


Hemisphere GPS

LV100

Integrator's Guide

Part No. 875-0211-000 Rev. B1

This device complies with part 15 of the FCC Rules. Operation is subject to the following two 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.

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Patents

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6,549,091	6,631,916	6,711,501	6,744,404	6,865,465
6,876,920	7,142,956	7,162,348	7,277,792	7,292,185
7,292,186	7,373,231	7,400,956	7,400,294	7,388,539
7,388,539				

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Hemisphere GPS	Telephone number:	(403) 259-3311
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Scottsdale, Arizona 85258
Phone 480.348.9919 Fax 480.348.6370
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Table of Contents

1: Quick Start

Introduction

Welcome to the LV100™ Integrator's Guide and congratulations on purchasing this high-performance GPS compass. The LV100 OEM GPS Compass is based upon Hemisphere GPS' exclusive Crescent-branded technology.

Note: Throughout this manual, the LV100 OEM GPS Compass is referred to simply as the LV100.

The LV100 is a complete GPS compass and positioning system on a single circuit board, and it requires only one power/data cable connection. The LV100 is primarily designed for marine applications. However, it is also can be used with other applications, such as machine control and agriculture guidance. The LV100 Integrator's Guide shows how to integrate the LV100 to marine applications. However, the LV100 Integrator's Guide can be used to integrate the LV100 in other applications.

The LV100 is an integrated system that contains the Crescent Vector OEM module, dual GPS antennas, secondary processor for NMEA 2000® communications, power supply, single-axis gyros and a tilt sensor. The gyros and tilt sensor improve system performance and provide backup heading information when a GPS heading is lost.

Crescent technology supports multiple radio frequency (RF) front ends. This enables tighter coupling of measurements from separate antennas. Crescent provides more accurate code phase measurements, improved multipath mitigation and fewer components, which result in excellent accuracy and stability.

The LV100's GPS antennas are separated by 0.35 meters (0.383 yards) between their phase centers. This results in better than 0.75° RMS heading performance. The LV100 provides heading and positioning updates of up to 20 Hz. The LV100 delivers positioning accuracy of better than 1 meter (1 yard) 95 percent of the time. It also provides 0.75° RMS, with 35 centimeter (13.78 inches) antenna separation when using

Differential GPS corrections from Space Based Augmentation Systems (SBAS) such as WAAS, EGNOS, MSAS and others.

The LV100 also features Hemisphere GPS' exclusive COAST technology. This enables Hemisphere GPS' receivers to utilize old differential GPS correction data for 40 minutes or more without significantly affecting the positioning quality. The LV100 is less likely to be affected by differential signal outages due to signal blockages, weak signals or interference when using COAST.

The purpose of Chapter 1 is to help get the LV100 module running quickly. Chapter 1 is not intended to replace the balance of this integrator's guide and it assumes a reasonable amount of knowledge of GPS navigation system installation and navigation. Novice GPS and SBAS users should consult Chapter 4 and Hemisphere GPS' GPS Technical Reference for further information on these services and technologies.

Configuring the LV100 OEM Module

The LV100 OEM module has three available communication ports referred to as A, B and D. Port A and Port B are fully independent and can have different message output at different rates. Each of these ports can be configured for external correction input or output, binary message information or even RTCM corrections from an outside source. The outputs for Port A and Port B can only be configured through Port A. Port A is configured for full duplex RS232 communications. Port B is configured for half-duplex (listen only) RS422 communications. Port D is reserved for RTCM differential corrections. It can be used by an external SBX™ board (no internal SBX board is available) or other differential correction source, like an external radio link.

NMEA 0183 Message Interface

The LV100 OEM module uses a NMEA 0183 interface. This allows configuration changes to be easily made by sending text-type commands to the receiver. Relevant commands for making the configuration changes are discussed in later in this manual. Hemisphere GPS' GPS Technical Reference describes the NMEA 0183 interface in detail.

Binary Message Interface

In addition to the NMEA 0183 interface, the LV100 OEM module also supports a selection of binary messages including NMEA 2000. There is a wider array of information available through the binary messages, plus binary messages are inherently more efficient with data. If the application has a requirement for raw measurement data, for instance, this information is available only in a binary format. See Hemisphere GPS' GPS Technical Reference for more information on binary messages.

PocketMAX Utility

Hemisphere GPS' PocketMAX and PocketMAX PC are free utility programs that run on your PDA or computer and allow you to easily interface with the LV100. It also allows you to:

- Turn on the beacon, WAAS and OmniSTAR receivers and monitor reception
- Configure GPS message output and port settings
- Configure and monitor Vector related settings]
- Record various types of data
- Monitor the LV100's status and function

Simply connect your computer or PDA to the LV100 via the com port and open the PocketMAX software. The menus and tabs within PocketMAX will allow you to control the LV100's settings and monitor its status.

For detailed instructions or using PocketMAX, please refer to the PocketMAX user guide and to the GPS Technical Reference for specific commands.

