height of the standoffs will be determined by the components that are populated on the application PCB, especially the height of the 10 pin receptacle. See Figures 4.2 and 4.3 for recommended layouts of the standoffs and

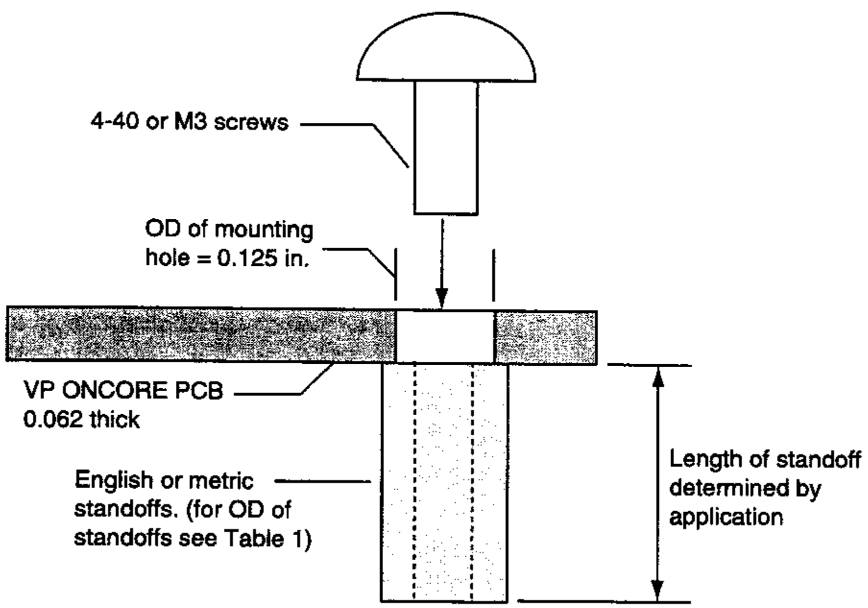
Mounting Hardware (Continued)

Mounting Hardware (Continued)

mating receptacles. Also see Motorola drawing in Chapter 3, which has an outline drawing of the VP Oncore receiver. The drawing describes the overall placement and height of large components and connectors populated on both sides of the VP Oncore PCB.

The recommended screws for the standoffs that will secure the VP Oncore to the standoffs are metal screws with 4-40 threads or M3 threads. The nominal torque to assemble the VP Oncore PCB with screws to the standoffs is 6 in-lb each with a maximum of 7 and minimum of 5 in-lb. Washers are not required nor recommended for use with the VP Oncore PCB. All design and process validation testing was completed with metal screws mounted directly onto the PCB without washers.

Figure 4.1: Layout of the VP Oncore PCB cross section with reference to the standoff and screw



Mounting Hardware (Continued)

Mounting Hardware (Continued)

Table 4.1: List of Threaded Standoff Suppliers

No.	Company Name	Part description of metal standoffs	Outside diameter
1	Keystone Electronic Corp. Tel: 718-956-8900 Fax: 718-956-9040	• Plain female standoffs 4-40 threads available in lengths from 0.250 to 1.0 in.	0.187 in. round or hex
		• Plain female standoffs M3x0.5 mm threads available in lengths from 5 to 25 mm	5 mm hex
2	RAF Electronics Hardware Tel: 203-888-2133 Fax: 203-888-9860	• Plain female standoffs 4-40 threads available in lengths from 0.250 to 1.0 in.	0.187 in. round
		• Plain female standoffs M3x0.5 mm threads available in lengths from 5 to 25 mm	4.5 mm hex
3	PEM Engineering & Manufacturing Corp Tel: 215-766-8853 Fax: 215-766-0143	• Self clinching female standoffs 4-40 threads available in lengths from 0.250 to 1.0 in.	0.165 in. round
		• Self clinching female standoffs M3x0.5 mm threads available in lengths from 5 to 25 mm	4. 2 mm round

Design and Process Validation Test Information

Motorola has conducted numerous design and process validation tests for different versions of the VP Oncore. Mechanically, the VP Oncore dimensions are exactly the same for different versions (model numbers) of the VP Oncore PCB.

One of the key legs of the design validation is the thermal shock testing followed by vibration testing. In thermal shock testing the temperature cycles every hour from -30°C to +85°C . The units are put through anywhere from 300 to 500 cycles before going on to the vibration table where they are mounted on metal standoffs.

Sturdiness and Reliability of Metal Standoffs

The VP Oncore PCB mounted on standoffs 0.375 or 0.500 in. long passed the vibration test successfully. The vibration test is three axes, one hour each, at 7.7 Gs random vibration. In the final analysis this is a severe military specification as per MIL-STD 810E. After the vibration test leg of the design validation, the screws lose about 60% to 80% torque, which is expected as per design. Also, all the parts populated on both sides of the VP Oncore PCB remain soldered to the PCB with no loose connections. Independent vibration testing at two hours per axis also proved successful.

Mounting Hardware (Continued)

Sturdiness and Reliability of Metal Standoffs (Continued)

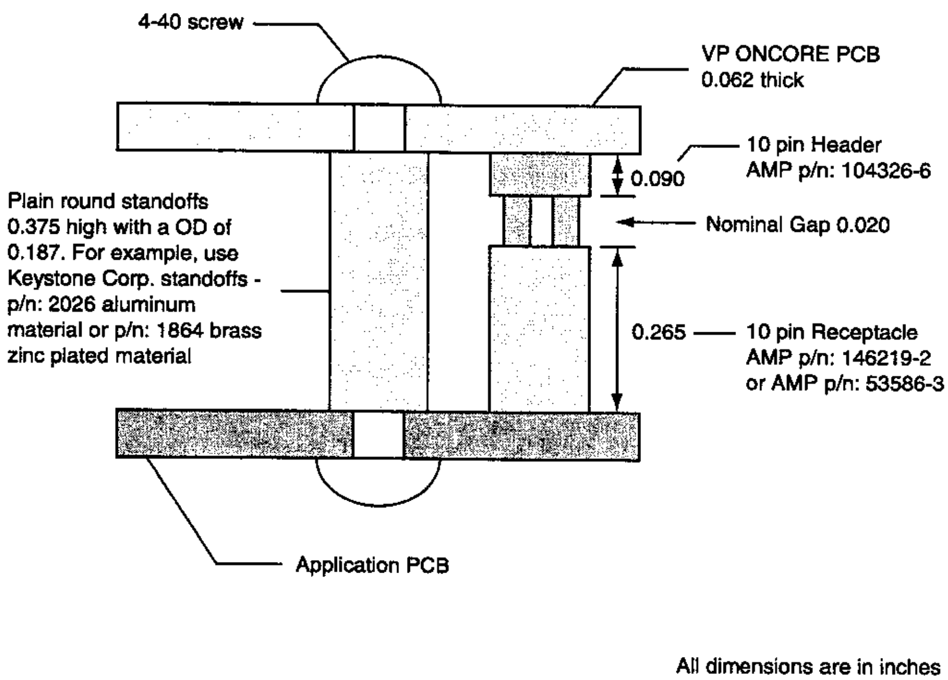
Motorola has also conducted independent vibration tests such as the SAE J1455 Truck Cab spec. (1.04 Gs for four hours per axis) and the SAE J1211 Car Chassis spec. (2.57 Gs for four hours per axis). Both of them passed successfully with the VP Oncore PCB mounted on 0.375 in. high standoffs.

Motorola conducted independent shock tests conducted at the 30 G level (10 ms duration) for 100 times, which also passed successfully.

Design Worksheets

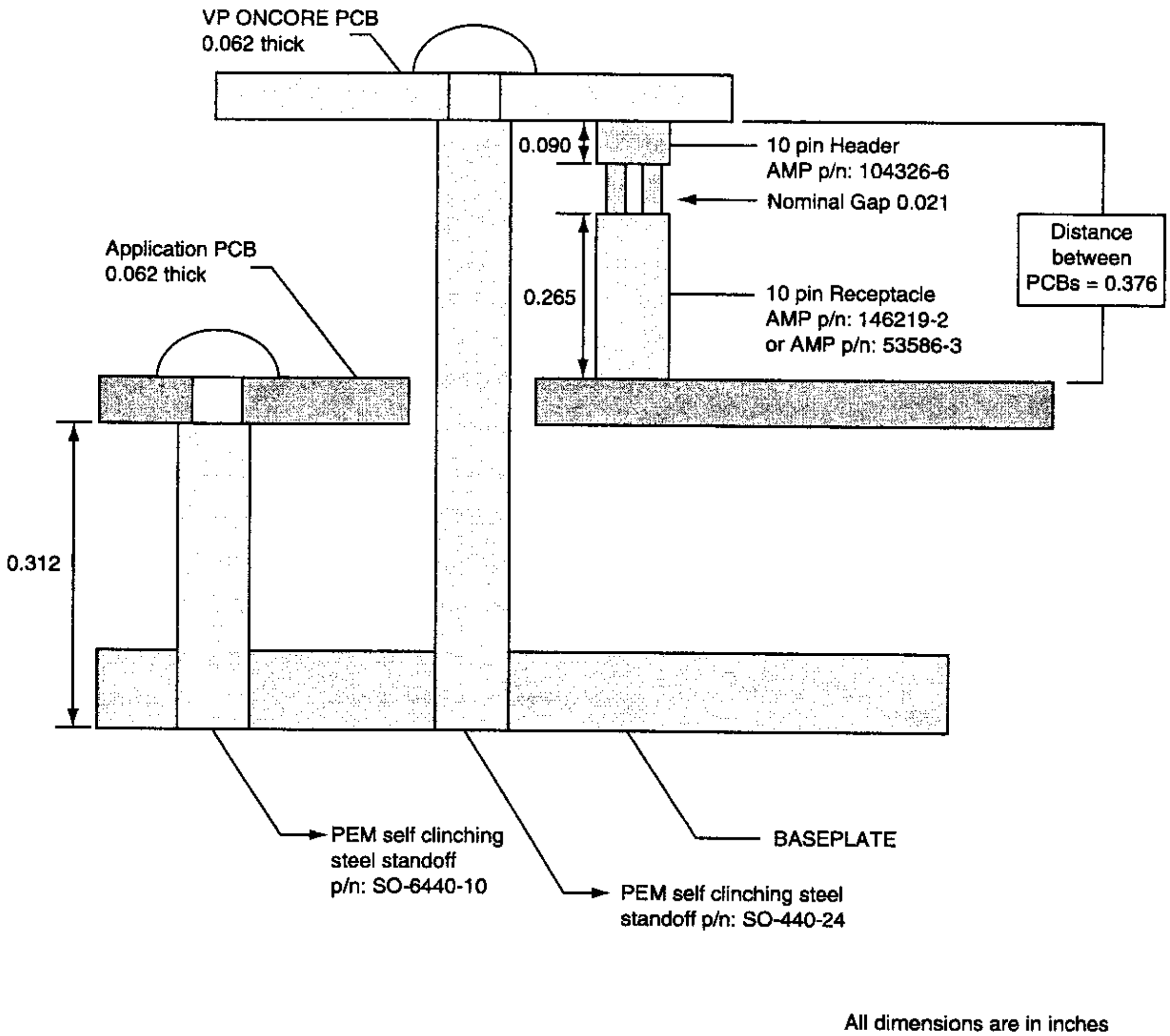
Given below in figures 4.2 and 4.3 are sample worksheets which show the VP Oncore and the application PCB mounted in two different ways. The purpose of these worksheets is to provide the reader with recommended design guidelines.

Figure 4.2: Sample layout of GPS VP Oncore PCB which is directly connected to the application PCB:



Design Worksheets (Continued)

Figure 4.3: Sample layout of GPS VP Oncore PCB and the application PCB independently mounted on a baseplate:



Antenna Module Mounting

ANTENNA MODULE CONNECTION AND MOUNTING

Your antenna module contains a low-profile antenna specifically designed for use with the Oncore receiver. GPS signals are received by the antenna, amplified within the antenna assembly, and then relayed via cable to the Oncore receiver module for processing. The antenna is enclosed in a plastic housing which protects it from harsh environmental conditions

Cable and Connector Requirements

The antenna module relays received GPS signals and receives power (5 Vdc @ 25 mA) from the receiver module via a single cable.

An RG-58 coaxial cable is recommended for proper connection of the antenna module to the receiver module. Note that the cable should have a stranded or braided inner wire rather than a solid inner wire. A female RF connector located in the base of the antenna module provides the necessary interface to the antenna's electrical circuitry. Note that the power loss along the cable should not exceed 6 dB at a frequency of 1575.42 MHz (GPS - L1). For RG-58 cables, the maximum cable length is restricted to 6 m to satisfy this 6 dB requirement.

RF connections between the antenna module and the receiver module are connected by cables having right angle subminiature snap-on connectors on both ends. The recommended suppliers for these RG-58 cable assemblies are:

- M/A-COM subminiature plugs; p/n: 5837-5006-13, and
- Phoenix Company subminiature plugs; p/n 13-2800-1200M.

  If you are planning to use other suppliers for the plugs, they must mate to the corresponding subminiature jacks that are currently on the GPS receivers and GPS antennas. For reference, the supplier name and their part numbers are:

- For GPS antennas: M/A-COM straight subminiature jack, p/n: 5862-5013-13,
- For GPS receivers: M/A-COM straight subminiature jack, p/n: 5862-5004-10 and M/A-COM right angle subminiature jack, p/n: 5864-5002-10, and Phoenix Company right angle subminiature jack; p/n: 13-3450-01N.

Mounting

The following five different antenna mount options are available for the antenna module:

- Direct Mount Kit.
- Lip Mount Kit.
- Magnet Mount Kit.
- Post Mount Kit.
- Marine Mount Kit

Refer to Table 4.2 for recommended antenna installation torques.

Detailed descriptions of the first four kit assemblies follow.

Antenna Module Mounting (Continued)

When mounting the antenna module, it is important to remember that GPS positioning performance will be most optimal when

- the antenna patch plane is level with the local geographic horizon, and
- the antenna has full view of the sky ensuring direct line-of-sight to all visible satellites over head.

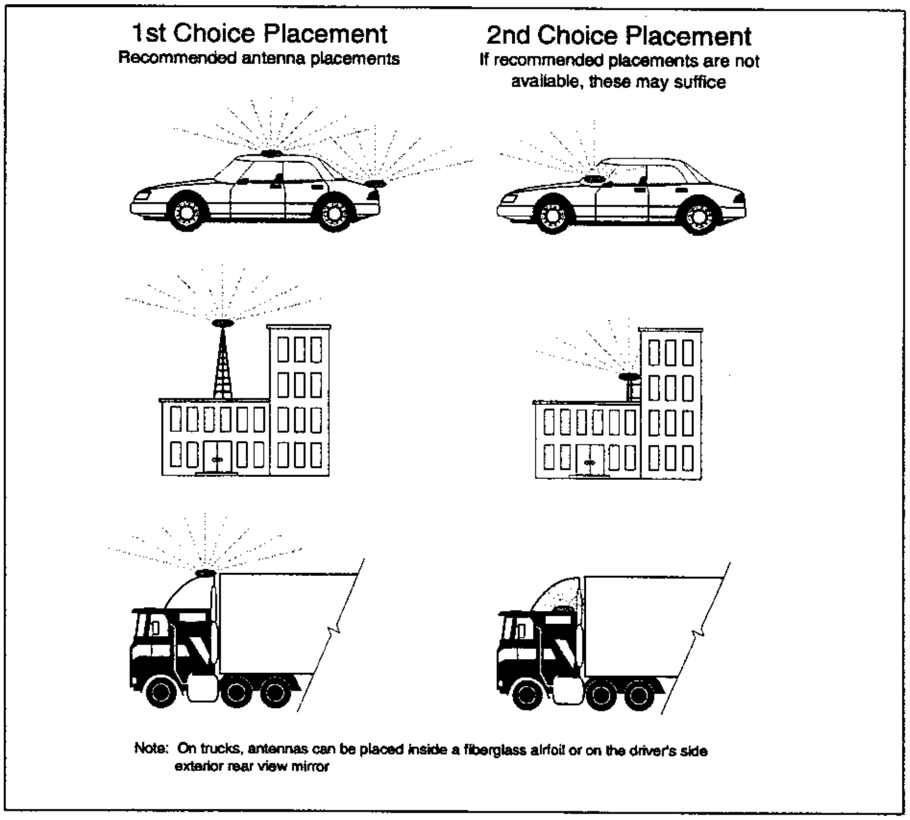
Table 4.2 Recommended Installation Torques
Assemble and/or mount GPS Antenna
Model # ANT6301A1 (grey) or ANT62301B1 (white)

Direct Mount	Model No. MNT62311A1:	**12 to 15 in-lb**
Post Mount	Model No. MNT62312A1:	**12 to 15 in-lb**
Lip Mount	Model No. MNT62313A1:	**10 to 12 in-lb**
Magnet Mount	Model No. MNT62314A1:	**10 to 12 in-lb**
Marine Mount	Model No. MNT62315B1:	**12 to 15 in-lb**

Notes: 1. For all antennas marked with Model Years 92 and 93, the recommended torque should not exceed 10 in-lb. for the different mounting versions.

2. English to metric - torque conversion:
   - 10 in-lb = 1.13 N-m = 0.115 kg-m
   - 12 in-lb = 1.35 N-m = 0.138 kg-m
   - 15 in-lb = 1.69 N-m = 0.173 kg-m

Figure 4.4: Proper Antenna Placement



Antenna Module Mounting (Continued)

Direct Mount Kit Installation

The direct mount accommodates applications requiring rigid, surface mounting.

Perform the following steps to install the direct mount kit:

1. Drill a 20 mm hole through the deck plane where you will place the antenna.
2. Attach the antenna cable connector to the mating connector on the antenna module base.

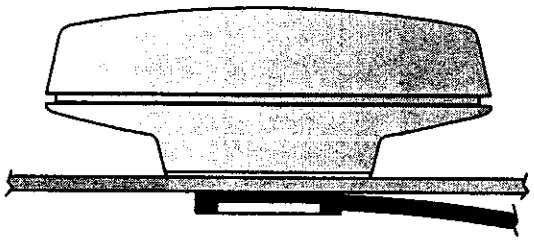


Figure 4.5: Direct Mounted Antenna Module

3. Insert the connector boot over the cable connection and into the circular boot socket.
4. Route the antenna cable along the strain relief track located in the base of the antenna module (see Figure 4.6).
5. Route the antenna cable through the hollow slot in the antenna module's threaded stem.
6. Remove the peel-off liner from the outer gasket and attach the gasket to the bottom of the mounting shroud.
7. Insert the threaded stem through the mounting shroud, outer gasket and deck plane.
8. Install and tighten the cable retaining nut to the threaded stem of the antenna module. Refer to Table 4.2 for torque requirements.

Direct Mount Kit Installation (Continued)

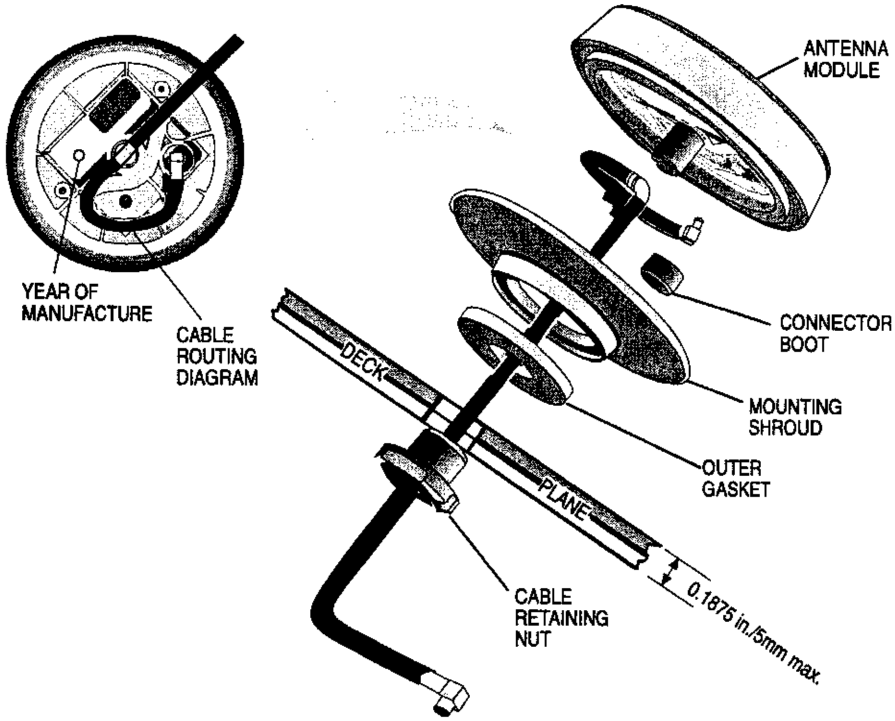


Figure 4.6: Direct Mount Kit Assembly

NOTE: For low-profile cable mounting, route the antenna interface cable through the side slot in the cable retaining nut.

Antenna Module Mounting (Continued)

Lip Mount Kit Installation

The lip mount allows for antenna placement along the edge of a deck plane (3.2 mm maximum thickness), such as the trunk lid of an automobile.

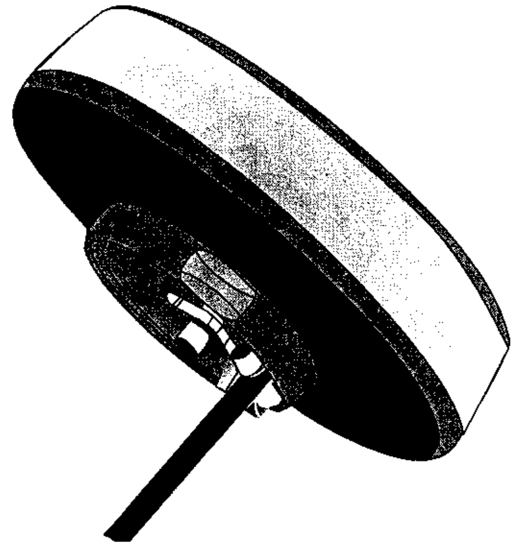


Figure 4.7: Lip Mounted Antenna Module

Perform the following steps to install the lip mount kit.

1. Attach the antenna cable connector to the mating connector at the antenna module base.
2. Insert the connector boot over the cable connection and into the circular boot socket.
3. Route the antenna cable along the strain relief track located in the bottom of the antenna module (see Figure 4.8).
4. Fit the mounting shroud to the antenna module.
5. Route the antenna cable through the side slot in the middle of the mounting shroud base.
6. Place the lip bracket over the threaded stem of the antenna module and pass the cable through the lip bracket cable notch.
7. Tighten the panel nut onto the threaded stem, securing the entire assembly. A 15 mm 6 point socket is recommended.
8. Remove the peel-off liner from lip bracket pad and adhere the pad to the lip bracket covering the panel nut.
9. Clip the lip bracket assembly to the selected antenna deck plane (3.2 mm maximum).
10. Tighten the entire assembly to the deck plane by tightening the set screw. (M5 x 0.8 hex Allen wrench).

Lip Mount Kit Installation (Continued)

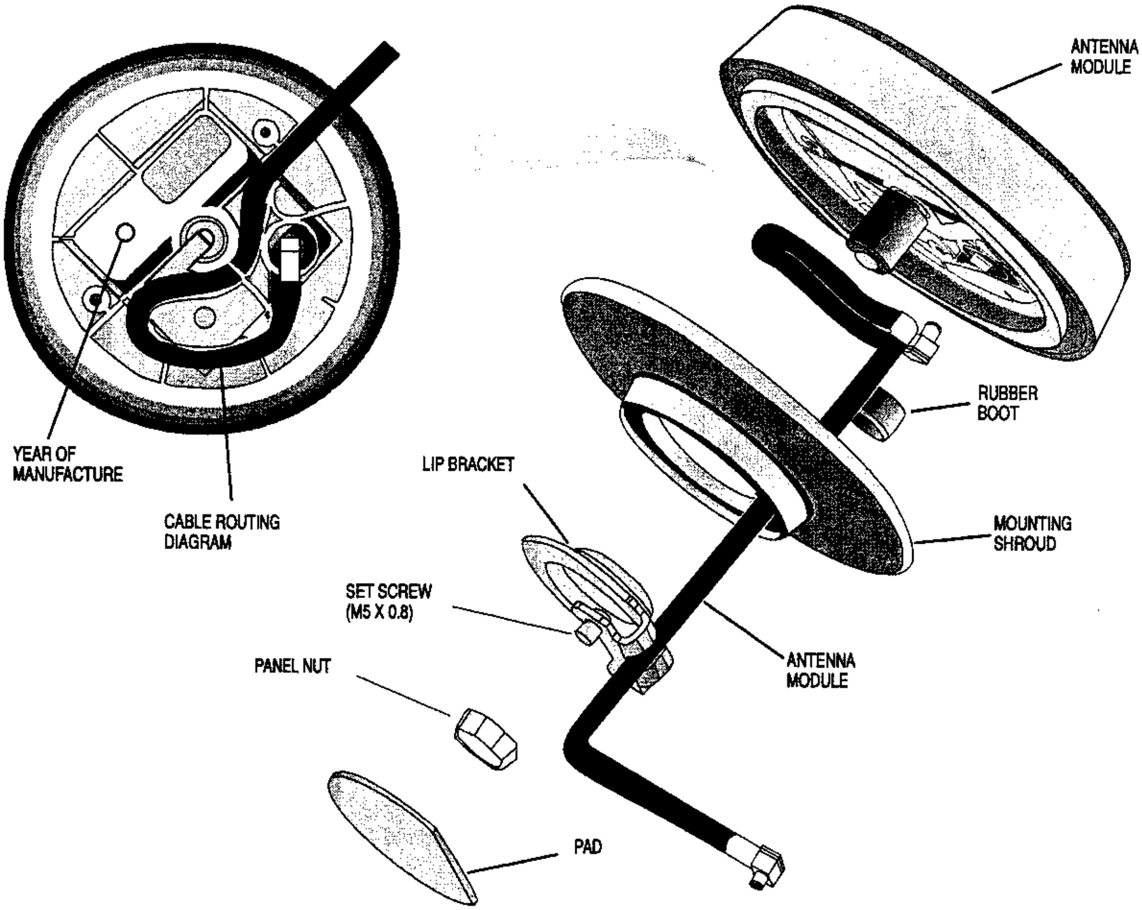


Figure 4.8: Lip Mount Kit Assembly

Magnet Mount Kit Installation

The magnet mount allows you to mount the antenna module on a flat metal surface without the need to drill mounting holes.

An adhesive-backed insulator is placed over the magnet at the base of the shroud to prevent surface scratching.

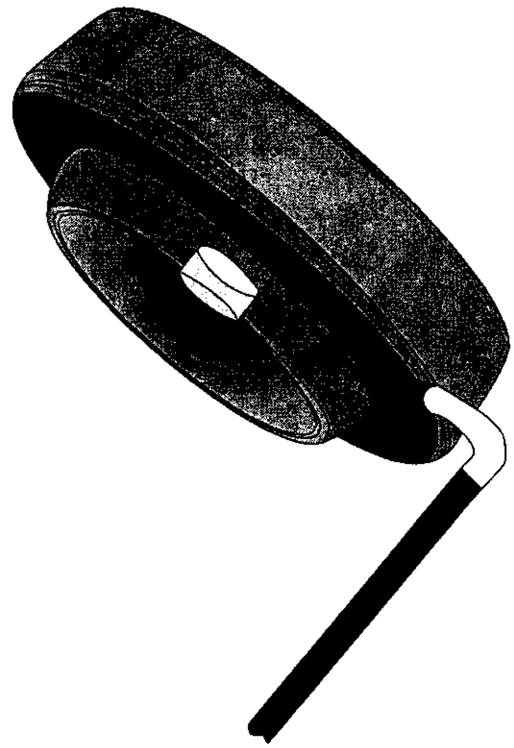


Figure 4.9: Magnet Mounted Antenna Module

Perform the following steps to assemble the magnet mount kit.

1. Attach the antenna cable connector to the mating connector at the antenna module base.
2. Insert the connector boot over the cable connection and into the circular boot socket (see Figure 4.10).
3. Route the antenna cable along the strain relief track located at the base of the antenna module.
4. Insert the antenna module into the mounting shroud. Align the shroud's cable exit slot over the cable.
5. Insert the magnet into the shroud such that the magnetic side faces outward.
6. Tighten the panel nut onto the threaded stem, securing the entire assembly.
7. Remove the peel-off liner from the insulator and adhere the protective insulator over the magnetic surface at the base of the shroud.

Magnet Mount Kit Installation (Continued)

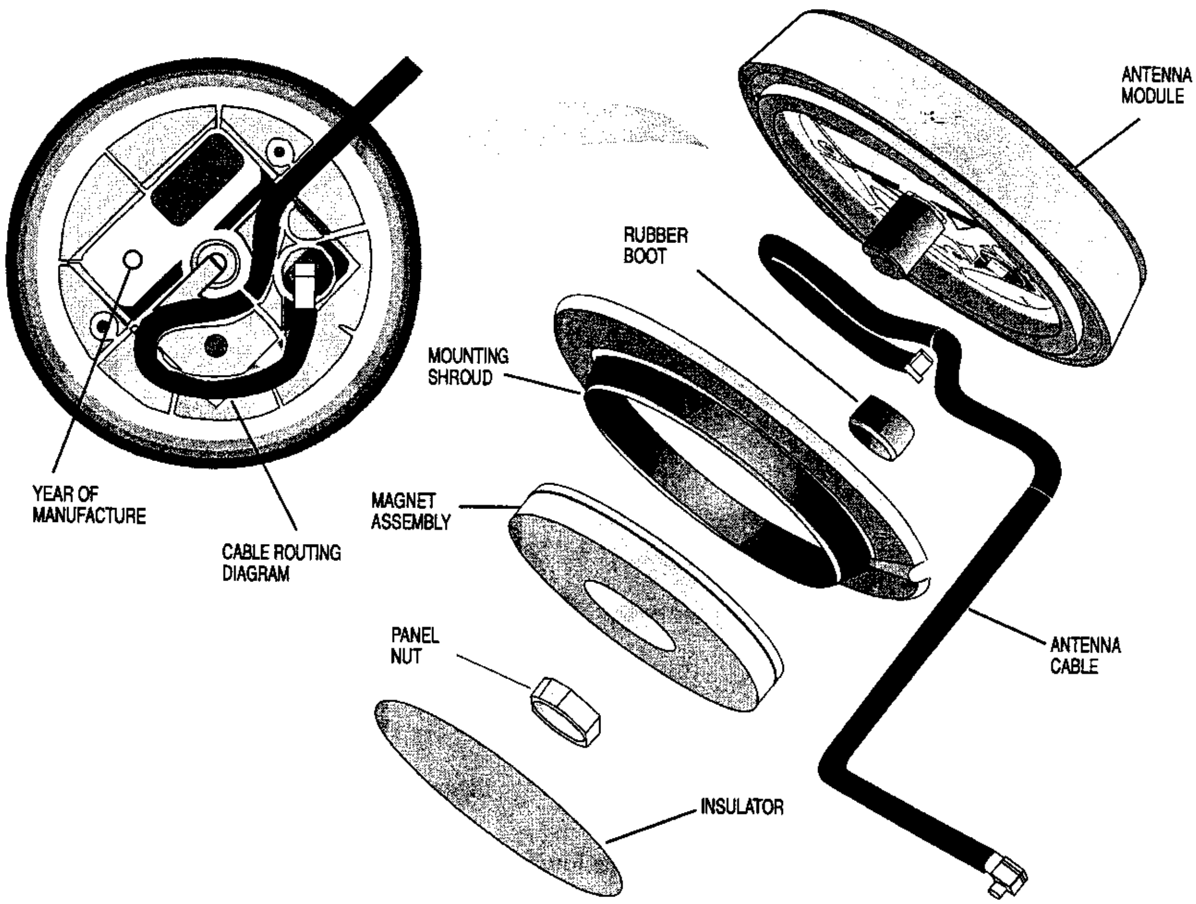


Figure 4.10: Magnet Mount Kit Assembly

Antenna Module Mounting (Continued)

Post Mount Kit Installation

The post mount allows you to mount the antenna module onto a vertical or horizontal post or bar with a maximum diameter of 30 mm (such as the support arm of a truck's external side mirror).

