GPS 15H & 15L TECHNICAL SPECIFICATIONS

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RECORD OF REVISIONS

Revision	Revision Date	Description	ECO #
A	8/16/02	Initial Release	--
B	10/22/04	Revised and Redrawn	28110
C	12/27/04	Revised and Redrawn	28960
D	2/17/06	Revised and Redrawn	36010

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1 INTRODUCTION

1.1 CAUTIONS

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Caution

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The GPS system is operated by the government of the United States, which is solely responsible for its accuracy and maintenance. Although the GPS 15H & 15L sensors are precision electronic NAVigation AIDs (NAVAID), any NAVAID can be misused or misinterpreted, and therefore become unsafe. Use these products at your own risk. To reduce the risk, carefully review and understand all aspects of these *Technical Specifications* before using the GPS 15H & 15L. When in actual use, carefully compare indications from the GPS to all available navigation sources including the information from other NAVAIDs, visual sightings, charts, etc. For safety, always resolve any discrepancies before continuing navigation.

<div align="center">

FCC Compliance

</div>

The GPS 15H & 15L sensors comply with Part 15 of the FCC interference limits for Class B digital devices FOR HOME OR OFFICE USE. These limits are designed to provide reasonable protection against harmful interference in a residential installation, and are more stringent than "outdoor" requirements.

Operation of this device is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.

- Increase the separation between the equipment and receiver.

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

- Consult the dealer or an experienced radio/TV technician for help.

The GPS 15H & 15L sensors do not contain any user-serviceable parts. Unauthorized repairs or modifications could result in permanent damage to the equipment and void your warranty and your authority to operate these devices under Part 15 regulations.

1.2 LIMITED WARRANTY

This Garmin product is warranted to be free from defects in materials or workmanship for one year from the date of purchase. Within this period, Garmin will at its sole option repair or replace any components that fail in normal use. Such repairs or replacement will be made at no charge to the customer for parts or labor, provided that the customer shall be responsible for any transportation cost. This warranty does not cover failures due to abuse, misuse, accident, or unauthorized alteration or repairs.

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IN NO EVENT SHALL GARMIN BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, WHETHER RESULTING FROM THE USE, MISUSE, OR INABILITY TO USE THIS PRODUCT OR FROM DEFECTS IN THE PRODUCT. Some states do not allow the exclusion of incidental or consequential damages, so the above limitations may not apply to you.

Garmin retains the exclusive right to repair or replace the unit or software or offer a full refund of the purchase price at its sole discretion. SUCH REMEDY SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY BREACH OF WARRANTY.

To obtain warranty service, contact your local Garmin authorized dealer or call Garmin Product Support at one of the numbers listed below for shipping instructions and an RMA tracking number. The unit should be securely packed with the tracking number clearly written on the <u>outside</u> of the package. The unit should then be sent, freight charges prepaid, to any Garmin warranty service station. A copy of the original sales receipt is required as the proof of purchase for warranty repairs.

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Online Auction Purchases: Products sold through online auctions are not eligible for rebates or other special offers from Garmin. Online auction confirmations are not accepted for warranty verification. To obtain warranty service, an original or copy of the sales receipt from the original retailer is required. Garmin will not replace missing components from any package purchased through an online auction.

International Purchases: A separate warranty is provided by international distributors for units purchased outside the United States. This warranty is provided by the local in-country distributor and this distributor provides local service for your unit. Distributor warranties are only valid in the area of intended distribution. Units purchased in the United States or Canada must be returned to the Garmin service center in the United Kingdom, the United States, Canada, or Taiwan for service.

1.3 OVERVIEW

The GPS 15H & 15L are part of Garmin's latest generation of GPS sensor boards designed for a broad spectrum of OEM (Original Equipment Manufacture) system applications. Based on the proven technology found in other Garmin 12-channel GPS receivers, the GPS 15H & 15L track up to 12 satellites at a time while providing fast time-to-first-fix, one-second navigation updates, and low power consumption. The GPS 15H & 15L also provide the capability of FAA Wide Area Augmentation System (WAAS) differential GPS. Their far-reaching capabilities meet the sensitivity requirements of land navigation, the timing requirements for precision timing applications, as well as the dynamics requirements of high-performance aircraft.

The GPS 15H & 15L designs utilize the latest technology and high-level circuit integration to achieve superior performance while minimizing space and power requirements. Critical components of the system, such as the digital baseband processor, were designed by Garmin to ensure that the GPS 15H & 15L provide the quality, performance, and capabilities that you have grown to expect from Garmin GPS receivers. The elegant hardware design, combined with software intelligence, makes the GPS 15H & 15L easy to integrate and use.

Because they are complete GPS receivers, the GPS 15H & 15L require minimal additional components from an OEM or system integrator. A minimum system must provide the GPS receiver with a source of power, a GPS antenna, and a clear view of GPS satellites within the 1.5 GHz band. For optimum performance, the GPS antenna should be an active antenna with a gain between 10 and 30 dB. If cost constraints prevent the use of an active antenna, a well-matched, efficient, passive antenna attached by a short cable can be used instead.

The system may communicate with the GPS 15H & 15L via two RS-232 compatible receive channels and one transmit channel. The GPS 15H & 15L internal FLASH memory allows the GPS to retain critical data such as satellite orbital parameters, last-known position, date and time. End-user interfaces such as keyboards and displays are the responsibility of the application designer.

1.4 FEATURES

- 12-channel GPS receiver tracks and uses up to 12 satellites for fast, accurate positioning and low power consumption.

- Differential DGPS capability utilizing real-time WAAS or RTCM corrections yielding 3–5 meter position accuracy (see section 1.5.4.4).

- Compact, rugged design ideal for applications with minimal space.

- May be remotely mounted in an out-of-the-way location.

- Receiver status information can be displayed directly on a chartplotter or PC.

- User initialization is not required. Once installed and a fix is obtained, the unit automatically produces navigation data.

- User-configurable navigation mode (2-dimensional or 3-dimensional fix).

- Highly accurate one-pulse-per-second (PPS) output for precise timing measurements. Pulse width is configurable in 20 millisecond increments from 20 ms to 980 ms.

- Configurable for binary format carrier phase data output on COM 1 port.

- Flexible input voltage levels of 3.3 to 5.4 VDC (GPS 15L) or 8.0 to 40 VDC (GPS 15H).

- Built-in backup battery to maintain real-time clock for up to 21 days. Provision for external power to maintain the real-time clock for longer intervals.

- FLASH-based program and non-volatile memory. New software revisions upgradeable through Web site download and serial interface. Non-volatile memory does not require battery backup.

1.5   TECHNICAL SPECIFICATIONS

Specifications are subject to change without notice.

1.5.1   Physical Characteristics

1.5.1.1 Size
1.400" (35.56 mm) wide x 1.805" (45.85 mm) long x 0.327" (8.31 mm) high

1.5.1.2 Weight
- GPS 15H: 0.53 oz. (15.0 g)
- GPS 15L: 0.50 oz (14.1 g)

1.5.1.3 Available Connector Options
- GPS 15H-F & 15L-F: 8-pin LIF (Low Insertion Force) flex connector, 1-millimeter pitch. For use with common 1 mm pitch, 8-conductor flex cable, available as Garmin Part Number 310-00040-01. This flex cable mates with common 1 mm pitch, 8-pin flex connectors, such as Garmin Part Number 330-00346-08 or Molex Part Number 52793-0890. Refer to the Molex Web site at www.molex.com.

- GPS 15H & 15L-W: 8-pin JST connector, 1-millimeter pitch. Mating wire harness included (Garmin Part Number 325-00118-01). The connector housing used on this harness is equivalent to JST Part Number SHR-08V-S-B. The 8-wire crimp socket is equivalent to JST Part Number SSH-003T-P0.2. Refer to the JST Web site at www.jst.com.

1.5.1.4 Antenna Connector
The GPS 15H & 15L sensors provide a MCX female connector for connection to an active GPS antenna, so the antenna's cable should be terminated in MCX male. A suitable antenna is Garmin's GA 27C Antenna (Garmin Part Number 010-10052-05). Other antennas that are terminated in male BNC connectors may be adapted via a Garmin MCX to BNC Adapter Cable (Garmin Part Number 010-10121-00).

1.5.2   Electrical Characteristics

1.5.2.1 Input Voltage
- GPS 15H: 8.0 VDC to 40 VDC unregulated
- GPS 15L: 3.3 VDC to 5.4 VDC (must have less than 100 mV peak-to-peak ripple)

1.5.2.2 Input Current
- GPS 15H: 60 mA peak, 50 mA nominal @ 8.0 VDC
  40 mA peak, 33 mA nominal @ 12 VDC
  15 mA peak, 12 mA nominal @ 40 VDC
- GPS 15L: 100 mA peak, 85 mA nominal @ 3.3 to 5.0 VDC

1.5.2.3 GPS Receiver Sensitivity
-165 dBW minimum

1.5.3   Environmental Characteristics
- Operating Temperature: -30°C to +80°C
- Storage Temperature: -40°C to +90°C

1.5.4   GPS Performance

1.5.4.1 Receiver
WAAS Enabled™, 12 parallel channel GPS receiver continuously tracks and uses up to 12 satellites (up to 11 with PPS active) to compute and update your position.

1.5.4.2 Acquisition Times
- Reacquisition: Less than 2 seconds

- Warm: Approx. 15 seconds (all data known)

- Cold: Approx. 45 seconds (initial position, time, and almanac known; ephemeris unknown)

- AutoLocate®:   5 minutes (almanac known; initial position and time unknown)

- SkySearch: 5 minutes (no data known)

1.5.4.3 Update Rate
1 second default; NMEA 0183 output interval configurable from 1 to 900 seconds in 1-second increments.

1.5.4.4 Accuracy
- GPS Standard Positioning Service (SPS)
  Position:< 15 meters, 95% typical
  Velocity: 0.1 knot RMS steady state

- DGPS (USCG/RTCM)
  Position:3-5 meters, 95% typical
  Velocity: 0.1 knot RMS steady state

- DGPS (WAAS)
  Position:< 3 meters, 95% typical
  Velocity: 0.1 knot RMS steady state

- PPS Time: ±1 microsecond at rising edge of PPS pulse (subject to Selective Availability)

- Dynamics: 999 knots velocity (only limited at altitude greater than 60,000 feet), 6g dynamics

1.5.5 Interfaces

1.5.5.1 *GPS 15H & 15L Electrical Characteristics*
- True RS-232 output (Port 2 output not used at time of publication), asynchronous serial input compatible with RS-232 or TTL voltage levels, RS-232 polarity.