2: LV100 OEM Module

LV100 OEM Module Mechanical Layout

Connectors

LV100 OEM Module Mechanical Layout

Figure 2-1 through Figure 2-4, on page 11, show the LV100 module's mechanical layout. All dimensions are in inches.

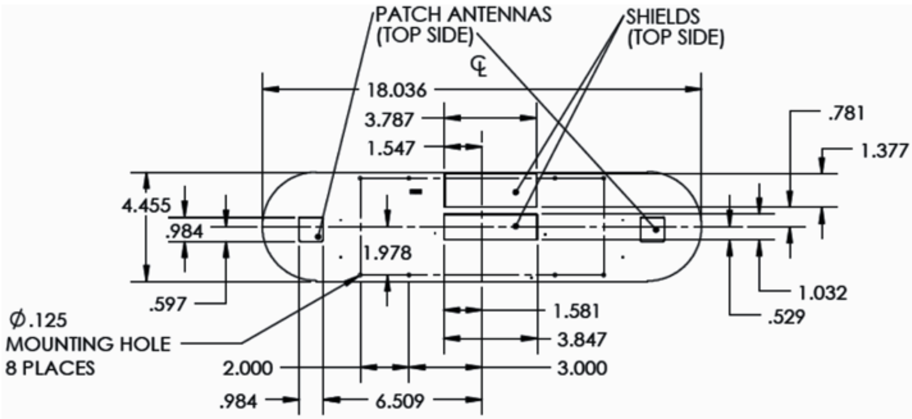

Figure 2-1. LV100 OEM module top view

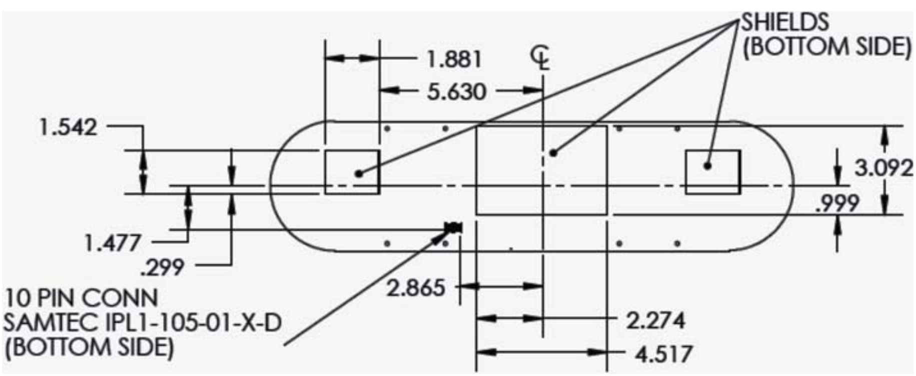

Figure 2-2. LV100 OEM module bottom view

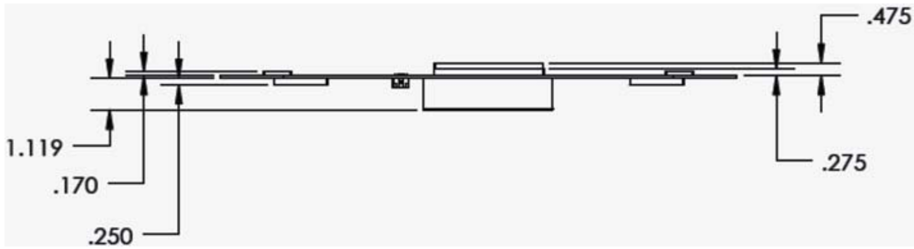

Figure 2-3. LV100 OEM module front side view

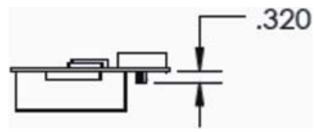

Figure 2-4. LV100 OEM module full side view

Connectors

Table 2-1 provides information on the LV100 OEM module's connectors. Hemisphere GPS also provides information on the mating connectors. Different compatible connectors can be used, however, the requirements may be different.

Table 2-1: LV100 OEM Module Connectors

Connector	OEM Module Connector	Mating Connector
J100 and J101	Samtec IPL1-105-01-X-D	Samtec MMSS-10 or MMSD-10 series connectors

Warning!

Never add, remove, change or short circuit any of the LV100 jumpers. Doing so can cause undesirable effects and may result in damage to the board. Always leave jumpers in their default positions, as shipped from the factory.

3: Installation

Creating an Enclosure

Board Mounting

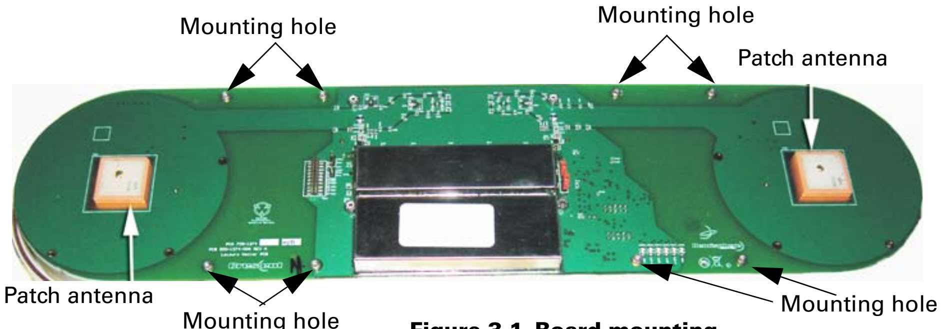

Figure 3-1. Board mounting

The LV100 has eight mounting holes available for securing the LV100 board to its enclosure (See Figure 3-1.). Use all the mounting holes to ensure that the LV100 board is securely fastened to the enclosure and structurally rigid.