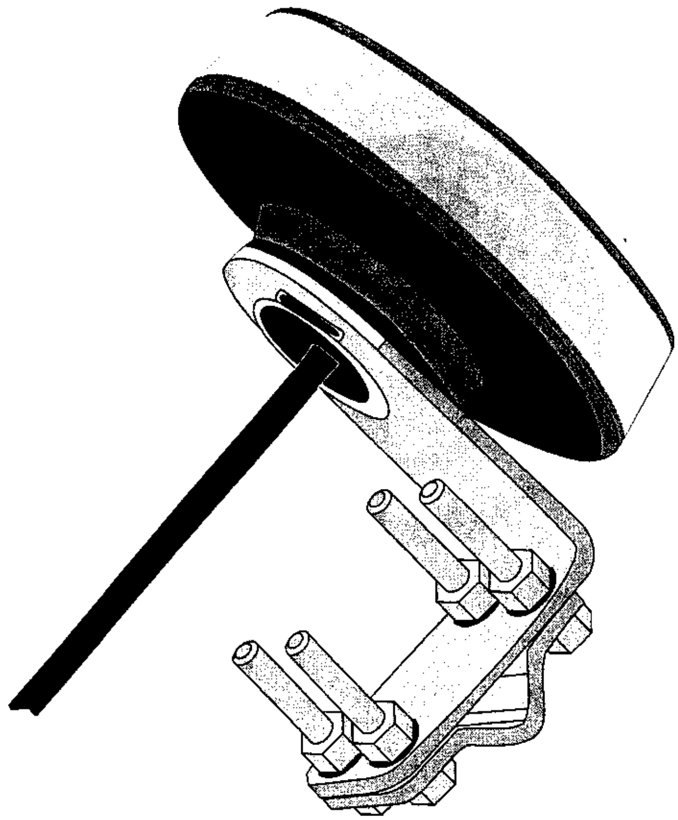


Figure 4.11: Post Mount Antenna Module

Perform the following steps to assemble the post mount kit.

1. Attach the antenna cable connector to the mating connector on the antenna module.
2. Insert the connector boot over the antenna cable connector and into the circular boot socket.
3. Route the antenna cable along the strain relief track located in the base of the antenna module.
4. Route the antenna cable through the hollow slot in the antenna module's threaded stem.
5. Remove the peel-off liner from the outer gasket and attach to the bottom of the shroud.
6. Insert the threaded stem through the mounting shroud, outer gasket, and post bracket.
7. Install and tighten the cable retaining nut to the threaded stem of the antenna module.

Post Mount Kit Installation (Continued)

8. Attach the post to the post bracket with the bolts, post clamp, lock washers, and nuts.

NOTE: The post bracket can support a vertical or horizontal post by rotating the post clamp. For low profile mounting, route the cable through the side slot in the cable retaining nut.

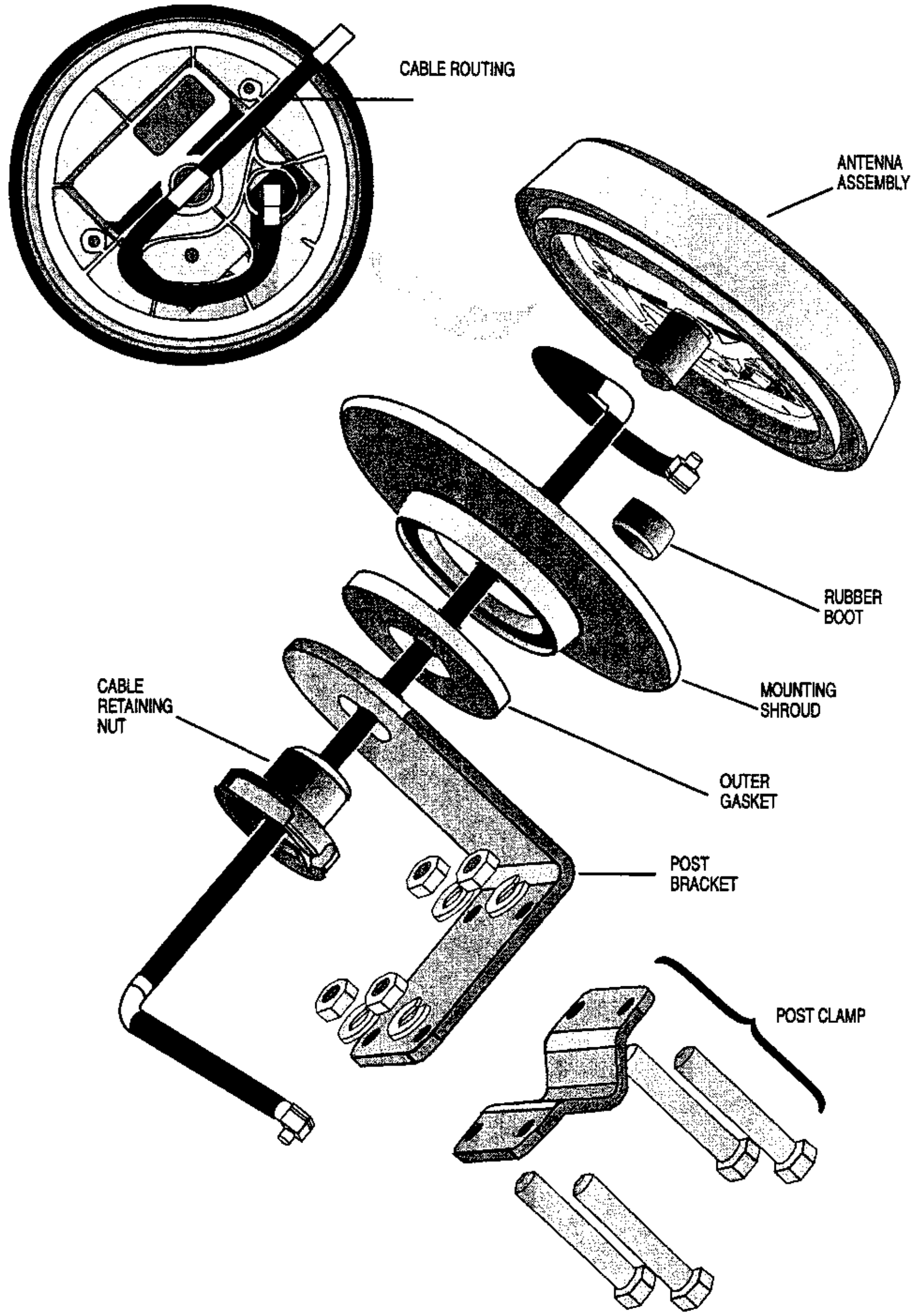


Figure 4.12: Post Mount Kit Assembly

CHAPTER 5 SYSTEM INTEGRATION

CHAPTER CONTENT

Refer to this chapter for the following:

- Interface protocol descriptions.
- Operational modes of your Oncore receiver.
- Additional customizing capabilities/operation.

Operational Overview

OVERVIEW

The Motorola Oncore receiver is an intelligent GPS sensor intended to be used as a component in a precision navigation system. The Oncore receiver is capable of providing autonomous position, velocity, and time information over a serial RS232 port. The minimum usable system combines the Oncore receiver and an intelligent system controller device.

Available Interface Protocols

INTERFACE PROTOCOL

The Motorola Oncore receiver is provided with one RS-232 serial data port. The port is configured as a data communications equipment (DCE) port and provides the main control and data path between the Oncore receiver and the system controller. The user can customize the I/O protocol on the Oncore port to be one of three different formats. In order to support differential applications, the Oncore receivers support various degrees of differential capabilities dependent on the selected protocol. The table below summarizes the built-in DGPS features as a function of the user-selected I/O protocol. The Basic and XT Oncore receivers use an RS-232 port, and the VP Oncore uses an inverted TTL port.

Available Interface Protocols

FORMAT	TYPE	BAUD	BITS	START/STOP	PARITY	FEATURES	DIFFERENTIAL CAPABILITY
Motorola	Binary	9600	8	1/1	No	Full control/all data	RTCM SC-104[1] or Motorola binary
NMEA	ASCII	4800	8	1/1	No	Partial control/selected messages	RTCM SC-104[1]
LORAN	ASCII	1200	8	1/1	No	Little control/one output message	None

Notes: 1. RTCM SC-104 decoding of Message Type #1 & 9 exists in deoptioned units. It is available to all users at no additional cost.

Available Interface Protocols (Continued)

INTERFACE PROTOCOL (CONTINUED)

Once you select a format type, the Oncore receiver operates in the selected protocol. The Oncore receiver remembers the protocol when the power is removed and initializes itself to the previous state when power is reapplied. You can switch to an alternate I/O protocol by issuing the valid "Switch Format" input command in the currently selected format. All parameters set in one format are remembered and applied in the alternate format.

The I/O port operates under interrupt control. Incoming data is stored in a buffer that is serviced by the Oncore receiver's operating program. In the Position Fix mode, this buffer is serviced every 1.0 seconds.

Description of the Motorola Binary Format

Motorola Binary Format

The binary data messages used by the Oncore receiver consist of a variable number of binary characters. These binary messages begin with the ASCII @@ characters and are terminated with the ASCII carriage return and line feed <CR><LF>. The first two bytes after the @@ characters are two ASCII message ID bytes that identify the particular structure and format of the remaining binary data. The last three bytes of all messages contain a single byte checksum (the exclusive-or of all message bytes after the @@ and before the checksum), and a message terminating ASCII carriage return line feed character sequence.

Message Start:
    @@ - (two hex 40s) denotes start of binary message.

Message ID:
    (A..Z)(a..z, A..Z, 0..9) - ASCII upper-case letter, followed by an ASCII lower-case or upper case letter, or digit. These two characters identify the message type, and implies the correct message length and format.

Binary Data Sequence:
    Variable number of bytes of binary data dependent on the command type.

Checksum:
    C - The exclusive-or of all bytes after the @@ and prior to the checksum.

Message Terminator:
    <CR><LF> - carriage return line feed denoting end of the binary message.

Every Oncore receiver input command has a corresponding response message so you can verify that the input commands have been accepted or rejected by the Oncore receiver. The message format descriptions in Chapter 6 detail the input command and response message formats. Information contained in the data fields is normally numeric. The interface design assumes that the operator display is under the control of an external system data processor and that display format and text messages reside in its memory. This approach gives you complete control of display format and language. The Oncore receiver reads the input command string on the input buffer once per second. If a full command has been received,

Description of the Motorola Binary Format (Continued)

Motorola Binary Format (Continued)

then it operates on that command and performs the indicated function. The following logic relates to the input character string checks that are performed on the input commands:

- A binary message is considered to be received if
  - (1) it began with @@ and is terminated with a carriage return and a line feed,
  - (2) the message is the correct length for its type, and
  - (3) the checksum validates.

You must take care in correctly formatting the input command. Pay particular attention to the number of parameters and their valid range. An invalid message could be interpreted as a valid unintended message. A beginning @@, a valid checksum, a terminating carriage return line feed, the correct message length and valid parameter ranges are the only indicators of a valid input command to the Oncore receiver. For multiparameter input commands, the Oncore receiver will reject the entire command if one of the input parameters is out of range.

Input and output data fields contain binary data that can be interpreted as scaled floating point or integer data. The field width and appropriate scale factors for each parameter are described in the individual I/O message format descriptions. Polarity of the data (positive or negative) is described via two's complement presentation.

Once the input command is detected, the Oncore receiver validates the message by checking the checksum byte in the message.

Input command messages can be stacked into the Oncore receiver input buffer, up to the depth of the message buffer (2048 characters long). The Oncore receiver will operate on all full messages received during the previous one second interval and will process them in the order they are received.

Every input command has a corresponding output response message. This enables you to verify that the Oncore receiver accepted the input command. The Oncore receiver response message to properly formatted commands with at least one out-of-range parameter is to return the original non-changed value of the parameter(s).

Input commands may be of the type that change a particular configuration parameter of the Oncore receiver. Examples of these input command types include commands to change the initial position, the Oncore receiver internal time and date, satellite mask angle, satellite almanac, etc. These input commands, when received and validated by the Oncore receiver, change the indicated parameter and result in a response message to show the new value of the particular parameter. If the new value shows no change, then the input command was either formatted improperly, or the parameter was out of its valid range.

Description of the Motorola Binary Format (Continued)

Motorola Binary Format (Continued)

Input commands may be of the type that enable or disable the output of data or status messages. These output status messages include those that the external controller will use for measuring position, velocity, time, pseudorange, and satellite ephemeris data. Status messages are output at the selected update rate (typically, once per second) for those messages that contain position, velocity, time, or range data, or can be commanded to output the data one time upon request. Those messages that include slowly changing data, such as satellite ephemeris data, satellite visibility tables, xDOP tables, etc., are output only when the Oncore receiver detects a change in the data from the previous output data. For example, if the user enables the Oncore receiver to output ephemeris data, the Oncore receiver will output the ephemeris data once upon receipt of the input command, and then once upon detection of the change of the ephemeris (typically once per hour).

All of the Position/Status/Data message types can be selected independently to be output in a continuous fashion (at the selected update rate), or once each time the data is requested (polled). The rate at which the data is output in the continuous output mode is dependent on the type of data in the message. The Data Message Output Rates table shows the rates at which the data messages are output for each type of message, depending on the setting of the continuous/one-time option that is part of the input command.

For the case where more than one output message is scheduled during the same one second interval, the GPS receiver will output all scheduled messages but will attempt to limit the total number of bytes transmitted each second to 750 bytes. For the case of multiple output messages, if the next message to be sent fits around the 750 byte length goal, then the message will be output. For example, if messages totaling 718 bytes are scheduled to be sent, and the user requests another 58 byte message, then 776 bytes will actually be sent. If the user requests yet another 86 byte message, then its output will be left pending and will be scheduled when the total number of output bytes allows. The order shown in the Data Message Output Rates table is the priority order for transmitting messages. Below this priority list, the Oncore receiver Control Parameters response messages and the Utilities response messages have the lowest priority. You can select each of the output data messages as either one-time output (polled), or output continuously (continuous) at a selected update rate.

The polled or continuous option of each output message is remembered during the power-off state in the Oncore receiver nonvolatile memory.

NOTE: Every "change-parameter type" input command has a corresponding response message showing the configuration parameter change. To request the current status of the Oncore receiver, enter an input command with at least one out-of-range parameter. The response message to properly formatted commands with out-of-range parameters is to output the original unchanged value of the parameter.

Motorola Binary Format (Continued)

Data Message Output Rates

OUTPUT MESSAGE TYPE	CONTINUOUS (m=1...255)	ONE TIME (m=0)
Position/Channel Status	At selected update rate	When requested
Position/Status/Data Extension Output Message	At selected update rate	When requested
8-Channel Position/Status/Data Output Message	At selected update rate	When requested
8-Channel Position/Status/Data Extension Output Message	At selected update rate	When requested
Satellite Range Data Output	At selected update rate	When requested
8-Channel Satellite Range Data Output	At selected update rate	When requested
Pseudorange Correction Output	At selected update rate	When requested
Ephemeris Data Output	When Eph data changes	When requested
Satellite Broadcast Data Msg	Once every six seconds*	One time**
Visible Satellite Status	When Vis data changes	When requested
DOP Table Status	When DOP data changes	When requested
8-Channel DOP Table Status	When DOP data changes	When requested
Almanac Status		When requested
Leap Second Pending		When requested

* The message is sent one second after word 10 of the current subframe is collected.
** One time after the current subframe (word 10) of data has been collected.

The Oncore receiver is capable of supporting the following optional capability via the Motorola Binary I/O Format. Receivers with no options installed will not respond to, nor create, the following input/output messages listed below. In addition, the 1 PPS hardware output of the receiver I/O port is deactivated. You can install these options independently at any time. Contact your Motorola PNSB customer representative for information about option installation.

Options

Option: Timing/Time RAIM

Option: Timing/1 PPS Capability
- Position Hold Position
- Position Hold Enable/Disable
- Measurement Epoch Offset
- 1 PPS Time Offset
- 1 PPS Cable Delay

Option: Real-Time Differential Capability (is now a standard feature)
- Position Hold Position
- Position Hold Enable/Disable
- Output Pseudorange Correction (Master Station)
- Input Pseudorange Correction (Remote Mobile)

Available Motorola Binary Format Options (Continued)

Motorola Binary Format (Continued)

Options: Satellite Pseudorange/Carrier Phase Data Capability
Satellite Range Data Output Message

The satellite Range Data Output Message contains all of the raw data necessary to do pseudorange and carrier phase processing in real-time or post-mission.

Motorola Binary Format Input/Output Processing Time

Input/Output Processing Time

The receiver operates in two modes: idle and position fix. When the receiver is in the idle mode, no satellites are being tracked, and only the last known receiver position is available. When the receiver is in the position fix mode, satellites are being tracked, and the current receiver position is available. In the idle mode, the receiver processes input buffer data as soon as a full command has been detected. In the position fix mode, the input buffer data is serviced once a second.

The message response time will be the time from the transmission of the first byte of input data to the transmission of the last byte of output data. For the idle mode, assuming 1 ms per transmission of a data byte, and assuming 50 ms command processing, the best case and worst case scenarios follow.

Best Case (Idle): Delete all waypoints

Tbci = shortest command input + command processing + shortest command output
= 7 ms + 50 ms + 7 ms
= 64 ms

Worst Case (Idle): Output route

Twci = longest command input + command processing + longest command output
= 21 ms + 50 ms + 377 ms
= 448 ms

In the position fix mode, the command processing time will be skewed since the time will be dependent on when the input message buffer is processed. For best case processing, the input command would have to arrive just before the input buffer data is processed, and the output response would have to be the first (or only) receiver output. For worst case processing, the input command would have to arrive just after the input buffer data had been processed, and the output response would have to be the last receiver output. Assuming one ms per transmission of a data byte, assuming 50 ms command processing, and assuming a uniform distribution for time of input command data entry, the best case, typical case, and worst case scenarios are shown below.

Motorola Binary Format Input/Output Processing Time (Continued)

Input/Output Processing Time (Continued)

Best Case (Position Fix): Delete all waypoints

Tbcf = shortest command input + command processing + shortest command output
= 7 ms + 50 ms + 7 ms
= 64 ms

Typical Case (Position Fix): Any command

Ttcf = input anywhere across one second period + command processing + output anywhere across one second period following command processing
= 0.5 sec + 0.05 sec + 0.475 sec
= 1.025 sec

Worst Case (Position Fix): Any command

Twcf = input beginning of one second period + output end of one second period
= 1 sec + 1 sec
= 2 sec

NMEA-0183 Format Overview

NMEA-0183 Format Description

Output of data in NMEA-0183 standard format allows interface via the RS232 port to an electronic navigation instrument that supports the specific messages that are transmitted. The Oncore receiver will support the following NMEA output messages as per the NMEA-0183 Revision 2.0.1

Specification:

GPGGA	GPS Fix Data
GPGLL	Geographic Position - Latitude/Longitude
GPGSA	GPS DOP and Active Satellites
GPGSV	GPS Satellites in View
GPRMC	Recommended Minimum Specific GPS/ TRANSIT Data
GPVTG	Track Made Good and Ground Speed
GPZDA	Time and Date

You can enable or disable each message output independently and control the update rate at which the information is output. Once enabled to output a particular message at a particular rate, the GPS receiver remembers the settings when powered off and reconfigures itself to the same state when powered up again.

NMEA-0183 Format Overview (Continued)

NMEA-0183 Format Description (Continued)

All NMEA messages are formatted in sentences that begin with ASCII $ (hex 24) and end with ASCII <CR><LF> (hex 0D and hex 0A). A five-character address occurs after the ASCII $. The first two characters are the talker ID (which is GP for GPS equipment), and the last three characters are the sentence formatter or message ID from the list above. Any number of fields and an optional checksum can occur in the sentence as long as the total number of characters does not exceed 79. Fields within the message are delimited by the ASCII comma.

The checksum is calculated by XORing the 8 data bits of each character in the sentence between, but excluding, the $ and the optional (*) or (CS) checksum. The high and low nibbles of the checksum byte are sent as ASCII characters.

You control the output of the above listed messages with Motorola NMEA format messages. Input messages are allowed in the NMEA specification, and take the form $PMOTG,,,,,*CS<CR><LF>. All input parameters are separated with comma delimiters. The P character identifies the message as Proprietary format, and the MOT is the manufacturer designator for Motorola Inc.

For the case where more than one output message is scheduled during the same one second interval, the GPS receiver will output all scheduled messages but will attempt to limit the number of bytes transmitted each second to 375 bytes. For the case of multiple output messages, if the next message to be sent fits around the 375 byte length goal, then the message will be output. For example, if messages totaling 334 bytes are scheduled to be sent, and the user requests another 80 byte message, then 414 bytes will actually be sent. If the user requests yet another 70 byte message, then its output will not be generated. The order for priority for transmitting messages is simply alphabetical.

LORAN Format Overview

LORAN Emulation Format Description

This particular output message format is intended to emulate the position status message string from a LORAN receiver. This allows you to use the GPS receiver to replace the LORAN receiver in embedded positioning system applications.

You can request the LORAN position status message string to be output at any update rate (from one second to one hour in one second increments) and can operate it in a polled mode where the host can request the receiver to output the position status message upon request. The selected rate of the output message is remembered between power on-off-on sequences.

RTCM SC-104 Format Overview

RTCM SC-104 Format Description Version 2.0

The receiver employs a decoding algorithm that allows the unit to directly decode the RTCM SC-104 Type 1 differential message from the input serial port. The technique employed allows the unit to simultaneously accept the RTCM SC-104 Type 1 format (6 of 8 type with two most significant bits always 01) data stream along with other receiver input commands (in either Motorola binary format or in

RTCM SC-104 Format Overview (Continued)

RTCM SC-104 Format Description (Continued)

NMEA format) on the receiver's single input RS-232 port. To input both RTCM SC-104 Type 1 data as well as Motorola binary or NMEA protocol commands, there is a simple set of rules that must be employed to ensure that one type of data is not interpreted as the other.

Operating Modes

OPERATIONAL CONSIDERATIONS

The Oncore receiver can operate in one of two modes:

- Position Fix Mode
- Idle Mode

In the Position Fix mode the Oncore receiver automatically acquires and tracks satellites; measures the pseudorange and integrated carrier phase data to each of up to six or eight satellites; decodes and collects satellite broadcast data; computes the Oncore receiver's position, velocity, and time; and outputs the results according to the current I/O configuration selected.

In the Idle mode, the Oncore receiver's real-time clock and battery-backed RAM are maintained, but no satellite tracking or positioning operations are performed. Power consumption is reduced slightly in this mode.

Time to First Fix

TTFF is a function of position uncertainty, time uncertainty, almanac age, and ephemeris age as described in the TTFF Information table. The following information assumes the 6-channel Oncore receiver Antenna has full view of the sky when turned on.

Reacquisition time for all GPS satellite signals after signal obscuration is a function of the obscuration time, as shown in the Reacquisition table.

6 or 8-Channel TTFF Information

POWER-UP STATE	INITIAL ERROR			AGE		TTFF	
	POS	VEL	TIME	ALMANAC	EPHEMERIS	(typical)	(90%)
Hot	100 km	75 m/sec	3 min	1 month	< 4 hrs	23 sec	30 sec
Warm	100 km	75 m/sec	3 min	1 month	U/A	53 sec	66 sec
Cold – 1	N/A	N/A	N/A	1 month	U/A	7.9 min	15.0 min
Cold – 2 (default)	N/A	N/A	N/A	U/A	U/A	13.0 min	25.0 min

U/A – This parameter is assumed to be not available.
N/A – Not applicable. Knowledge of this parameter has no effect on TTFF in this configuration

Reacquisition Time

TIME OBSCURED	REACQUISITION TIME (Typical)
15 sec	< 2.5 (<1.0 seconds internal)
30 sec	< 3.5
45 sec	< 3.5
60- sec	< 3.6

Power On/Off/On Logic

First Time On

When the Oncore receiver powers up for the first time after factory shipment, it is configured in the Position Fix mode and Motorola Binary format. By default, the initial date and time will be incorrect. This will force the Oncore receiver into a cold power-up state (cold start), and it will begin to search the sky for all available satellites. After one satellite has been acquired, the date and time automatically will be set from the satellite. When three or more satellites are tracked, automatic position computation is initiated.

At power down, the Oncore receiver remembers its current configuration. This is the configuration it will be in upon the next power up.

"Keep Alive" Power Disconnect

If you disconnect the "Keep Alive" power (BATT power), then the real-time clock and the battery backed RAM memory will be erased. In this scenario, date and time are lost and the Oncore receiver will enter the cold power-up state when power is reapplied.

Motorola Binary Format Initialization

The Oncore receiver powers up in the same mode it was in the last time it was used. If it was left in the Position Fix mode, the Oncore receiver executes the satellite acquisition and tracking algorithms and will compute position when it acquires at least three satellites. The type of message output also depends on the previous state. For each of the user-requestable outputs, the receiver remembers the previously requested message state and rate (continuous or one-time) and outputs the previously requested messages. If no messages were requested continuously the last time the receiver was used, it waits for an input command before it outputs any other data, even though it may have acquired satellites and is computing position internally.

The Oncore receiver need not be initialized to its approximate user position coordinates to acquire satellite and output position, nor does it require a current satellite almanac. However, the TTFF will be considerably shorter if you help the Oncore receiver find satellites by setting the approximate initial position coordinates, setting the time and date correctly, and installing a current satellite almanac.

When it is turned off, the Oncore receiver remembers all of the user-set input parameters with the following exceptions:

- It always configures itself into the automatic satellite selection mode when power is applied. You can command the receiver into manual satellite select mode after applying power.
- After being powered down, the receiver does not remember manual satellite assignments to channels or the state of the ephemeris hold switch.

Motorola Binary Format Initialization (Continued)

The Oncore receiver stores its last used position coordinates in nonvolatile memory and uses this information in the satellite acquisition algorithm. It also stores time and date information in an internal real-time clock so you do not have to initialize this information after you initially set the time or after it is obtained from the satellites. In addition, the receiver retains the last used satellite ephemeris as long as the 5/12V_BATT power is applied. If you move the Oncore receiver a great distance before using it again, it will find and acquire satellites, but the TTFF will be longer than normal the first time you use the receiver. You can initialize the approximate position coordinates for faster TTFF if desired.

Each parameter in the I/O format description shows the factory-set default value for each parameter.

NMEA Format Receiver Initialization

The Oncore receiver powers up in the same mode it was in the last time it was used. If it was in the Position Fix mode, it executes the satellite acquisition and tracking algorithms and will compute position when it acquires at least three satellites. The type of message output also depends on the previous state. For each of the user-requestable outputs, the Oncore receiver remembers the previously requested message state and update rate and outputs the previously requested messages. If no messages were requested the last time the Oncore receiver was used, the receiver waits for an input command before it outputs any other data, even though it may have acquired satellites and is computing position internally.

LORAN Format Receiver Initialization

The Oncore receiver powers up in the same mode it was in the last time it was used and remembers the timed position update count. If it was in the Position Fix mode, it executes the satellite acquisition and tracking algorithms and will compute position data when it acquires at least three satellites.

When you power up the receiver, it will output the first verified position (quality factor = 1) when it acquires the first three or more satellites and computes a valid position. It will then reset the timed interval counter and begin to output the data on the timed update rate.

If the Oncore receiver cannot obtain a verified position after the timed update period is completed, it will output the last known verified valid position with the Q status set to 0 and restart the timed update interval.

If the record output at the end of a timed interval contains Q = 0, the Oncore receiver will send out one more record the next time it computes valid data and the Q status will be set to one in this record. Timed outputs will continue without modification of the timer; that is, the timed interval will not be reset to zero coincident with the secondary Q = 1 output.

Operating Modes (Continued)

RTCM SC-104 TYPE 1/9 MESSAGE DECODING

When using the RTCM SC-104 Type 1/9 data (6 of 8 type, with two most significant bits always 01) in conjunction with either the Motorola Binary or the NMEA protocol, special care must be exercised by the user to ensure that the RTCM SC-104 Type 1/9 data messages and the Motorola Binary/NMEA data messages do not interfere with each other.

To better understand what the user must do to insert both RTCM SC-104 data and either Motorola binary data or NMEA format commands, the user should understand how the receiver RS-232 message decoding software operates.

The Oncore receiver RS-232 decoding logic operates as follows:

The received data from the RS-232 port is placed into two buffers via interrupt driven software. Label these two data buffers B1 and B2. The Motorola binary Data format and the NMEA data format is orthogonal to the RTCM data. Consequently the receiver message decoding logic first looks for Motorola format data (or NMEA data, depending on the message format selected) first by decoding the appropriate format data from buffer B1. If any GPS input commands or data is detected in the stream, the internal software executes that command and then removes the Motorola binary data message out of buffer B1 and B2. Any remaining data left in B2 is passed to the RTCM SC-104 decode software.

The user of the receiver in a differential system (based on the RTCM SC-104 Type 1/9 correction stream) can configure their system into two classes, depending on their requirements. These two configurations consist of:

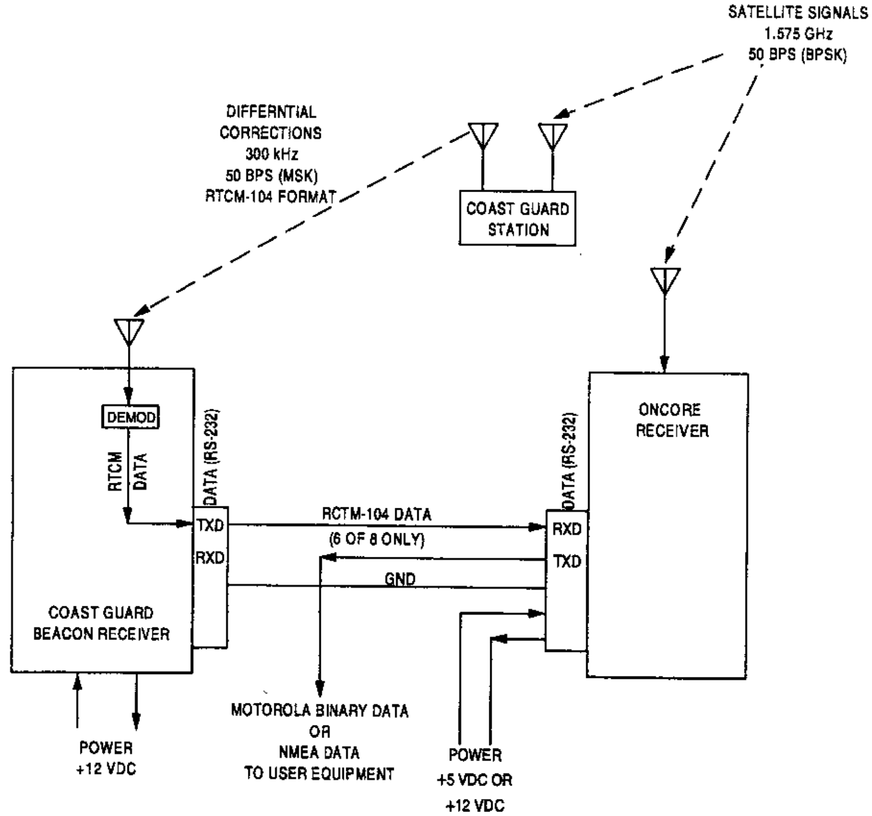
(1) Applications NOT requiring real-time GPS control.
(2) Applications requiring real-time GPS control.

Applications NOT Requiring Real-Time

To operate the Oncore receiver with a beacon receiver, the Oncore receiver must first be configured into its desired operating mode with the Oncore IBM-PC controller (supplied) or the user's custom equivalent. This requires connecting the Oncore receiver I/O port directly to a PC with a standard serial cable, running the receiver control software, and setting the configuration desired. Configuring the receiver establishes the desired operating mode and allows the user to select which type of output data format they desire (examples, Motorola binary or NMEA).

Applications NOT Requiring Real-Time (Continued)

System Interconnect and Data Flow of Differential System Not Requiring Real-Time GPS receiver Control



In the differential application shown above, the Oncore receiver cannot be controlled by an external device while in operation as the input port is tied up by the beacon receiver input. In addition, the output port of the Oncore receiver is dedicated to the user's output data logging or display system.

Applications Requiring Real-Time

In order to utilize the Oncore receivers' I/O port for both input of differential corrections and receiver commands, the user must install some form of system controller between his source of the RTCM SC-104 data and the receiver. The following figure shows the interconnect diagram of the Oncore receiver, the beacon receiver, and the user control-display processing unit.

The Oncore receiver is designed to accept its normal I/O commands and at the same time accept RTCM SC-104 format differential corrections. The user's controller-display processor acts as a traffic cop and appends user directed commands to the RTCM SC-104 decoded data before the combined data is sent to the Oncore receiver.