- User selectable NMEA 0183 baud rate (300, 600, 1200, 2400, 4800, 9600, 19200, 38400). Factory setting is 4800 baud.

1.5.5.2 *Port 1 Protocols*
- Configurable between NMEA 0183 Versions 2.00 and 3.00.

- ASCII output sentences: GPALM, GPGGA, GPGLL, GPGSA, GPGSV, GPRMC, and GPVTG (NMEA-approved sentences); and PGRMB, PGRME, PGRMF, PGRMM, PGRMT, and PGRMV (Garmin proprietary sentences).

- NMEA 0183 Outputs (see section 4.2 for full protocol specifications)
  Position, velocity and time
  Receiver and satellite status
  Differential Reference Station ID and RTCM Data age
  Geometry and error estimates

- NMEA 0183 Inputs (see section 4.1 for full protocol specifications)
  Initial position, date and time (not required)
  Earth datum and differential mode configuration command, PPS Enable, GPS satellite almanac

- Configurable for binary data output including GPS carrier phase data

1.5.5.3 *Port 2 Protocols*
Real-time Differential Correction input (RTCM SC-104 message types 1, 2, 3, 7, and 9)

1.5.5.4 *PPS*
1 Hz pulse, programmable width, 1 μs accuracy

1.5.6 Antenna Specifications
Should be an active antenna with the following specifications:

Gain:	Antenna should provide between 10 dB to 30 dB net gain between the antenna feed point and the connection to the GPS 15H & 15L. Consider all amplifier gains, filter losses, cable losses, etc. when calculating the gain.
RF Connection:	GPS 15H & 15L RF Connection: MCX Female connector (on the GPS 15H & 15L board). Antenna Connection: MCX Male connector (on the end of the antenna cable).
Garmin Antenna:	GPS 27C (Garmin Part Number 010-10052-05) provides the required MCX Male connector. Other Garmin antennas terminated in a BNC Male connector may also be used if a Garmin MCX to BNC Adapter Cable (Garmin Part Number 010-10121-00) is used. Place the MCX to BNC Adapter Cable between the connector on the end of the antenna cable and the connector on the GPS 15H & 15L.

Noise Figure/Gain: The total noise figure on the external antenna must be ≤ 7 dB. Refer to the table below.
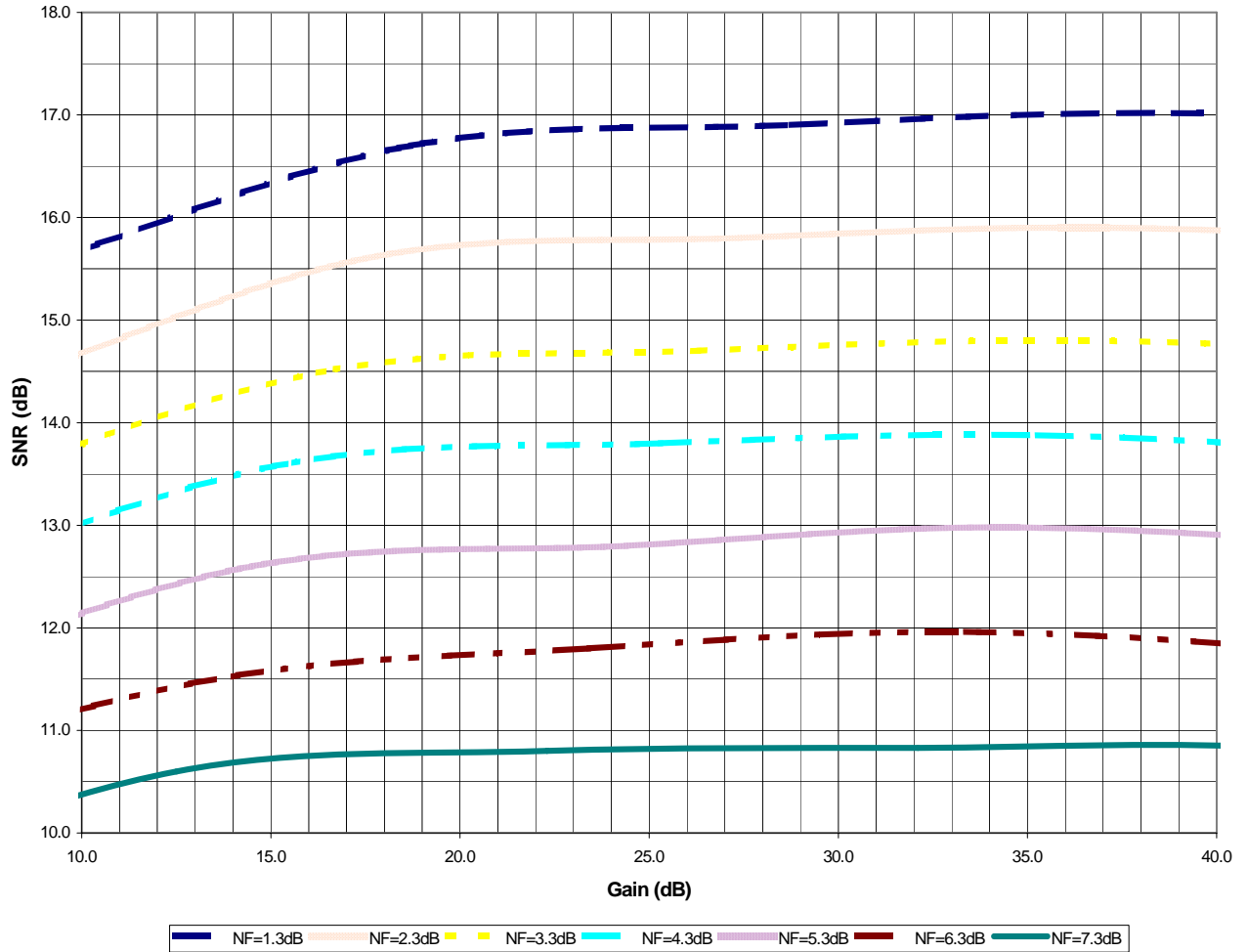
Table 1: Gain vs. SNR for Given Noise Figure

Properly bias the antenna from an on-board source or an external source:

Bias voltage from on-board source: GPS 15H supplies 3.3 VDC to the center conductor of the MCX female, relative to the connector shell ground.

GPS 15L supplies 3.0 VDC to the center conductor of the MCX female, relative to the connector shell ground

In both the GPS 15H and 15L, the source resistance of the DC supply to the center conductor of the connector is approximately 10 Ohms, which is included as a current limiting resistance. This resistance allows the receiver to survive momentary shorting of the antenna port.

The GPS 15H and 15L sensors with serial numbers between 27700000 and 28099999 can detect if the antenna is shorted. GPS 15H and 15L sensors no in the serial number range listed above do not have a provision to protect against a continuously shorted antenna port.

The antenna must not draw more than 60 mA.

Bias voltage from external source: 4.0 to 8.0 VDC bias through the series combination of an on-board ~10 Ohm current limiting resistance and a Schottky diode.

The antenna must not draw more than 60 mA.

2 GPS 15H & 15L WIRE DESCRIPTIONS AND WIRING DIAGRAMS

The GPS 15H-F & 15L-F use an eight-contact flex circuit LIF (low insertion force) connector. The GPS 15H-W & 15L-W use an eight-pin JST connector (mating wire harness included). See section 1.5.1.3.

2.1 GPS 15H & 15L WIRE DESCRIPTIONS

Pin #	Signal Name	Description
1	BACKUP POWER	This input provides external power to maintain the real-time clock. This enables the user to provide backup power if needed for longer than the on-board backup battery provides (roughly 21 days). Input voltage must be between +2.8 and +3.4 VDC.
2	GROUND	Power and Signal Ground
3	POWER	**GPS 15L:** +3.3 to +5.4 VDC (±100 mV ripple) input. Peak operating current is 100 mA. Nominal operating current is 85 mA. This voltage drives an LDO with a nominal 3.0 VDC output. **GPS 15H:** Unregulated 8.0 to 40 VDC input. Peak operating current is 40 mA @ 12 VDC input. Nominal operating current is 33 mA @ 12 VDC input. This voltage drives a switching regulator with a nominal 3.3 VDC output. Although a regulated supply is not required, the peak-to-peak voltage ripple on this line should be kept to less than 100 mV.
4	PORT 1 DATA OUT	Serial Asynchronous Output RS-232 compatible output normally provides serial data which is formatted per *NMEA 0183, Version 2.0*. This output is also capable of outputting phase data information; see Appendix B: Binary Phase Output Format for details. The NMEA 0183 baud rate is selectable in the range of 300 to 38400 baud. The default baud rate is 4800.
5	PORT 1 DATA IN	First Serial Asynchronous Input RS-232 compatible with maximum input voltage range of -25 < V < 25. This input may also be directly connected to standard 3 to 5 VDC CMOS logic that utilizes RS-232 polarity. The low signal voltage requirement is < 0.6 V, and the high signal voltage requirement is > 2.4 V. Minimum load impedance is 500 Ω. This input may be used to receive serial initialization/ configuration data as specified in section 4.1 Received NMEA 0183 Sentences.
6	RF BIAS	This input allows the user to supply an external RF bias voltage in the range of 4 VDC to 8 VDC to the active antenna. The voltage should be from a clean, regulated supply and should be well isolated from potential sources of interference. The supply should not share RF current paths with other system devices such as microprocessors or other RF circuits. By default, the unit uses an internal voltage to power the active antenna. **Note:** This pin is only operational on units whose serial numbers are higher than the serial numbers given below: 010-00240-01 GPS 15H-W serial no. 81301857 010-00240-02 GPS 15L-W serial no. 81408976 010-00240-11 GPS 15H-F serial no. 81901632 010-00240-12 GPS 15L-F serial no. 82001471
7	PPS	One-Pulse-Per-Second Output Typical voltage rise and fall times are 100 ns. Impedance is 250 Ω. The open circuit output voltage toggles between the low (0 V) and the high (3.3 V for 15H and 3.0 V for 15L). The default format is a 100 ms wide active-high pulse at a 1 Hz rate, with the pulse width configurable in 20 ms increments. Rising edge is synchronized to the start of each GPS second. This output provides a nominal 450 mVp-p signal into a 50 Ω load. The pulse time measured at the 50% voltage point will be approximately 15 ns earlier with a 50 Ω load than with no load.
8	PORT 2 DATA IN	Second Serial Asynchronous Input This input may be used to receive serial differential GPS data formatted per *RTCM SC-104 Recommended Standards For Differential Navstar GPS Service, Version 2.2* (see section 4.5 for more details).