Of course, there are some restrictions as to how the user's control-display unit appends the GPS commands to the RTCM SC-104 decoded data so as to prevent

Applications Requiring Real-Time (Continued)

data collisions and corruption. These requirements, and others, are described below.

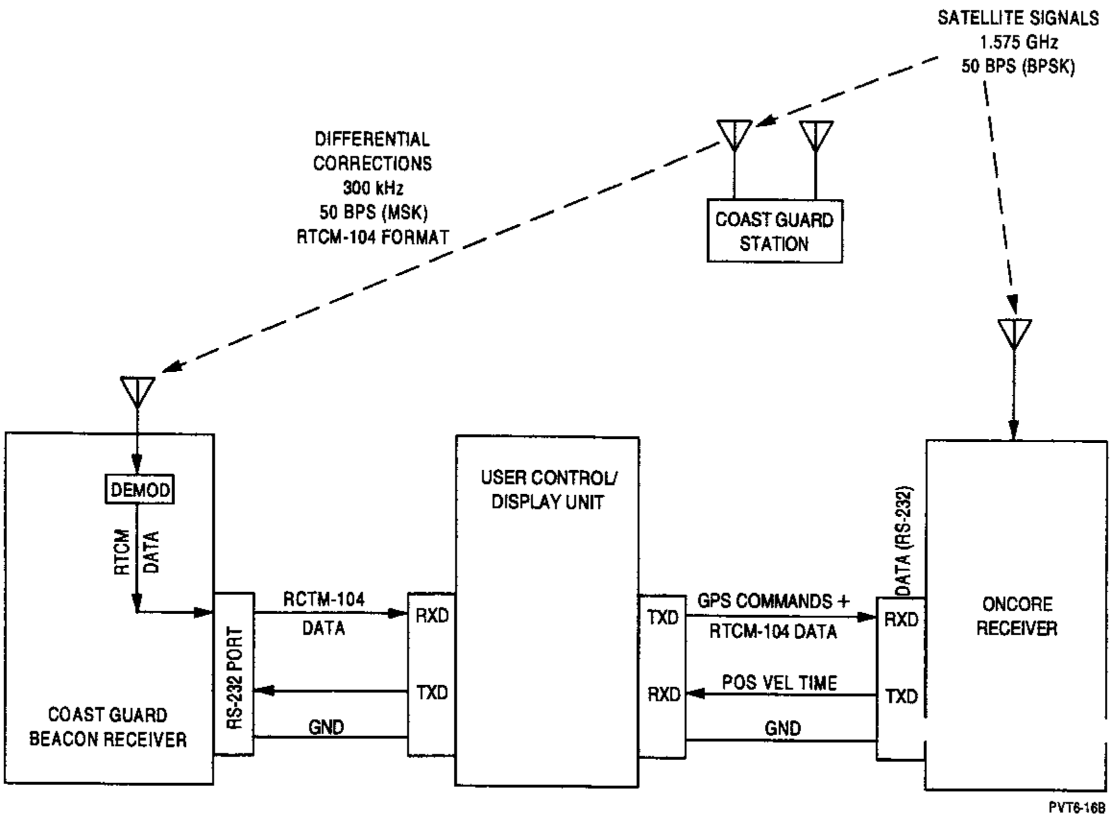
Recommended logic to prevent data collisions is as follows:

The User Controller/Display unit can pass the RTCM SC-104 data stream directly from its beacon input port to the Oncore receiver output port.

When it is time for the Control/Display unit to issue a series of commands to the Oncore receiver, the Control/Display unit buffers the RTCM SC-104 data stream in a local buffer while the command(s) are being passed to the Oncore receiver.

System Interconnect and Data Flow of Differential System Requiring Real-Time GPS receiver Control

After all of the commands are sent to the Oncore receiver, the Control/ Display



unit can then send all buffered RTCM SC-104 data to the Oncore receiver without loss of any data.

The Oncore receiver automatically outputs a short binary response message (@@Ck...Motorola binary format) to every correctly decoded RTCM SC-104 Type 1 message received. If operating in NMEA protocol, the NMEA sentence GGA has a field that indicates the age of the last RTCM SC-104 Type 1 correction.

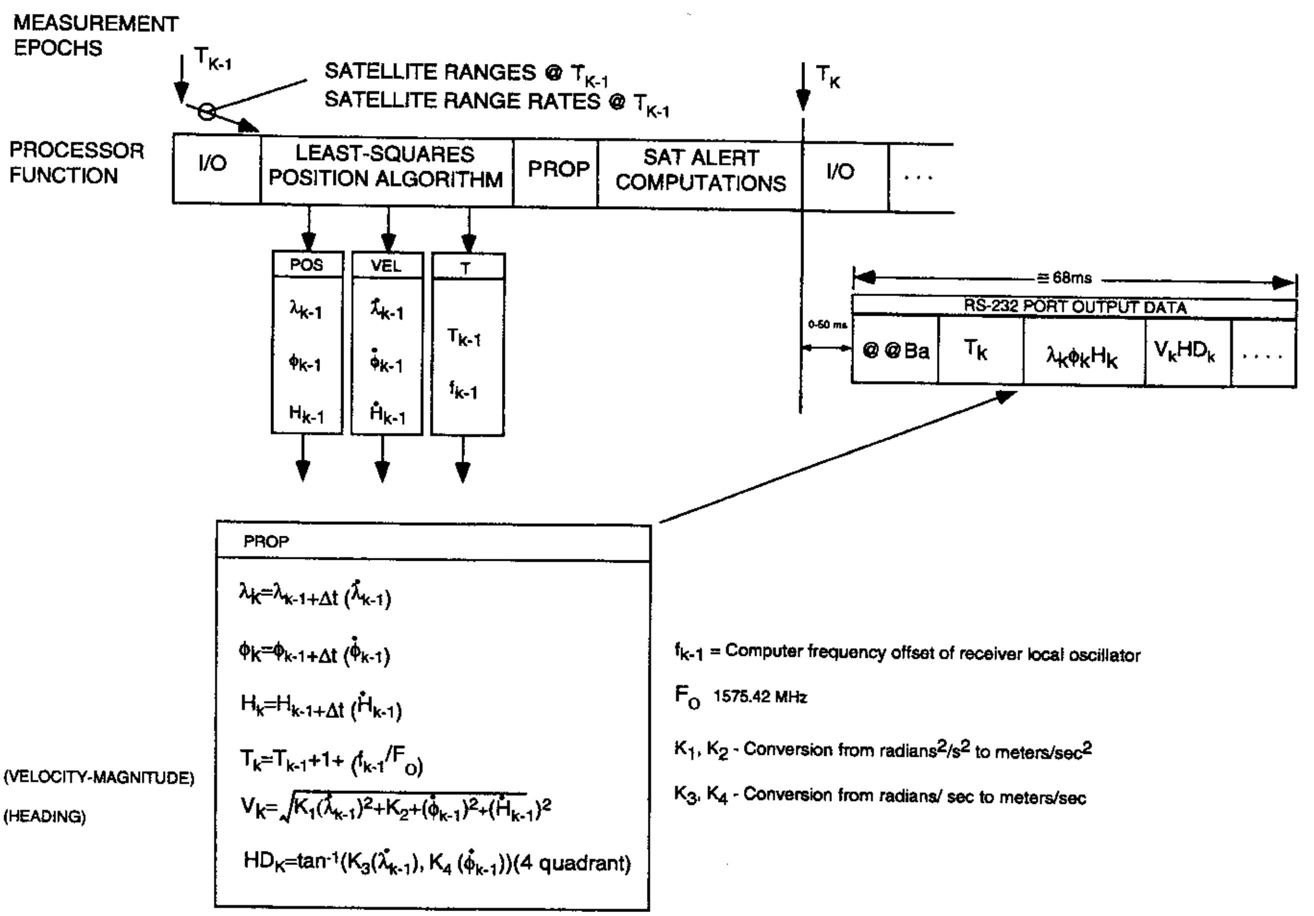
OUTPUT DATA LATENCY

The Oncore receiver outputs position, velocity, and time data on the RS232 port once each second. The start of the output data is timed to closely correspond with the receiver measurement epoch. (The measurement epoch is that point in time at which the receiver makes satellite range measurements for the purpose of computing position). The first byte of RS232 data in the position message is output between 0 and 50 msec after the most recent Oncore receiver measurement epoch.

Refer to the Position Channel Status Output Message Latency figure for the discussions that follow.

Let T_k be the most recent measurement epoch. The Oncore receiver takes about one second to compute data from the satellite range measurements. Consequently, the data output 0 to 50 ms after T_k represents the best estimate of the position, velocity, and time based on the measurements taken one second in the past; that is, at time T_{k-1}. Position data (latitude, longitude, and height) is computed from the most recent measurement epoch data, and is available about 0.3 to 0.7 seconds after the measurements are taken.

Position Channel Status Output Message Latency



OUTPUT DATA LATENCY (CONTINUED)

To compensate for the one second computational pipeline delay, a one second propagated position is also computed that corresponds to T_k based on the position and velocity data computed from measurements taken at time T_{k-1}. In this way, the position data output on epoch T_k will most closely correspond with the receiver true position when the data is output on the RS232 port. Of course, there can be a position error due to the propagation process if the receiver is undergoing acceleration. The error can be as large as 4.5 meters for every g of acceleration. There is no significant error under stationary or constant velocity conditions.

Position Data Latency

The position data output in the current data packet; i.e., at time T_k, is the result of a least squares estimation (LSE) algorithm operating on satellite pseudorange measurements taken at time T_{k-1}. The resulting LSE position corresponding to time T_{k-1} is then propagated one second forward by the velocity vector (also the result of an LSE fit based on satellite pseudorange rate measurements taken at T_{k-1}). The resulting propagated position is output at the T_k epoch.

Velocity Data Latency

The velocity data output in the current data packet (i.e., at time T_k) is the result of a least squares algorithm operating on satellite pseudorange rate measurements taken at time T_{k-1}. The pseudorange rate measurements are derived from the difference in integrated carrier phase data sampled at measurement epochs T_{k-1} and T_{k-1} -200 milliseconds.

Time Data Latency

The time data output in the current data packet; i.e., at time T_k, is the result of a least squares algorithm operating on satellite pseudorange measurements taken at time T_{k-1}. The time estimate at T_{k-1} is then propagated by one second plus the computed receiver clock bias rate at time T_{k-1} before being output at time T_k. The resulting time data is the best estimate of the local time corresponding to the T_k measurement epoch based on data available at T_{k-1}.

Satellite Range/Range Rate Data Latency

The satellite time data fields output in the current data packet; i.e., at time T_k, represent the time indicated by the received data for each satellite at the T_{k-1} measurement epoch. The satellite time data is precisely the same data the Oncore receiver uses in the computation of satellite pseudoranges for use in its internal LSE algorithm. The satellite time data is the result of a narrow band code tracking filter that is carrier aided. This smoothing process reduces the measurement jitter to a very small quantity, yet still allows the output position to respond to dynamic behavior with no associated filtering lag.

Satellite Range/Range Rate Data Latency (Continued)

The raw code phase and code discriminator data is not smoothed and reflects the instantaneous code phase at the T_{k-1} measurement epoch.

The integrated carrier phase data is the instantaneous phase of the L1 carrier at the T_{k-1} measurement epoch. The data contains both integer and fractional carrier cycle data.

The "GPS local time" field in the message corresponds to the best estimate (i.e., LSE derived) of the measurement epoch time at time T_{k-1}.

Pseudorange Correction Data Latency

The data output in the current data packet (i.e., at time T_k) represents the corrections to pseudorange and pseudorange rate as observed by the GPS receiver at time T_{k-1} The Oncore time reference field in the message corresponds to the Oncore receiver's best estimate (i.e., LSE derived) of the measurement epoch time at time T_{k-1}.

ONE PULSE PER SECOND (1PPS) TIMING

System Timing - Measurement Epoch

The Oncore receiver timing is established relative to an internal, asynchronous, 1 kHz clock derived from the local oscillator. The receiver counts the one kHz clock cycles, and uses each successive 1000 clock cycles to define the time when the measurement epoch is to take place. The measurement epoch is the point at which the receiver captures the pseudorange and pseudorange rate measurements for computing position, velocity, and time.

When the receiver starts, it defines the first clock cycle as the measurement epoch. Every 1000 clock cycles from that point define the next measurement epoch. Each measurement epoch is about one second later than the previous measurement epoch, where any difference from 1.000000000 seconds is the result of the receiver local oscillator intentional offset (about +13 microseconds per second) and the oscillator's inherent instability (±2 parts per million over temperature range).

When the Oncore process computes receiver local time, this time corresponds to the time of the last receiver measurement epoch. This time is precisely known by the Oncore process to an accuracy of approximately 20 to 300 nanoseconds depending on satellite geometry and the effects of SA.

The Oncore receiver allows users to specify the fractional part of time for the measurement epoch to within one millisecond. For example, suppose the user specifies the measurement epoch offset to be 0.123 seconds. When this occurs, the measurement epoch of the receiver is adjusted so that the fractional part of

System Timing (Continued)

receiver local time is between 0.123000000 and 0.123999999 seconds. Time is relative to UTC or GPS time depending on the time-type as specified by the user by the UTC Time Correction Enable/Disable parameter.

The Oncore system timing is designed to slip time when necessary in discrete one millisecond intervals so that the receiver local time corresponds to the desired measurement epoch offset. The Oncore observes the error between actual receiver local time and the desired measurement epoch offset and then slips the appropriate integer milliseconds to place the measurement epoch to the correct integer millisecond. When a time skew occurs (such as after initial acquisition or to keep time within limits due to local oscillator drift), the receiver lengthens or shortens the next processing period in discrete one millisecond steps.

Valid range for the timing skew is -1 to +999 milliseconds. The -1 input is intended to compensate for local oscillator intentional offset. Recall that the receiver local oscillator is tuned slightly low in frequency, which causes slightly more than one second of time to be clicked off between each 1000 clock cycles. At the first fix, when the system measures time for the first time, there can be up to 999 additional milliseconds in the next one second interval (that is, the very next interval can be extended by up to 0.999 seconds) in order to place the measurement epoch at the user-selected value of integer millisecond time range.

1PPS Timing

Users can specify an offset (via the One Pulse Per Second Time Offset) for the 1PPS output anywhere between 0.000000000 to 0.999999999 seconds from the measurement epoch time. Users also can compensate for antenna cable length with the parameter One Pulse Per Second Cable Delay. The rising edge of the 1PPS is placed so that it corresponds to the time indicated by the following equation:

1PPS Rising Edge Time =

Measurement Epoch Offset Time + 1PPS Offset Time - 1PPS Cable Delay Time

Consider the following example:

Measurement Epoch Offset Time =	0.100(+)
1PPS Offset Time =	0.500987654(+)
1PPS Cable Delay Time =	0.000654321(-)
TOTAL: 1PPS Rising Edge Time =	0.600333333

The rising edge of the 1PPS signal is adjusted so that it occurs corresponding to the fractional part of time equal to the total above. The fractional part of time is measured relative to UTC time or GPS time depending on the setting of the UTC Time Correction Enable/Disable parameter.

1PPS Timing (Continued)

The rising edge of the 1PPS signal is the time reference. The falling edge will occur approximately 200 milliseconds (+/-1 ms) after the rising edge. The falling edge should not be used for accurate time keeping.

1PPS Signal Definition

- 0 to 5 V live pulse
- 1 PPS time mark is synchronous with rising edge of pulse rising from 0 V to 5 V.
- Rise time is approximately 20 to 30 ns
- 5 V pulse width is approximately 200 ms ± 1 ms
- The falling edge will occur approximately 200 ms after the rising edge.
- Accurate to 300 to 500 ns in stand alone mode
- Accurate to under 50 ns in position-hold mode

Output Data Timing Relative to Measurement Epoch

The receiver outputs six messages containing time information:

(1) Position/Status/Data Output Message (hours, minutes, seconds, fractional seconds)

(2) Satellite Range Data Output Message (GPS local time in integer and fractional seconds)

(3) Pseudorange Correction Message (GPS reference time for the corrections)

(4) NMEA GPGGA Message (hours, minutes, seconds, hundredths of second)

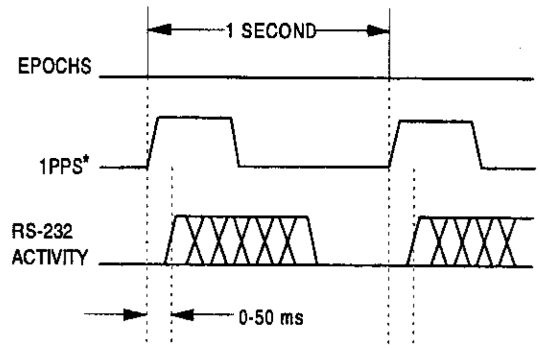
(5) NMEA GPRMC Message (hours, minutes, seconds, hundredths of second)

(6) NMEA GPGLL Message (hours, minutes, seconds, hundredths of second)

These six messages, if enabled, will be output from the receiver shortly after a measurement epoch. Generally, the first data byte in the first message will be output between 0 to 50 milliseconds after a measurement epoch. For the Position/Status/Data message as well as all of the NMEA messages, the time output in the message reflects the best estimate of the most recent measurement epoch. For the Satellite Range Data message and the Pseudorange Correction message,

Output Data Timing Relative to Measurement Epoch (Continued)

the time data indicates the best estimate of the measurement epoch two epochs ago (that is, approximately 1.0 to 1.05 seconds ago). A simple timing diagram is shown below.



* 1PPS OFFSET AND 1PPS CABLE DELAY = 0

Inverted TTL Output

The serial interface signals, RXD and TXD, are available for user connection. A ground signal is also required to complete the serial interface. There is no additional protection and signal conditioning besides the internal protection of the microprocessor. These signals are coming from the microprocessor directly. They are regular TTL signals with voltage ranges from 0 to 5V. For input signals, minimum input high voltage is 2.0V and the maximum input high voltage is 5V. Minimum input low voltage is 0V and the maximum input low voltage is 0.8V. For output signals, minimum output high voltage is 2.4V and the maximum output low voltage is 0.5V.

This interface is not a conventional RS-232 interface that can connect to a PC (which is normally equipped with an RS-232 interface) directly. An RS-232 driver/receiver is required to make this connection. The driver/receiver provides a voltage shift from 0 to 5V to a positive and negative voltage (for example, ±10V), and also has an inversion process in it. Some RS-232 driver/receiver integrated circuits (ICs)—for example; Motorola's MC145407—will provide all these functions with only a +5 V supply.

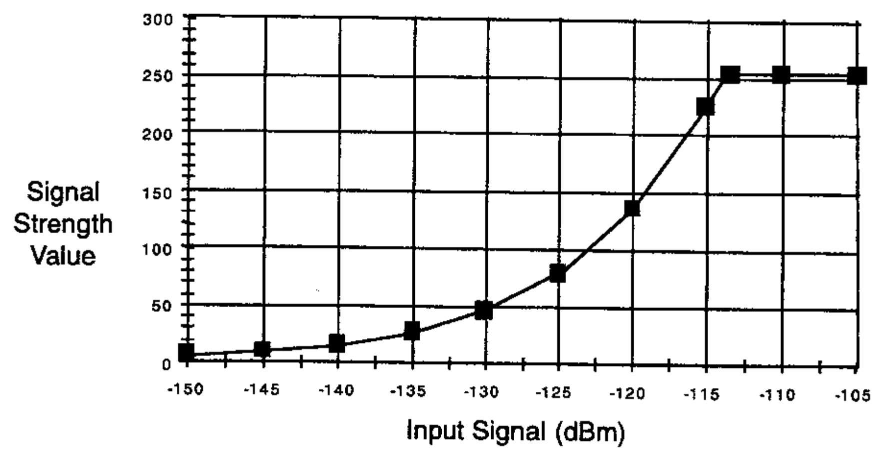
TTL	0 V to 0.8 V = logic 0
	2.4 V to 5.0 V = logic 1
RS-232	-5 V to -15 V = logic 1
	5 V to 15 V = logic 0

NOTE: 50 pf maximum capacitance on TTL level output

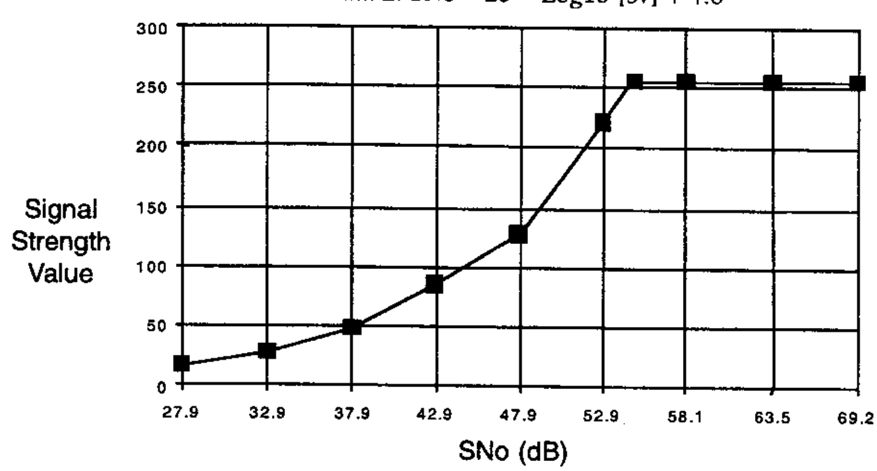
SIGNAL STRENGTH VALUES

The **Position/Status Data Output Message** has a unitless signal strength valve that can be used to determine the relative signal levels of received satellite signals (refer to the figures below). The accompanying formulas are approximations for the assumed typical receiver parameters and should be accurate to approximately ± 2 dB. Formula 1 translates the signal strength value to dBm, and Formula 2 yields the signal to noise ratio (SNo). Both formula assume a 1 Hz bandwidth. The greatest margin of error will occur at the stronger levels, and the formulas will not work at levels where the signal strength value has been limited to the maximum value of 255.

Signal Strength Value vs. Input Signal Level
Formula 1: dBm = 20 * Log10 [sv] - 163.4



Signal Strength Value vs. Signal to Noise Spectral Density
Formula 2: SNo = 20 * Log10 [sv] + 4.6



ONCORE

CHAPTER 6 I/O SOFTWARE COMMANDS

The following **Input and Output** data fields contain **binary data** that can be interpreted as scaled floating point or integer data. The field width and appropriate scale factors for each parameter are described in the individual I/O message format descriptions. Polarity of the data is described via the two's complement presentation. Input commands may be of the type that enable or disable the output of data or status messages. These output status messages include those that the external controller will use for measuring position, velocity, time, pseudorange, and satellite ephemeris data.

Immediately following this page is a listing of the Input and Output fields in alphabetic order by function. You may use this to find the appropriate binary command that you may wish to look up in this section.

Command List Alphabetically by Function

Note: This is a Quick Reference of PC controller commands. The commands are listed by both the "controller command" and the "binary @@ command".

Function	Description	Controller Command	Default Setting	Binary Command	User Guide Page #
1PPS	1PPS CABLE DELAY OPTION	ppsdelay	0.000	@@Az	6.58
1PPS	MEASUREMENT EPOCH OFFSET OPTION	NONE	0.000	@@Ax	6.54
1PPS	TIME RAIM SETUP AND STATUS 6-CHANNEL	trstat	Time RAIM Algorithm "OFF"	@@Bn	6.102
1PPS	TIME RAIM SETUP AND STATUS 8-CHANNEL	trstat8	Time RAIM Algorithm "OFF"	@@En	6.138
1PPS	1PPS TIME OFFSET	ppsoff	0	@@Ay	6.56
2-D	2-D TO 0-D HDOP THRESHOLD	dopmask	12.0	@@AC	6.64
3-D	3-D TO 2-D xDOP THRESHOLD	dopthr	6.0	@@Al	6.28
ALERT-PLANNING	ALERT PLANNING - 6-CHANNEL	alert	N/A	@@Cd	6.110
ALERT-PLANNING	ALERT PLANNING - 8-CHANNEL	alert8	N/A	@@Fd	6.144
ALMANAC	ALMANAC UPDATE OPTION	almhold	Update	@@An	6.32
ALMANAC	ALMANAC STATUS MESSAGE	alm	Polled	@@Bd	6.80
ALMANAC	ALMANAC DATA OUTPUT MESSAGE	almout	Polled	@@Be	6.82
ALMANAC	ALMANAC DATA INPUT	almin	N/A	@@Cb	6.108
APPLICATION	APPLICATION TYPE	aptype	Land	@@AB	6.62
BROADCAST	SATELLITE BROADCAST DATA MESSAGE	NONE	Polled	@@Bl	6.100
DATE	DATE	date	No change	@@Ac	6.10
DATUM	DATUM ID CODE	datum	WGS-84	@@Ao	6.34
DATUM	USER DEFINED DATUMS	udatum	WGS-84	@@Ap	6.36
DEFAULTS	SET-TO-DEFAULTS	default	N/A	@@Cf	6.116
DOP	xDOP TYPE	doptype	PDOP	@@Aj	6.24
DGPS	DIFFERENTIAL CORRECTION TIME-OUT	dto	90 seconds	@@AJ	6.70
DGPS	OUTPUT PSEUDORANGE CORRECTION OUTPUT MESSAGE	corout	Polled	@@Bh	6.90
DGPS	PSEUDORANGE CORRECTION INPUT	corin	N/A	@@Ce	6.114
DOP - 6CH	xDOP TABLE STATUS MESSAGE - 6-CHANNEL	dop	Polled	@@Bc	6.78
DOP - 8CH	xDOP TABLE STATUS MESSAGE - 8-CHANNEL	dp8	Polled	@@Ec	6.128
EPHEMERIS	EPHEMERIS HOLD OPTION	ephhold	Disable	@@AA	6.60
EPHEMERIS	INPUT EPHEMERIS DATA	ephin	N/A	@@Bf	6.84
EPHEMERIS	EPHEMERIS DATA OUTPUT MESSAGE	ephout	Polled	@@Bi	6.92
EXTENSION MSG	POSITION/STATUS/DATA EXTENSION MSG. - 6-CH	ext	Polled	@@Bk	6.96
EXTENSION MSG	POSITION/STATUS/DATA EXTENSION MSG. - 8-CH	et8	Polled	@@Ek	6.134
FIX	POSITION FIX ALGORITHM TYPE	fix	N-in-view	@@Ar	6.42
HOLD	HOLD POSITION PARAMETERS	php	0	@@As	6.44
HOLD	POSITION-HOLD OPTION	ph	Disable	@@At	6.46
HOLD	ALTITUDE-HOLD HEIGHT PARAMETER	ahp	0	@@Au	6.48
HOLD	ALTITUDE-HOLD OPTION	ah	Disable	@@Av	6.50

Command List Alphabetically by Function
(Continued)

Function	Description	Controller Command	Default Setting	Binary Command	User Guide Page #
HEIGHT	HEIGHT	hgt	0.00	@@Af	6.16
ID	RECEIVER ID COMMAND STRING	id	N/A	@@Cj	6.122
IGNORE	SATELLITE IGNORE LIST	ignore	None	@@Am	6.30
IONOSPHERE	IONOSPHERE CORRECTION OPTION	ion	Enable	@@Aq	6.40
LATITUDE	LATITUDE	lat	0 degrees	@@Ad	6.12
LEAP	LEAP SECOND PENDING STATUS MESSAGE	leapsec	Polled	@@Bj	6.94
LONGITUDE	LONGITUDE	lon	0 degrees	@@Ae	6.14
LORAN	SWITCH I/O FORMAT	NONE	N/A	BIN	6.168
LORAN	OUTPUT TIME INTERVAL	NONE	Polled	T	6.166
LORAN	POSITIONING DATA OUTPUT	NONE	Polled	Z	6.164
MASK	SATELLITE MASK ANGLE	mask	10 degrees	@@Ag	6.18
MESSAGE	OUTPUT ALIGN	NONE	Disable	@@AE	6.68
MODE	POSITION FIX/IDLE MODE OPTION	mode	Idle	@@Cg	6.118
NMEA	SWITCH I/O FORMAT	NONE	N/A	FOR	6.162
NMEA	GPGGA (GPS FIX DATA)	NONE	Polled	GGA	6.148
NMEA	GPGLL (GEOGRAPHIC POSITION-LATITUDE/LONGITUDE)	NONE	Polled	GLL	6.152
NMEA	GPGSA (GPS DOP AND ACTIVE SATELLITES)	NONE	Polled	GSA	6.154
NMEA	GPGSV (GPS SATELLITES IN VIEW)	NONE	Polled	GSV	6.156
NMEA	GPRMC (RECOMMENDED MINIMUM SPECIFIC GPS/TRANSIT DATA)	NONE	Polled	RMC	6.150
NMEA	GPVTG (TRACK MADE GOOD AND GROUND SPEED)	NONE	Polled	VTG	6.158
NMEA	GPZDA (TIME AND DATE)	NONE	Polled	ZDA	6.160
POSITION - 6CH	POSITION/STATUS/DATA OUTPUT MESSAGE - 6-CH	pos	Polled	@@Ba	6.72
POSITION - 8CH	POSITION/CHANNEL DATA - 8-CHANNEL	ps8	Polled	@@Ea	6.124
RANGE DATA-6CH	SATELLITE RANGE DATA OUTPUT MESSAGE - 6-CH	rng	Polled	@@Bg	6.86
RANGE DATA-8CH	SATELLITE RANGE DATA OUTPUT MESSAGE - 8-CH	rg8	Polled	@@Eg	6.130
SATELLITE	SATELLITE SELECT	ss	None	@@Ai	6.22
SATELLITE	SATELLITE SELECT OPTIONS	sm	Automatic	@@Ah	6.20
SATELLITE	VISIBLE SATELLITE STATUS MESSAGE	vis	Polled	@@Bb	6.76
SELF-TEST - 6CH	SELF-TEST - 6-CHANNEL	selftest	N/A	@@Ca	6.106
SELF-TEST - 8CH	SELF-TEST - 8-CHANNEL	selftest8	N/A	@@Fa	6.142
SWITCH	SWITCH I/O FORMAT	ioformat	Motorola	@@Ci	6.120
THRESHOLD	xDOP HYSTERESIS	dophys	1.0	@@Ak	6.26
THRESHOLDS	CORRECTION THRESHOLDS	corthr	0/32	@@AD	6.66
TIME	GMT	gmt	00:00	@@Ab	6.8
TIME	TIME OF DAY	time	No change	@@Aa	6.6
TIME	UTC TIME CORRECTION OPTION	utc	Enable	@@Aw	6.52