Table 2: GPS 15H & 15L Wire Descriptions

2.2   GPS 15H & 15L WIRING DIAGRAMS
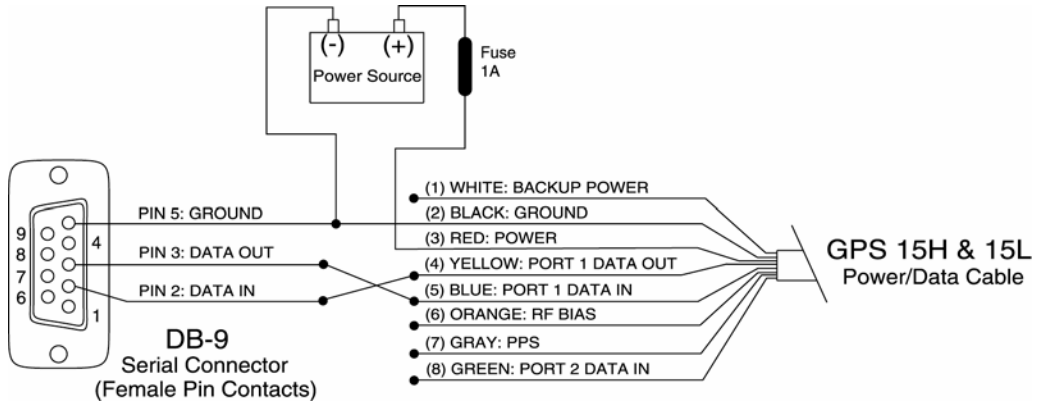
Figure 1: Computer Serial Port Interconnection
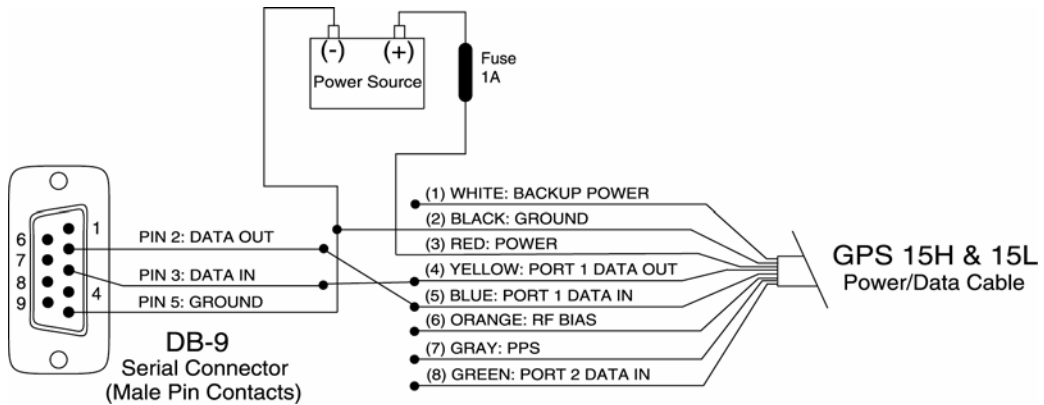
Figure 2: PDA Serial Port Interconnection
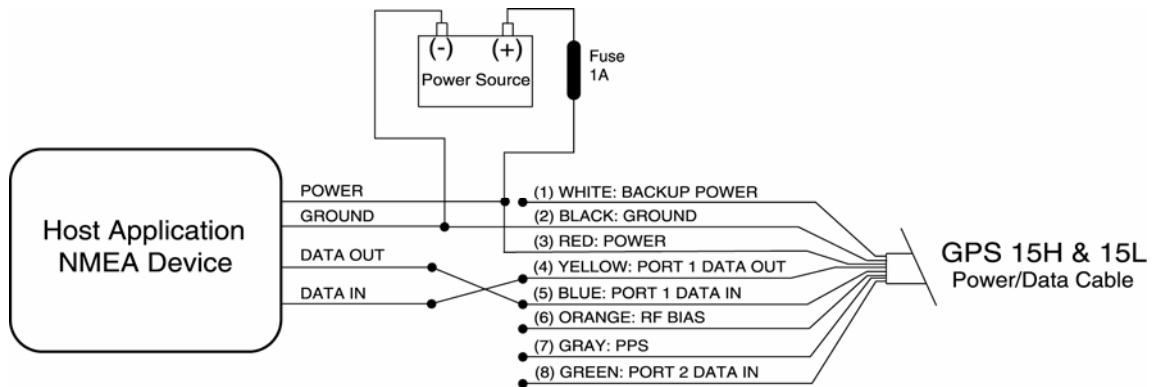
Figure 3: Basic NMEA Device Interconnection

3   MECHANICAL CHARACTERISTICS & MOUNTING
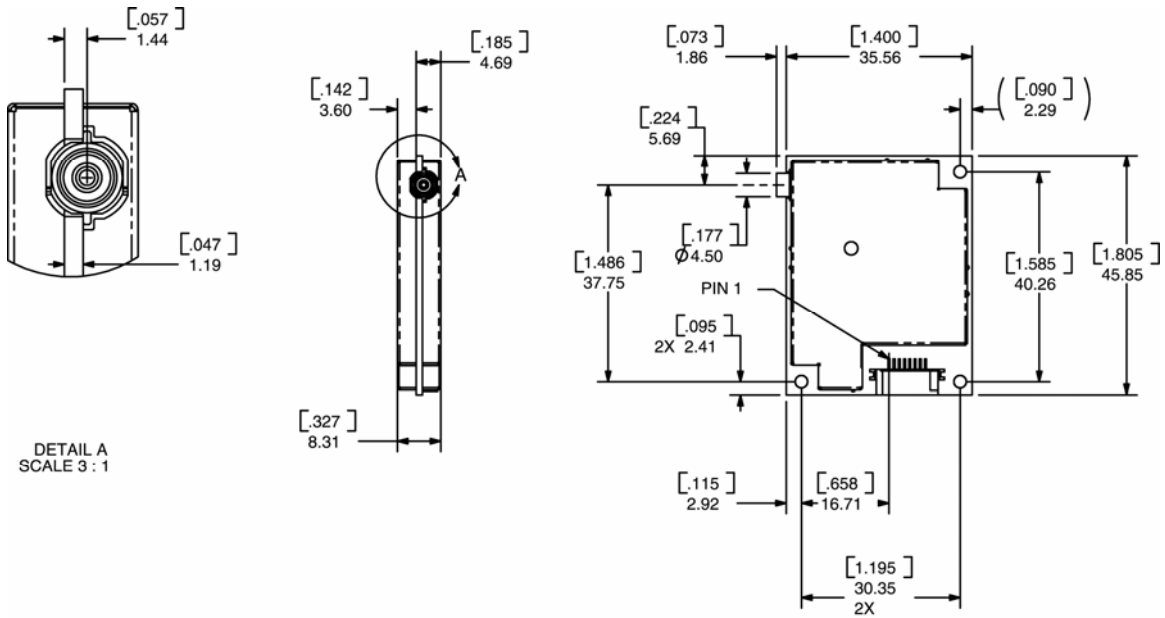
1. Dimensions in millimeters [inches]
2. Dimension tolerance: +/-0.25 mm [±0.01"]
3. Use M2 mounting screws

Figure 4: GPS 15H-F & 15L-F Dimensions
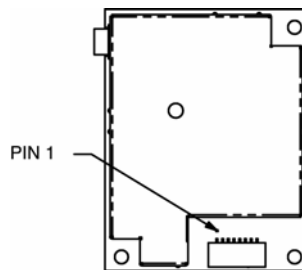
1. Dimensions identical to GPS 15H-F and GPS 15L-F
2. Use M2 mounting screws

Figure 5: GPS 15H-W & 15L-W Outline Drawing

4   <u>GPS 15H & 15L SOFTWARE INTERFACE</u>

The GPS 15H & 15L interface protocol design on COM 1 is based on the National Marine Electronics Association's NMEA 0183 ASCII interface specification. The COM 2 port can receive differential GPS (DGPS) correction data using the Radio Technical Commission for Maritime Services' RTCM SC-104 standard. These standards are fully defined in *NMEA 0183, Version 3.0* (copies may be obtained from NMEA, www.nmea.org) and *RTCM Recommended Standards For Differential Navstar GPS Service, Version 2.2, RTCM Special Committee No.104* (copies may be obtained from RTCM, www.rtcm.org).

The GPS 15H & 15L interface protocol, in addition to transmitting navigation information as defined by NMEA 0183, transmits additional information using the convention of Garmin proprietary sentences. These proprietary sentences begin with the characters, "$PGRM", instead of the characters "$G" that are typical of the standard NMEA 0183 sentences. The characters "$P" indicate that the sentence is a proprietary implementation and the characters and the characters "GRM" indicate that it is Garmin's proprietary sentence. The letter (or letters) that follow the characters "$PGRM" uniquely identifies that particular Garmin proprietary sentence.

Binary phase data information can alternatively be output on the COM 1 port; see Appendix B: Binary Phase Output Format for details.

The following sections describe the NMEA 0183 data format of each sentence transmitted and received by the GPS 15H & 15L.

4.1   RECEIVED NMEA 0183 SENTENCES

The following paragraphs define the sentences that can be received on the GPS sensor's port. Null fields in the configuration sentence indicate no change in the particular configuration parameter. All sentences received by the GPS sensor must be terminated with <CR><LF>, the ASCII characters for carriage return (0D hexadecimal) and line feed (0A hexadecimal), respectively. The checksum *hh is used for parity checking data and is recommended for use in environments containing high electromagnetic noise. It is generally not required in normal PC environments. When used, the parity bytes (hh) are the ASCII representation of the upper and lower nibbles of the exclusive-or (XOR) sum of all the characters between the "$" and "*" characters, non-inclusive. The hex representation must be a capital letter, such as 3D instead of 3d. Sentences may be truncated by <CR><LF> after any data field and valid fields up to that point will be acted on by the sensor.

4.1.1   Almanac Information (ALM)

The $GPALM sentence can be used to initialize the GPS sensor's stored almanac information in the unlikely event of non-volatile memory loss, or after storage of greater than six months without tracking GPS satellites.

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

|	
<1>	Total number of ALM sentences to be transmitted by the GPS sensor during almanac download. This field can be null or any number when sending almanac to the GPS sensor.
<2>	Number of current ALM sentence. This field can be null or any number when sending almanac to the GPS sensor.
<3>	Satellite PRN number, 01 to 32
<4>	GPS week number
<5>	SV health, bits 17-24 of each almanac page
<6>	Eccentricity
<7>	Almanac reference time
<8>	Inclination angle
<9>	Rate of right ascension
<10>	Root of semi major axis
<11>	Omega, argument of perigee
<12>	Longitude of ascension node
<13>	Mean anomaly
<14>	af0 clock parameter
<15>	af1 clock parameter

4.1.2 Sensor Initialization Information (PGRMI)

The $PGRMI sentence provides information used to initialize the GPS sensor's set position and time used for satellite acquisition. Receipt of this sentence by the GPS sensor causes the software to restart the satellite acquisition process. If there are no errors in the sentence, it is echoed upon receipt. If an error is detected, the echoed PGRMI sentence will contain the current default values. Current PGRMI defaults (with the exception of the Receiver Command, which is a command rather than a mode) can also be obtained by sending $PGRMIE to the GPS sensor.

$PGRMI,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Latitude, ddmm.mmm format (leading zeros must be transmitted)
<2>	Latitude hemisphere, N or S
<3>	Longitude, dddmm.mmm format (leading zeros must be transmitted)
<4>	Longitude hemisphere, E or W
<5>	Current UTC date, ddmmyy format
<6>	Current UTC time, hhmmss format
<7>	Receiver Command, A = Auto Locate, R = Unit Reset

4.1.3 Sensor Configuration Information (PGRMC)

The $PGRMC sentence provides information used to configure the GPS sensor's operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS sensor echoes this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC sentence will contain the current default values. Current default values can also be obtained by sending $PGRMCE to the GPS sensor.

$PGRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>*hh<CR><LF>

<1>	Fix mode, A = automatic, 2 = 2D exclusively (host system must supply altitude), 3 = 3D exclusively
<2>	Altitude above/below mean sea level, -15H & 15L00.0 to 18000.0 meters
<3>	Earth datum index. If the user datum index (96) is specified, fields <4> through <8> must contain valid values. Otherwise, fields <4> through <8> must be null. Refer to Appendix A: Earth Datums for a list of earth datums and the corresponding earth datum index.
<4>	User earth datum semi-major axis, 6360000.000 to 6380000.000 meters (.001 meters resolution)
<5>	User earth datum inverse flattening factor, 285.0 to 310.0 (10^{-9} resolution)
<6>	User earth datum delta x earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<7>	User earth datum delta y earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<8>	User earth datum delta z earth centered coordinate, -5000.0 to 5000.0 meters (1 meter resolution)
<9>	Differential mode, A = automatic (output DGPS data when available, non-DGPS otherwise), D = differential exclusively (output only differential fixes)
<10>	NMEA 0183 Baud rate, 1 = 1200, 2 = 2400, 3 = 4800, 4 = 9600, 5 = 19200, 6 = 300, 7 = 600, 8 = 38400
<11>	Velocity filter, 0 = No filter, 1 = Automatic filter, 2-255 = Filter time constant (e.g., 10 = 10 second filter)
<12>	PPS mode, 1 = No PPS, 2 = 1 Hz
<13>	PPS pulse length, 0-48 = (n+1)*20 ms. Example: n = 4 corresponds to a 100 ms wide pulse
<14>	Dead reckoning valid time 1-30 (sec)

All configuration changes take effect after receipt of a valid value except baud rate and PPS mode. Baud rate and PPS mode changes take effect on the next power cycle or an external reset event.

4.1.4 Additional Sensor Configuration Information (PGRMC1)

The $PGRMC1 sentence provides additional information used to configure the GPS sensor operation. Configuration parameters are stored in non-volatile memory and retained between power cycles. The GPS sensor echoes this sentence upon its receipt if no errors are detected. If an error is detected, the echoed PGRMC1 sentence will contain the current default values. Current default values can also be obtained by sending $PGRMC1E to the GPS sensor.

$PGRMC1,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>*hh<CR><LF>

<1>	NMEA 0183 output time 1-900 (sec)
<2>	Binary Phase Output Data, 1 = Off, 2 = On
<3>	Automatic Position Averaging when Stopped, 1 = Off, 2 = On
<4>	DGPS beacon frequency – 0.0, 283.5 – 325.0 kHz in 0.5 kHz steps
<5>	DGPS beacon bit rate – 0, 25, 50, 100, or 200 bps
<6>	DGPS beacon scanning, 1 = Off, 2 = On
<7>	NMEA 0183 version 2.30 mode indicator, 1 = Off, 2 = On
<8>	DGPS mode, A = Automatic, W = WAAS Only, R = RTCM Only, N = None (DGPS disabled)
<9>	Power Save Mode, P = Power Save mode, N = Normal

At power up or external reset, a stored beacon frequency other than 0.0 causes the GPS sensor to tune the beacon receiver. Configuration changes take effect immediately, with the exception of Binary Phase Output Data, which takes effect on the next power cycle or a reset event. A reset can be commanded by sending the sentence "$PGRMI,,,,,,,R" (refer to section 4.1.2).

If the GPS sensor is in the Binary data mode, it is necessary to send the following eight-byte data stream to the COM 1 input to temporarily change the data format to NMEA 0183. Then send a PGRMC1 sentence that turns off the Binary Phase Output Data format:

10 0A 02 26 00 CE 10 03 (Hexadecimal)

4.1.5 Output Sentence Enable/Disable (PGRMO)

The $PGRMO sentence provides the ability to enable and disable specific output sentences. The following sentences are enabled at the factory: GPGGA, GPGSA, GPGSV, GPRMC, PGRMB, PGRME, PGRMM, PGRMT, and PSLIB.

$PGRMO,<1>,<2>*hh<CR><LF>

<1>	Target sentence description (e.g., PGRMT, GPGSV, etc.)
<2>	Target sentence mode, where: 0 = disable specified sentence 1 = enable specified sentence 2 = disable all output sentences (except PSLIB) 3 = enable all output sentences (except GPALM) 4 = restore factory default output sentences

The following notes apply to the PGRMO input sentence:

1. If the target sentence mode is '2' (disable all), '3' (enable all), or '4' (restore defaults), the target sentence description is not checked for validity. In this case, an empty field is allowed (e.g., $PGRMO,,3), or the mode field may contain from 1 to 5 characters.

2. If the target sentence mode is '0' (disable) or '1' (enable), the target sentence description field must be an identifier for one of the sentences that can be output by the GPS sensor.

3. If either the target sentence mode field or the target sentence description field is not valid, the PGRMO sentence will have no effect.

4. $PGRMO,GPALM,1 causes the GPS sensor to transmit all stored almanac information. All other NMEA 0183 sentence transmission is suspended temporarily.

5. $PGRMO,,G causes the COM 1 port to change to Garmin Data Transfer format for the duration of the power cycle. The Garmin mode is required for GPS 15H & 15L product software updates.

4.1.6   Tune DGPS Beacon Receiver (PSLIB)

The $PSLIB sentence provides the ability to tune a Garmin GBR 21, GBR 23 or equivalent beacon receiver.

$PSLIB,<1>,<2>*hh<CR><LF>

<1>	Beacon tune frequency, 0.0, 283.5–325.0 kHz in 0.5 kHz steps
<2>	Beacon bit rate, 0, 25, 50, 100, or 200 bps

If valid data is received, the GPS sensor stores it in the EEPROM and echoes the PSLIB command to the beacon receiver. If the GPS sensor is using any stored beacon frequency other than 0.0, it will tune the beacon receiver once immediately after power up or external reset.

4.2 TRANSMITTED NMEA 0183 SENTENCES

The subsequent paragraphs define the sentences that can be transmitted on COM 1 by the GPS sensor.

4.2.1 Sentence Transmission Rate

Sentences are transmitted with respect to the user-selected baud rate.

Regardless of the selected baud rate, the information transmitted by the GPS sensor is referenced to the one-pulse-per-second output pulse immediately preceding the GPRMC sentence, or whichever sentence is output first in the burst (see Table 3 below).

The GPS sensor transmits each sentence (except where noted in particular transmitted sentence descriptions) at a periodic rate based on the user-selected baud rate and user-selected output sentences. The GPS sensor transmits the selected sentences contiguously. The contiguous transmission starts at a GPS second boundary. Determine the length of the transmission with the following equation and Tables 3 and 4:

$$\text{length of transmission} = \frac{\text{total characters to be transmitted}}{\text{characters transmitted per second}}$$

Sentence	Output by Default?	Maximum Characters
GPRMC	✓	74
GPGGA	✓	82
GPGSA	✓	66
GPGSV	✓	70
PGRME	✓	35
GPGLL		44
GPVTG		42
PGRMV		32
PGRMF		82
PGRMB	✓	40
PGRMM	✓	32
PGRMT	Once per minute	50

Table 3: NMEA 0183 Output Sentence Order and Size

Baud	Characters per Second
300	30
600	60
1200	120
2400	240
4800	480
9600	960
19200	1920
38400	3840

Table 4: Characters per Second for Available Baud Rates

The maximum number of fields allowed in a single sentence is 82 characters including delimiters. Values in the table include the sentence start delimiter character "$" and the termination delimiter <CR><LF>. The factory set defaults result in a once per second transmission at the NMEA 0183 specification transmission rate of 4800 baud.