Command List Alphabetically by Binary Command

Function	Description	Controller Command	Default Setting	Binary Command	User Guide Page #
EPHEMERIS	EPHEMERIS HOLD OPTION	ephhold	Disable	@@AA	6.60
TIME	TIME OF DAY	time	No change	@@Aa	6.6
APPLICATION	APPLICATION TYPE	aptype	Land	@@AB	6.62
TIME	GMT	gmt	00:00	@@Ab	6.8
DATE	DATE	date	No change	@@Ac	6.10
2-D	2-D TO 0-D HDOP THRESHOLD	dopmask	12.0	@@AC	6.64
LATITUDE	LATITUDE	lat	0 degrees	@@Ad	6.12
THRESHOLDS	CORRECTION THRESHOLDS	corthr	0/32	@@AD	6.66
LONGITUDE	LONGITUDE	lon	0 degrees	@@Ae	6.14
MESSAGE	OUTPUT ALIGN	NONE	Disable	@@AE	6.68
HEIGHT	HEIGHT	hgt	0.00	@@Af	6.16
MASK	SATELLITE MASK ANGLE	mask	10 degrees	@@Ag	6.18
SATELLITE	SATELLITE SELECT OPTIONS	sm	Automatic	@@Ah	6.20
SATELLITE	SATELLITE SELECT	ss	None	@@Ai	6.22
DOP	xDOP TYPE	doptype	PDOP	@@Aj	6.24
DGPS	DIFFERENTIAL CORRECTION TIME-OUT	dto	90 seconds	@@AJ	6.70
THRESHOLD	xDOP HYSTERESIS	dophys	1.0	@@Ak	6.26
3-D	3-D TO 2-D xDOP THRESHOLD	dopthr	6.0	@@Al	6.28
IGNORE	SATELLITE IGNORE LIST	ignore	None	@@Am	6.30
ALMANAC	ALMANAC UPDATE OPTION	almhold	Update	@@An	6.32
DATUM	DATUM ID CODE	datum	WGS-84	@@Ao	6.34
DATUM	USER DEFINED DATUMS	udatum	WGS-84	@@Ap	6.36
IONOSPHERE	IONOSPHERE CORRECTION OPTION	ion	Enable	@@Aq	6.40
FIX	POSITION FIX ALGORITHM TYPE	fix	N-in-view	@@Ar	6.42
HOLD	HOLD POSITION PARAMETERS	php	0	@@As	6.44
HOLD	POSITION-HOLD OPTION	ph	Disable	@@At	6.46
HOLD	ALTITUDE-HOLD HEIGHT PARAMETER	ahp	0	@@Au	6.48
HOLD	ALTITUDE-HOLD OPTION	ah	Disable	@@Av	6.50
TIME	UTC TIME CORRECTION OPTION	utc	Enable	@@Aw	6.52
1PPS	MEASUREMENT EPOCH OFFSET OPTION	NONE	0.000	@@Ax	6.54
1PPS	1PPS TIME OFFSET	ppsoff	0	@@Ay	6.56
1PPS	1PPS CABLE DELAY OPTION	ppsdelay	0.000	@@Az	6.58
POSITION - 6CH	POSITION/STATUS/DATA OUTPUT MESSAGE - 6-CH	pos	Polled	@@Ba	6.72
SATELLITE	VISIBLE SATELLITE STATUS MESSAGE	vis	Polled	@@Bb	6.76
DOP - 6CH	xDOP TABLE STATUS MESSAGE - 6-CHANNEL	dop	Polled	@@Bc	6.78
ALMANAC	ALMANAC STATUS MESSAGE	alm	Polled	@@Bd	6.80
ALMANAC	ALMANAC DATA OUTPUT MESSAGE	almout	Polled	@@Be	6.82
EPHEMERIS	INPUT EPHEMERIS DATA	ephin	N/A	@@Bf	6.84

Command List Alphabetically by Binary Command
(Continued)

Function	Description	Controller Command	Default Setting	Binary Command	User Guide Page #
RANGE DATA-6CH	SATELLITE RANGE DATA OUTPUT MESSAGE - 6-CH	rng	Polled	@@Bg	6.86
DGPS	OUTPUT PSEUDORANGE CORRECTION OUTPUT MESSAGE	corout	Polled	@@Bh	6.90
EPHEMERIS	EPHEMERIS DATA OUTPUT MESSAGE	ephout	Polled	@@Bi	6.92
LEAP	LEAP SECOND PENDING STATUS MESSAGE	leapsec	Polled	@@Bj	6.94
EXTENSION MSG	POSITION/STATUS/DATA EXTENSION MSG. - 6-CH	ext	Polled	@@Bk	6.96
BROADCAST	SATELLITE BROADCAST DATA MESSAGE	NONE	Polled	@@Bl	6.100
1PPS	TIME RAIM SETUP AND STATUS 6-CHANNEL	trstat	Time RAIM Algorithm "OFF"	@@Bn	6.102
SELF-TEST - 6CH	SELF-TEST - 6-CHANNEL	selftest	N/A	@@Ca	6.106
ALMANAC	ALMANAC DATA INPUT	almin	N/A	@@Cb	6.108
ALERT-PLANNING	ALERT PLANNING - 6-CHANNEL	alert	N/A	@@Cd	6.110
DGPS	PSEUDORANGE CORRECTION INPUT	corin	N/A	@@Ce	6.114
DEFAULTS	SET-TO-DEFAULTS	default	N/A	@@Cf	6.116
MODE	POSITION FIX/IDLE MODE OPTION	mode	Idle	@@Cg	6.118
SWITCH	SWITCH I/O FORMAT	ioformat	Motorola	@@Ci	6.120
ID	RECEIVER ID COMMAND STRING	id	N/A	@@Cj	6.122
POSITION - 8CH	POSITION/CHANNEL DATA - 8-CHANNEL	ps8	Polled	@@Ea	6.124
DOP - 8CH	xDOP TABLE STATUS MESSAGE - 8-CHANNEL	dp8	Polled	@@Ec	6.128
RANGE DATA-8CH	SATELLITE RANGE DATA OUTPUT MESSAGE - 8-CH	rg8	Polled	@@Eg	6.130
EXTENSION MSG	POSITION/STATUS/DATA EXTENSION MSG. - 8-CH	et8	Polled	@@Ek	6.134
1PPS	TIME RAIM SETUP AND STATUS 8-CHANNEL	trstat8	Time RAIM Algorithm "OFF"	@@En	6.138
SELF-TEST - 8CH	SELF-TEST - 8-CHANNEL	selftest8	N/A	@@Fa	6.142
ALERT-PLANNING	ALERT PLANNING - 8-CHANNEL	alert8	N/A	@@Fd	6.144
LORAN	SWITCH I/O FORMAT	NONE	N/A	BIN	6.168
NMEA	SWITCH I/O FORMAT	NONE	N/A	FOR	6.162
NMEA	GPGGA (GPS FIX DATA)	NONE	Polled	GGA	6.148
NMEA	GPGLL (GEOGRAPHIC POSITION-LATITUDE/LONGITUDE)	NONE	Polled	GLL	6.152
NMEA	GPGSA (GPS DOP AND ACTIVE SATELLITES)	NONE	Polled	GSA	6.154
NMEA	GPGSV (GPS SATELLITES IN VIEW)	NONE	Polled	GSV	6.156
NMEA	GPRMC (RECOMMENDED MINIMUM SPECIFIC GPS/TRANSIT DATA)	NONE	Polled	RMC	6.150
LORAN	OUTPUT TIME INTERVAL	NONE	Polled	T	6.164
NMEA	GPVTG (TRACK MADE GOOD AND GROUND SPEED)	NONE	Polled	VTG	6.158
LORAN	POSITIONING DATA OUTPUT	NONE	Polled	Z	6.164
NMEA	GPZDA (TIME AND DATE)	NONE	Polled	ZDA	6.160

TIME OF DAY

This input command changes the current time in the GPS receiver to the time specified in the command. The time normally will be correct because it is updated by the optional internal real-time clock (RTC). It is not necessary for the user to enter the time of day if power is removed, however the TTFF will be greatly reduced if the time is initialized. The GPS receiver corrects the time data in the real-time clock with time information decoded from the satellite broadcast data. The GMT Correction parameter first must be specified before this "Change Current Time of Day" input command is sent to the GPS receiver.

The user can send the "Change Current Time of Day" command in either the Position Fix mode, or the Idle mode. However, if the GPS receiver has acquired at least one satellite in the Position Fix mode, it will ignore this command since it obtains time information from the satellites as a normal part of tracking. For this reason, the user must place the GPS receiver in the Idle mode in order to change the time if the unit is in the Position Fix mode and is already tracking at least one satellite. The GPS receiver will accept and execute the "Change Current Time of Day" command if it is in the Position Fix mode and the GPS receiver has yet to acquire the first satellite.

Time is stored as local time or GMT time, depending on the setting of the GMT Correction parameter. The GPS receiver automatically compensates for leap-second corrections, thus the response message can contain "seconds" parameter equal to 60. Leap seconds are inserted approximately once per year.

Range:	00:00:00 to 23:59:59
Default value:	Time not changed if RTC backup power present
	12:00:00 (GPS time) if RTC and backup power not present

TIME OF DAY
Motorola Binary Format

Input Command Description

- *Send Current Time of Day:*

@@AaxxxC<CR><LF>

xxx – $ffffff (three bytes, all hex ff)
C – checksum
Message Length: 10 bytes

- Change Current Time of Day:

@@AahmsC<CR><LF>

h – hours	0 .. 23
m – minutes	0 .. 59
s – seconds	0 .. 59

Message Length: 10 bytes

Response Message

- *(to either command):*

@@AahmsC<CR><LF>

h – hours	0 .. 23
m – minutes	0 .. 59
s – seconds	0 .. 60

C – checksum

Message Length: 10 bytes

GMT CORRECTION

This command changes the correction factor between GMT and local time.
The GPS receiver computes local time from GMT time and the correction factor by the equation:

LOCAL TIME = GMT_TIME + GMT_CORRECTION

The minutes correction is provided for those locations in the world that do not use an even offset of hours between GMT and local time. If it is desired to operate on GMT time, the correction is set to 0 hours, 0 minutes and the time set in the Time of Day parameter must be entered in GMT time.

Range:	hours: -23 to +23 minutes: 00 to 59
Default value:	00:00 (No GMT Correction)

GMT CORRECTION
Motorola Binary Format

Input Command Description

- *Send Current GMT Correction:*

@@AbxxxC<CR><LF>

xxx – $ffffff (three bytes, all hex ff)
C – checksum
Message Length: 10 bytes

- Change Current GMT Correction:

@@AbshmC<CR><LF>

s – sign	00 – positive
	ff – negative
h – hours	0 .. 23
m – minutes	0 .. 59
C – checksum	
Message Length: 10 bytes	

Response Message

- *(to either command):*

@@AbshmC<CR><LF>

s – sign	00 – positive
	ff – negative
h – hours	0 .. 23
m – minutes	0 .. 59
C – checksum	
Message Length: 10 bytes	

DATE

This command changes the current date in the GPS receiver real-time clock to the date specified in the input command. The date in the receiver normally will be correct because it is updated by the internal real-time clock (RTC). It is not necessary for the user to enter the current date if the real time clock power is removed, however the TTFF will be greatly reduced if the date is initialized. The GPS receiver corrects the date data in the real-time clock with date information decoded from the satellite broadcast data. The GMT Correction parameter must first be specified before the "Change Current Date" input command is sent to the GPS receiver.

The user can send the GPS receiver a "Change Current Date" command in either the Position Fix mode, or the Idle mode. However, if the GPS receiver has acquired at least one satellite in the Position Fix mode, it will ignore this command since it obtains date information from the satellites as a normal part of tracking. For this reason, the user must place the GPS receiver in the Idle mode in order to change the GPS receiver date if the GPS receiver is in the Position Fix mode and is already tracking at least one satellite. The GPS receiver will accept and execute the "Change Current Date" command if it is in the Position Fix mode and the GPS receiver has yet to acquire the first satellite.

When the date command is executed and the change is accepted, the year is stored in the EEPROM. This year is then used as the default year if the RTC and backup power are not applied. Caution: if the date is set to more than two years into the future, the wrong 20 year GPS window will be selected. This will result in the date being incorrect (the position will still be valid). If this occurs, issue the date command with the correct year while the receiver is in idle mode.

Default value:	Date not changed if RTC and backup power present
	1/1/xx if RTC and backup power not present

DATE
Motorola Binary Format

Input Command Description

- *Send Current Date:*

@@AcxxxxC<CR><LF>

xxxx – $ffffffff (four bytes, all hex ff)
C – checksum
Message Length: 11 bytes

- Change Current Date:

@@AcmdyyC<CR><LF>

m – month	1 .. 12
d – day	1 .. 31
yy – year	1980 .. 2077
C – checksum	

Message Length: 11 bytes

Response Message

- *(to either command)*

@@AcmdyyC<CR><LF>

m – month	1 .. 12
d – day	1 .. 31
yy – year	1980 .. 2077
C – checksum	

Message Length: 11 bytes

LATITUDE

The following three parameters (latitude, longitude, and height) are used to establish the initial position of the GPS receiver. The initial position estimate provides the GPS receiver with a starting point to begin the satellite acquisition process. It is not necessary for the user to initialize the coordinates with a position estimate, however the TTFF will be minimized by providing an estimate that is close (within one degree is sufficient) to the user's position.

Latitude is measured in degrees north (+) or degrees south (-) of the earth equator. The datum for the latitude is specified by setting the Datum ID parameter. This input command sets the initial latitude coordinate if the GPS receiver is not yet computing a position fix, or is used to replace the current latitude with a new latitude while in the Position Fix mode.

Range:	-90 (South Pole) to +90 (North Pole) degrees latitude
Default value:	0 latitude (Equator)
Units:	milliarcseconds (mas) (1° = 3,600,000 mas)

LATITUDE

Motorola Binary Format

Input Command Description

- *Send Current Latitude:*

  @@AdxxxxC<CR><LF>

  xxxx = $99999999 (four bytes, all hex 99)
  C – checksum
  Message Length: 11 bytes

- Change Current Latitude:

  @@AdddddC<CR><LF>

  dddd – latitude in mas -324,000,000 .. 324,000,000 (-90° to +90°)
  C – checksum
  Message Length: 11 bytes

Response Message

- *(to either command):*

  @@AdddddC<CR><LF>

  dddd – latitude in mas -324,000,000 ..324,000,000 (-90° to +90°)
  C – checksum
  Message Length: 11 bytes

Note: 1 degree of latitude equals 3,600 arcseconds or 3,600,000 milliarcseconds (mas)

LONGITUDE

Longitude is measured in degrees west (-) or degrees east (+) of the Greenwich Meridian. The datum for the longitude is specified by setting the Set Datum ID parameter. This input command sets the initial longitude coordinate if the GPS receiver is not computing a fix, or is used to replace the current longitude with a new input longitude while in the Position Fix mode.

Range:	-180 to +180 degrees longitude
Default value:	0 longitude (Greenwich Meridian)
Units:	milliarcseconds (mas) (1° = 3,600,000 mas)

LONGITUDE
Motorola Binary Format

Input Command Description

- *Send Current Longitude:*

@@AexxxxC<CR><LF>

xxxx = $99999999 (four bytes, all hex 99)
C – checksum
Message Length: 11 bytes

- Change Current Longitude:

@@AeddddC<CR><LF>

dddd – longitude in mas	-648,000,000 .. 648,000,000 (-180° to +180°)
C – checksum	
Message Length: 11 bytes	

Response Message

- *(to either command)*

@@AeddddC<CR><LF>

dddd – longitude in mas	-648,000,000 .. -648,000,000 (-180° to +180°)
C – checksum	
Message Length: 11 bytes	

Note: 1 degree of latitude equals 3,600 arcseconds or 3,600,000 milliarcseconds (mas)

HEIGHT

This command sets the initial height coordinate if the GPS receiver is not computing a position fix, or is used to replace the current height with a new input height while in the Position Fix mode. The user can enter the height in either of the two following references:

- GPS Ellipsoid Height – the height above the reference ellipsoid, or
- MSL Height – the height above mean sea level

The units of hieght are meters. If the "Change Current Height" command is performed while the GPS receiver is in the Position Fix mode, the height parameter is set to the new value entered.

Range:	-1000.00 to 18000.00 meters
Default value:	0.00 meters
Resolution:	0.01 meter

HEIGHT

Motorola Binary Format

Input Command Description

- *Send Current Height:*

@@AfxxxxxC<CR><LF>

xxxx = $9999999999 (five bytes, all hex 99)
C – checksum
Message Length: 12 bytes

- Change Current Height:

@@AfhhhhtC<CR><LF>

hhhh – height in cm	-100000 .. 1,800,000
	(-1000.00 to + 18000.00 meters)
t – height type	0 = GPS ellipsoid height
	1 = MSL height
C – checksum	
Message Length:12 bytes	

Response Message

- *(to either command)*

@@AfhhhhmmmmC<CR><LF>

hhhh – height in cm	-100000 .. 1,800,000
(GPS Ellipsoid Height)	(-1000.00 to +18000.00 meters)
mmmm – height in cm	-100000 .. 1,800,000
(MSL Height)	(-1000.00 to +18000.00 meters)
C – checksum	
Message Length: 15 bytes	

SATELLITE MASK ANGLE

The GPS receiver will attempt to track satellites for which the elevation angle is greater than the satellite mask angle. This parameter allows the user to control the elevation angle that was used for this decision.

Range:	0 to 89 degrees
Default value:	10 degrees

SATELLITE MASK ANGLE

Motorola Binary Format

Input Command Description

- *Send Current Satellite Mask Angle:*

@@AgxC<CR><LF>

x = $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Satellite Mask Angle:

@@AgdC<CR><LF>

d – degrees	0 .. 89
C – checksum	
Message Length: 8 bytes	

Response Message

- *(to either command):*

@@AgdC<CR><LF>

d – degrees	0 .. 89
C – checksum	
Message Length: 8 bytes	

SATELLITE SELECT OPTIONS

This command sets the Satellite Select option to either automatic, manual, or highest-in-the-sky satellite selection. With the "automatic" option enabled, the GPS receiver automatically selects the set of satellites to track with the best geometry (selection criteria optimized for the selected xDOP type, the xDOP hysteresis parameter and position fix type). With the automatic satellite select option enabled, the GPS receiver will change satellites to maintain the set with the best geometry based on each new computation of satellite geometry. Selection of the manual satellite select option requires the user to select the satellites to be tracked.

With the "automatic highest-in-sky" mode, the receiver simply tracks the six (or eight, if the receiver has eight channels) satellites currently highest above the horizon. Use of this option will result in more position fixes in urban canyon environments when more than six (or eight) satellites are visible at the expense of accuracy since geometry is not considered as a satellite selection criterion when this option is selected

The GPS receiver will power-up to either automatic or highest-in-the-sky, depending on which option was last selected by the user. The receiver will never power-up in manual mode. When manual mode is selected the receiver will continue to track those satellites set by either the automatic or highest-in-the-sky selection processes when the Satellite Select option is set to manual satellite select. The user can then change any satellite on any channel using the Manual Satellite Select command.

The GPS receiver always defaults to the automatic satellite mode last used option when the GPS receiver is powered up. The GPS receiver continues to track those satellites set by automatic satellite selection processes when the Satellite Select option is set to manual satellite select. The user can then change any satellite on any channel using the Manual Satellite Select command.

Default value: Automatic

SATELLITE SELECT OPTIONS

Motorola Binary Format

Input Command Description

- *Send Current Satellite Select:*

@@AhxC<CR><LF>

x = $ff (one byte, hex ff)

C – checksum

Message Length: 8 bytes

- Change Satellite Select:

@@AhoC<CR><LF>

o – option	0 – Automatic
	1 – Manual
	2 – Automatic highest-in-sky

C – checksum

Message Length:8 bytes

Response Message

- *(to either command):*

@@AhoC<CR><LF>

o – option	0 – Automatic
	1 – Manual
	2 – Automatic highest-in-sky

C – checksum

Message Length:8 bytes

SATELLITE SELECT

This option is used to manually change the satellites tracked. This input command is used by the GPS receiver only when the Manual Satellite Select option is enabled. The input command has no effect if the Automatic or highest-in-the-sky Satellite Select option is enabled.

Default value: none

SATELLITE SELECT
Motorola Binary Format

Input Command Description

- *Send Current Satellite Assignment on Channel:*

@@AicxC<CR><LF>

c – channel number 1 .. 8
x = $ff (one byte, hex ff)
C – checksum
Message Length: 9 bytes

- Change Satellite Assignment on Channel:

@@AicsC<CR><LF>

c – channel number 1 .. 8
s – sat ID per channel 0 .. 37
  0 – disable channel
  1..37 - sat ID including pseudolite IDs
C – checksum
Message Length: 9 bytes

Response Message

- *(to either command)*

@@AicsC<CR><LF>

c – channel number 1 .. 8
s – sat ID per channel 0 .. 37
  0 – disable channel
  1..37 – sat ID including pseudolite IDs
C – checksum
Message Length: 9 bytes

xDOP TYPE

The xDOP Type parameter specifies which DOP type to use for satellite selection criteria. The user has the choice of allowing the GPS receiver to optimize its satellite selection based on minimum value of the chosen DOP type as defined by the following table:

PARAM	DEFINITION	GEOMETRY CONSIDERED
GDOP	Geometric Dilution of Precision	X, Y, Z, T or ϕ, λ, H, T
PDOP	Position Dilution of Precision	X, Y, Z or ϕ, λ, H
HDOP	Horizontal Dilution of Precision	ϕ, λ
VDOP	Vertical Dilution of Precision	H
TDOP	Time Dilution of Precision	T

Default value: PDOP

xDOP TYPE

Motorola Binary Format

Input Command Description

- *Send Current xDOP Type:*

@@AjxC<CR><LF>

x = $ff (one byte, hex ff)
C - checksum
Message Length: 8 bytes

- Change xDOP Type:

@@AjdC<CR><LF>

d – DOP Type	0 – GDOP
	1 – PDOP
	2 – HDOP
	3 – VDOP
	4 – TDOP

C – checksum
Message Length: 8 bytes

Response Message

- *(to either command)*

@@AjdC<CR><LF>

d - DOP Type	0 – GDOP
	1 – PDOP
	2 – HDOP
	3 – VDOP
	4 – TDOP

C – checksum
Message Length: 8 bytes

xDOP HYSTERESIS

Setting this parameter allows the user to change the criteria by which the GPS receiver selects satellites. The GPS receiver evaluates the geometry for all satellites in view every few seconds. In doing so, it evaluates every combination of the visible satellites (based on the Position Fix Algorithm Type selection), computes an xDOP parameter for each combination (xDOP type as selected) and sorts them into ascending order. If three or four satellites are visible, the GPS receiver tracks the visible satellites and computes position without regard to geometry (xDOP) since these satellites represent the only choice at that time. However, if five satellites are visible, then five combinations of four satellites are possible for navigation (with the Position Fix Algorithm Type set for "Best-4"). The GPS receiver computes an xDOP for each combination and determines position from the set of four satellites corresponding to the best xDOP, leaving any remaining satellites that are tracked in reserve for use if one or more of the primary four satellites are lost momentarily. With the Position Fix Algorithm Type set for "N-in-View," the GPS receiver compares the closeness of xDOP for all combinations of visible satellites greater than the number of receiver channels.

There are periods in the satellite pass where the relative difference in xDOP among the many satellite combinations is small, and the GPS receiver would switch satellites needlessly if it were not for this parameter. To combat this, the xDOP hysteresis command can be used. When set to a non-zero number, a threshold on the change in xDOP is added to the satellite selection criteria. If the parameter is set to zero, then the GPS receiver will select the best satellites after every satellite alert computation without regard to the "closeness" of xDOP. If the parameter is set relatively high, then the receiver will switch satellites only if the geometry on the tracked satellites becomes very poor, or if one of the tracked satellites goes below the satellite elevation mask angle.

Range:	0.0 to 99.9
Default value:	1.0
Resolution:	0.1

xDOP HYSTERESIS

Motorola Binary Format

Input Command Description

- *Send Current xDop Hysteresis:*

@@AkxxC<CR><LF>

xx – $ffff (two bytes, all hex ff)
C – checksum
Message Length: 9 bytes

- Change xDop Hysteresis:

@@AkxxC<CR><LF>

xx – xDop Hysteresis	0 .. 999
0.1 resolution	(0.0 .. 99.9)
C – checksum	
Message Length: 9 bytes	

Response Message

- *(to either command):*

@@AkxxC<CR><LF>

xx – xDop hysteresis	0 .. 999
0.1 resolution	(0.0 .. 99.9)
C – checksum	
Message Length: 9 bytes	

3-D TO 2-D xDOP THRESHOLD

There are periods in the satellite pass where the 3-dimensional (3-D) dilution of precision (PDOP and GDOP) grows very large, but the 2-D HDOP stays relatively small. This command allows the user to set the DOP threshold above which the GPS receiver will switch from 3-D positioning to altitude-hold at the current height. This allows the GPS receiver to maintain a relatively accurate position fix, and avoids the condition of a 3-D fix algorithm singularity.

Range:	1.0 to 99.9
Default value:	6.0
Resolution:	0.1

3-D TO 2-D xDOP THRESHOLD

Motorola Binary Format

Input Command Description

- *Send Current 3-D to 2-D DOP threshold:*

@@AlxxC<CR><LF>

(Note: The second character is a lowercase "L" not the number "1")

xx – $ffff (two bytes, all hex ff)
C – checksum
Message Length: 9 bytes

- Change Current 3-D to 2-D DOP threshold:

@@AlxxC<CR><LF>

xx – threshold	10 . . 999
(0.1 resolution)	(1.0 . . 99.9)
C – checksum	
Message Length: 9 bytes	

Response Message

- *(to either command):*

@@AlxxC<CR><LF>

xx – threshold	10 . . 999
(0.1 resolution)	(1.0 . . 99.9)
C – checksum	
Message Length: 9 bytes	

SATELLITE IGNORE LIST

It is useful to have the flexibility to delete particular satellite identifications (IDs) from the selection process. The GPS receiver includes, in its list of satellites to track, all satellites that are healthy and in the almanac. The user can elect to ignore particular satellites in the almanac by issuing an Ignore Satellite Command. In addition, the user can restore any previously ignored satellite IDs by issuing an Include Satellite Command. This command also affects the satellite Alert-Planning settings. Satellites that have been removed by this command are not included in the produced Alert-Planning output. The user may notice a delay between issuing this command and the actual removal or inclusion of particular satellites.

Default value: All satellite IDs included.

SATELLITE IGNORE LIST

Motorola Binary Format

Input Command Description

- *Send Current Satellite Ignore List:*

  @@AmxxxxxC<CR><LF>

  xxxxx - $ff00000000 (five bytes, hex ff00000000)
  C – checksum
  Message Length: 12 bytes

- Change Satellite Ignore List:

  @@AmkssssC<CR><LF>

  k – 00 fixed binary constant
  ssss - 32 bit binary field, Each bit represents one SVID
  (MSB = SVID 32
  LSB = SVID 1)
  1 – Ignore
  0 – Include
  C – checksum
  Message Length: 12 bytes

Response Message

- *(to either command):*

  @@AmkssssC<CR><LF>

  k – 00 fixed binary constant
  ssss – 32 bit binary field, Each bit represents one SVID
  (MSB = SVID 32
  LSB = SVID 1)
  1 – Ignore
  0 – Include
  C – checksum
  Message Length: 12 bytes

ALMANAC UPDATE OPTION

The user has the flexibility of allowing or disallowing the GPS receiver to update its internal almanac when a new one is received. With the automatic almanac update enabled, the GPS receiver will continuously gather the satellite-transmitted almanac from any of the active channels and compare the new almanac to the old one stored in its nonvolatile memory. When a new almanac is received, the GPS receiver will store the new almanac to nonvolatile memory and begin the process again. With the no-update almanac option enabled, the GPS receiver will not obtain a new almanac from the received satellite signal.

Default value: Update

ALMANAC UPDATE OPTION
Motorola Binary Format

Input Command Description

- *Send Current Almanac Update Mode:*

@@AnxC<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Almanac Update Mode:

@@AnmC<CR><LF>

m – mode: 1 – Update; 0 – No-Update
C – checksum
Message Length: 8 bytes

Response Message

- *(to either command):*

@@AnmC<CR><LF>

m – mode: 1 – Update; 0 – No-Update
C – checksum
Message Length: 8 bytes

DATUM ID CODE

The GPS receiver has 49 predefined datums in its internal memory and two user definable datums. The datums are referenced by an ID number. The predefined datums are numbered 1 through 49 and the user defined datums are numbered 50 and 51. A table of the ID number vs datum name is provided in Appendix A. The user instructs the GPS receiver which datum to use by sending the "Change Datum ID Number" command. The command contains the ID number of the desired datum and the GPS receiver returns the response message which gives the user the ability to validate that the input command was accepted. The user can instruct the GPS receiver to use one of the two user defined datums by sending the "Change Datum ID Number" command with the datum ID set to 50 or 51. Datum IDs 50 and 51 are set at the factory to default to WGS-84 parameters.

Default Datum: WGS-84 (ID code 49)

DATUM ID CODE
Motorola Binary Format

Input Command Description

- *Output Current Datum ID Number:*

@@AoXC<CR><LF>

X – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Datum ID Number:

@@AodC<CR><LF>

d – Datum ID	1 .. 51
C – checksum	
Message Length: 8 bytes	

Response Message

- *(to either command):*

@@ApdsssffiiffffxxyyzzC<CR><LF>

d – datum ID	1 .. 51
sssff – semi-major axis	
sss – integer part	6,000,000 .. 7,000,000 (6,000,000.0 .. 7,000,000.0)
ff – fractional part	0 .. 999 (0.0 .. 0.999)
iiffff – inverse flattening	
ii – integer part	285 .. 305 (285.0 .. 305.0)
ffff – fractional part	0 .. 999,999,999 (0.0 .. 0.999999999)
xx – delta X 0.1 meter resolution	-32768 .. 32767 (3276.8 .. 3276.7)
yy – delta Y 0.1 meter resolution	-32768 .. 32767 (-3276.8 .. 3276.7)
zz – delta Z 0.1 meter resolution	-32768 .. 32767 (-3276.8 .. 3276.7)
C – checksum	
Message Length: 25 bytes	

USER DEFINED DATUMS

The GPS receiver has two user defined datums stored in Datum ID numbers 50 and 51. The following commands allow the user to define the constants used for a custom datum given a semi-major axis; an inverse flattening constant; and delta-X, delta-Y, and delta-Z parameters.

Default Datum: User defined datums are factory set to WGS-84 parameters.

USER DEFINED DATUMS

Motorola Binary Format

Input Command Description

- *Output User Defined Datum Parameters:*

@@ApdxxxxxxxxxxxxxxxxxC<CR><LF>

d – Desired User Datum	50 or 51
xxxxxxxxxxxxxxxxx (17 bytes, all hex 00)	
C – checksum	
Message Length: 25 bytes	

- Change User Defined Datum Parameters:

@@ApdsssffiiffffxxyyzzC<CR><LF>

d – Datum ID	50 .. 51
sssff – semi-major axis	
sss – integer part	6,000,000 .. 7,000,000 (6,000,000.0 .. 7,000,000.0)
ff – fractional part	0 .. 999 (0.0 .. 0.999)
iiffff – inverse flattening	
ii – integer part	285 .. 305 (285.0 .. 305.0)
ffff – fractional part	0 .. 999,999,999 (0.0 .. 0.999999999)
xx – delta X 0.1 meter resolution	-32768 ..32767 (3276.8 .. 3276.7)
yy – delta Y 0.1 meter resolution	-32768 .. 32767 (3276.8 .. 3276.7)
zz – delta Z 0.1 meter resolution	-32768 .. 32767 (3276.8 .. 3276.7)
C – checksum	
Message Length: 25 bytes	

Response Message on Following Page

USER DEFINED DATUMS

Motorola Binary Format

Response Message

- *(to either command):*

@@ApdsssffiiffffxxyyzzC<CR><LF>

d – datum ID	50 .. 51
sssff – semi-major axis	
sss – integer part	6,000,000 .. 7,000,000 (6,000,000.0 .. 7,000,000.0)
ff – fractional part	0 .. 999 (0.0 .. 0.999)
iiffff – inverse flattening	
ii – integer part	285 .. 305 (285.0 .. 305.0)
ffff – fractional part	0 .. 999,999,999 (0.0 .. 0.999999999)
xx – delta X 0.1 meter resolution	-32768 ..32767 (3276.8 .. 3276.7)
yy – delta Y 0.1 meter resolution	-32768 .. 32767 (3276.8 .. 3276.7)
zz – delta Z 0.1 meter resolution	-32768 .. 32767 (3276.8 .. 3276.7)
C – checksum	

Message Length: 25 bytes

IONOSPHERE CORRECTION OPTION

The user has the flexibility of turning the GPS ionospheric correction on or off. The correction does a reasonable job of taking out the range error induced by the earth's ionosphere by using an algorithm and parameters transmitted to the users by the satellites. Some users (i.e., differential systems) choose to disable the ionospheric model.

Default value: Enabled

IONOSPHERE CORRECTION OPTION

Motorola Binary Format

Input Command Description

- *Send Current Ionospheric Correction Selection:*

@@AqxC<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Ionospheric Correction Selection:

@@AqsC<CR><LF>

s – selection	0 – Disabled
	1 – Enabled
C – checksum	
Message Length: 8 bytes	

Response Message

- *(to either command):*

@@AqsC<CR><LF>

s – selection	0 – Disabled
	1 – Enabled
C – checksum	
Message Length: 8 bytes	

POSITION FIX ALGORITHM TYPE

The GPS receiver uses a least-squares position computation algorithm, and operates in one of two Position Fix modes as set by the user: Best-4 or N-in-View.

Best-4: When enabled, the GPS receiver uses the best four satellites out of N satellites that the GPS receiver can track for the computation of position, where N is the number of satellites that the receiver is currently tracking. The GPS receiver uses the best four satellites as defined by the xDOP selection. The GPS receiver can have other satellites on the remaining channels that the receiver will use in the case that one or more of the primary selected satellites is lost due to signal blockage.

N-in-View: When enabled, the GPS receiver will use all satellites that it is tracking for the position fix. The assignment of satellites to channels is optimized for the N-in-View condition.