4.2.2   Transmitted Time

The GPS sensor outputs UTC (Coordinated Universal Time) date and time of day in the transmitted sentences. Before the initial position fix, the on-board clock provides the date and time of day. After the initial position fix, the date and time of day are calculated using GPS satellite information and are synchronized with the one-pulse-per-second output.

The GPS sensor uses information obtained from the GPS satellites to add or delete UTC leap seconds and correct the transmitted date and time of day. The transmitted date and time of day for leap second correction follow the guidelines in *National Institute of Standards and Technology Special Publication 432 (Revised 1990).* This document is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, U.S.A.

When a positive leap second is required, one second is inserted at the beginning of the first hour (0h 0m 0s) of the day that the positive leap is occurring. The minute containing the leap second is 61 seconds long. The GPS sensor would have transmitted this information for the leap second added December 31, 1998 as follows:

$GPRMC,235959,A,3851.3651,N,09447.9382,W,000.0,221.9,071103,003.3,E*69

$GPRMC,000000,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*67

$GPRMC,000000,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*67

$GPRMC,000001,A,3851.3651,N,09447.9382,W,000.0,221.9,081103,003.3,E*66

If a negative leap second should be required, one second is deleted at the end of some UTC month. The minute containing the leap second will be only 59 seconds long. In this case, the GPS sensor will not transmit the time of day 0h 0m 0s (the "zero" second) for the day from which the leap second is removed.

$GPRMC,235959,A,3851.3650,N,09447.9373,W,000.0,000.0,111103,003.3,E*69

$GPRMC,000001,A,3851.3650,N,09447.9373,W,000.0,000.0,121103,003.3,E*6A

$GPRMC,000002,A,3851.3650,N,09447.9373,W,000.0,000.0,121103,003.3,E*69

4.2.3   Global Positioning System Almanac Data (ALM)

Almanac sentences are not normally transmitted. Almanac transmission can be initiated by sending the GPS sensor a $PGRMO,GPALM,1 command. Upon receipt of this command, the GPS sensor transmits available almanac information on GPALM sentences. During the transmission of almanac sentences, other NMEA 0183 data output is suspended temporarily.

$GPALM,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<field information> can be found in section 4.1.1.

4.2.4   Global Positioning System Fix Data (GGA)

$GPGGA,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,M,<10>,M,<11>,<12>*hh<CR><LF>

<1>	UTC time of position fix, hhmmss format
<2>	Latitude, ddmm.mmmm format (leading zeros are transmitted)
<3>	Latitude hemisphere, N or S
<4>	Longitude, dddmm.mmmm format (leading zeros are transmitted)
<5>	Longitude hemisphere, E or W
<6>	GPS quality indication, 0 = fix not available, 1 = Non-differential GPS fix available, 2 = differential GPS fix available, 6 = estimated (only if NMEA 0183 version 2.30 mode is enabled in field 7 of the PGRMC1 sentence; see section 4.1.4.)
<7>	Number of satellites in use, 00 to 12 (leading zeros are transmitted)
<8>	Horizontal dilution of precision, 0.5 to 99.9
<9>	Antenna height above/below mean sea level, -9999.9 to 99999.9 meters
<10>	Geoidal height, -999.9 to 9999.9 meters
<11>	Differential GPS (RTCM SC-104) data age, number of seconds since last valid RTCM transmission (null if not an RTCM DGPS fix)
<12>	Differential Reference Station ID, 0000 to 1023 (leading zeros are transmitted, null if not an RTCM DGPS fix)

4.2.5 GPS DOP and Active Satellites (GSA)

$GPGSA,<1>,<2>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<3>,<4>,<5>,<6>*hh<CR><LF>

<1>	Mode, M = manual, A = automatic
<2>	Fix type, 1 = not available, 2 = 2D, 3 = 3D
<3>	PRN number, 01 to 32, of satellite used in solution, up to 12 transmitted (leading zeros are transmitted)
<4>	Position dilution of precision, 0.5 to 99.9
<5>	Horizontal dilution of precision, 0.5 to 99.9
<6>	Vertical dilution of precision, 0.5 to 99.9

4.2.6 GPS Satellites in View (GSV)

$GPGSV,<1>,<2>,<3>,<4>,<5>,<6>,<7>,...<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Total number of GSV sentences to be transmitted
<2>	Number of current GSV sentence
<3>	Total number of satellites in view, 00 to 12 (leading zeros are transmitted)
<4>	Satellite PRN number, 01 to 32 (leading zeros are transmitted)
<5>	Satellite elevation, 00 to 90 degrees (leading zeros are transmitted)
<6>	Satellite azimuth, 000 to 359 degrees, true (leading zeros are transmitted)
<7>	Signal to noise ratio (C/No) 00 to 99 dB, null when not tracking (leading zeros are transmitted)

Note: Items <4>,<5>,<6>, and <7> repeat for each satellite in view to a maximum of four (4) satellites per sentence. Additional satellites in view information must be sent in subsequent bursts of NMEA 0183 data. These fields will be null if unused.

4.2.7 Recommended Minimum Specific GPS/TRANSIT Data (RMC)

$GPRMC,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>*hh<CR><LF>

<1>	UTC time of position fix, hhmmss format
<2>	Status, A = Valid position, V = NAV receiver warning
<3>	Latitude, ddmm.mmmm format (leading zeros are transmitted)
<4>	Latitude hemisphere, N or S
<5>	Longitude, dddmm.mmmm format (leading zeros are transmitted)
<6>	Longitude hemisphere, E or W
<7>	Speed over ground, 000.0 to 999.9 knots (leading zeros are transmitted)
<8>	Course over ground, 000.0 to 359.9 degrees, true (leading zeros are transmitted)
<9>	UTC date of position fix, ddmmyy format
<10>	Magnetic variation, 000.0 to 180.0 degrees (leading zeros are transmitted)
<11>	Magnetic variation direction, E or W (westerly variation adds to true course)
<12>	Mode indicator (only output if NMEA 0183 version 2.30 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.8 Track Made Good and Ground Speed (VTG)

$GPVTG,<1>,T,<2>,M,<3>,N,<4>,K,<5>*hh<CR><LF>

<1>	True course over ground, 000 to 359 degrees (leading zeros are transmitted)
<2>	Magnetic course over ground, 000 to 359 degrees (leading zeros are transmitted)
<3>	Speed over ground, 000.0 to 999.9 knots (leading zeros are transmitted)
<4>	Speed over ground, 0000.0 to 1851.8 kilometers per hour (leading zeros are transmitted)
<5>	Mode indicator (only output if NMEA 0183 version 3.00 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.9 Geographic Position (GLL)

$GPGLL,<1>,<2>,<3>,<4>,<5>,<6>,<7>*hh<CR><LF>

<1>	Latitude, ddmm.mmmm format (leading zeros are transmitted)
<2>	Latitude hemisphere, N or S
<3>	Longitude, dddmm.mmmm format (leading zeros are transmitted)
<4>	Longitude hemisphere, E or W
<5>	UTC time of position fix, hhmmss format
<6>	Status, A = Valid position, V = NAV receiver warning
<7>	Mode indicator (only output if NMEA 0183 version 3.00 active), A = Autonomous, D = Differential, E = Estimated, N = Data not valid

4.2.10 Estimated Error Information (PGRME)

$PGRME,<1>,M,<2>,M,<3>,M*hh<CR><LF>

<1>	Estimated horizontal position error (HPE), 0.0 to 999.9 meters
<2>	Estimated vertical position error (VPE), 0.0 to 999.9 meters
<3>	Estimated position error (EPE), 0.0 to 999.9 meters

4.2.11 GPS Fix Data Sentence (PGRMF)

$PGRMF,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>,<10>,<11>,<12>,<13>,<14>,<15>*hh<CR><LF>

<1>	GPS week number (0 - 1023)
<2>	GPS seconds (0 - 604799)
<3>	UTC date of position fix, ddmmyy format
<4>	UTC time of position fix, hhmmss format
<5>	GPS leap second count
<6>	Latitude, ddmm.mmmm format (leading zeros are transmitted)
<7>	Latitude hemisphere, N or S
<8>	Longitude, dddmm.mmmm format (leading zeros are transmitted)
<9>	Longitude hemisphere, E or W
<10>	Mode, M = manual, A = automatic
<11>	Fix type, 0 = no fix, 1 = 2D fix, 2 = 3D fix
<12>	Speed over ground, 0 to 1851 kilometers/hour
<13>	Course over ground, 0 to 359 degrees, true
<14>	Position dilution of precision, 0 to 9 (rounded to nearest integer value)
<15>	Time dilution of precision, 0 to 9 (rounded to nearest integer value)

4.2.12 Map Datum (PGRMM)

The Garmin Proprietary sentence $PGRMM gives the name of the map datum currently in use by the GPS sensor. This information is used by the Garmin MapSource® real-time plotting application.

$PGRMM,<1>*hh<CR><LF>

<1>	Name of map datum currently in use (variable length field, e.g., "WGS 84")

4.2.13 Sensor Status Information (PGRMT)

The Garmin Proprietary sentence $PGRMT gives information concerning the status of the GPS sensor. This sentence is transmitted once per minute regardless of the selected baud rate.