Default value: N-in-View

POSITION FIX ALGORITHM TYPE

Motorola Binary Format

Input Command Description

- *Send Current Position Fix Algorithm Type:*

@@ArxC<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Position Fix Algorithm Type:

@@ArsC<CR><LF>

s – selection	0 – Best-4
	1 – N-in-View
C – checksum	
Message Length: 8 bytes	

Response Message

- *(to either command):*

@@ArsC<CR><LF>

s – selection	0 – Best-4
	1 – N-in-View
C – checksum	
Message Length: 8 bytes	

HOLD POSITION PARAMETERS

NOTE: The input/output messages described here are available only if GPS receiver Options A, B, or I are installed.

The user can specify receiver coordinates for position-hold applications such as timing and real-time differential master stations. This command is used when the Hold Position option is enabled, to instruct the GPS receiver the position to be held, and to have a means of manually enabling/disabling the position-hold function on and off. The position to be held is specified in the same units as the initial position coordinates of latitude, longitude, and height (to the same resolution). The height parameter can be referenced to either the GPS reference ellipsoid height or to mean sea level. The datum specifying the coordinate system for the fixed position coordinates must be the same as the coordinate system specified by the datum currently in use.

Default values: Latitude = 0
Longitude = 0 GPS Height = 0

HOLD POSITION PARAMETERS
Motorola Binary Format

Input Command Description

- *Send Current Position-Hold Position:*

@@AsxxxxxxxxxxxxxC<CR><LF>

xxxxxxxxxxxxx = $7fffffff7fffffff7fffffffff (13 bytes)
C – checksum
Message Length: 20 bytes

- Change Current Position:

@@AsllllooooohhhhtC<CR><LF>

llll – latitude in msec	-324,000,000 .. 324,000,000 (-90° to +90°)
oooo – longitude in msec	-648,000,000 .. 648,000,000 (-180° to +180°)
hhhh – height in cm	-100000 .. 1,800,000 (-1000.00 to +18000.00)
t – height type	0 – GPS ellipsoid height ref
	1 – MSL ref

C – checksum
Message Length: 20 bytes

Response Message

- *(to either command):*

@@AsllllooooohhhhtC<CR><LF>

llll – latitude in msec	-324,000,000 .. 324,000,000 (-90° to +90°)
oooo – longitude in msec	-648,000,000 .. 648,000,000 (-180° to +180°)
hhhh – height in cm	-100000 .. 1,800,000 (-1000.00 to +18000.00)
t – height type	0 – GPS ellipsoid height ref
	1 – MSL ref
C – checksum	Message Length: 20 bytes

Note: 1 degree equals 3,600 seconds or 3,600,000 msec

POSITION-HOLD OPTION

NOTE: The input/output messages described here are available only if GPS receiver Options A, B, or I are installed.

The user can specify coordinates for position-hold applications such as timing and real-time differential applications. This option enables/disables the Hold Position Parameters entered into the GPS receiver. The coordinates of the current GPS position fix are not used for the position-hold mode; the Hold Position Parameters Command must be used to enter the coordinates of the point.

Default value: Disabled

POSITION-HOLD OPTION

Motorola Binary Format

Input Command Description

- *Send Current Position Hold Mode:*

@@AtxC<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Position Hold Mode:

@@AtmC<CR><LF>

m – mode	0 – Disabled
	1 – Enabled

C – checksum
Message Length: 8 bytes

Response Message

- *(to either command):*

@@AtmC<CR><LF>

m – mode	0 – Disabled
	1 – Enabled

C – checksum
Message Length: 8 bytes

ALTITUDE-HOLD HEIGHT PARAMETER

The user can specify receiver height for manual altitude-hold applications. Use of the Altitude Hold Option enables/disables this application. The altitude-hold height is specified in the units of meters to a resolution of 0.01 meters. The user can reference the height parameter to the GPS reference ellipsoid or to mean sea level. The datum specifying the coordinate system for the altitude-hold height must be the same as the coordinate system specified by the Datum ID currently in use by the GPS receiver.

Default value: 0 meters

ALTITUDE-HOLD HEIGHT PARAMETER

Motorola Binary Format

Input Command Description

- *Send Current Altitude-Hold Height:*

@@AuxxxxxC<CR><LF>

xxxxx – $7ffffffff (five bytes, hex 7ffffffff)
C – checksum
Message Length: 12 bytes

- Change Current Altitude-Hold Height:

@@AuhhhhtC<CR><LF>

hhhh – height in cm	-100000 .. 1,800,000 (-1000.00 to +18000.00)
t – height type	0 – GPS ref ellipsoid 1 –MSL height
C – checksum	
Message Length: 12 bytes	

Response Message

- *(to either command):*

@@AuhhhhtC<CR><LF>

hhhh – height in cm	-100000 .. 1,800,000 (-1000.00 to +18000.00)
t – height type	0 – GPS ref ellipsoid 1 –MSL height
C – checksum	
Message Length: 12 bytes	

ALTITUDE-HOLD OPTION

The user can specify a height coordinate for altitude-hold applications. This selection allows the user to manually enable or disable the altitude hold function. Remember, the GPS receiver automatically holds altitude to the current height when the xDOP is greater than the "3D to 2D DOP Threshold," or when the GPS receiver is tracking three satellites.

Default value: Disabled

ALTITUDE-HOLD OPTION

Motorola Binary Format

Input Command Description

- *Send Current Altitude-Hold Mode:*

@@AvxC<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Altitude-Hold Mode:

@@AvmC<CR><LF>

m – mode	0 – Disabled
	1 – Enabled
C – checksum	
Message Length: 8 bytes	

Response Message

- *(to either command):*

@@AvmC<CR><LF>

m – mode	0 – Disabled
	1 – Enabled
C – checksum	
Message Length: 8 bytes	

UTC TIME CORRECTION OPTION

NOTE: A portion of this message described here is available only if GPS receiver Option 1 is installed.

This command selects the type of time (either GPS or UTC) to be output in the Position/Status/Data output messages during the Position Fix mode, and to be used as the synchronization point for the 1PPS timing pulse.

When the GPS receiver is defaulted, it may take ten to fifteen minutes for the UTC correction parameters to be downloaded from the satellites. During this time, the UTC and GPS time will be equal. Loading the almanac into the receiver with the Almanac Data Input command does not speed up the process.

Default value: UTC

UTC TIME CORRECTION OPTION

Motorola Binary Format

Input Command Description

- *Send current UTC Correction Mode:*

@@AwxC<CR><LF>

x - $ff (one byte, hex ff)
C - checksum
Message Length: 8 bytes

- *Change UTC Correction Mode:*

@@AwmC<CR><LF>

m - mode — 0 = GPS, 1 = UTC

C - checksum
Message Length: 8 bytes

- *(to either command):*

@@AwmC<CR><LF>

m - mode — 0 = GPS, 1 = UTC

C - checksum
Message Length: 8 bytes

Note: The receiver will echo mode 0 for an input of either mode 0 or mode 4. The receiver will echo mode 1 for an input of either mode 1 or mode 3.

MEASUREMENT EPOCH OFFSET OPTION

NOTE: The input/output messages described here are available only if GPS receiver Option A or I is installed.

The GPS receiver computes a position relative to a measurement epoch that occurs once per second. The GPS receiver can place the measurement epoch on any of 1000 one-millisecond measurement sample points. This one-millisecond time reference clock is synchronous to the receiver's internal oscillator and is asynchronous to GPS/UTC system time. The user can move the measurement epoch with this command.

At power-up, the GPS receiver selects a measurement epoch by simply, choosing one of the 1000 clock cycles. This epoch is asynchronous to GPS/UTC time mark. When the GPS receiver acquires satellites, it will compute the local time of the asynchronous measurement epoch (one of the 1000 1 kHz clock cycles), and then skew receiver timing so as to place the measurement epoch within 0.001 seconds of the desired measurement epoch offset. The skew action inserts between 0.000 and 0.999 seconds between measurement epoch so as to move the epoch to the desired sample point. In addition, the GPS receiver automatically will insert or delete one millisecond when necessary to keep the measurement epoch on the selected time because of the receiver local oscillator drift.

As an example, consider the case where the user specifies 0.333 for the Measurement Epoch Offset. For this case, the receiver skews the receiver times so that the fractional part of local receiver time is 0.333 for the Measurement Epoch Offset. For this case, the receive skews the receiver timing so that the fractional part of the local receiver time is 0.333xxxx... The receiver position output will be relative to this new measurement epoch until this parameter is changed again.

The corrected time reference is relative to either GPS or UTC time, as specified and set by the user via the UTC Time Correction option.

Range:	0.000 to 0.999 seconds
Default value:	0.000 seconds
Resolution:	0.001 seconds

MEASUREMENT EPOCH OFFSET OPTION
Motorola Binary Format

Input Command Description

- *Send Current Measurement Epoch Offset:*

@@AxxxC<CR><LF>

xx – $ffff (two bytes, all hex ff)
C – checksum
Message Length: 9 bytes

- Change Current Measurement Epoch Offset:

@@AxttC<CR><LF>

tt – Time offset in msec	0 .. 999 (0.000 to 0.999 sec)
C – checksum	
Message Length: 9 bytes	

Response Message

- *(to either command):*

@@AxttC<CR><LF>

tt – Time offset in msec	0 .. 999 (0.000 to 0.999 sec)
C – checksum	
Message Length: 9 bytes	

1PPS TIME OFFSET OPTION

NOTE: The input/output messages described here are available only if Oncore GPS receiver Option A or I is installed.

The GPS receiver computes position relative to a measurement epoch that occurs once per second. In addition, the GPS receiver outputs a one pulse-per-second (1PPS) signal, the rising edge of which is placed on top of the GPS/UTC one second tic mark epoch. The 1PPS Time offset allows the user to offset the one-pulse per second time mark in one nanosecond increments. The offset is relative to the Measurement Epoch offset. The corrected time reference is relative to either GPS or UTC time, as specified and set by the user.

The resolution of this parameter is one nanosecond. This does not imply that the accuracy of the 1PPS output signal is to this level. The absolute accuracy of the signal is a function of GPS time accuracy, and is subject to degradation due to U.S. Department of Defense policy.

Range:	0.000000000 to 0.999999999 seconds
Default value:	0.000 seconds
Resolution:	1 nanosecond

1PPS TIME OFFSET OPTION

Motorola Binary Format

Input Command Description

- *Send Current 1PPS Offset:*

@@AyxxxxC<CR><LF>

xxxx – $ffffffff (four bytes, all hex ff)
C – checksum
Message Length: 11 bytes

- Change Current 1PPS Offset:

@@AyttttC<CR><LF>

tttt – Time offset in nsec	0.. 999999999 (0.0 to 0.999999999 sec)
C – checksum	
Message Length: 11 bytes	

Response Message

- *(to either command)*

@@AyttttC<CR><LF>

tttt – Time offset in nsec	0.. 999999999 (0.0 to 0.999999999 sec)
C – checksum	
Message Length: 11 bytes	

1PPS CABLE DELAY OPTION

NOTE: The input/output messages described here are available only if Oncore GPS receiver Option A or I is installed.

The GPS receiver outputs a 1PPS signal, the rising edge of which is placed on top of the GPS/ UTC one second tic mark epoch. The 1PPS Cable Delay offset allows the user to offset the one-pulse per second time mark in one nanosecond increments relative to the Measurement Epoch. The Cable Delay allows the user to select between zero and one additional millisecond to compensate for the length of the antenna cable.

This parameter instructs the GPS receiver to output the 1PPS output pulse earlier in time to compensate for antenna cable delay. Up to one millisecond of equivalent cable delay can be removed. Zero cable delay is set for a zero-length antenna cable. The user should consult a cable data book for the delay per foot for the particular antenna cable used in order to compute the total cable delay needed for a particular installation.

The corrected time reference is relative to either GPS or UTC time, as specified and set by the user.

Range:	0.000 to 0.000999999 seconds
Default Value:	0.000 seconds
Resolution:	1 nanosecond

1PPS CABLE DELAY OPTION

Motorola Binary Format

Input Command Description

- *Send Current 1PPS Offset:*

@@AzxxxxC<CR><LF>

xxxx – $ffffffff (four bytes, all hex ff)
C – checksum
Message Length: 11 bytes

- Change Current 1PPS offset:

@@AzttttC<CR><LF>

tttt – Time offset	0 .. 999999
res = 1 nsec	(0.0 to 0.000999999 sec)
C – checksum	
Message Length: 11 bytes	

Response Message

- *(to either command):*

@@AzttttC<CR><LF>

tttt – Time offset	0 .. 999999
res = 1 nsec	(0.0 to 0.000999999 sec)
C – checksum	
Message Length: 11 bytes	

EPHEMERIS HOLD OPTION

When this option is disabled, the GPS receiver automatically acquires and uses the latest satellite ephemerides from the GPS satellites. When the GPS receiver detects a new ephemeris data set, it collects the new data and immediately begins using the new data.

When this option is enabled, the GPS receiver holds the current ephemerides in memory and will not collect new ephemerides from the GPS satellites. With ephemeris hold enabled, the GPS receiver will only accept and use new ephemeris data input via the RS232 port.

Ephemeris Hold Option is always disabled at power-on.

Default value: Disabled

EPHEMERIS HOLD OPION

Motorola Binary Format

Input Command Description

- *Send Current Ephemeris Hold Mode:*

@@AAxC<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Current Ephemeris Hold Mode:

@@AAmC<CR><LF>

m – mode	0 – Disabled
	1 – Enabled

C – checksum
Message Length: 8 bytes

Response Message

- *(to either command):*

@@AAmC<CR><LF>

m – mode	0 – Disabled
	1 – Enabled

C – checksum
Message Length: 8 bytes

APPLICATION TYPE

This option is used to manually change the receiver application type. Setting this parameter allows the user to select optimized search and reacquisition strategies for different receiver applications.

Note the initial satellite search time is the time the receiver spends searching for the assumed visible satellites (based on the almanac and initial receiver position). Further note, for all application types, that if the set of assumed visible satellites have not been found by the end of the initial search time, the receiver begins a systematic search for all satellites in the GPS constellation.

Default value: Land

Application Type	Maximum Expected Velocity	Velocity Averaging	Approximate Initial Satellite Search Time
Air	> 100 m/s	1 sec	15 min
Handheld	< 100 m/s	5 sec	2 min
Land	< 100 m/s	1 sec	30 min
Marine	< 100 m/s	5 sec	2 min
Static	< 100 m/s	1 sec	2 min

APPLICATION TYPE
Motorola Binary Format

Input Command Description

- *Send Current Application Type:*

@@ABx<CR><LF>

x – $ff (one byte, hex ff)
C – checksum
Message Length: 8 bytes

- Change Current Application Type:

@@ABtC<CR><LF>

t – application type	0 – Air
	1 – Handheld
	2 – Land
	3 – Marine
	4 – Static

C – checksum
Message Length: 8 bytes

Response Message

- *(to either command):*

@@ABtC<CR><LF>

t – application type	0 – Air
	1 – Handheld
	2 – Land
	3 – Marine
	4 – Static

C – checksum
Message Length: 8 bytes

2-D TO 0-D HDOP THRESHOLD

There are periods in the satellite pass where the two-dimensional (2-D) dilution of precision (HDOP) grows very large, and the position is too inaccurate for use. This command allows the user to set the DOP threshold above which the GPS receiver will quit 2-D positioning.

Range:	1.0 to 99.9
Default Value:	12.0
Resolution:	0.1

2-D TO 0-D HDOP THRESHOLD

Motorola Binary Format

Input Command Description

- *Send Current 2-D to 0-D DOP threshold:*

@@ACxxC<CR><LF>

xx – $ffff (two bytes, all hex ff)
C – checksum
Message Length: 9 bytes

- Change Current 2-D to 0-D threshold:

@@ACttC<CR><LF>

tt – 2-D to 0-D threshold	10.. 999 (0.1 resolution) (1.0.. 99.9)
C – checksum	
Message Length: 9 bytes	

Response Message

- *(to either command):*

@@ACttC<CR><LF>

tt – 2-D to 0-D threshold	10..999 (0.1 resolution) (1.0.. 99.9)
C – checksum	
Message Length: 9 bytes	

CORRECTION THRESHOLDS

This command allows the control of two timer thresholds that affect the following:

- the "smoothness" of the position fix (FIX_THR), and
- the "smoothness" of the differential correction output (OUT_THR).

The Oncore GPS receiver filters the noisy raw code phase measurements with the very smooth carrier phase measurements. This filtering process begins as soon as the signal is acquired and continues as long as the signal is tracked. The filter bandwidth is narrowed gradually and reaches its final state after 128 seconds. The Oncore keeps a filter timer for each channel to control the timing of the bandwidth changes. The filter bandwidth is reset to its initial wide setting and the timer is set to zero whenever the signal is lost.

The user-controllable threshold OUT_THR can be used to gate a channel's output of differential corrections until it has had some user-defined adequate time to filter the raw code phase. Earlier versions of the Oncore software used 32 as an internal threshold for this parameter.

There is an inherent interdependence in the use of these two thresholds. For instance, if FIX_THR is set to 16 and OUT_THR is set to 8, then the receiver will filter the raw code phase for 16 seconds before using that channel for fix and then will immediately output differential corrections for that channel (if the message has been requested). The 8 second OUT_THR threshold is effectively overridden by the 16 second FIX_THR threshold in this example.

Default values: FIX_THR = 0
OUT_THR = 32

CORRECTION THRESHOLDS

Motorola Binary Format

Input Command Description

- *Send Correction Thresholds:*

@@ADxxC<CR><LF>

xx – $ffff (two bytes, all hex ff)
C – checksum
Message Length: 9 bytes

- Change Correction Thresholds:

@@ADfdC<CR><LF>

f – FIX_THR	0..127 secs
d – OUT_THR	0..127 secs
C – checksum	
Message Length: 9 bytes	

Response Message

- *(to either command):*

@@ADfdC<CR><LF>

f – FIX_THR	0..127 secs
d – OUT_THR	0..127 secs
C – checksum	
Message Length: 8 bytes	

OUTPUT ALIGN

Motorola Binary Format

Input Command Description

- *Send Output Alignment*

@@AExC<Cr><Lf>

x - $ff (one byte, hex ff)
C - checksum
Message Length: 8 bytes

- *Change Output Alignment*

@@AEmC<Cr><Lf>

m - mode	0 - Disabled
	1 - Enabled

C - checksum
Message Length: 8 bytes

Response Message

- *(to either command)*

@@AEmC<Cr><Lf>

m - mode	0 - Disabled
	1 - Enabled

C - checksum
Message Length: 8 bytes

DIFFERENTIAL TIME-OUT MESSAGE

The differential time-out message allows the user to determine what the differential timeout will be at which, if no differential corrections are received, the GPS receiver will switch to autonomous from differential mode. The GPS receiver will stay in differential mode as long as it has a current and valid differential correction message.

The user should note that excessive differential correction latencies can lead to significant error growth. As a rough guideline, an acceleration error of 1cm/sec^2 due to Selective Availability can be assumed producing the following (one-sigma) error component values in the differentially corrected solution:

CORRECTION LATENCY (s)	INDUCED POSITION ERROR (m)
30	4.5
60	18.0
90	40.5
120	72.0
150	112.5
180	162.0

Range: 5 to 180 seconds

Default: 90 seconds

Resolution: 1 second

DIFFERENTIAL TIME-OUT MESSAGE

Motorola Binary Format

Input Command Description

- *Send current differential time-out:*

@@AJxC<CR><LF>

x - $ff (one byte, hex ff)
C - checksum
Message Length: 8 bytes

- *Change differential time-out:*

@@AJsC<CR><LF>

s - seconds	5 .. 180
C - checksum	
Message Length: 8 bytes	

Response Message

- *(to either command):*

@@AJsC<CR><LF>

s - seconds	5 .. 180
C - checksum	
Message Length: 8 bytes	

POSITION/STATUS/DATA OUTPUT MESSAGE

The input command sets the rate that the position/status/data information (see Response Message) is output. The mode parameter (m) in the input message instructs the GPS receiver to either output this message one time (polled), or to output this message at the indicated update rate (continuously). Once the GPS receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time output request. The GPS receiver will output the message one more time, then terminate any further message outputs. If the GPS receiver has its Idle Mode option enabled, it outputs the last known valid position/status/data message once when polled.

The state of the mode bit is stored in nonvolatile memory. If the GPS receiver was continuously outputting the position/status/data output when turned off, it will begin to output this message continuously (at the selected update rate) again when power is reapplied.

The position/status/data output is explained in the response message section. Refer to the Date, Time of Day, Latitude, Longitude, and Height commands for more details on the formats of these parameters. Refer to the glossary for definitions of the DOP values.

The number of satellites visible is computed using the current date, time, position, almanac, and a mask angle of ten degrees. If no almanac is available, this number will be zero. This condition will not prevent satellites from being tracked.

In order for a satellite to be used for positioning, the satellite mode must reach eight, indicating that the ephemeris for that satellite has been acquired. Once the ephemeris is available, the satellite can be used for positioning in modes five through eight. Refer to page 5.13 for a description of the signal value.

The signal strength value is meaningless when the channel tracking mode is zero.

The Oncore GPS receiver has a propagate mode that is used to extend coverage when dropouts occur. When a 2D fix can no longer be computed, the last known velocity vector is used to propagate the position solution ahead for up to five seconds. This condition is indicated in the receiver status message.

NOTE: United States export laws prohibit GPS receiver from outputting valid data if the altitude is greater than 18,000 meters and the velocity is greater than 514 meters per second. If the GPS receiver is used above both these limits, the height and velocity outputs are clamped to the maximum values. In addition, the latitude and longitude data will be incorrect.

POSITION/STATUS/DATA OUTPUT MESSAGE

Motorola Binary Format

Input Command Description

•*Set response message rate:*

@@BamC<CR><LF>

m – mode

0 – output response message once

1...255 – response message output at indicated rate (continuous)

1 – once per second

2 – once every two seconds

255 – once every 255 seconds

C – checksum

Message Length: 8 bytes

Response Message

• *(to command)*

@@Bamdyyhmsffffaaaaoooohhhhmmmmvvhhddtntimsdims dimsdimsdimsdimsdsC<CR><LF>

Date	
m – month	1 .. 12
d – day	1 .. 31
yy year	1980 .. 2079
Time	
h – hours	0 .. 23
m – minutes	0 .. 59
s – seconds	0 .. 60
ffff – fractional seconds	0 .. 999, 999,999 (0.0 to 0.999999999)
Position	
aaaa – latitude in mas	-324,000,000 .. 324,000,000 (-90° to 90°)
oooo – longitude in mas	-648,000,000 .. +648,000,000 (-180° to 180°)
hhhh – height in cm (GPS, ref ellipsoid)	-100,000 .. 1,800,000 (-1000.00 to 18000.00 m)
mmmm – height in cm (msl ref)	-100,000 .. 1,800,000 (-1,000.00 to +18,000.00 m)
Velocity	
vv – velocity in cm/s	0 .. 51400 (0 to 514.00 m/s)
hh – heading (true north. res 0.1°)	0 .. 3599 (0.0 to 359.9°)

Geometry
Response Message Continued on Following Page

POSITION/STATUS/DATA OUTPUT MESSAGE

Motorola Binary Format

Response Message (Continued)

dd – current DOP	0, 0..999 (0.0 to 99.9 DOP)
(0.1 res)	(0 – not computable, or position-hold, or position prop)
t – DOP type	0 – PDOP (in 3D mode)
	1 – HDOP (in 2D mode)
Satellite visibility and tracking status	
n – num of visible sat	0 .. 12
t – num of sat tracked	0 .. 6
For each of six receiver channels	
i – sat ID	0 .. 37
m – channel tracking mode	0 .. 8
0 – Code Search	5 – Message Sync Detect
1 – Code Acquire	6 – Satellite Time Avail
2 – AGC Set	7 – Ephemeris Acquire
3 – Freq Acquire	8 – Avail for Position
4 – Bit Sync Detect	
s – Signal Strength	0 .. 255
(number proportional to SNR)	
d – Channel Status Flag	
Each bit represents one of the following:	
(msb)	Bit 7: Using for Position Fix
	Bit 6: Satellite Momentum Alert Flag Set
	Bit 5: Satellite Anti-Spoof Flag Set
	Bit 4: Satellite Reported Unhealthy
	Bit 3: Satellite Reported Inaccurate (>16 m)
	Bit 2: Spare
	Bit 1: Spare
(lsb)	Bit 0: Parity Error
(End of Channel Dependent Data)	
s – Receiver Status Message-	
(msb)	Bit 7: Position Propagate mode
	Bit 6: Poor Geometry (DOP > 20)
	Bit 5: 3D fix
	Bit 4: Altitude Hold (2D fix)
	Bit 3: Acquiring Satellites/Position Hold
	Bit 2: Differential
	Bit 1: Insufficient visible satellites (< 3)
(lsb)	Bit 0: Bad Almanac
C – checksum	
Message Length: 68 bytes	

VISIBLE SATELLITE STATUS MESSAGE

This command requests the results of the most current satellite alert computation. The response message gives a summary of the satellite visibility status showing the number of visible satellites, the Doppler frequency and location of the currently visible satellites (up to 12 satellites). The reference position for the most recent satellite alert is the current position coordinates. Note that these coordinates may not compare to the GPS receiver's actual position when initially turned on, since the GPS receiver may have moved a great distance since it was last used.

VISIBLE SATELLITE STATUS MESSAGE

Motorola Binary Format

Input Command Description

- *Request Visible Satellite Status:*

@@BbmC<CR><LF>

m – mode	0 – output response message once (polled)
	1 – output response message when visibility data changes
C – checksum	

Message Length: 8 bytes

Response Message

- *(to command)*

@@BbniddeaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaasC<CR><LF>

Sat Visibility Info –

n – number of visible sats	0 .. 12

For each visible satellite, up to n fields contain the following valid data –

i – satellite PN code ID	1 .. 32
dd – Doppler in Hz	-5000 .. 5000
e – elevation (deg)	0 .. 90
aa – Azimuth (degrees)	0 .. 359
s – satellite health	0 – healthy & not removed
	1 – healthy & removed
	2 – unhealthy & not removed
	3 – unhealthy & removed

C – checksum

Message Length: 92 bytes

xDOP TABLE STATUS MESSAGE

This command requests the xDOP parameters corresponding to combinations of currently visible satellites based on the latest satellite visibility calculation. The GPS receiver will send up to nine combinations of satellites with the corresponding xDOP parameter. The type of DOP is defined by the xDOP Type parameter, and the GPS receiver will compute xDOP of all combinations of satellites taken N at a time (GPS receiver is selected for N-in-View Position Fix mode) or for all satellites taken four at a time (GPS receiver is selected for Best-4 Position Fix mode).

xDOP TABLE STATUS MESSAGE

Motorola Binary Format

Input Command Description

- *Request xDOP Table Status:*

@@BcmC<CR><LF>

m – mode: 0 – output response message once (polled); 1 – output response message when data changes (continuous)

C – checksum

Message Length: 8 bytes

Response Message

- *(to command)*

@@Bctnmddssssssddssssssddssssssddssssssddssssssddssss ssddssssssddssssssddssssssC<CR><LF>

t – xDOP Type: 0 – GDOP; 1 – PDOP; 2 – HDOP; 3 – VDOP; 4 – TDOP

n – number of valid combinations: 0 . . 9

m – Best-4 or N-in-View: 4 or 6 or 8

For n valid combinations of satellites

dd – x DOP	10 .. 999
resolution 0.1	(1.0 .. 99.9)
ssssss – Sat Combo ID's	each s = 0 .. 32 for sat ID

C – checksum

Message Length: 82 bytes

Note: The number of valid "s" fields is given by m.

ALMANAC STATUS MESSAGE

This command requests the almanac status information corresponding to the currently used satellite almanac data (in RAM), as well as the almanac data currently stored in receiver nonvolatile memory (EEPROM). The GPS receiver captures a new almanac to internal RAM first and uses this data immediately to compute satellite visibility information. The receiver also copies the RAM data to nonvolatile EEPROM using a slow background process. Consequently, there is a delay between the receipt of a new almanac and copying the new one to EEPROM. The user is given status information on both almanac data sets.

ALMANAC STATUS MESSAGE

Motorola Binary Format

Input Command Description

- *Request Almanac Status Command:*

@@BdmC<CR><LF>

m – mode	0 – Output status once (polled)
	1 – Output status when RAM almanac data changes (continuous)
C – checksum	

Message Length: 8 bytes

Response Message

- *(to command):*

@@BdvwtassssvwtassssC<CR><LF>

RAM Almanac Status –	
v – Almanac valid flag	
0 – no almanac in receiver	
1 – valid almanac in receiver	
w – almanac week number (raw)	0 .. 255 (ICD-GPS-200 Ref)
t – time of almanac (raw)	0 .. 147 (ICD-GPS-200 Ref)
a – number of avail sats	0 .. 32
ssss – sat IDs in almanac	0 – SV not available
32 bit binary field, each bit represents one SVID (msb = SVID 32; lsb = SVID 1)	1 – SV included
EEPROM Almanac Status –	
v – almanac valid flag	0 – no almanac in receiver
	1 – valid almanac in receiver
w – almanac week number (raw)	0 .. 255 (ICD-GPS-200 Ref)
t – time of almanac (raw)	0 .. 147 (ICD-GPS-200 Ref)
a – number of avail sats	0 .. 32
ssss – sat IDs in Almanac	0 – SV not available
32 bit binary field, each bit represents one SVID (msb = SVID 32, lsb = SVID 1)	1 – SV included

C – checksum

Message Length: 23 bytes

ALMANAC DATA OUTPUT MESSAGE

This parameter determines the rate the almanac data is output. The user has the option of requesting the almanac data output one time (polled), or each time the almanac data changes (continuously). The almanac data output parameter set is stored in nonvolatile memory.

Almanac data for the GPS satellites is transmitted in words 3 through 10 of subframe 5 (pages 1 through 25), and words 3 through 10 of subframe 4 (pages 2 through 5, 7 through 10, and 25) of the satellite broadcast data message. The user is directed to the ICD-GPS-200 for specifics on the format of the almanac data.

The GPS receiver outputs the almanac data through a series of output messages, each of which is identified by the particular subframe and page. The data fields of each individual message corresponds to words 3 through 10 of the broadcast data. Each word contains 24 data bits.

The entire almanac data output consists of 34 output response messages corresponding to the 25 pages of subframe 5 and the 9 pages in subframe 4 that contain almanac data (pages 2 through 5, 7 through 10, and 25). The total message output for one output request is 1122 bytes including the @@Be prefix and the checksum / carriage return / line feed for each output. The output message begins with subframe 5 page 1.

The GPS receiver will output about 750 bytes of message data for each one second output opportunity. If selected, the almanac response message is output until the total number of bytes sent on a 1-second epoch exceeds 750. The remainder of the almanac message is sent on the next 1-second epoch (up to the 750 byte limit per second) until all of the almanac data is output.

If the user issues this command and the GPS receiver does not contain an almanac, then the GPS receiver returns one response message with the subframe and page bytes equal to zero.

ALMANAC DATA OUTPUT MESSAGE

Motorola Binary Format

Input Command Description

- *Set Almanac Data Output Rate:*

@@BemC<CR><LF>

m – mode: 0 – output response message once (polled)
1 – output response message when almanac data changes (continuous)

C – checksum

Message Length: 8 bytes

Response Message

- *(to command)*

@@Cbspxxxxx. . .xxxxC<CR><LF>

sp – subframe/page Number: sf 5 / pgs 1 – 25
or
sf 4 / pgs 2 – 5,
7 – 10, 25

xxx....xxx Words 3 - 10, each word is 3 bytes long (format per ICD-GPS-200)

C – checksum

Message Length: 33 bytes

Note: If no almanac is present in GPS receiver, then the receiver returns one output response message with the "sp" field set to 0, and all other bytes in the field set to 0.

INPUT EPHEMERIS DATA

This command will cause the receiver to accept satellite ephemeris data input via the RS-232 port. The receiver keeps the ephemerides decoded from all satellites in its nonvolatile memory as long as the 5/12V_BATT voltage is applied to the receiver, and the ephemerides are still valid (t-toe < 4 hours). However, the ephemeris data that the user inputs via the RS-232 port is only remembered until the next time the receiver power is cycled, or until it is replaced as a normal part of decoding new ephemeris data from a satellite. This is true even though the 5/12V_BATT voltage may have been applied during the receiver off period. The ephemeris-hold switch can be used to prevent the receiver from replacing the user input ephemeris with new data decoded from the satellites.