$PGRMT,<1>,<2>,<3>,<4>,<5>,<6>,<7>,<8>,<9>*hh<CR><LF>

<1>	Product, model and software version (variable length field, e.g., "GPS 15H & 15L VER 2.05")
<2>	ROM checksum test, P = pass, F = fail
<3>	Receiver failure discrete, P = pass, F = fail
<4>	Stored data lost, R = retained, L = lost
<5>	Real time clock lost, R = retained, L = lost
<6>	Oscillator drift discrete, P = pass, F = excessive drift detected
<7>	Data collection discrete, C = collecting, null if not collecting
<8>	GPS sensor temperature. Use for a reference only, but could be null
<9>	GPS sensor configuration data, R = retained, L = lost
<10>	P = pass (Antenna is NOT shorted), F = fail (Antenna is shorted) **Note:** This field is only available on units whose serial numbers are in the range listed below: 010-00240-01 GPS 15H-W serial number between 27700000 through 27799999 010-00240-02 GPS 15L-W serial number between 27800000 through 27899999 010-00240-11 GPS 15H-F serial number between 27900000 through 27999999 010-00240-12 GPS 15L-F serial number between 28000000 through 28099999

4.2.14 3D velocity Information (PGRMV)

$PGRMV,<1>,<2>,<3>*hh<CR><LF>

<1>	True east velocity, -514.4 to 514.4 meters/second
<2>	True north velocity, -514.4 to 514.4 meters/second
<3>	Up velocity, -999.9 to 9999.9 meters/second

4.2.15 DGPS Beacon Information (PGRMB)

$PGRMB,<1>,<2>,<3>,<4>,<5>,K,<6>,<7>*hh<CR><LF>

<1>	Beacon tune frequency, 0.0, 283.5–325.0 kHz in 0.5 kHz steps
<2>	Beacon bit rate, 0, 25, 50, 100, or 200 bps
<3>	Beacon SNR, 0 to 31
<4>	Beacon data quality, 0 to 100
<5>	Distance to beacon reference station in kilometers
<6>	Beacon receiver communication status (0 = Check Wiring, 1 = No Signal, 2 = Tuning, 3 = Receiving, 4= Scanning)
<7>	DGPS fix source (R = RTCM, W = WAAS, N = Non-DGPS Fix)
<8>	DGPS mode, A = Automatic, W = WAAS Only, R = RTCM Only, N = None (DGPS disabled)

4.3 BAUD RATE SELECTION

Baud rate selection can be performed by sending the appropriate configuration sentence to the GPS sensor as described in the $PGRMC section 4.1.3, field <10>.

4.4 ONE-PULSE-PER-SECOND (PPS) OUTPUT

The highly accurate one-pulse-per-second (PPS) output is provided for applications requiring precise timing measurements. The signal is generated after the initial position fix has been calculated and continues until power down. The rising edge of the signal is synchronized to the start of each GPS second.

Regardless of the selected baud rate, the information transmitted by the GPS 15H & 15L is referenced to the pulse immediately preceding the NMEA 0183 RMC sentence.

The accuracy of the one-pulse-per-second output is maintained only while the GPS 15H & 15L can compute a valid position fix. To obtain the most accurate results, the one-pulse-per-second output should be calibrated against a local time reference to compensate for cable and internal receiver delays and the local time bias.

The default pulse width is 100 ms, however; it may be programmed in 20 ms increments between 20 ms and 980 ms as described in $PGRMC section 4.1.3, field <13>.

4.5 RECEIVED RTCM DATA

Position accuracy of less than 5 meters can be achieved with the GPS 15H & 15L by using Differential GPS (DGPS) real-time pseudo-range correction data in RTCM SC-104 format, with message types 1, 2, 3, 7, and 9. These corrections can be received by the GPS 15H & 15L on COM 2. The RTCM data must be received at the same baud rate as the COM 1 port. For details on the SC-104 format, refer to RTCM Paper 134-89/SC 104-68 by the Radio Technical Commission for Maritime Services.

APPENDIX A: EARTH DATUMS

The following is a list of the Garmin GPS 15H & 15L Earth datum indices and the corresponding earth datum name (including the area of application):

0   ADINDAN - Ethiopia, Mali, Senegal, Sudan

1   AFGOOYE - Somalia

2   AIN EL ABD 1970 - Bahrain Island, Saudi Arabia

3   ANNA 1 ASTRO 1965 - Cocos Island

4   ARC 1950 - Botswana, Lesotho, Malawi, Swaziland, Zaire, Zambia, Zimbabwe

5   ARC 1960 - Kenya, Tanzania

6   ASCENSION ISLAND 1958 - Ascension Island

7   ASTRO BEACON "E" - Iwo Jima Island

8   AUSTRALIAN GEODETIC 1966 - Australia, Tasmania Island

9   AUSTRALIAN GEODETIC 1984 - Australia, Tasmania Island

10   ASTRO DOS 71/4 - St. Helena Island

11   ASTRONOMIC STATION 1952 - Marcus Island

12   ASTRO B4 SOROL ATOLL - Tern Island

13   BELLEVUE (IGN) - Efate and Erromango Islands

14   BERMUDA 1957 - Bermuda Islands

15   BOGOTA OBSERVATORY - Colombia

16   CAMPO INCHAUSPE - Argentina

17   CANTON ASTRO 1966 - Phoenix Islands

18   CAPE CANAVERAL - Florida, Bahama Islands

19   CAPE - South Africa

20   CARTHAGE - Tunisia

21   CHATHAM 1971 - Chatham Island (New Zealand)

22   CHUA ASTRO - Paraguay

23   CORREGO ALEGRE - Brazil

24   DJAKARTA (BATAVIA) - Sumatra Island (Indonesia)

25   DOS 1968 - Gizo Island (New Georgia Islands)

26   EASTER ISLAND 1967 - Easter Island

27   EUROPEAN 1950 - Austria, Belgium, Denmark, Finland, France, Germany, Gibraltar, Greece, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland

28   EUROPEAN 1979 - Austria, Finland, Netherlands, Norway, Spain, Sweden, Switzerland

29   FINLAND HAYFORD 1910 - Finland

30   GANDAJIKA BASE - Republic of Maldives

31   GEODETIC DATUM 1949 - New Zealand

32   ORDNANCE SURVEY OF GREAT BRITAIN 1936 - England, Isle of Man, Scotland, Shetland Islands, Wales

33   GUAM 1963 - Guam Island

34   GUX 1 ASTRO - Guadalcanal Island

35   HJORSEY 1955 - Iceland

---

36   HONG KONG 1963 - Hong Kong

37   INDIAN - Bangladesh, India, Nepal

38   INDIAN - Thailand, Vietnam

39   IRELAND 1965 - Ireland

40   ISTS O73 ASTRO 1969 - Diego Garcia

41   JOHNSTON ISLAND 1961 - Johnston Island

42   KANDAWALA - Sri Lanka

43   KERGUELEN ISLAND - Kerguelen Island

44   KERTAU 1948 - West Malaysia, Singapore

45   L.C. 5 ASTRO - Cayman Brac Island

46   LIBERIA 1964 - Liberia

47   LUZON - Mindanao Island

48   LUZON - Phillippines (excluding Mindanao Island)

49   MAHE 1971 - Mahe Island

50   MARCO ASTRO - Salvage Islands

51   MASSAWA - Eritrea (Ethiopia)

52   MERCHICH - Morocco

53   MIDWAY ASTRO 1961 - Midway Island

54   MINNA - Nigeria

55   NORTH AMERICAN 1927 - Alaska

56   NORTH AMERICAN 1927 - Bahamas (excluding San Salvador Island)

57   NORTH AMERICAN 1927 - Central America (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua)

58   NORTH AMERICAN 1927 - Canal Zone

59   NORTH AMERICAN 1927 - Canada (including Newfoundland Island)

60   NORTH AMERICAN 1927 - Caribbean (Barbados, Caicos Islands, Cuba, Dominican Republic, Grand Cayman, Jamaica, Leeward Islands, Turks Islands)

61   NORTH AMERICAN 1927 - Mean Value (CONUS)

62   NORTH AMERICAN 1927 - Cuba

63   NORTH AMERICAN 1927 - Greenland (Hayes Peninsula)

64   NORTH AMERICAN 1927 - Mexico

65   NORTH AMERICAN 1927 - San Salvador Island

66   NORTH AMERICAN 1983 - Alaska, Canada, Central America, CONUS, Mexico

67   NAPARIMA, BWI - Trinidad and Tobago

68   NAHRWAN - Masirah Island (Oman)

69   NAHRWAN - Saudi Arabia

70   NAHRWAN - United Arab Emirates

71   OBSERVATORIO 1966 - Corvo and Flores Islands (Azores)

72   OLD EGYPTIAN - Egypt

73   OLD HAWAIIAN - Mean Value

74   OMAN - Oman

75	PICO DE LAS NIEVES - Canary Islands
76	PITCAIRN ASTRO 1967 - Pitcairn Island
77	PUERTO RICO - Puerto Rico, Virgin Islands
78	QATAR NATIONAL - Qatar
79	QORNOQ - South Greenland
80	REUNION - Mascarene Island
81	ROME 1940 - Sardinia Island
82	RT 90 - Sweden
83	PROVISIONAL SOUTH AMERICAN 1956 - Bolivia, Chile, Colombia, Ecuador, Guyana, Peru, Venezuela
84	SOUTH AMERICAN 1969 - Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Venezuela, Trinidad and Tobago
85	SOUTH ASIA - Singapore
86	PROVISIONAL SOUTH CHILEAN 1963 - South Chile
87	SANTO (DOS) - Espirito Santo Island
88	SAO BRAZ - Sao Miguel, Santa Maria Islands (Azores)
89	SAPPER HILL 1943 - East Falkland Island
90	SCHWARZECK - Namibia
91	SOUTHEAST BASE - Porto Santo and Madeira Islands
92	SOUTHWEST BASE - Faial, Graciosa, Pico, Sao Jorge, and Terceira Islands (Azores)
93	TIMBALAI 1948 - Brunei and East Malaysia (Sarawak and Sabah)
94	TOKYO - Japan, Korea, Okinawa
95	TRISTAN ASTRO 1968 - Tristan da Cunha
96	User defined earth datum
97	VITI LEVU 1916 - Viti Levu Island (Fiji Islands)
98	WAKE-ENIWETOK 1960 - Marshall Islands
99	WORLD GEODETIC SYSTEM 1972
100	WORLD GEODETIC SYSTEM 1984
101	ZANDERIJ - Surinam
102	CH-1903 - Switzerland
103	Hu - Tzu - Shan
104	Indonesia 74
105	Austria
106	Potsdam
107	Taiwan - modified Hu-Tzu-Shan
108	GDA - Geocentric Datum of Australia
109	Dutch

APPENDIX B: BINARY PHASE OUTPUT FORMAT

In binary phase output mode, GPS 15H & 15L series products transmit two types of packets once per second. One record contains primarily post-process information such as position and velocity information. The second record contains receiver measurement information. For the GPS 15H & 15L, the records are sent at a default baud rate of 9600 baud, 8 data bits, and no parity.

To turn these records on, use the $PGRMC1 NMEA sentence as described in section 4 GPS 15H & 15L Software Interface. (Refer to the *Garmin GPS Interface Specification* for details on how to form and parse Garmin packets. At the time of this printing, these specs are available from the technical support section of our Web site: http://www.garmin.com/support/commProtocol.html.)