The input format is identical to the format output by the receiver for the output ephemeris command to allow the same ephemeris output file to be used by the receiver for an ephemeris input file. The receiver echoes the input ephemeris data format message so the user can validate the ephemeris data with the new user supplied ephemeris upon completion of the receipt of a valid ephemeris.

INPUT EPHEMERIS DATA

Motorola Binary Format

Input Command Description

- *Input satellite ephemeris data:*

@@Bfixxx...xxxC<CR><LF>

i – sat ID	1 .. 37
xxx ... xxx ephemeris	sf 1 – 3/words 3 – 10 (72 bytes per sat; format per ICD-GPS-200)
C – checksum	
Message Length: 80 bytes	

Response Message

- *(to command)*

@@Ccixxx...xxxC<CR><LF>

i – Sat ID	1 .. 37
xxx ... xxx ephemeris	sf 1 – 3/words 3 – 10 (72 bytes per sat; format per ICD-GPS-200)
C – checksum	
Message Length: 80 bytes	

SATELLITE RANGE DATA OUTPUT MESSAGE

NOTE: The input/output messages described here are available only if GPS receiver Option is installed.

This parameter determines the rate that basic satellite range and range-rate information for each of the satellites that the GPS receiver is tracking is output. The user has the option of requesting the satellite range data status one time (polled), or continuously at a user specified update rate. The selected rate is stored in the GPS receiver's non-volatile memory. If the GPS receiver was continuously outputting the satellite range data output when turned off, it will begin to output this message continuously (at the selected update rate) again when power is reapplied.

If the GPS receiver has its Idle mode option enabled, this parameter selection does not exist, and the GPS receiver outputs the last known valid Range Data Output information once when polled.

Two bits in each of the channel tracking mode words of the response message are used to denote whether or not the channel has lost phase lock or frequency lock since the last output of this message. This information is helpful for users who perform post-processing and it eliminates the need to output this message at a one second rate.

The channel tracking mode in this response message is not necessarily the same as the channel tracking mode in the Position/Status/Data Output Message. When the receiver is not using the channel as part of the position fix solution, the GPS satellite time (Integrated Carrier Phase Filtered) will be zero, and the channel tracking mode will report mode 4 or lower. When the receiver is using the channel as part of the position fix solution (modes 5 through 8 after reaching mode 8 once), the GPS satellite time (Integrated Carrier Phase Filtered) will be valid, and the channel tracking mode will be the same as the channel tracking mode in the Position/Status/Data Output Message.

SATELLITE RANGE DATA OUTPUT MESSAGE
Motorola Binary Format

Input Command Description

- *Set response message rate:*

@@BgmC<CR><LF>

m - mode
0 - output response message once (polled)
1..255 - response message output at indicated rate (continuous)
1 - once per second
2 - once every two seconds
255 - once every 255 seconds

C - checksum
Message Length: 8 bytes

Response Message

- *(to command)*

@@Bgtttffffimsssffffccffrrrddimsssffffcc
ffrrddimsssffffccffrrrddimsssffffccffrrr
ddimsssffffccffrrrddimsssffffccffrrrddC
<CR><LF>

Response Message Continued on Following Page

SATELLITE RANGE DATA OUTPUT MESSAGE

Motorola Binary Format

Response Message (Continued)

ttt - GPS local time in seconds 0 .. 604799
ffff - GPS local fractional time in ns 0 .. 0.999999999
resolution - 1 ns
(0 .. 0.999999999)

For each of six channels:
i - satellite ID 0 .. 32
0 - channel not used
1 - 32 satellite ID

m - channel tracking mode where bits 0 - 3 are decoded as
0 - code search
1 - code acquire
2 - AGC set
3 - frequency acquire
4 - bit sync detect
5 - message sync detect
6 - sat time available
7 - ephemeris acquire
8 - avail for position
where bit 6 is decoded as
0 - frequency locked since last range message
1 - not frequency locked since last range message
and where bit 7 (MSB) is decoded as
0 - phase locked since last range message
1 - not phase locked since last range message
sssffff - GPS satellite time (Integrated Carrier Phase Filtered)
sss - integer part 0 .. 604799
(resolution - 1 sec)
ffff - fractional part 0 .. 999,999,999
(resolution - 1 nsec) (0 .. 0.999999999)
ccff - integrated carrier phase
cc - integer part 0 .. 65535
16 MS bits of carrier (cycles)
phase (above decimal point)
ff - fractional part 0 .. 65535
16 bits of carrier NCO (0 .. 359.9945 degrees)
below decimal point at
measurement epoch
rrr - raw code phase (carrier cycles) 0 .. 1575420
dd - code discriminator -32,768 .. 32767
output at measurement epoch
LSB = (2^{-12})* SOL*0.001/28644 meters
C - checksum
Message Length: 122 bytes

In the discussions that follow, the subscript $(_k)$ refers to the current measurement data, and the subscript $(_{k-1})$ refers to the previous (1 second old) data.
The user can convert the above message into pseudorange and pseudorange rate for each satellite by using the following formulas:

Conversion Formulas on Following Page

SATELLITE RANGE DATA OUTPUT MESSAGE

Motorola Binary Format

Conversion Formulas

Pseudorange (in meters) = (GPS local time - GPS satellite time) * SOL

Note: Not corrected for possible End-Of-Week Rollovers.

Pseudorange rate (in meters per second) = K2 * (ICP_k - ICP_{k-1})

ICP is the integer and fractional part of ICP treated as a 32 bit unsigned quantity. Use 32 bit unsigned integer subtraction to avoid rollovers.

Absolute carrier phase at measurement epoch in degrees = K4 * ICP_f

The GPS satellite time used in the first equations for the computation of pseudorange is the same value that the Oncore uses internally. This satellite time value combines code and carrier information and has been pre-smoothed using carrier aided filtering with a very narrow-band (0.005 Hz) low-pass filter algorithm. The user has access to the unfiltered raw code phase via the following:

Raw Code Phase (in meters) = K1 * RCP - K2 * ICP_f + K3 * K5 * CD
where:
RCP is the raw code phase from the message
ICP_f is the fractional part of the integrated carrier phase
CD is the code discriminator output from the message
K5 is a variable code discriminator calibration constant

Code discriminator calibration constant: When tracking satellites, the receiver causes the raw code phase to move back and forth once per second in discrete steps of 1 code phase quantum. One code phase quantum is equal to 55 carrier cycles, or about 10.4662 meters. This intentional dither allows the receiver to calibrate the output of the code discriminator.

The user can accurately calibrate the code discriminator output by using the fact that the long term average difference between subsequent code discriminator measurements will be equal to 1 quantum. K5, the calibration constant, varies slowly over time as a function of received signal to noise ratio and multipath. Typical values of K5 are between 0.5 and 1.5. A simple low-pass filter can be used to generate K5 as follows:

diff = K3 * abs (CD_k - CD_{k-1})
CD_{k-1} = CD_k
LPF = LPF + beta * (diff - LPF) (initialize LPF = 10.4662 meters)
K5 = 10.4662/LPF

The constant "beta" establishes the filter time constant. Typical values of beta are 0.001 (maximum filtering) to 0.5 (minimum filtering). The Oncore uses a constant of 0.05 internally.

OTHER FIXED CONSTANTS:

L1F0 = 1,575,420,000.0 Hz (L1 carrier frequency)
SOL = 299,792,458.0 m/s (GPS value for the speed of light)
K1 = SOL / L1F0
K2 = K1 / 65536
K3 = (2^{-11}) * SOL * 0.001 / 28644
K4 = 360 / 65536

OUTPUT PSEUDORANGE CORRECTION OUTPUT MESSAGE

This parameter sets the rate the pseudorange correction status is output from the GPS receiver.

The pseudorange correction response message allows the GPS receiver to be used as a master site receiver in a real-time differential system. The message is structured to return a pseudo-range and pseudorange rate correction for up to six receiver channels, and identifies the satellite ID that corresponds to each channel. To use this output properly, the GPS receiver must have the position-hold option enabled with the current GPS receiver position entered into the position-hold-position coordinates. The assignment of satellites to channels is accomplished during normal receiver operation (or may done manually).

If the GPS receiver is in the Idle mode, the GPS receiver outputs the last known valid Pseudorange Correction response message only when polled.

For an eight channel receiver, two consecutive messages are output with the data for the seventh and eigth channels in the second message. The rest of the channel data in the second message is filled with zeros.

OUTPUT PSEUDORANGE CORRECTION OUTPUT MESSAGE

Motorola Binary Format

Input Command Description

- *Set response rate:*

@@BhmC<CR><LF>

m - mode	0 - output response message (once polled) 1 .. 255 - response message output at indicated rate (continuous) 1 - once per second 2 - once every two seconds 255 - once every 255 seconds
C - checksum	
Message Length: 8 bytes	

Response Message

- *(to command):*

@@Cetttippprrdippprrdippprrdippprrdippprrdippprrd C<CR><LF>

ttt - GPS time ref	0 .. 6047999 (0.0 ..604799.9)
i - Satellite ID 0 = not used 1 - 32 = Sat ID	0 .. 32

For each of six channels:

ppp -pseudorange correction 0.01 meter resolution	-1,048,576 ..+1,048,576 (-10,485.76 .. +10,485.76)
rr - pseudorange rate correction 0.001 m/s resolution	-4096 .. +4096 (-4.096 .. +4.096)
d - issue of data ephemeris	0 .. 255

C - checksum

Message length: 52 bytes

EPHEMERIS DATA OUTPUT MESSAGE

This parameter determines the rate that satellite ephemeris data is output. The user has the option of requesting the ephemeris data output one time (polled), or each time the satellite ephemeris data changes (continuously). The GPS receiver remembers the last rate of the satellite ephemeris data output (with 5/12V_BATT signal applied) when turned off.

Ephemeris data for each of the GPS satellites is contained in subframes 1, 2, and 3, words 3 through 10. Each satellite transmits the ephemeris data for itself only. The user is directed to the ICD-GPS-200 for specifics on the format of the ephemeris data.

When polled, the GPS receiver outputs a complete Ephemeris Data Output Message for each of the satellites that the receiver is currently using for position fix. When requested continuously, the GPS receiver outputs the current ephemerides once for all satellites currently tracked, then outputs individual channel ephemerides again any time the ephemerides on that channel change.

The GPS receiver outputs the ephemeris data through a series of output messages, each of which corresponds to a particular satellite. The data fields of each message corresponds to words 3 through 10 of subframes 1 through 3. Each word contains 24 data bits.

The GPS receiver will output about 750 bytes of message data for each one-second output opportunity. If selected, the ephemeris response message is output for each satellite that is currently tracked until the total number of bytes sent on a one-second epoch exceeds 750. The remainder of the ephemeris message is sent on the next one-second epoch (up to the 750 byte limit per second) until all of the ephemeris data for all satellites is output.

EPHEMERIS DATA OUTPUT MESSAGE

Motorola Binary Format

Input Command Description

- *Set Response Message Rate:*

@@BimC<CR><LF>

m – mode	0 – output response message once (polled)
	1 – output response message when ephemeris data changes (continuous)
C – checksum	

Message Length: 8 bytes

Response Message

- *(to command):*

@@Bfixxxxx...xxxxC<CR><LF>

i – Sat ID	1 .. 37
xxx ... xxx - Ephemeris	sf 1 – 3 / words 3 – 10
	(72 bytes per sat; format ICD-GPS-200)
C – checksum	

Message Length: 80 bytes

Note: The GPS receiver returns one output response message for each of the currently tracked satellites. For example, if the GPS receiver is currently tracking five satellites, five output response messages will be sent by the receiver, one for each satellite.

LEAP SECOND PENDING STATUS MESSAGE

This command causes the receiver to send a message to the user indicating the status of any pending leap second correction to UTC time due at the end of the current month. If a leap second correction is pending, the direction of the correction is also indicated. This is a polled-only output message.

Leap seconds are occasionally inserted in UTC time and generally occur on midnight UTC June 30 or midnight UTC December 31. The GPS control segment notifies GPS users of pending leap second insertions to UTC time several weeks before the event via a special broadcast message in the satellite downlink message. The receiver decodes this data and then inserts the time correction in the appropriate one-second time bin.

LEAP SECOND PENDING STATUS MESSAGE

Motorola Binary Format

Input Command Description

@@BjmC<CR><LF>

m-mode	0-output response message once polled
C – checksum	
Message Length: 8 bytes	

Response Message

@@BjmC<CR><LF>

m – message	0 – No leap second pending
	1 – Addition of 1 second pending
	2 – Subtraction of 1 second pending
C – checksum	

Message Length: 8 bytes

POSITION/STATUS/DATA EXTENSION MESSAGE

This message contains information that can be considered an extension of the data output in the Position/Status/Data message (@@Ba). Some users may have applications requiring use of this data at the same rate as the Position/ Status/Data message while other users may only need portions of this data at a much slower rate (e.g., magnetic variation).

Magnetic variation can be used to correct the true north heading (see Position/Status/Data Message) to magnetic north. The correction is computed using an algorithm developed by the U.S. Naval Oceanographic Office. It is based on the WMM-95 (World Magnetic Model 1995) magnetic field model which was generated from actual field measurements and is valid until January 1, 2000. Another table will be available from the U.S. Defense Mapping Agency (DMA) at that time. The algorithm primarily characterizes that portion of the Earth's magnetic field which is generated by the Earth's conducting fluid outer core. Portions of the geomagnetic field generated by the Earth's crust, mantle, ionosphere, and magnetosphere are for the most part not represented in these models. Consequently, a magnetic sensor such as a compass or magnetometer may observe spatial and temporal magnetic anomalies when referenced to the appropriate World Magnetic Model. In particular, certain local, regional, and temporal magnetic declination anomalies can exceed 10 degrees. Anomalies of this magnitude are not common, but they do exist. Declination anomalies on the order of 2 or 3 degrees are not uncommon, but are of small spatial extent and relatively isolated. From a global perspective, the root-mean-square (RMS) error at sea level of the World Magnetic Model are estimated to be less than 1.0 degrees over the entire 5-year life of the model.

POSITION/STATUS/DATA EXTENSION MESSAGE
Motorola Binary Format

Input Command Description

- *Request extension message:*

@@BkmC<CR><LF>

m – mode	0 – output response message once (polled)
	1 .. 255 – output response message at indicated rate (continuous)
	1 – once per second
	2 – once every two seconds
	255 – once every 255 seconds
C – checksum	
Message Length: 8 bytes	

Response Message

- *(to command):*

@@Bkggpphhvvttmmnneeuuaaxxxxyyyyzzzzrrrrriiiii iiiiiiiiiiiiiccooC<CR><LF>

Note: DOP values are NOT valid if in position hold mode.

Current GDOP gg –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 3D Fix mode)
Current PDOP pp –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 3D Fix mode)
Current HDOP hh –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 2D or 3D Fix mode)
Current VDOP vv –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 3D Fix mode)
Current TDOP tt –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if tracking at least one satellite)
Magnetic variation mm –	–1800 to +1800 (–180.0° to +180.0°) resolution = 0.1 positive angles are east negative angles are west
Velocity in north, east, up coordinate system nn –	north – 32767 to 32767 (m/s) resolution = 0.1
ee –	east – 32767 to 32767 (m/s) resolution = 0.1
uu –	up – 32767 to 32767 (m/s) resolution = 0.1

Response Message Continued on Following Page

POSITION/STATUS/DATA EXTENSION MESSAGE

Motorola Binary Format

Response Message (Continued)

Age of differential correction data (for slave receiver)

aa –	0 to 65535 resolution 0.1s

Receiver position in ECEF coordinate system (X, Y, Z)

xxxx –	resolution = 0.01 meters
yyyy –	resolution = 0.01 meters
zzzz –	resolution = 0.01 meters

URA for each of six receiver channels (6 elements)

r –	as decoded from the GPS satellite message (0–15 is valid URA, 63 if not decoded yet) see NAVSTAR GPS-ICD-200 Section 20.3.3.3.1.3

Least Squares A–1 Symmetrical Matrix element (10 elements)

ii –	A–1 Matrix element where element #1 is A–1[0][0] element #2 is A–1[0][1] element #3 is A–1[0][2] element #4 is A–1[0][3] element #5 is A–1[1][1] element #6 is A–1[1][2] element #7 is A–1[1][3] element #8 is A–1[2][2] element #9 is A–1[2][3] element #10 is A–1[3][3] resolution = 0.1 (unitless)

Receiver clock bias

cc –	–32767 to +32767 (in meters) resolution = 0.1

Receiver oscillator offset

oo –	0 to 65535 (in m/s) resolution = 0.1

C – checksum

Message Length: 69 bytes

SATELLITE BROADCAST DATA MESSAGE

The Global Positioning System satellites each broadcast a 50 bits per second (BPS) data message called the Navigation data. The structure of each satellite data message consists of 1500 bits (transmission time is 30 seconds) distributed across 5 subframes (6 seconds each). Each subframe is further subdivided into ten 30 bit words, where each word consists of 24 bits of data and 6 bits of parity. Subframes 4 and 5 are commutated over 25 pages spread over 12.5 minutes.

The data transmitted by the satellites consists of satellite Keplerian orbital elements (ephemerides), almanac data, telemetry word, hand-over word, ionospheric correction data, satellite health data, UTC time correction data, special message fields, etc. More information on the content of the message is provided in the Navstar GPS Space Segment/Navigation User Interface Control Document ICD-GPS-200.

Only the 24 data bits of each word is output. The 6 parity bits from each word are not output but are used to verify the contents of the data field internal to the receiver. The receiver collects each subframe (6 seconds of data) and then outputs the data on the serial port after successful receipt of all 10 words of a particular subframe for each satellite tracked.

No format conversion is applied to the data; it is output in its raw binary form for subsequent processing outside the receiver.

If the user selects the satellite broadcast data in the continuous output mode, the receiver outputs a single satellite broadcast data message record for all channels for the current subframe after word ten of that subframe has been collected. Consequently, in continuous mode, the receiver outputs one message per satellite approximately every six seconds (the subframe transmission rate). Data being output for any channel will output data for all channels (active or inactive).

If the user selects satellite broadcast data in the polled output mode, the receiver outputs a single satellite broadcast data record for all satellites tracked for the current subframe after word ten of that subframe has been collected. No other data is output after that time unless the user selects the data to be output again in the polled or continuous modes.

For either case, the GPS receiver outputs the broadcast data through a series of output messages, each of which is identified by the particular channel, satellite ID (PRN number), subframe, and when appropriate, the page number (subframes 4 and 5 only).

The entire broadcast data output message consists of N output response messages corresponding to the N receiver channels.

If the user requests the satellite broadcast data message and the receiver does not properly receive the next subframe of data, only the valid words will be output with the remaining fields set to zero.

SATELLITE BROADCAST DATA MESSAGE

Motorola Binary Format

Input Command Description

- *Request Broadcast message:*

@@BlmC<CR><LF>

(Note: The second character is a lower case "L" not the number "1")

m - mode	0 - Output Next Subframe Data when collected (polled)
	1 - Output Next and Subsequent data Messages (continuous)
C - checksum	
Message Length: 8 bytes	

Response Message

- *(to command)*

- ***@@Bl****cispxxxxx...xxxxC<CR><LF>*

c - channel number	1 .. 8
i - Satellite ID	0 . . 32
	0 = channel not used
	1-32 = sat ID
s - Subframe number/ valid words where bits 0-2 (i.e. the LS nibble) are decoded as:	0 = no subframe
	1-5 = subframe
where bits 4-7 (i.e. the MS nibble) are decoded as:	0-10 = number of contiguous, valid words starting at word 1
p - Page number	0 .. 25
	0 = no page number
	1-25 = page number
xxx....xxx -	Data Words 1 - 10, each word is 3 bytes long (Format per ICD-GPS-200)
C - checksum	
Message Length: 41 bytes	

Note: If a particular channel of the receiver is not assigned to a satellite, then the satellite PRN ID field (i) will be set to zero. If the receiver cannot decode any single word of a particular subframe, then the subframe number, page number, and data word fields will all be set to zero for that particular subframe. Since the data words represent the stream of contiguous data starting at word one, the VALID_WORDS field represents the number of valid words of data starting with one through the word number indicated by the VALID_WORDS parameter. The last (10 - VALID WORDS) three-byte-words will be zero.

6 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

NOTE: The input/output messages described here are available only if GPS receiver option I is installed.

The GPS receiver uses the Time RAIM algorithm to exploit redundancy in the GPS time solution in order to detect and isolate faulty satellites. The Time RAIM Setup and Status Message allows the user to change the update rate, the configuration for the 1PPS output, and the Time RAIM alarm limit.

The rate parameter instructs the GPS receiver to either output this message one-time (polled), or to output this message at the indicated update rate (continuously). If the message rate is the same as the 1PPS rate, then the message and the 1PPS pulse are synchronized. Once the GPS receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time output request. The GPS receiver will output the message one more time, then terminate any further message outputs. The state of the rate parameter is stored in nonvolatile memory. If the GPS receiver was continuously outputting the message when turned off, it will begin to output this message continuously (at the selected rate) again when power is reapplied. If the GPS receiver has its Idle Mode option enabled, the rate parameter selection is unavailable, and the GPS receiver outputs the last valid message once when polled.

The state of the rate byte is stored in RAM. If the GPS receiver was continuously outputting the message when turned off and backup power is applied, then it will begin to output this message continuously (at the selected update rate) again when the main power is reapplied. If backup power is not applied during power down, then the GPS receiver will start up with a default rate of zero. The other Time RAIM control parameters are also stored in RAM, so they will be reset to their default values if backup power is not applied during power down.

The pulse generation can be controlled with the 1PPS control mode byte. The pulse can be on all the time, off all the time, on only when the receiver is tracking at least one satellite, or on only when the time solution is within the alarm threshold.

The number of satellites appearing in the table below are the minimum which must be tracked to ensure the detection, isolation, and removal of faulty satellites. The probability of detection and isolation of a faulty satellite is greater than 99.99%, which corresponds to less than one missed detection every 10,000 failures. Given the infrequency of GPS satellite failures, this makes a missed detection virtually impossible. The probability of a false alarm is less than 2.e-4%, which coresponds to less than one false alarm every 5.7 days. Given that lock is maintained on eight satellites, the time alarm can be set as low as 300 ns without compromising performance.

Time Alarm (ns)	SVs needed to detect	SVs needed to isolate
T >1000	2	3
1000 > T > 700	3	3
700 > T > 500	4	4
500 > T > 300	4	8
300 > T > 250	8*	8*

*The minimum time required false alarm rate of 2.e-4% cannot be achieved for this time alarm range.

6 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

Motorola Binary Format

The Time RAIM Setup and Status Message outputs the status of the Time RAIM solution when the algorithm is on. This messaage also outputs several values relating to the Time RAIM solution.

The receiver can make an estimate of the overall accuracy of the time solution. The one sigma accuracy estimate is computed using the residuals of the least-squares time solution. This number is a measure of the spread of the observations, not an estimate of the absolute time accuracy.

The underlying noise due to the granularity of the clock generating the 1PPS signal is deterministic on every pulse. The receiver computes and outputs the negative sawtooth residual so that the user can compensate for the error and remove granularity.

Finally, the time solution of each individual satellite is output.

Default values:	Time RAIM algorithm	off
	Time RAIM alarm limit	1000 ns
	1PPS control mode	setting 1

6 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

Motorola Binary Format

Input Command Description

- Send current Time RAIM Setup and Status:

@@BnxxxxxxxxxxxxxxxC<CR><LF>

x	15 out af range bytes	$ff ff ff ff...
C	checksum	

Message length: 22 bytes

- Change current Time RAIM Setup:

@@BnotaapxxxxxxxC<CR><LF>

o	output message rate	0 .. 255 0 = output response message once (polled) 1..255 = response message output at indicated rate (continuous) 1 = once per second 2 = once every two seconds 255 = once every 255 seconds
t	Time RAIM algorithm on/off	0 = off 1 = on
aa	Time RAIM alarm limit in 100s of nanoseconds	3 .. 65535
p	1PPS control mode	0 = 1PPS output pulse is off all the time 1 = 1PPS on all the time 2 = pulse active only when tracking at least one satellite 3 = pulse active only when Time RAIM algorithm confirms time solution error is within the user defined alarm limit
nnn	not used	0
mdyyhms	not used	0
C	checksum	

Message length: 22 bytes

Response Message

- *(to either command):*

@@Bnotaapnnnmdyyhmspysreensffffsffffsffffs
ffffsffff$ffffC<CR><LF>

o	output message rate	0 .. 255
t	Time RAIM algorithm on/off	0 = off 1 = on
aa	Time RAIM alarm limit in 100s of nanoseconds	3 .. 65535

Response Message Continued on Following Page

6 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

Motorola Binary Format

Response Message (Continued)

p	1PPS control mode	0 = 1PPS output pulse is off all the time 1 = 1PPS on all the time 2 = pulse active only when tracking at least one satellite 3 = pulse active only when Time RAIM algorithm confirms time solution error is within the user defined alarm limit
nnn	1PPS output rate	0 .. 86400
mdyyhms	time to next fire	
	m months	0 .. 12
	d days	0 .. 31
	yy years	1980 .. 2079
	h hours	0 .. 23
	m minutes	0 .. 59
	s seconds	0 .. 60
p	pulse status	0 = off 1 = on
y	1PPS pulse sync	0 = pulse referenced to UTC 1 = pulse referenced to GPS time
s	Time RAIM solution status	0 = OK: solution within alarm limits 1 = ALARM: user specified limit exceeded 2 = UNKNOWN: due to ... a) alarm threshold set too low b) Time RAIM turned off c) insufficient satellites being tracked
r	Time RAIM status	0 = detection and isolation possible 1 = detection only possible 2 = neither possible
ee	time solution one sigma accuracy estimate in nanoseconds	0 .. 65535
n	negative sawtooth time error of next 1PPS pulse in nanoseconds	-128 .. 127

For each of six receiver channels

s	satellite ID	0 .. 37
ffff	fractional GPS local time estimate of satellite in nanoseconds	0 .. 999999999

C	checksum Message length: 59 bytes	

SELF-TEST

The GPS receiver user has the ability to initiate an extensive self-test. The tests that are accomplished during the commanded self-test are as follows:

ROM checksum
RAM
EEPROM
Correlator IC
SPI port comm with DCXO
SPI port comm with RTC and Time increment
SCI comm is verified operational if the RS232 port is active

The output of the self-test command is a 16-bit field, where each bit of the field represents the go/no-go condition of the particular item tested.

SELF-TEST
Motorola Binary Format

Input Command Description

- *Initiates Self-Test:*

@@CaC<CR><LF>

C – checksum

Message Length: 7 bytes

Response Message

- *(to command)*

@@CaxxC<CR><LF>

xx – self test result

Each bit of the self-test result field is either zero (pass) or one (fail) and represents the result of the following tests:

(msb)	Bit 15:	Spare
	Bit 14:	Spare
	Bit 13:	RTC Comm & Time
	Bit 12:	DCXO SPI Comm
	Bit 11:	EEPROM
	Bit 10:	RAM MSByte
	Bit 9:	RAM LSByte
	Bit 8:	ROM MSByte Checksum
	Bit 7:	ROM LSByte Checksum
	Bit 6:	1 KHz Presence
	Bit 5:	Channel 6 Correlation test
	Bit 4:	Channel 5 Correlation test
	Bit 3:	Channel 4 Correlation test
	Bit 2:	Channel 3 Correlation test
	Bit 1:	Channel 2 Correlation test
(lsb)	Bit 0:	Channel 1 Correlation test

C – checksum

Message Length: 9 bytes

INPUT ALMANAC DATA

This input data utility command installs an almanac into the receiver's nonvolatile memory. This command will cause the GPS receiver to accept an almanac data file via its RS232 port. The entire almanac data message consists of 34 unique formatted messages that correspond to the subframe and page number of the almanac data (see the GPS-ICD-200 for format description).

The GPS receiver echoes the input almanac data subframe and page numbers of messages received so that the user can validate that each almanac slice has been accepted. The Oncore GPS receiver will collect an entire almanac in local storage, then check the almanac for validity. The receiver will update the internal almanac data with the new user-supplied almanac upon completion of the receipt of a valid almanac.

Upon completion of the receipt of a valid almanac, the GPS receiver outputs an almanac status message (see Almanac Status). This output verifies that the almanac was accepted and is currently being used for satellite visibility and DOP computations. Upon completion of the storage of the new almanac to nonvolatile memory (EEPROM), the GPS receiver will output another almanac status message to verify successful storage of the almanac.

Any single input message that has an invalid subframe (i.e., not 4 or 5) will reset the almanac collection software so that the local collection of almanac data can begin fresh. Subframe 5 page 1 marks the beginning message and resets the collection process. The data for subframe 5 page 1 must appear first in the string of 34 commands that make up the total almanac input data. Order for the remaining data is not important.

At 9600 baud, the user can insert up to about 1K of data per second into the RS232 port. Consequently, the user should be aware that the 34 total messages that make up the almanac data will take longer than 1 second to input into the receiver. Also, the output response message to each input is limited by the 750 maximum byte transfers per second. As a result, the GPS receiver will take several seconds to operate on all 34 input almanac data commands.

If the GPS receiver is currently storing an almanac when the user inputs another almanac, the GPS receiver will complete the storage of the first almanac to nonvolatile memory before accepting the new user input almanac.

INPUT ALMANAC DATA
Motorola Binary Format

Input Command Description

@@Cbspxxx...xxxC<CR><LF>

sp – Subframe/Page Number	sf 5 / pgs 1 – 25 or sf 4 / pgs 2 – 5, 7 – 10, 25
xxx....xxx	words 3 – 10, each word is 30 bits long (Format per ICD-GPS-200)

C – checksum

Message Length: 33 bytes

Response Message

- *(to each of 34 commands):*

@@ChspC<CR><LF>

sp – Subframe/Page Number	sf 5 / pgs 1 – 25 or sf 4 / pgs 2 – 5, 7 – 10, 25

C – checksum

Message Length: 9 bytes

ALERT-PLANNING

This utility command allows the user to compute satellite visibility information for other locations than the GPS receiver's current location. This can be accomplished in either the Idle or the Position Fix modes. The input command allows the user to specify the date, time, location, satellite mask angle, and GMT time correction to compute the satellite visibility information, and the output response message returns satellite elevation, azimuth, and Doppler information for up to 12 visible satellites as well as DOP vs satellite selection combinations for up to 9 different combinations. The receiver uses the current datum ID, Satellite Ignore List, Position Fix Algorithm Type, and xDOP Computation Type parameters in order to compute the Alert Plan.

The time the GPS receiver requires to compute the output response message is a function of the current loading on the Oncore GPS receiver CPU. The response message will be output much faster if the GPS receiver is placed in the Idle mode before the input command string is entered. Otherwise, the output message is made available when there is sufficient time for the GPS receiver to process the input command and compute the output visibility data. The user can build a visibility vs time table by inputting alert request commands, one at a time, that increase the time parameter at some constant rate (i.e., every 15 minutes).

ALERT-PLANNING
Motorola Binary Format

Input Command Description

- *Initiate Alert-Planning:*

@@CdmdyyhmsggaaaaoooohhmC<CR><LF>

Date	
m – month	1..12
d – day	1..31
yy – year	1980 .. 2079
Time-	
h – hours	0 .. 23
m – minutes	0 .. 59
GMT Correction-	
s – sign of GMT corr	00 – positive ff – negative
gg – GMT Corr (hrs,min)	
hrs:	0 .. 12
min:	0 .. 59
Position-	
aaaa – latitude in msec	-324000000..324000000 (-90° - +90°)
oooo – longitude in msec	-648000000..648000000 (-180° – +180°)
hh – height in meters	-1000 .. 18000
Satellite Mask Angle –	
m – Sat Mask Angle in deg	0 .. 89
C – checksum	
Message Length: 27 bytes	

Note: The response message to an alert-planning command with at least one out-of-range input parameter is to return all fields of the response message below zero-filled. In addition, the response is zero filled when no almanac is present in the Oncore GPS receiver.