Note: The satellite data information is also enabled when the position record is enabled.

Records sent over RS232 begin with a delimiter byte (10 hex). The second byte identifies the record type (33 hex for a position record and 34 hex for a receiver measurement). The third byte indicates the size of the data. The fourth byte is the first byte of data. The data is then followed by a checksum byte, a delimiter byte (10 hex), and an end-of-transmission character (03 hex). Additionally, any DLEs (0x10) that appear between the delimeters are escaped with a second DLE. Refer to the end of this section for sample code that strips off the DLEs and ETXs.

RS232 Packet:

- 0x10	(DLE is first byte)
- 0x##	(Record ID – single byte)
- 0x##	(Number of data bytes – single byte)
- data bytes	(See descriptions below)
- 0x##	(2's complement of the arithmetic sum of the bytes between the delimiters)
- 0x10	(DLE)
- 0x03	(ETX is last byte)

The data bytes of each packet contain the record specified by the record ID. A description of each record follows.

Satellite Data Record

The satellite data has a record ID of 0x72 with 84 (0x54) data bytes. The data bytes contain the data for the 12 channels as described below. For each satellite, the following data is available:

```
typedef    struct
           {
           uint8     svid;        //space vehicle identification (1–32 and 33–64 for WAAS)
           uint16    snr;         //signal-to-noise ratio
           uint8     elev;        //satellite elevation in degrees
           uint16    azmth;       //satellite azimuth in degrees
           uint8     status;      //status bit-field
           } cpo_sat_data;
```

The status bit field represents a set of booleans described below:

Bit	Meaning when bit is one (1)
0	The unit has ephemeris data for the specified satellite.
1	The unit has a differential correction for the specified satellite.
2	The unit is using this satellite in the solution.

This pattern is repeated for all 12 channels for a total of 12 X 7 bytes = 84 (0x54) bytes :

typedef   struct

      {

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      cpo_sat_data

      } cpo_all_sat_data

The RS-232 Packet for the Satellite Record looks like:

- 0x10   (DLE is first byte)

- 0x72   (Record ID – single byte)

- 0x54   (Number of data bytes – single byte)

- cpo_all_sat_data

- 0x##   (2's complement of the arithmetic sum of the bytes between the delimiters)

- 0x10   (DLE)

- 0x03   (ETX is last byte)

Position Record

The Position Record has a record identifier of

```
typedef struct
    {
    float       alt;
    float       epe;
    float       eph;
    float       epv;
    int         fix;
    double      gps_tow;
    double      lat;
    double      lon;
    float       lon_vel;
    float       lat_vel;
    float       alt_vel;
    float       msl_hght;
    int         leap_sec;
    long        grmn_days;
    } cpo_pvt_data;
```

alt   Ellipsoid altitude (meters)
epe   Est pos error (meters)
eph   Pos err, horizontal (meters)
epv   Pos err, vertical (meters)
fix   0 = no fix; 1 = no fix; 2 = 2D; 3 = 3D; 4 = 2D differential; 5 = 3D differential;
                6 and greater - not defined
gps_tow   GPS time of week (sec)
lat   Latitude (radians)
lon   Longitude (radians)
lon_vel   Longitude velocity (meters/second)
lat_vel   Latitude velocity (meters/second)
alt_vel   Altitude velocity (meters/second)
msl_hght   Mean sea level height (meters)
leap_sec   UTC leap seconds
grmn_days   Garmin days (days since December 31, 1989)

Receiver Measurement Record

```
typedef struct
    {
    unsigned long    cycles;
    double           pr;
    unsigned int     phase;
    char             slp_dtct;
    unsigned char    snr_dbhz;
    char             svid;
    char             valid;
} cpo_rcv_sv_data;

typedef struct
    {
    double           rcvr_tow;
    int              rcvr_wn;
    cpo_rcv_sv_data  sv[ 12 ];
} cpo_rcv_data;
```

rcvr_tow   Receiver time of week (seconds)
rcvr_wn   Receiver week number
cycles   Number of accumulated cycles
pr   Pseudorange (meters)
phase   To convert to (0 -359.999) multiply by 360.0 and divide by 2048.0
slp_dtct   0 = no cycle slip detected; non-zero = cycle slip detected
snr_dbhz   Signal strength - db Hz

svid	Satellite number (0-31 and 119-138 for WAAS) Note: Add 1 to offset to current svid numbers.
valid	0 = information not valid; non-zero = information valid

Sample C Code

DLE and ETX bytes:

Sample C code to receive the two records should filter DLE and ETX bytes as described below:

```c
typedef enum
    {
    DAT,
    DLE,
    ETX
    } rx_state_type;

/* Declare and initialize static variables */
static char         in_que[ 256 ];
static int          in_que_ptr = 0;
static rx_state_type rx_state = DAT;
.
.
.
void add_to_que( char data )
{
#define DLE_BYTE 0x10
#define ETX_BYTE 0x03

if ( rx_state == DAT )
    {
    if ( data == DLE_BYTE )
        {
        rx_state = DLE;
        }
    else
        {
        in_que[ in_que_ptr++ ] = data;
        }
    }
else if ( rx_state == DLE )
    {
    if ( data == ETX_BYTE )
        {
        rx_state = ETX;
        }
    else
        {
        rx_state = DAT;
        in_que[ in_que_ptr++ ] = data;
        }
    }
else if ( rx_state == ETX )
    {
    if ( data == DLE_BYTE )
        {
        rx_state = DLE;
        }
    }

if ( in_que_ptr > 255 )
    {
    in_que_ptr = 0;
    }
}
```

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APPENDIX C: CHANGING THE BAUD RATE IN GARMIN MODE

In certain cases, you may need to change the default baud rate of your Garmin GPS receiver while in Garmin mode. Follow these steps to temporarily change the baud rate.

Refer to the *Garmin Device Interface Specification* for details on how to form and parse Garmin packets. At the time of this printing, these specs are available from the technical suppport section of our Web site: http://www.garmin.com/support/commProtocol.html.

1. Turn off all requests by transmitting packet:

    id = IOP_RQST_DATA (0x1C)

    data = 0 (16-bit unsigned integer)

2. The GPS unit will respond by sending a packet with id = IOP_ACK_BYTE (0x06)

3. After you receive the above packet, transmit packet:

    id = IOP_BAUD_RQST_DATA (0x30)

    data = baud rate to change to (32-bit unsigned integer; for example, 38400)

4. The GPS unit will respond by sending a packet:

    id = IOP_BAUD_ACPT_DATA (0x31)

    data = highest acceptable baud rate closest to what was requested
    (32-bit unsigned integer; for example, 38361 decimal)

5. Determine the actual baud rate value from the data sent in step 4. This value will be within +/- 5% of the actual baud rate. (For example, the GPS unit might send a baud rate of 38361, which correlates to a baud rate of 38400).

6. If the baud rate in step 5 is acceptable, transmit packet:

    id = IOP_ACK_BYTE (0x06)

    data = IOP_BAUD_ACPT_DATA (0x31)

7. Sleep for a small amount of time, about 100 milliseconds, to make sure the packet in (6) was successfully transmitted to the GPS unit.

8. Close the current connection to the GPS unit and immediately open a new connection with the new baud rate obtained in step 5.

9. Immediately after establishing a connection, transmit packet:

    id = IOP_CMND_DATA (0x0A)

    data = IOP_ACK_PING (0x3A)

10. The GPS will respond by sending a packet:

    id = IOP_ACK_BYTE (0x06)

    data = IOP_CMND_DATA (0x0A)

11. After you receive the above packet, transmit the same packet in step 9 again.

    id = IOP_CMND_DATA (0x0A)

    data = IOP_ACK_PING (0x3A)

12. The GPS will respond again with the same packet in step 10.

    id = IOP_ACK_BYTE (0x06)

    data = IOP_CMND_DATA (0x0A)

13. The baud rate has been successfully changed upon receiving the above packet. If the GPS unit does not receive these two IOP_CMND_DATA packets within two seconds, it will reset its baud rate to 9600.

APPENDIX D: EPHEMERIS DATA DOWNLOAD (PROGRAMMING EXAMPLE)

Synopsis
This section describes, using an example, how to download ephemeris information from a Garmin 15, 16, 17 or 18 family GPS unit with the exception of the GPS 15-W and the GPS 15-F.

Garmin Binary Format Review
In order to download the ephemeris data, you must first command the unit to output information in Garmin Binary Format (Garmin mode) instead of the default NMEA output format. To put the unit in Garmin mode, connect to the unit using a terminal program and send the following NMEA sentence:
$PGRMO,,G*hh<CR><LF>

The checksum *hh is used for parity checking data and is not required, but is recommended for use in environments containing high electromagnetic noise. It is generally not required in normal PC environments. When used, the parity bytes (hh) are the ASCII representation of the exclusive-or (XOR) sum of all the characters between the "$" and "*" characters, non-inclusive. Sentences may be truncated by <CR><LF> after any data field and valid fields up to that point are acted on by the GPS sensor. The unit stays in Garmin mode until the next power cycle.

Now that unit is in Garmin binary format, transmitted and received packets are structured as follows:

Byte Description	Name	Notes
Packet Delimiter	DLE	0x10
Packet ID (type)	ID	Packet type
Data Size	SIZE	Number of bytes in data portion(not including escaped DLEs. See below)
Data bytes	DATA	Not to exceed 256 bytes
.	.	.
.	.	.
.	.	.
Checksum	CHKSUM	2's complement of the arithmetic sum of all the bytes from the Packet ID byte to the last DATA byte(inclusive) not counting escaped DLEs. See below
Packet Delimiter	DLE	0x10
End of Packet	ETX	0x03

The DLE (0x10) is a delimiter byte used in conjunction with the ETX byte to determine beginning and ending of a packet. However, a 0x10 could appear in the data itself, so if this occurs the byte is escaped with another DLE byte (sometimes referred to as DLE stuffing). In other words, if a DLE occurs in the data, another DLE is transmitted immediately after to indicate that it is a data byte and it is not being used as a delimiter. Note that the size byte of the packet does not count the second DLE byte in an escaped DLE pair in the data field. Since a DLE that is a part of the data will have a second DLE to escape it, a single DLE followed by an ETX byte means that the end of a packet has been reached.

In order to interpret these packets properly, one must remove the escaped DLE bytes. This can be achieved using an algorithm similar to the Sample C Code fragment on the previous page.

Ephemeris Download Procedure

The following is the sequence of events that occurs when downloading ephemeris data.

Send a packet containing the command that requests ephemeris data (IOP_DOWN_LOAD_EPH). The packet should look like this:

TX Packet: Ephemeris Data Request

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Command Data ID	IOP_CMND_DATA	0x0A
Number of bytes in data	SIZE	0x02
Request to D/L ephemeris	IOP_DOWN_LOAD_EPH	0x5D
Pad to 2 bytes	DATA	0x00
Checksum calculation	CHKSUM	0x97*
Delimiter	DLE	0x10
End	ETX	0x03

* From now on, checksum calculation will not be shown for every packet example

The unit returns an acknowledgement packet that looks like this:

RX Packet: Acknowledgement

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Acknowledgement ID	IOP_ACK_BYTE	0x06
Number of bytes in data	SIZE	0x02
Request to D/L ephemeris	IOP_CMND_DATA	0x0A
Pad	DATA	0x00
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

Then, the unit immediately sends a packet communicating how many data packets to expect for the ephemeris download (a maximum of twelve):

RX Packet: Number of Data Packets to Expect

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Record ID	IOP_RECORDS	0x1B
Number of bytes in data	SIZE	0x02
Number of records	NUM_SV	0x0C
Pad	DATA	0x00
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

This packet requires acknowledgement, as shown below (note that the data field contains the IOP_RECORDS ID to indicate the acknowledgement of the IOP_RECORDS packet):

TX Packet: Acknowledgement

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Record ID	IOP_ACK_BYTE	0x06
Number of bytes in data	SIZE	0x02
Pad	DATA	0x00
ID of packet being ACK'd	IOP_RECORDS	0x1B
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

Next, the unit sends the specified number of packets containing the ephemeris information. An example packet is shown below. Each packet should be acknowledged as before (be sure to modify the ACK packet to indicate what type of packet being acknowledged—for ephemeris data the ID is 0x35).

RX Packet: Ephemeris Data

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Ephemeris data ID	IOP_SPC_EPH_DATA	0x35
Number of bytes in data	SIZE	0x78
Ephemeris data	DATA	----
.	.	.
.	.	.
.	.	.
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

The data portion of each packet can then be parsed into an instance of the following structure. Each of these structures represents data from a single satellite.

```
typedef struct      /* ephemeris data record for SPC                  */
{
sint16  wn;         /* week number (weeks)                            */
float   toc;        /* reference time of clock parameters (s)         */
float   toe;        /* reference time of ephemeris parameters (s)     */
float   af0;        /* clock correction coefficient - group delay  (s) */
float   af1;        /* clock correction coefficient          (s/s)   */
float   af2;        /* clock correction coefficient        (s/s/s)   */
float   ura;        /* user range accuracy                    (m)    */
double  e;          /* eccentricity                           (-)    */
double  sqrta;      /* square root of semi-major axis (a)  (m**1/2)  */
double  dn;         /* mean motion correction              (r/s)     */
double  m0;         /* mean anomaly at reference time        (r)     */
double  w;          /* argument of perigee                   (r)     */
double  omg0;       /* right ascension                       (r)     */
double  i0;         /* inclination angle at reference time   (r)     */
float   odot;       /* rate of right ascension             (r/s)     */
float   idot;       /* rate of inclination angle           (r/s)     */
float   cus;        /* argument of latitude correction, sine   (r)   */
float   cuc;        /* argument of latitude correction, cosine (r)   */
float   cis;        /* inclination correction, sine          (r)     */
float   cic;        /* inclination correction, cosine        (r)     */
float   crs;        /* radius correction, sine               (m)     */
float   crc;        /* radius correction, cosine             (m)     */
unsigned char  iod; /* issue of data                                 */
} SDM_spc_eph_type;
```

An example function to complete the parsing is shown below. Note that the double data types are converted by the function `cnvt_ieee_double()`. This function merely swaps the upper and lower words of the double. This is necessary on GPS 15, 16, 17 series sensors due to a compatibility issue with the IEEE floating point standard): In this example, the array `m_TempArray` contains the data portion of the ephemeris packet (with DLE stuffing removed).

```
/***************************************************************************
*
*   PROCEDURE NAME:
*    copyData - ephemeris data unpacker
*
*   DESCRIPTION:
*    unpacks data from ephemeris packet DATA field after extraneous DLEs
*    have been removed. Note that sint16 refers to a signed 16-bit
*    integer type.
*
***************************************************************************/
void GPM_ephList::copyData     /* ephemeris data unpacker                 */
     (
     GPM_ephData* pTemp         /* pointer to ephemeris data array         */
     )
{
pTemp->EphStruct.wn  = *(sint16*)&m_TempArray[IDX_EPH_WN];
pTemp->EphStruct.toc = *(float*)&m_TempArray[IDX_EPH_TOC];
pTemp->EphStruct.toe = *(float*)&m_TempArray[IDX_EPH_TOE];
pTemp->EphStruct.af0 = *(float*)&m_TempArray[IDX_EPH_AF0];
pTemp->EphStruct.af1 = *(float*)&m_TempArray[IDX_EPH_AF1];
pTemp->EphStruct.af2 = *(float*)&m_TempArray[IDX_EPH_AF2];
pTemp->EphStruct.ura = *(float*)&m_TempArray[IDX_EPH_URA];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_E]);
pTemp->EphStruct.e = *(double*)&m_TempArray[IDX_EPH_E];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_SQRTA]);
pTemp->EphStruct.sqrta = *(double*)&m_TempArray[IDX_EPH_SQRTA];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_DN]);
pTemp->EphStruct.dn = *(double*)&m_TempArray[IDX_EPH_DN];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_M0]);
pTemp->EphStruct.m0 = *(double*)&m_TempArray[IDX_EPH_M0];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_W]);
pTemp->EphStruct.w = *(double*)&m_TempArray[IDX_EPH_W];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_OMG0]);
pTemp->EphStruct.omg0 = *(double*)&m_TempArray[IDX_EPH_OMG0];

cnvt_ieee_double((long *)&m_TempArray[IDX_EPH_I0]);
pTemp->EphStruct.i0 = *(double*)&m_TempArray[IDX_EPH_I0];

pTemp->EphStruct.odot = *(float*)&m_TempArray[IDX_EPH_ODOT];
pTemp->EphStruct.idot = *(float*)&m_TempArray[IDX_EPH_IDOT];
pTemp->EphStruct.cus = *(float*)&m_TempArray[IDX_EPH_CUS];
pTemp->EphStruct.cuc = *(float*)&m_TempArray[IDX_EPH_CUC];
pTemp->EphStruct.cis = *(float*)&m_TempArray[IDX_EPH_CIS];
pTemp->EphStruct.cic = *(float*)&m_TempArray[IDX_EPH_CIC];
pTemp->EphStruct.crs = *(float*)&m_TempArray[IDX_EPH_CRS];
pTemp->EphStruct.crc = *(float*)&m_TempArray[IDX_EPH_CRC];
pTemp->EphStruct.iod = *(unsigned char*)&m_TempArray[IDX_EPH_IOD];

return;

}    /*                              copyData                           */
```

Each data member of the ephemeris data structure is indexed into the data array of the ephemeris packet and cast as the appropriate data type. The indices are as follows (note that they correlate to the data members of the structure respectively):

```
#define IDX_EPH_WN          0
#define IDX_EPH_TOC         4
#define IDX_EPH_TOE         8
#define IDX_EPH_AF0         12
#define IDX_EPH_AF1         16
#define IDX_EPH_AF2         20
#define IDX_EPH_URA         24
#define IDX_EPH_E           28
#define IDX_EPH_SQRTA       36
#define IDX_EPH_DN          44
#define IDX_EPH_M0          52
#define IDX_EPH_W           60
#define IDX_EPH_OMG0        68
#define IDX_EPH_I0          76
#define IDX_EPH_ODOT        84
#define IDX_EPH_IDOT        88
#define IDX_EPH_CUS         92
#define IDX_EPH_CUC         96
#define IDX_EPH_CIS         100
#define IDX_EPH_CIC         104
#define IDX_EPH_CRS         108
#define IDX_EPH_CRC         112
#define IDX_EPH_IOD         116
```

The last packet is a "download complete" packet that looks like this:
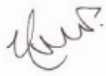
TX Packet: Download Complete

Byte Description	Name	HEX Value
Delimiter	DLE	0x10
Download Complete ID	IOP_DL_CMPLT	0x0c
Number of bytes in data	SIZE	0x02
Ephemeris Download ID	IOP_DOWN_LOAD_EPH	0x5D
Pad	DATA	0x00
Checksum calculation	CHKSUM	----
Delimiter	DLE	0x10
End of packet	ETX	0x03

After properly acknowledging this packet (ACK the IOP_DL_CMPLT ID), the ephemeris download is complete.

APPENDIX E: DECLARATION OF CONFORMITY

Hereby, Garmin Ltd., declares that this GPS 15H/15L is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

&GARMIN

Issued: 08/03/2005
Revised: 08/03/2005
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DECLARATION of CONFORMITY

Application of Council Directive:	89/336/EEC, 1999/5/EC
Standard to which Conformity is Declared:	EN 55022:1998 (CISPR 22) Electromagnetic Emissions Interference
	EN 60950-1:2001 Safety of Information Technology Equipment
	EN 61000-6-1:2001 Electromagnetic Compatibility – Generic Immunity Standard
	EN 61000-6-3:2001 Electromagnetic Compatibility – Generic Emissions Standard

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	U.S.A		TAIWAN, R.O.C.

Authorised Representative: GARMIN (Europe) Ltd, The Quadrangle,
Abbey Park Ind. Estate, Romsey, Hampshire,
SO51 9DL, U.K.

Type of Equipment: Information Technology Equipment (Global Positioning System Receiver)

Model Number(s): GPS 15 L/H

The undersigned does hereby declare that the equipment complies to the above Directives

Paul Morrow
Quality Manager
GARMIN (Europe) Ltd   Date: 8th March 2005

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