Response Message

- *(to command)*

@@Cdmdyyhmniddeaasiddeaasiddeaasiddeaasiddeaa
siddeaasiddeaasiddeaasiddeaasiddeaasiddeaasid
deaastddssssssddssssssddssssssddssssssddsssss
sddssssssddssssssddssssssddssssssC<CR><LF>

Date –	
m – month	1..12
d – day	1..31
yy – year	1980 .. 2079

Response Message Continued on Following Page

ALERT-PLANNING
Motorola Binary Format

Response Message (Continued)

Time –	
h – hours	0 .. 23
m – minutes	0 .. 59
Sat Visibility Info –	
n – number of visible sats	0 .. 12
(for each visible sat, up to n fields contain valid data)	
i – satellite PN code ID	1 .. 32
dd – Doppler in Hz	-5000 .. 5000
e – elevation (degrees)	0 .. 90
aa – Azimuth (degrees)	0 .. 359
s – sat health	0 – healthy 1 – removed from sv sel 2 – unhealthy
xDOP vs Satellite Selection Info (up to 9 combinations) –	
t – xDOP type	0 – GDOP 1 – PDOP 2 – HDOP 3 – VDOP 4 – TDOP
dd – DOP (0.1 resolution)	0,10 .. 999 (0,1.0 .. 99.9) dd = 0 if the combination is not valid
ssssss – SVID per chan	each s = 0 .. 32 for sat ID (zero indicates chan not used)
C – checksum	
Message Length: 171 bytes	

INPUT PSEUDORANGE CORRECTION

NOTE: The input/output messages described here are available only if GPS receiver Option B is installed.

Enabling this option allows the GPS receiver to accept pseudorange correction messages from a differential master site receiver. The input message is structured to accept pseudorange and pseudorange-rate corrections for up to six satellites. The slave receiver uses the corrections in the input message by associating the satellite ID with the corresponding satellite (channel) that the slave is tracking. The user can specify up to 12 satellite corrections through the use of two back-to-back input commands.

INPUT PSEUDORANGE CORRECTION
Motorola Binary Format

Input Command Description

- *Enable Pseudorange Correction (for up to six sat):*

@@CetttipppprrdipppprrdipppprrdipppprrdipppprrdipppprrdC<CR><LF>

ttt – GPS time ref	0 .. 6047999 (0.0 .. 604799.9)
i – Sat ID	0..37
	0 = not used
	1-37 = sat ID
ppp – pseudorange corr	-1,048,576 ..+1,048,576
0.01 meter resolution	(-10485.76 ..+10485.76)
rr – pseudorange-rate corr	-4096 .. 4096
0.001 m/s resolution	(-4.096 .. 4.096)
d – issue of data ephemeris	0 .. 255
C – checksum	

Message Length: 52 bytes

Response Message

- *(to command):*

@@CkC<CR><LF>

C – checksum

Message Length: 7 bytes

SET-TO-DEFAULTS

This utility sets all the GPS receiver parameters to their factory default values. Performance of this utility results in all continuous messages being reset to polled output, clears pseudorange corrections contained in the GPS receiver, places receiver in idle mode, and clears almanac/ephemeris data. However, the time and date stored in the internal real-time clock is not changed by performance of this utility.

SET-TO-DEFAULTS
Motorola Binary Format

Input Command Description

- *Set Oncore GPS receiver to default values:*

@@CfC<CR><LF>

C – checksum

Message Length: 7 bytes

Response Message

- *(to command):*

@@CfC<CR><LF>

C – checksum

Message Length: 7 bytes

POSITION FIX/IDLE MODE OPTION

This utility allows the user to place the GPS receiver into one of two operating modes: Position Fix mode or Idle mode. The Position Fix mode is the normal operating mode of the GPS receiver in which it acquires and tracks satellites and computes position from the satellite measurements. The Idle mode is a reduced power mode in which the GPS receiver does not track satellites. The receiver's MPU is active only while it operates on input commands and creates output response messages. All other times, the receiver is placed in a low-power wait-state in which it waits for the next command string to be entered via the RS232 port.

Default value: Idle

POSITION FIX/IDLE MODE OPTION
Motorola Binary Format

Input Command Description

- *Select Operating Mode:*

@@CgmC<CR><LF>

m – mode	0 – Go to Idle mode
	1 – Go to Position Fix Mode
	2 – Send current receiver Mode

C – checksum

Message Length: 8 bytes

Response Message

- *(to command)*

@@CgmC<CR><LF>

m – mode	0 – Idle Mode
	1 – Position Fix Mode

C – checksum

Message Length: 8 bytes

Note: The response message is output when the GPS receiver reaches the desired mode. For example, if the GPS receiver is in the Position Fix mode and the user issues the Idle mode command, the response message occurs only after the GPS receiver is configured into the low-power Idle mode. This can take several seconds, depending on the current status of the GPS receiver. For example, if the receiver is storing almanac data to its internal nonvolatile memory (EEPROM), the Idle mode will be reached only after the completion of the storage of the data, which may take 12 seconds to accomplish.

SWITCH I/O FORMAT

This utility command switches GPS receiver from Motorola binary format to one of the other embedded formats.

SWITCH I/O FORMAT

Motorola Binary Format

Input Command Description

- *Select I/O format:*

@@CimC<CR><LF>

m – format	1 – NMEA-0183 Format
	2 – LORAN Emulation Format
C – checksum	

Message Length: 8 bytes

Response Message

- *(to command):*

NOTE: There is no response message to this input command. The GPS receiver configures the RS232 port parameters (baud rate, start bits, stop bits, etc.) to the selected format, and input commands are recognized in this new format only.

RECEIVER ID COMMAND STRING

The GPS receiver outputs an ID message upon request. The information contained in the ID string is self-explanatory.

RECEIVER ID
Motorola Binary Format

Input Command Description

- Poll Receiver ID string:

`@@Cj`C<CR><LF>

C checksum
Message length: 7 bytes

Response Message

- *(to command):*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
@	@	C	j	(cr)	(lf)	C	O	P	Y	R	I	G	H	T		1	9	9	1	-	1	9	9	x	1
	M	O	T	O	R	O	L	A		I	N	C	.	(cr)	(lf)	S	F	T	W		P	/	N		2
#		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	(cr)	(lf)	S	O	F	T	W	A	3
R	E		V	E	R		#		X	X	X	X	X	X	X	X	X	X	X	(cr)	(lf)	S	O	F	4
T	W	A	R	E		R	E	V		#		X	X	X	X	X	X	X	X	X	X	X	(cr)	(lf)	5
S	O	F	T	W	A	R	E		D	A	T	E			X	X	X	X	X	X	X	X	X	X	6
X	(cr)	(lf)	M	O	D	E	L		#					X	X	X	X	X	X	X	X	X	X	X	7
X	X	X	X	(cr)	(lf)	H	D	W	R		P	/	N		#		X	X	X	X	X	X	X	X	8
X	X	X	X	X	X	X	(cr)	(lf)	S	E	R	I	A	L		#				X	X	X	X	X	9
X	X	X	X	X	X	X	X	X	X	(cr)	(lf)	M	A	N	U	F	A	C	T	U	R		D	A	10
T	E		X	X	X	X	X	X	X	X	X	X	(cr)	(lf)	O	P	T	I	O	N	S		L	I	11
S	T					X	X	X	X	X	X	X	X	X	X	C	(cr)	(lf)							12

C checksum
Message length: 294 bytes

8-CHANNEL POSITION/STATUS/DATA OUTPUT MESSAGE

The input command sets the rate that the position/status/data information (see Response Message) is output. The mode parameter (m) in the input message instructs the GPS receiver to either output this message one time (polled), or to output this message at the indicated update rate (continuously). Once the GPS receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time output request. The GPS receiver will output the message one more time, then terminate any further message outputs. If the GPS receiver has its Idle Mode option enabled, it outputs the last known valid position/status/data message once when polled.

The state of the mode bit is stored in nonvolatile memory. If the GPS receiver was continuously outputting the position/status/data output when turned off, it will begin to output this message continuously (at the selected update rate) again when power is reapplied.

The position/status/data output is explained in the response message section. Refer to the Date, Time of Day, Latitude, Longitude, and Height commands for more details on the formats of these parameters. Refer to the glossary for definitions of the DOP values.

The number of satellites visible is computed using the current date, time, position, almanac, and a mask angle of ten degrees. If no almanac is available, this number will be zero. This condition will not prevent satellites from being tracked.

In order for a satellite to be used for positioning, the satellite mode must reach eight, indicating that the ephemeris for that satellite has been acquired. Once the ephemeris is available, the satellite can be used for positioning in modes five through eight. Refer to page 5.13 for a description of the signal value.

The signal strength value is meaningless when the channel tracking mode is zero.

The Oncore GPS receiver has a propagate mode that is used to wxtend coverage when dropouts occur. When a 2D fix can no longer be computed, the last known velocity vector is used to propagate the position solution ahead for up to five seconds. This condition is indicated in the receiver status message.

NOTE: United States export laws prohibit GPS receiver from outputting valid data if the altitude is greater than 18,000 meters and the velocity is greater than 514 meters per second. If the GPS receiver is used above both these limits, the height and velocity outputs are clamped to the maximum values. In addition, the latitude and longitude data will be incorrect.

8-CHANNEL POSITION/STATUS/DATA OUTPUT MESSAGE
Motorola Binary Format

Input Command Description

- *Set response message rate:*

@@EamC<CR><LF>

m - mode	0 - output response message once (polled) 1..255 - response message output at indicated rate (continuous) 1 - once per second 2 - once every two seconds 255 - once every 255 seconds

C - checksum
Message Length: 8 bytes

Response Message

- *(to command)*

@@Eamdyyhmsffffaaaaoooohhhhmmmmvvhhddtntim
sdimsdimsdimsdimsdimsdimsdimsdsC<CR><LF>

Date	
m - month	1 .. 12
d - day	1 .. 31
yy - year	1980 .. 2079
Time	
h - hours	0 .. 23
m - minutes	0 .. 59
s - seconds	0 .. 60
ffff - fractional seconds	0 .. 999,999,999 (0.0 to 0.999999999)
Position	
aaaa - latitude in mas	-324,000,000 324,000,000 (-90° to 90°)
oooo -longitude in mas	-648,000,000 ..648,000,000 (-180° to 180°)
hhhh - height in cm (GPS, ref ellipsoid)	-100,000 .. 1,800,000 (-1000.00 to 18,000.00 m)
mmmm - height in cm (MSL ref)	-100,000 .. 1,800,000 (-1000.00 to 18,000.00 m)
Velocity	
vv - velocity in cm/s (true north res 0.1°)	0 .. 51400 (0 to 514.00 m/s)
hh - heading	0 .. 3599 (0.0 to 359.9°)

Response Message Continued on Following Page

Response Message (Continued)

Geometry	
dd - current DOP (0.1 res)	0 .. 999 (0.0 to 99.9 DOP) (0 - not computable), or position-hold, or position prop)
t - DOP type	0 - PDOP (in 3D) 1 - HDOP (in 2D)
Satellite visibility and tracking status	
n - num of visible sats	0 .. 12
t - num of satellites tracked	0 .. 8
For each of eight receiver channels	
i - sat ID	0 .. 37
m - channel tracking mode	0 .. 8
0 - Code Search	5 - Message Sync Detect
1 - Code Acquire	6 - Satellite Time Avail
2 - AGC Set	7 - Ephemeris Acquire
3 - Freq Acquire	8 - Avail for Position
4 - Bit Sync Detect	
s - Signal Strength (number proportional to SNR)	0 .. 255
d - Channel Status Flag	
Each bit represents one of the following:	
(msb)	Bit 7: Using for Position Fix
	Bit 6: Satellite Momentum Alert Flag
	Bit 5: Satellite Anti-Spoof Flag Set
	Bit 4: Satellite Reported Unhealthy
	Bit 3: Satellite Reported Inaccurate (>16 m)
	Bit 2: Spare
	Bit 1: Spare
(lsb)	Bit 0: Parity Error
(End of Channel Dependent Data)	
s - Receiver Status Message	
(msb)	Bit 7: Position Propagate mode
	Bit 6: Poor Geometry (DOP > 20)
	Bit 5: 3D fix
	Bit 4: Altitude Hold (2D fix)
	Bit 3: Acquiring Satellites/Position hold
	Bit 2: Differential
	Bit 1: Insufficient visible satellites (<3)
(lsb)	Bit 0: Bad Almanac
C - checksum	
Message Length: 76 bytes	

8-CHANNEL xDOP TABLE STATUS MESSAGE

This command requests the xDOP parameters corresponding to combinations of currently visible satellites based on the latest satellite visibility calculation. The GPS receiver will send up to nine combinations of satellites with the corresponding xDOP parameter. The type of DOP is defined by the xDOP Type parameter, and the GPS receiver will compute xDOP of all combinations of satellites taken eight at a time (GPS receiver is selected for N-in-View Position Fix mode) or for all satellites taken four at a time (GPS receiver is selected for Best-4 Position Fix mode).

8-CHANNEL xDOP TABLE STATUS MESSAGE

Motorola Binary Format

Input Command Description

- *Request xDOP Table Status:*

@@EcmC<CR><LF>

m - mode	0 - output response message (once polled) 1 - output response message when data changes (continuous)
C - checksum	
Message Length: 8 bytes	

Response Message

- *(to command):*

@@Ectnmddssssssssddssssssssddssssssssddssssssssdd
ssssssssddssssssssddssssssssddssssssssddssssssssC
<CR><LF>

t - xDOP Type	0 - GDOP 1 - PDOP 2 - HDOP 3 - VDOP 4 - TDOP
n - number of valid combinations	0 .. 9
m - Best-4 or N-in-View	4 or 8
For n valid combinations of satellites	
dd - xDOP (resolution 0.1)	10 .. 999 (1.0 .. 99.9)
ssssssss - Sat Combo ID's	each s = 0..32 for Sat ID
C - checksum	
Message Length: 100 bytes	

Note: The number of valid "s" fields is given by "m".

8-CHANNEL SATELLITE RANGE DATA OUTPUT MESSAGE

NOTE: The input/output messages described here are available only if GPS receiver Option C is installed.

This parameter determines the rate basic satellite range and range-rate information for each of the satellites that the GPS receiver is tracking is output. The user has the option of requesting the satellite range data status one time (polled), or continuously at a user specified update rate. The selected rate is stored in the GPS receiver's non-volatile memory. If the GPS receiver was continuously outputting the satellite range data output when turned off, it will begin to output this message continuously (at the selected update rate) again when power is reapplied.

If the GPS receiver has its Idle mode option enabled, this parameter selection does not exist, and the GPS receiver outputs the last known valid Range Data Output information once when polled.

Two bits in each of the channel tracking mode words of the response message are used to denote whether or not the channel has lost phase lock or frequency lock since the last output of this message. This information is helpful for users who perform post-processing and it eliminates the need to output this message at a one second rate.

The channel tracking mode in this response message is not necessarily the same as the channel tracking mode in the Position/Status/Data Output Message. When the receiver is not using the channel as part of the position fix solution, the GPS satellite time (Integrated Carrier Phase Filtered) will be zero, and the channel tracking mode will report mode 4 or lower. When the receiver is using the channel as part of the position fix solution (modes 5 through 8 after reaching mode 8 once), the GPS satellite time (Integrated Carrier Phase Filtered) will be valid, and the channel tracking mode will be the same as the channel tracking mode in the Position/Status/Data Output Message.

8-CHANNEL SATELLITE RANGE DATA OUTPUT MESSAGE

Motorola Binary Format

Input Command Description

- *Set response message rate:*

@@EgmC<CR><LF>

m - mode	0 - output response message once (polled)
	1..255 - response message output at indicated rate (continuous)
	1 - once per second
	2 - once every two seconds
	255 - once every 255 seconds
C- checksum	
Message Length: 8 bytes	

Response Message

- *(to command)*

@@Egtttffffimsssffffccffrrrddimsssffffccffrrrddim
sssffffccffrrrddimsssffffccffrrrddimsssffffccffrr
rddimsssffffccffrrrddimsssffffccffrrrddimsssffffc
cffrrrddC<CR><LF>

Message Length: 158 bytes

ttt - GPS local time in seconds	0 .. 604799
ffff - GPS local fractional time in nanoseconds	0 .. 0.999999999
resolution - 1 ns	(0 .. 0.999999999)

For each of eight Channels:

i - satellite ID	0 .. 32
	0 - channel not used
	1 - 32 satellite ID

Response Message Continued on Following Page

8-CHANNEL SATELLITE RANGE DATA OUTPUT MESSAGE

Motorola Binary Format

Response Message (Continued)

m - channel tracking mode where bits 0 - 3 are decoded as
- 0 - code search
- 1 - code acquire
- 2 - AGC set
- 3 - frequency acquire
- 4 - bit sync detect
- 5 - message sync detect
- 6 - sat time available
- 7 - ephemeris acquire
- 8 - avail for position

where bit 6 is decoded as
- 0 - frequency locked since last range message
- 1 - not frequency locked since last range message

and where bit 7 (MSB) is decoded as
- 0 - phase locked since last range message
- 1 - not phase locked since last range message

sssffff - GPS satellite time (Integrated Carrier Phase Filtered)	
sss - integer part (resolution - 1 sec)	0 .. 604799
ffff - fractional part (resolution - 1 nsec)	0 .. 999,999,999 (0 .. 0.999999999)
ccff - integrated carrier phase	
cc - integer part 16 MS bits of carrier phase (above decimal point)	0 .. 65535 (cycles)
ff - fractional part 16 bits of carrier phase NCO below decimal point at measurement epoch	0 .. 65535 (0 .. 359.9945 degrees)
rrr - raw code phase (carrier cycles)	0 .. 1575420
dd - code discriminator output at measurement epoch LSB = (2^{-12}) * SOL*0.001/28644 meters	-32,768 .. 32767

C - checksum

Message Length: 158 bytes

Conversion Formulas

In the discussions that follow, the subscript ($_k$) refers to the current measurement data, and the subscript ($_{k-1}$) refers to the previous (one second old) data.

The user can convert the above message into pseudorange and pseudorange rate for each satellite by using the following formulas:

Pseudorange (in meters) = (GPS local time - GPS satellite time) * SOL

Note: Not corrected for possible End-Of-Week Rollovers.

Pseudorange rate (in meters per second) = K2 * (ICP_k - ICP_{k-1})

ICP is the integer and fractional part of ICP treated as a 32 bit unsigned quantity.

Conversion Formulas Continued on Following Page

8-CHANNEL SATELLITE RANGE DATA OUTPUT MESSAGE

Motorola Binary Format

Conversion Formulas (Continued)

Use 32 bit unsigned integer subtraction to avoid rollovers.

Absolute carrier phase at measurement epoch in degrees = K4 * ICP_f

The GPS satellite time used in the first equations for the computation of pseudorange is the same value that the Oncore uses internally. This satellite time value combines code and carrier information and has been pre-smoothed using carrier aided filtering with a very narrow-band (0.005 Hz) low-pass filter algorithm. The user has access to the unfiltered raw code phase via the following:

Raw Code Phase (in meters) = K1 * RCP - K2 * ICP_f + K3 * K5 * CD
where:
RCP is the raw code phase from the message
ICP_f is the fractional part of the integrated carrier phase
CD is the code discriminator output from the message
K5 is a variable code discriminator calibration constant

Code discriminator calibration constant: When tracking satellites, the receiver causes the raw code phase to move back and forth once per second in discrete steps of one code phase quantum. One code phase quantum is equal to 55 carrier cycles, or about 10.4662 meters. This intentional dither allows the receiver to calibrate the output of the code discriminator.

The user can accurately calibrate the code discriminator output by using the fact that the long term average difference between subsequent code discriminator measurements will be equal to one quantum. K5, the calibration constant, varies slowly over time as a function of received signal to noise ratio and multipath. Typical values of K5 are between 0.5 and 1.5. A simple low-pass filter can be used to generate K5 as follows:

diff = K3 * abs (CD_k - CD_{k-1})
CD_{k-1} = CD_k

LPF = LPF + beta * (diff - LPF) (initialize LPF = 10.4662 meters)

K5 = 10.4662/LPF

The constant "beta" establishes the filter time constant. Typical values of beta are 0.001 (maximum filtering) to 0.5 (minimum filtering). The Oncore uses a constant of 0.05 internally.

OTHER FIXED CONSTANTS:
- L1F0 = 1,575,420,000.0 Hz (L1 carrier frequency)
- SOL = 299,792,458.0 m/s (GPS value for the speed of light)
- K1 = SOL / L1F0
- K2 = K1 / 65536
- K3 = (2^{-11}) * SOL * 0.001 / 28644
- K4 = 360 / 65536

8-CHANNEL POSITION/STATUS/DATA EXTENSION MESSAGE

This message contains information that can be considered to be an extension of the data output in the 8-Channel Position/Status/Data Message (@@Ea). Some users may have applications requiring use of this data at the same rate as the "Ea" message while other users may only need portions of this data at a much slower rate (e.g. magnetic variation).

Magnetic variation can be used to correct the true north heading (see 8-Channel Position/ Status/Data Message) to magnetic north. The correction is computed using an algorithm developed by the U.S. Naval Oceanographic Office. It is based on the WMM-95 (World Magnetic Model 1995) magnetic field model which was generated from actual field measurements and is valid until January 1, 2000. Another table will be available from the U.S. Defense Mapping Agency (DMA) at that time. The algorithm characterizes primarily that portion of the Earth's magnetic field which is generated by the Earth's conducting fluid outer core. Portions of the geomagnetic field generated by the Earth's crust, mantle, ionosphere, and magnetosphere are for the most part not represented in these models. Consequently, a magnetic sensor such as a compass or magnetometer may observe spatial and temporal magnetic anomalies when referenced to the appropriate World Magnetic Model. In particular, certain local, regional, and temporal magnetic anomalies can exceed 10 degrees. Anomalies of this magnitude are not uncommon, but are of small spatial extent and relatively isolated. From a global perspective, the root-mean-square (RMS) error at sea level of the World Magnetic Model are estimated to be less than 1.0 degrees over the entire 5-year life of the model.

8-CHANNEL POSITION/STATUS/DATA EXTENSION MESSAGE

Motorola Binary Format

Input Command Description

- *Request extension message:*

@@EkmC<CR><LF>

m - mode	0 - output response message once (polled) 1 .. 255 - output response message at indicated rate (continuous) 1 - once per second 2 - once every two seconds 255 - once every 255 seconds

C - checksum
Message Length: 8 bytes

Response Message

- *(to command):*

@@Ekggpphhvvttmmnneeuuaaxxxxyyyyzzzzrrrrrrrriiiii iiiiiiiiiiiiiccooC<CR><LF>

Note: Dop values are NOT valid if in position hold mode.

Current GDOP gg –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 3D Fix mode)
Current PDOP pp –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 3D Fix mode)
Current HDOP hh –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 2D or 3D Fix mode)
Current VDOP vv –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if in 3D Fix mode)
Current TDOP tt –	0 to 32767 (0.0 to 3276.7 DOP) resolution 0.1 (only valid if tracking at least one satellite)
Magnetic variation mm –	–1800 to +1800 (–180.0° to +180.0°) resolution = 0.1 positive angles are east negative angles are west
Velocity in north, east, up coordinate system	
nn –	north – 32767 to 32767 (m/s) resolution = 0.1
ee –	east – 32767 to 32767 (m/s) resolution = 0.1
uu –	up – 32767 to 32767 (m/s) resolution = 0.1

Age of differential correction data (for slave receiver)

Response Message Continued on Following Page

8-CHANNEL POSITION/STATUS/DATA EXTENSION MESSAGE

Motorola Binary Format

Response Message (Continued)

aa –	0 to 65535 resolution 0.1 s
Receiver position in ECEF coordinate system (X, Y, Z)	
xxxx –	resolution = 0.01 meters
yyyy –	resolution = 0.01 meters
zzzz –	resolution = 0.01 meters
URA for each of six receiver channels (8 elements)	
r –	as decoded from the GPS satellite message (0–15 is valid URA, 63 if not decoded yet) see NAVSTAR GPS-ICD-200 Section 20.3.3.3.1.3
Least Squares A–1 Symmetrical Matrix element (10 elements)	
ii –	A–1 Matrix element where element #1 is A–1[0][0] element #2 is A–1[0][1] element #3 is A–1[0][2] element #4 is A–1[0][3] element #5 is A–1[1][1] element #6 is A–1[1][2] element #7 is A–1[1][3] element #8 is A–1[2][2] element #9 is A–1[2][3] element #10 is A–1[3][3] resolution = 0.1 (unitless)
Receiver clock bias	
cc –	–32767 to +32767 (in meters) resolution = 0.1
Receiver oscillator offset	
oo –	0 to 65535 (in m/s) resolution = 0.1
C – checksum	
Message Length: 71 bytes	

8 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

NOTE: The input/output messages described here are available only if GPS receiver option I is installed.

The GPS receiver uses the Time RAIM algorithm to exploit redundancy in the GPS time solution in order to detect and isolate faulty satellites. The Time RAIM Setup and Status Message allows the user to change the update rate, the configuration for the 1PPS output, and the Time RAIM alarm limit.

The rate parameter instructs the GPS receiver to either output this message one-time (polled), or to output this message at the indicated update rate (continuously). If the message rate is the same as the 1PPS rate, then the message and the 1PPS pulse are synchronized. Once the GPS receiver is set to continuous output, the continuous message flow can be stopped by sending a one-time output request. The GPS receiver will output the message one more time, then terminate any further message outputs. The state of the rate parameter is stored in nonvolatile memory. If the GPS receiver was continuously outputting the message when turned off, it will begin to output this message continuously (at the selected rate) again when power is reapplied. If the GPS receiver has its Idle Mode option enabled, the rate parameter selection is unavailable, and the GPS receiver outputs the last valid message once when polled.

The state of the rate byte is stored in RAM. If the GPS receiver was continuously outputting the message when turned off and backup power is applied, then it will begin to output this message continuously (at the selected update rate) again when the main power is reapplied. If backup power is not applied during power down, then the GPS receiver will start up with a default rate of zero. The other Time RAIM control parameters are also stored in RAM, so they will be reset to their default values if backup power is not applied during power down.

The pulse generation can be controlled with the 1PPS control mode byte. The pulse can be on all the time, off all the time, on only when the receiver is tracking at least one satellite, or on only when the time solution is within the alarm threshold.

The number of satellites appearing in the table below are the minimum which must be tracked to ensure the detection, isolation, and removal of faulty satellites. The probability of detection and isolation of a faulty satellite is greater than 99.99%, which corresponds to less than one missed detection every 10,000 failures. Given the infrequency of GPS satellite failures, this makes a missed detection virtually impossible. The probability of a false alarm is less than 2.e-4%, which coresponds to less than one false alarm every 5.7 days. Given that lock is maintained on eight satellites, the time alarm can be set as low as 300 ns without compromising performance.

Time Alarm (ns)	SVs needed to detect	SVs needed to isolate
T >1000	2	3
1000 > T > 700	3	3
700 > T > 500	4	4
500 > T > 300	4	8
300 > T > 250	8*	8*

*The minimum time required false alarm rate of 2.e-4% cannot be achieved for this time alarm range.

8 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

Motorola Binary Format

The Time RAIM Setup and Status Message outputs the status of the Time RAIM solution when the algorithm is on. This messaage also outputs several values relating to the Time RAIM solution.

The receiver can make an estimate of the overall accuracy of the time solution. The one sigma accuracy estimate is computed using the residuals of the least-squares time solution. This number is a measure of the spread of the observations, not an estimate of the absolute time accuracy.

The underlying noise due to the granularity of the clock generating the 1PPS signal is deterministic on every pulse. The receiver computes and outputs the negative sawtooth residual so that the user can compensate for the error and remove granularity.

Finally, the time solution of each individual satellite is output.

Default values:	Time RAIM algorithm	off
	Time RAIM alarm limit	1000 ns
	1PPS control mode	setting 1

8 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

Motorola Binary Format

Input Command Description

- Send current **Time RAIM Setup and Status**:

@@EnxxxxxxxxxxxxxxxC<CR><LF>

x	15 out af range bytes	$ff ff ff ff...
C	checksum	

Message length: 22 bytes

- Change current Time RAIM Setup:

@@EnotaapxxxxxxxC<CR><LF>

o	output message rate	0 .. 255 0 = output response message once (polled) 1..255 = response message output at indicated rate (continuous) 1 = once per second 2 = once every two seconds 255 = once every 255 seconds
t	Time RAIM algorithm on/off	0 = off 1 = on
aa	Time RAIM alarm limit in 100s of nanoseconds	3 .. 65535
p	1PPS control mode	0 = 1PPS output pulse is off all the time 1 = 1PPS on all the time 2 = pulse active only when tracking at least one satellite 3 = pulse active only when Time RAIM algorithm confirms time solution error is within the user defined alarm limit
nnn	not used	0
mdyyhms	not used	0
C	checksum	

Message length: 22 bytes

Response Message

- *(to either command):*

@@Enotaapnnnmdyyhmspysreensffffsffffsffffs ffffsffffsffffsffffsffffC<CR><LF>

o	output message rate	0 .. 255
t	Time RAIM algorithm on/off	0 = off 1 = on
aa	Time RAIM alarm limit in 100s of nanoseconds	3 .. 65535

Response Message Continued on Following Page

8 CHANNEL TIME RAIM SETUP AND STATUS MESSAGE

Motorola Binary Format

Response Message (Continued)

p	1PPS control mode	0 = 1PPS output pulse is off all the time 1 = 1PPS on all the time 2 = pulse active only when tracking at least one satellite 3 = pulse active only when Time RAIM algorithm confirms time solution error is within the user defined alarm limit
nnn	1PPS output rate	0 .. 86400
mdyyhms	time to next fire	
	m months	0 .. 12
	d days	0 .. 31
	yy years	1980 .. 2079
	h hours	0 .. 23
	m minutes	0 .. 59
	s seconds	0 .. 60
p	pulse status	0 = off 1 = on
y	1PPS pulse sync	0 = pulse referenced to UTC 1 = pulse referenced to GPS time
s	Time RAIM solution status	0 = OK: solution within alarm limits 1 = ALARM: user specified limit exceeded 2 = UNKNOWN: due to ... a) alarm threshold set too low b) Time RAIM turned off c) insufficient satellites being tracked
r	Time RAIM status	0 = detection and isolation possible 1 = detection only possible 2 = neither possible
ee	time solution one sigma accuracy estimate in nanoseconds	0 .. 65535
n	negative sawtooth time error of next 1PPS pulse in nanoseconds	-128 .. 127

For each of eight receiver channels

s	satellite ID	0 .. 37
ffff	fractional GPS local time estimate of satellite in nanoseconds	0 .. 999999999

C	checksum Message length: 69 bytes

8-CHANNEL SELF-TEST

The GPS receiver user has the ability to initiate an extensive self-test. The tests that are accomplished during the commanded self-test are as follows:

ROM checksum

RAM

EEPROM

Correlator IC

SPI port communication with DCXO

SPI port comm with RTC and Time increment

SCI communication is verified operational if the RS232 port is active

The output of the self-test command is a 16-bit field, where each bit of the field represents the go/no-go condition of the particular item tested.

8-CHANNEL SELF-TEST

Motorola Binary Format

Input Command Description

- *Initiate 8-Channel Self-Test:*

@@FaC<CR><LF>

C - checksum
Message Length: 7 bytes

Response Message

- *(to command):*

@@FaxxC<CR><LF>

xx - self-test result

Each bit of the self-test result field is either zero (for pass) or one (for fail) and represents the result of the following test:

(msb)	Bit 15:	RTC Comm & Time
	Bit 14:	DCXO SPI Comm
	Bit 13:	EEPROM
	Bit 12:	RAM MSByte
	Bit 11:	RAM LSByte
	Bit 10:	ROM MSByte Checksum
	Bit 9:	ROM LSByte Checksum
	Bit 8:	1 KHz Presence
	Bit 7:	Channel 8 Correlation test
	Bit 6:	Channel 7 Correlation test
	Bit 5:	Channel 6 Correlation test
	Bit 4:	Channel 5 Correlation test
	Bit 3:	Channel 4 Correlation test
	Bit 2:	Channel 3 Correlation test
	Bit 1:	Channel 2 Correlation test
(lsb)	Bit 0:	Channel 1 Correlation test

C - checksum
Message Length: 9 bytes

8-CHANNEL ALERT-PLANNING

This utility command allows the user to compute satellite visibility information for other locations than the GPS receiver's current location. This can be accomplished in either the Idle or the Position Fix modes. The input command allows the user to specify the date, time, location, satellite mask angle, and GMT offset correction to compute the satellite visibility information, and the output response message returns satellite elevation, azimuth, and Doppler information for up to 12 visible satellites as well as DOP vs satellite selection combinations for up to 9 different combinations. The receiver uses the current datum ID, Satellite Ignore List, Position Fix Algorithm Type, and xDOP Computation Type parameters in order to compute the Alert Plan.

The time the GPS receiver requires to compute the output response message is a function of the current loading on the Oncore GPS receiver CPU. The response message will be output much faster if the GPS receiver is placed in the Idle mode before the input command string is entered. Otherwise, the output message is made available when there is sufficient time for the GPS receiver to process the input command and compute the output visibility data. The user can build a visibility vs time table by inputting alert request commands, one at a time, that increase the time parameter at some constant rate (i.e. every 15 minutes).

8-CHANNEL ALERT-PLANNING

Motorola Binary Format

Input Command Description

- *Initiate 8-Channel Alert-Planning:*

@@FdmdyyhmsggaaaaoooohhmC<CR><LF>

Date	
m - month	1 .. 12
d - day	1 .. 31
yy - year	1980 .. 2079
Time	
h - hours	0 .. 23
m - minutes	0 .. 59
GMT Correction	
s - sign of GMT corr	00 - positive ff - negative
gg - GMT Correction (hrs, min)	
hrs:	0 .. 12
min:	0 .. 59
Position	
aaaa - latitude (in msec)	-324,000,000 . 324,000,000 (-90° to +90°)
oooo- longitude (in msec)	-648,000,000 .. 648,000,000 (-180° to +180°)
hh - height in meters	-1000 .. 18,000
Satellite Mask Angle	
m - Sat mask (angle in degrees)	0 .. 89
C - Checksum	
Message length: 27 bytes	

Note: The response message to an alert-planning command with at least one out-of-range input parameter is to return all fields of the above response message zero-filled. In addition, the response is zero filled when no almanac is present in the Oncore GPS receiver.

Response Message

- *(to command):*

@@Fdmdyyhmniddeaasiddeaasiddeaasiddeaasiddeaasid-deaasiddeaasiddeaasiddeaasiddeaasiddeaasiddeaast-ddssssssssddssssssssddssssssssddssssssssddssssssssddssssssssssddssssssssddssssssssddssssssssC<CR><LF>

Date	
m - month	1 .. 12
d - day	1 .. 31
yy - year	1980 .. 2079
Time	
h - hours	0 .. 23

Response Message Continued on Following Page

8-CHANNEL ALERT-PLANNING

Motorola Binary Format

Response Message (Continued)

m - minutes	0 .. 59
Satellite Visibility Information	
n - number of visible sats	0 .. 12 (for each visible sat, up to n fields contain valid data)
i - Satellite PN code ID	1 .. 32
dd - Doppler in Hz	-5000 .. 5000
e - elevation (degrees)	0 .. 90
aa - Azimuth (degrees)	0 .. 359
s - satellite health	0 - healthy 1 - removed from sv sel 2 - unhealthy
xDOP vs Satellite Selection Information	(up to 9 combinations)
t - xDOP type	0 - GDOP 1 - PDOP 2 - HDOP 3 - VDOP 4 - TDOP
dd - DOP (0.1 resolution)	0, 10 .. 999 dd = 0 if the combination is not valid
ssssssss - SVID per channel	each s = 0..32 for sat ID (0 indicates chan not used)
C - checksum	
Message Length: 189 bytes	

GPGGA (GPS FIX DATA)

Input Command Description

This command enables the GPGGA GPS Fix Data message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in nonvolatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

If the receiver has just powered up and has yet to compute a position fix (GPS quality indicator field will be zero (q = 0)), then the time (hhmmss.ss) and HDOP (y.y) fields will be nulled. After the first fix, if the receiver is not computing a position fix (GPS quality indicator field will be zero (q = 0)), the time field (hhmmss.ss) will be frozen and the HDOP field (y.y) will be nulled. If the receiver is not using differential GPS (GPS quality indicator field will not be two (q = 0 or q = 1)), then the age of differential data (t.t) and differential reference station ID (iiii) fields will be nulled. A negative number for the geoidal separation field (g.g) indicates mean sea level below ellipsoid.

Default value: Message disabled

GPGGA (GPS FIX DATA)

NMEA-0183 Format

Input Command Description

$PMOTG,GGA,yyyyCC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional checksum	hex 00 .. 7f

Response Message

$GPGGA,hhmmss.ss,ddmm.mmmm,n,
dddmm.mmmm,e,q,ss,y.y,a.a,z,
g.g,z,t.t,iiii*CC<CR><LF>

hhmmss.ss – UTC of position fix	
hh – hours	00 .. 24
mm – minutes	00 .. 59
ss.ss – seconds	00.000 .. 59.99
ddmm.mmmm,n – latitude	
dd – degrees	00 .. 90
mm.mmm – minutes	00.000 .. 59.999
n – direction	N – north
	S – south
dddmm.mmmm,e – longitude	
ddd – degrees	000 ..180
mm.mmm – minutes	00.00 .. 59.9999
e – direction	E – east
	W – west
q – GPS quality indicator	0 – GPS not available
	1 – GPS available
	2 – GPS differential fix
ss – Number of sat being used	0 .. 12
y.y – HDOP	
a.a,z – antenna height	
a.a – height	
z – units	M – meters
g.g,z – geoidal separation	
g.g – height	
z – units	M – meters
t.t – age of differential data	
iiii – differential reference station ID	0000 . . 1023
CC – checksum	hex 00 .. 7f

GPRMC (RECOMMENDED MINIMUM SPECIFIC GPS/TRANSIT DATA)

This command enables the GPRMC Recommended Minimum Specific GPS/TRANSIT Data message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in nonvolatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

If the receiver has just powered up and has yet to compute a position fix (status field will be invalid (a = V)), then the time (hhmmss.ss) and date (ddmmyy) fields will be nulled. After the first fix, if the receiver is not computing a position fix (status field will be invalid (a = V)), then the time (hhmmss.ss) and date (ddmmyy) fields will be frozen. If the receiver is not computing a position fix (status field will be invalid (a = V)), then the speed over ground (z.z) and track made good (y.y) fields will be nulled.

Default value: Message disabled

GPRMC (RECOMMENDED MINIMUM SPECIFIC GPS/TRANSIT DATA)

NMEA-0183 Format

Input Command Description

$PMOTG,RMC,yyyyCC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional checksum	hex 00 .. 7f

Response Message

$GPRMC,hhmmss.ss,a,ddmm.mmmm, n,dddmm.mmmm,w,z.z,y.y, ddmmyy,d.d,v*CC<CR><LF>

hhmmss.ss – UTC time of position fix	
hh – hours	00 .. 24
mm – minutes	00 .. 59
ss.ss – seconds	00.00 .. 59.99
a – status	A – valid
	V – invalid
ddmm.mmmm,n – latitude	
dd – degrees	00 .. 90
mm.mmmm – minutes	00.000 .. 59.9999
n – direction	N – north
	S – south
dddmm.mmmm,w - longitude	
ddd – degrees	00 .. 180
mm.mmmm – minutes	00.000 .. 59.9999
w – direction	E – east
	W – west
z.z – speed over ground (knots)	0.0
y.y – track made good (reference to true north)	0.0 .. 359.9
ddmmyy – UTC date of position fix	
dd – day	01 .. 31
mm – month	01 .. 12
yy – year	00 .. 99
d.d – magnetic variation (degrees)	0.0 .. 180.0
v – variation sense	E – east
	W – west
CC – checksum	hex 00 .. 7f

GPGLL (GEOGRAPHIC POSITION-LATITUDE/LONGITUDE)

This command enables the GPGLL Geographic Position Latitude/Longitude message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in nonvolatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

If the receiver has just powered up and has yet to compute a position fix (GPS quality indicator will be zero (q = 0)), then the time field (hhmmss.ss) will be nulled. After the first fix, if the receiver is not computing a position fix (GPS quality indicator will be zero (q = 0)), the time field (hhmmss.ss) will be frozen.

Default value: Message disabled

GPGLL (GEOGRAPHIC POSITION-LATITUDE/LONGITUDE)

NMEA-0183 Format

Input Command Description

$PMOTG,GLL,yyyyCC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional checksum	hex 00 .. 7f

Response Message

$GPGLL,ddmm.mmmm,n,dddmm.mmmm,e,hhmmss.ss,a*CC<CR><LF>

ddmm.mmmm,n – latitude	
dd – degrees	00 .. 90
mm.mmmm – minutes	00.000 .. 59.9999
n – direction	N – north
	S – south
dddmm.mmmm,e – longitude	
ddd – degrees	00 ..180
mm.mmmm – minutes	00.000 .. 59.9999
e – direction	E – east
	W – west
hhmmss.ss – UTC of position fix	
hh – hours	00 ..24
mm – minutes	00 .. 59
ss.ss – seconds	00.00 .. 59.99
a – status	A – valid
	V – invalid
CC – checksum	hex 00 .. 7f

GPGSA (GPS DOP AND ACTIVE SATELLITES)

This command enables the GPGSA GPS DOP and Active Satellites message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in nonvolatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

If the receiver is not computing a position fix (mode field will be one (b = 1)), then the xDOP fields (p.p, q.q, r.r) will be nulled. If the receiver is computing a 2-D position fix (mode field will be two (b = 2)), then the PDOP field (p.p) and the VDOP field (r.r) will be nulled. Only satellite IDs used in the solution will be output; the remaining satellite ID fields will be nulled.

Default value: Message disabled

GPGSA (GPS DOP AND ACTIVE SATELLITES)

NMEA-0183 Format

Input Command Description

$PMOTG,GSA,yyyyCC<CR><LF>

yyyy – update rate	0 .. 9999 sec
CC – Optional checksum	hex 00 .. 7f

Response Message

$GPGSA,a,b,cc,dd,ee,ff,gg,
hh,ii,jj,kk,mm,nn,oo,p.p,
q.q,r.r*CC<CR><LF>

a – sat acquisition mode	M – manual (forced to operate in 2-D or 3-D mode)
	A – automatic (auto switch 2-D/3-D)
b - pos mode	1 – fix not available
	2 – 2-D
	3 – 3-D
cc, dd, ee, ff, gg, hh, ii, jj, kk, mm, nn, oo	Sat IDs used in solution (null for unused fields)
p.p – PDOP	1.0 .. 9.9
q.q – HDOP	1.0 .. 9.9
r.r – VDOP	1.0 .. 9.9
CC – checksum	hex 00 .. 7f

GPGSV (GPS SATELLITES IN VIEW)

This command enables the GPGSV GPS Satellites in View message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in non-volatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

If the receiver is not tracking the satellite, the SNR field (ss) will be nulled. Further, an entire group — satellite ID field (ii), elevation field (ee), azimuth field (aaa), and SNR field (ss) — will be nulled if not needed.

Default value: Message disabled

GPGSV (GPS SATELLITES IN VIEW)

NMEA-0183 Format

Input Command Description

$PMOTG,GSV,yyyyCC<Cr><Lf>

yyyy - update rate	0 .. 9999 sec
CC - Optional checksum	hex 00 .. 7f

Response Message

$GPGSV,t,m,n,ii,ee,aaa,ss,ii,ee,aaa,ss,ii,ee,aaa ,ss,ii,e e,aaa,ss*CC<Cr><Lf>

t - total number of messages	1 .. 3
m - message number	1 .. 3
n - total number of satellites in view	
For each visible satellite (four groups per message)	
ii - satellite PRN number	
ee - elevation (degrees)	0 .. 90
aaa - azimuth (degrees True)	0 .. 359
ss - SNR (dB)	0 .. 99
CC - checksum	hex 00 .. 7f

GPVTG (TRACK MADE GOOD AND GROUND SPEED)

This command enables the GPVTG Track Made Good and Ground Speed message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in nonvolatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

If the receiver is not computing a position fix, all numeric fields (a.a, c.c, e.e, g.g) will be nulled.

Default value: Message disabled

GPVTG (TRACK MADE GOOD AND GROUND SPEED)

NMEA-0183 Format

Input Command Description

$PMOTG,VTG,yyyyCC<Cr><Lf>

yyyy - update rate	0 .. 9999 sec
CC - Optional checksum	hex 00 .. 7f

Response Message

$GPVTG,a.a,b,c.c,d,e.e,f,g.g ,h*CC<Cr><Lf>

a.a - track (degrees True)	
b - units	T - degrees True
c.c - track (degrees Magnetic)	
d - units	M - degrees Magnetic
e.e - speed (knots)	
f - units	N - knots
g.g - speed (Km/hr)	
f - units	K - km/hr
CC - checksum	hex 00 .. 7f

GPZDA (TIME AND DATE)

This command enables the GPZDA Time and Date message and determines the rate at which the information is transmitted. The periodic rate field (yyyy) instructs the receiver either to output this message once (polled), or to output this message at the indicated update rate (continuously). Once the receiver is set to continuous output, the continuous flow can be stopped by sending a one-time (polled) output request. The receiver will output the response one final time, and then terminate any further message outputs. The value of the periodic rate is stored in nonvolatile memory. If the receiver was continuously outputting this message when turned off, then the receiver will begin to output this message continuously (at the selected rate) again when power is reapplied.

Currently, there is no mechanism to set the local zone description in NMEA I/O format, and the receiver operates as if set to 00:00.

Default value: Message disabled

GPZDA (TIME AND DATE)

NMEA-0183 Format

Input Command Description

$PMOTG,ZDA,yyyyCC<Cr><Lf>

yyyy - update rate	0 .. 9999 sec
CC - Optional checksum	hex 00 .. 7f

Response Message

$GPZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*CC<Cr><Lf>

hhmmss.ss - UTC time

hh - hours	0 .. 23
mm - minutes	0 .. 59
ss.ss - seconds	0 .. 59.99

dd - day	1 .. 31
mm - month	1 .. 12
yyyy - year	
xx - local zone description hours	–13 .. 13
yy - local zone description minutes	0 .. 59
CC - checksum	hex 00 .. 7f

SWITCH I/O FORMAT

This utility command switches the Oncore GPS receiver I/O protocol from NMEA-0183 Format to one of the embedded formats. The format selected is retained in nonvolatile memory.

SWITCH I/O FORMAT

NMEA-0183 Format

Input Command Description

- *Select Format:*

$PMOTG,FOR,xCC<CR><LF>

x – format	0 – Motorola Binary Format
	2 – LORAN Format
CC –Optional checksum	hex 00 .. 7f

Response Message

- *(to command):*

NOTE: There is no response message to this input command. The GPS receiver configures the RS232 port parameters (baud rate, start bits, stop bits, etc.) to the selected format, and input commands are recognized in this new format only.

POSITIONING DATA OUTPUT

This message provides the position fix information in the LORAN emulation format. Using the polled input command results in the response message to be output immediately. The response message is in printable ASCII characters.

POSITIONING DATA OUTPUT

Loran Emulation Format

Input Command Description

Z<CR><LF>

Response Message

ddmmhhNdddmmhhWSSSDDDQ<CR><LF>

ddmmhhN – latitude	
dd – degrees	00 .. 90
mm – minutes	00 .. 59
hh – hundredths of minutes	00 .. 99
N – direction	N – north S – south
dddmmhhW – longitude	
ddd – degrees	00 .. 180
mm – minutes	00 .. 59
hh – hundredths of minutes	00 .. 99
W – direction	E – east W – west
SSS – speed (mph)	0..999
DDD – heading (referenced to true north)	0..359
Q – Quality factor	1 – 2D or 3D avail 0 – positioning data not avail

OUTPUT TIME INTERVAL

The user can select a timed output rate (up to 2.77 hours in one second increments), or request the position output to occur immediately. The output rate selected is stored in the GPS receiver nonvolatile memory.

OUTPUT TIME INTERVAL
Loran Emulation Format

Input Command Description

- *Send Output Time Interval:*

T<CR><LF>

- *Change Output Time Interval*

Tssss<CR><LF>

ssss – Time interval in sec	0 .. 9999

Response Message

- *(either command):*

Tssss<CR><LF>

ssss – Time interval in sec	0 .. 9999

and

ddmmhhNdddmmhhWSSSDDDQ<CR><LF>

ddmmhhN – latitude	
dd – degrees	00 .. 90
mm – minutes	00 .. 59
hh –hundredths of minutes	00 .. 99
N – direction	N – north
	S – south
dddmmhhW – longitude	
ddd – degrees	00 .. 180
mm – minutes	00 .. 59
hh – hundredths of minutes	00 .. 99
W – direction	E – east
	W – west
SSS – speed mph	0..999
DDD – heading (referenced to true north)	0 .. 359
Q – Quality factor	1 – 2D or 3D avail
	0 – positioning data not avail

SWITCH I/O FORMAT

This utility command switches the GPS receiver from LORAN Emulation Format to one of the other embedded formats.

SWITCH I/O FORMAT
Loran Emulation Format

Input Command Description

- *Select Motorola Binary Format:*

BIN<CR><LF>

- *Select NMEA-0183 Format:*

NMEA<CR><LF>

Response Message

- *(to command):*

NOTE: There is no response message to this input command. The GPS receiver reconfigures the RS232 port parameters (baud rate, start bits, stop bits, etc) to the selected format, and input commands are recognized in this new format only.

APPENDIX A DATUMS

Datums

ID	LOCAL GEODETIC SYSTEM	ELLIPSOID	DX	DY	DZ
1	ARC_1950	Clarke_1880	-143.0	-90.0	-294.0
2	ARC_1960	Clarke_1880	-160.0	-8.0	-300.0
3	AUSTRALIAN_ GEODETIC_1966	Australian_National	-133.0	-48.0	+148.0
4	AUSTRALIAN_ GEODETIC_1984	Australian_National	-134.0	-48.0	+149.0
5	BOGOTA_OBSERVATORY	International	+307.0	+304.0	-318.0
6	CAMPO_INCHAUSPE	International	-148.0	+136.0	+90.0
7	CAPE	Clarke_1880	-136.0	-108.0	-292.0
8	CARTHAGE	Clarke_1880	-263.0	+6.0	+431.0
9	CHATHAM_1971	International	+175.0	-38.0	+113.0
10	CHUA_ASTRO	International	-134.0	+229.0	-29.
11	CORREGO_ALLEGRE	International	-206.0	+172.0	-6.0
12	EUROPEAN_1950_WestEurope	International	-87.0	-96.0	-120.0
13	EUROPEAN_1950_CYPRUS	International	-104.0	-101.0	-140.0
14	EUROPEAN_1950_EGYPT	International	-130.0	-117.0	-151.0
15	EUROPEAN_1950_IRAN	International	-117.0	-132.0	-164.0
16	EUROPEAN_1950_SICILY	International	-97.0	-88.0	-135.0
17	EUROPEAN_1979	International	-86.0	-98.0	-119.0
18	GANDAJIKA_BASE	International	-133.0	-321.0	+50.0
19	GEODETIC_DATUM_1949	International	+84.0	-22.0	+209.0
20	HJORSEY_1955	International	-73.0	+46.0	-86.0
21	INDIAN (Thailand/Vietnam)	Everest	+214.0	+836.0	+303.0
22	INDIAN(Bngldsh/India/Nepal)	Everest	+289.0	+734.0	+257.0
23	IRELAND_1965	Airy_Modified	+506.0	-122.0	+611.0
24	KERTAU_1948	Everest_modified	-11.0	+851.0	+5.0
25	LIBERIA_1964	Clarke_1880	-90.0	+40.0	+88.0
26	LUZON	Clarke_1866	-133.0	-77.0	-51.0
27	MASSAWA	Bessel_1841	+639.0	+405.0	+60.0
28	MERCHICH	Clarke_1880	+31.0	+146.0	+47.0
29	MINNA	Clarke_1880	-92.0	-93.0	+122.0
30	NAHRWAN	Clarke_1880	-247.0	-148.0	+369.0
31	NORTH_AMERICAN_ 1927_CONUS	Clarke_1866	-8.0	+160.0	+176.0
32	NORTH_AMERICAN_ 1927_ALASKA	Clarke_1866	-5.0	+135.0	+172.0
33	NORTH_AMERICAN_ 1927_CANADA	Clarke_1866	-10.0	+158.0	+187.
34	NORTH_AMERICAN_ 1927_C_AMER	Clarke_1866	-0.0	+125.0	+194.0
35	NORTH_AMERICAN_1983	GRS-80	-0.0	-0.0	0.0
36	OLD_EGYPTIAN	Helmert_1906	-130.0	+110.0	-13.0
37	OLD_HAWAIIAN	Clarke_1866	+61.0	-285.0	-181.0
38	OMAN	Clarke_1880	-346.0	-1.0	+224.0
39	ORD_SRVY_GRT_ BRITAIN_1936	Airy	+375.0	-111.0	+431.0
40	PITCAIRN_ASTRO_1967	International	+185.0	+165.0	+42.0
41	QUATAR_NATIONAL	International	-128.0	-283.0	+22.0
42	QORNOQ	International	+164.0	+138.0	-189.0
43	SCHWARZECK	Bessel_1841_in_Nambia	+616.0	+97.0	-251.0
44	SOUTH_AMERICA_1969	South_America_1969	-57.0	+1.0	-41.0
45	TIMBALAI_1948	Everest	-689.0	+691.0	-46.0
46	TOKYO	Bessel_1841	-128.0	+481.0	+664.0
47	ZANDERIJ	International	-265.0	+120.0	-358.0
48	WGS-1972	WGS-72	-0.0	-0.0	+4.5
49	WGS-1984	WGS-84	-0.0	-0.0	0.0

User Defined Datums

ID	ELLIPSOID	DX	DY	DZ	LOCATION
*	Adindan	-166	-15	204	MEAN FOR Ethiopia, Sudan
*	Adindan	-118	-14	218	Burkina Faso
*	Adindan	-134	-2	210	Cameroon
*	Adindan	-165	-11	206	Ethiopia
*	Adindan	-123	-20	220	Mali
*	Adindan	-128	-18	224	Senegal
*	Adindan	-161	-14	205	Sudan
*	Afgooye	-43	-163	45	Somalia
*	Ain el Abd 1970	-150	-251	-2	Bahrain
*	Ain el Abd 1970	-143	-236	7	Saudi Arabia
*	Anna 1 Astro 1965	-491	-22	435	Cocos Islands
*	Antigua Island Astro 1943	-270	13	62	Antigua (Leeward Islands)
*	Arc 1950	-138	-105	-289	Botswana
*	Arc 1950	-153	-5	-292	Burundi
*	Arc 1950	-125	-108	-295	Lesotho
*	Arc 1950	-161	-73	-317	Malawi
*	Arc 1950	-134	-105	-295	Swaziland
*	Arc 1950	-169	-19	-278	Zaire
*	Arc 1950	-147	-74	-283	Zambia
*	Arc 1950	-142	-96	-293	Zimbabwe
*	Ascension Island 1958	-191	103	51	Ascension Island
*	Astro Beacon E 1945	145	75	-272	Iwo Jima
*	Astro DOS 71/4	-320	550	-494	St Helena Island
*	Astro Tern Island (FRIG) 1961	114	-116	-333	Tern Island
*	Astronomical Station 1952	124	-234	-25	Marcus Island
*	Ayabelle Lighthouse	-79	-129	145	Djibouti
*	Bellevue (IGN)	-127	-769	472	Efate & Erromango Islands
*	Bermuda 1957	-73	213	296	Bermuda
*	Bissau	-173	253	27	Guinea-Bissau
*	Bukit Rimpah	-384	664	-48	Indonesia (Bangka & Belitung Islands)
*	Camp Area Astro	-104	-129	239	Antarctica (McMurd Camp Area)
*	Canton Astro 1966	298	-304	-375	Phoenix Islands
*	Cape Canaveral	-2	151	181	Bahamas, Florida
*	Dabola	-83	37	124	Guinea
*	Djakarta (Batavia)	-377	681	-50	Indonesia (Sumatra)
*	DOS 1968	230	-199	-752	New Georgia Islands (Gizo Island)
*	Easter Island 1967	211	147	111	Easter Island
*	European 1950	-103	-106	-141	MEAN FOR Iraq, Israel, Jordan, Lebanon
*	European 1950	-103	-106	-141	Kuwait, Saudi Arabia, Syria
*	European 1950	-86	-96	-120	England, Channel Islands, Ireland
*	European 1950	-86	-96	-120	Scotland, Shetland Islands
*	European 1950	-84	-95	-130	Greece
*	European 1950	-107	-88	-149	Malta
*	European 1950	-84	-107	-120	Portugal, Spain
*	Fort Thomas 1955	-7	215	225	Nevis, St. Kitts (Leeward Islands)
*	Graciosa Base SW 1948	-104	167	-38	Azores (Faial, Graciosa, Pico)
*	Graciosa Base SW 1948	-104	167	-38	Sao (Jorge, Terceira)
*	Guam 1963	-100	-248	259	Guam
*	Gunung Segara	-403	684	41	Indonesia (Kalimantan)
*	GUX 1 Astro	252	-209	-751	Guadalcanal Island
*	Herat North	-333	-222	114	Afghanistan
*	Hong Kong 1963	-156	-271	-189	Hong Kong
*	Hu-Tzu-Shan	-637	-549	-203	Taiwan
*	ISTS 061 Astro 1968	-794	119	-298	South Georgia Islands
*	ISTS 073 Astro 1969	208	-435	-229	Diego Garcia
*	Johnston Island 1961	189	-79	-202	Johnston Island
*	Kandawala	-97	787	86	Sri Lanka
*	Kerguelen Island 1949	145	-187	103	Kerguelen Island
*	Kusaie Astro 1951	647	1777	-1124	Caroline Islands
*	L. C. 5 Astro 1961	42	124	147	Cayman Brac Island

User Defined Datums (Continued)

ID	ELLIPSOID	DX	DY	DZ	LOCATION
*	Leigon	-130	29	364	Ghana
*	Mahe 1971	41	-220	-134	Mahe Island
*	Midway Astro 1961	912	-58	1227	Midway Islands
*	Minna	-81	-84	115	Cameroon
*	Montserrat Island Astro 1958	174	359	365	Montserrat (Leeward Islands)
*	M'Poraloko	-74	-130	42	Gabon
*	Nahrwan	-243	-192	477	Saudi Arabia
*	Nahrwan	-249	-156	381	United Arab Emirates
*	Naparima BWI	-10	375	165	Trinidad & Tobago
*	North American 1927 9	-9	161	179	Including Louisiana, Missouri, Minnesota
*	North American 1927	-4	154	178	Bahamas (Except San Salvador Island)
*	North American 1927	1	140	165	Bahamas (San Salvador Island)
*	North American 1927	-7	162	188	Canada (Alberta, British Columbia)
*	North American 1927	-9	157	184	Canada (Manitoba, Ontario)
*	North American 1927	-22	160	190	Canada (New Brunswick, Newfoundland
*	North American 1927	-22	160	190	Nova Scotia, Quebec)
*	North American 1927	4	159	188	Canada (Northwest Territories, Saskatchewan)
*	North American 1927	-7	139	181	Canada (Yukon)
*	North American 1927	-9	152	178	Cuba
*	North American 1927	11	114	195	Greenland (Hayes Peninsula)
*	North American 1927	-12	130	190	Mexico
*	Observatorio Metereo. 1939	-425	-169	81	Azores (Corvo & Flores Islands)
*	Old Hawaiian	89	-279	-183	Hawaii
*	Old Hawaiian	45	-290	-172	Kauai
*	Old Hawaiian	65	-290	-190	Maui
*	Old Hawaiian	58	-283	-182	Oahu
*	Ord. Survey G. Britain 1936	375	-111	431	Shetland Islands, Wales
*	Ord. Survey G. Britain 1936	371	-112	434	England
*	Ord. Survey G. Britain 1936	371	-111	434	England,Isle of Man, Wales
*	Ord. Survey G. Britain 1936	384	-111	425	Scotland, Shetland Islands
*	Ord. Survey G. Britain 1936	370	-108	434	Wales
*	Pico de las Nieves	-307	-92	127	Canary Islands
*	Point 58	-106	-129	165	MEAN FOR Burkina Faso & Niger
*	Pointe Noire 1948	-148	51	-291	Congo
*	Porto Santo 1936	-499	-249	314	Porto Santo, Madeira Islands
*	Provisional S. American 1956	-288	175	-376	MEAN FOR Bolivia, Chile, Colombia
*	Provisional S. American 1956	-288	175	-376	Ecuador, Guyana, Peru, Venezuela
*	Provisional S. American 1956	-270	188	-388	Bolivia
*	Provisional S. American 1956	-270	183	-390	Chile (Northern, Near 19°S)
*	Provisional S. American 1956	-305	243	-442	Chile (Southern, Near 43°S)
*	Provisional S. American 1956	-282	169	-371	Colombia
*	Provisional S. American 1956	-278	171	-367	Ecuador
*	Provisional S. American 1956	-298	159	-369	Guyana
*	Provisional S. American 1956	-279	175	-379	Peru
*	Provisional S. American 1956	-295	173	-371	Venezuela
*	Provisional S. Chilean 1963	16	196	93	Chile (South, Near 53°S) (Hito XVIII)
*	Puerto Rico	11	72	-101	Puerto Rico, Virgin Islands
*	Reunion	94	-948	-1262	Mascarene Islands
*	Rome 1940	-225	-65	9	Italy (Sardinia)
*	Santo (DOS) 1965	170	42	84	Espirito Santo Island
*	Sao Braz	-203	141	53	Azores (Sao Miguel, Santa Maria Islands)
*	Sapper Hill 1943	-355	21	72	East Falkland Island
*	Selvagem Grande	-289	-124	60	Salvage Islands
*	SGS 85	3	9	-9	Soviet Geodetic System 1985
*	South American 1969	-62	-1	-37	Argentina
*	South American 1969	-61	2	-48	Bolivia

User Defined Datums (Continued)

ID	ELLIPSOID	DX	DY	DZ	LOCATION
*	South American 1969	-60	-2	-41	Brazil
*	South American 1969	-75	-1	-44	Chile
*	South American 1969	-44	6	-36	Colombia
*	South American 1969	-48	3	-44	Ecuador
*	South American 1969	-47	27	-42	Ecuador (Baltra, Galapagos)
*	South American 1969	-53	3	-47	Guyana
*	South American 1969	-61	2	-33	Paraguay
*	South American 1969	-58	0	-44	Peru
*	South American 1969	-45	12	-33	Trinidad & Tobago
*	South American 1969	-45	8	-33	Venezuela
*	South Asia	7	-10	-26	Singapore
*	Tananarive Observatory 1925	-189	-242	-91	Madagascar
*	Timbalai 1948 Tokyo	-679	669	-48	Brunei, East Malaysia (Sabah, Sarawak)
*	Tokyo	-148	507	685	MEAN FOR Japan, Korea, Okinawa
*	Tokyo	-148	507	685	Japan
*	Tokyo	-146	507	687	Korea
*	Tokyo	-158	507	676	Okinawa
*	Tristan Astro 1968	-632	438	-609	Tristan da Cunha
*	Viti Levu 1916	51	391	-36	Fiji (Viti Levu Island)
*	Wake-Eniwetok 1960	102	52	-38	Marshall Islands
*	Wake Island Astro 1952	276	-57	149	Wake Atoll
*	WGS 1972	0	0	0	Global Definition
*	Yacare	-155	171	37	Uruguay

DoD World Geodetic System 1984 DMA TR 8350.2-B 1 DEC 87, Second Printing, Includes 1 SEP 91 Updates

* As a user option, User Defined Datums can be assigned to Datum IDs 50 and 51.

ONCORE

APPENDIX B ELLIPSOIDS

Ellipsoid Name	Semi-Major Axis	Inverse Flattening
Airy	6377563.396	299.3249646
Airy_Modified	6377340.189	299.3249646
Australian_National	6378160.0	298.25
Bessel_1841	6377397.155	299.1528128
Bessel_1841_in_Nambia	6377483.865	299.1528128
Clarke_1866	6378206.4	294.9786982
Clarke_1880	6378249.145	293.465
Everest_1830	6377276.345	300.8017
Everest_1948	6377304.063	300.8017
Everest_1956	6377301.243	300.8017
Everest_1969	6377295.664	300.8017
Everest_(Sabah & Sarawak)	6377298.556	300.8017
Fischer_1960	6378166	298.3
Modified_Fischer_1960	6378155	298.3
Fischer_1968	6378150	298.3
GRS-80	6378137.0	298.257222101
Helmert_1906	6378200.0	298.3
Hough	6378270	297
International	6378388.0	297.0
Krassovsky	6378245	298.3
SGS_85	6378136	298.257
South_America_1969	6378160.0	298.25
WGS_60	6378165	298.3
WBS_66	6378145	298.25
WGS_72	6378135.0	298.26
WGS_84	6378137.0	298.257223563