The board can be secured from the top or bottom. The board must be mounted with the patch antennas facing upwards (towards the sky).

Use a self tapping Plastite® torx screw, 4-20 x .375, stainless screw with a metal washer when securing the LV100 board to a plastic enclosure. If the board is being mounted to a material other than plastic, ensure that an appropriate screw is used to properly secure the board.

Plastic Design

For plastics design, Hemisphere GPS recommends using the GELOY® CR7520 resin by SABIC Innovative Plastics™. This is a high quality ASA copolymer with excellent weatherability, good flow, aesthetics and high impact resistance.

A plastic cover over the patch antennas is mandatory when designing the enclosure. The enclosure must be within the antennas' reactive near field. (See Figure 3-2.) The plastic dome over the patch antennas shifts the center frequency of the patch antennas to the GPS L1 frequency. The LV100 board's GPS patch antennas are tuned to a frequency higher than the GPS L1 central frequency and require the plastic cover to be placed over the antennas within 2 centimeters (0.787 inches) over the top of the antenna. When this is done, the central frequency shifts from 1575.42 MHz.

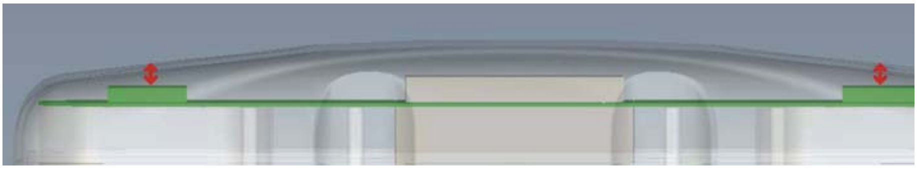

Figure 3-2. Plastic cover

Without an appropriate plastic cover on the patch antenna, the center frequency of the received signal through the antenna will not coincide with the GPS L1 center frequency. This results in less than optimal signal reception and increased susceptibility to in-band and out-of-band interference sources.

In very benign RF environments, there may be no perceived positioning or heading performance difference between a system with or without a proper cover on the antenna. The broadcast GPS L1 signal has a 20 MHz bandwidth and the patch antenna captures only about 8 MHz of that signal. It is possible to achieve a functioning system with an offset central frequency. However, there will be reduced signal-to-noise (SNR) values as compared to an optimally design system.

Installation Locations

Both GPS (and hence SBAS) reception and installation orientation need consideration when choosing mounting locations. The following two sections provide information that will help determine the best location for the LV100.

GPS Reception

Consider the following recommendations closely when choosing various locations to mount the LV100:

- Mount the LV100 in the desired location with respect to the primary GPS antenna. The LV100 computes a position based upon the internal primary GPS antenna element.
- Ensure a clear view of the sky is available to the LV100 when choosing a location to mount the antenna. This will ensure that GPS and SBAS satellites are not masked by obstructions, potentially reducing system performance.
- Move any transmitting antennas away from the LV100 by at least 0.61 meters (2 feet). This ensures that tracking performance is not compromised, giving the best possible performance.
- Ensure that there is enough cable length to route the LV100 into the vessel in order to reach a breakout box or terminal strip.
- Do not locate the antenna where environmental conditions exceed those specified in Table B-5 in Appendix B.

Installation Orientation

The LV100 has two installation orientation options, one to measure pitch and one to measure roll. The most commonly used is the pitch orientation. The pitch orientation provides both the heading and pitch of the vessel. To use the pitch orientation, mount the LV100 enclosure pointing parallel to the boat's axis, facing the bow.

The roll orientation provides the vessel's heading and roll. To use the roll orientation, mount the LV1oo enclosure perpendicular to the boat's symmetrical axis. Then configure the LV100 with a heading bias of +90 degrees or -90 degrees, depending on if it points towards the port or starboard, to correct the heading. You can change the roll/pitch measurements to a positive or negative value as needed. Please consult Hemisphere GPS' GPS Technical Reference for more information.

A gyrocompass is used to smooth the GPS measurements of pitch and roll. It can help acquire the first heading value of the LV100 if the gyriod is enabled. This is done by entering a heading bias into the LV100 configuration if a gyrocompass is on board. For example, if a gyrocompass heading provides 183.2 degrees while the LV100 provides a heading of 184.0 degrees, a bias of -0.8 (the bias is added) should be programmed into the LV100 to calibrate its heading. The LV100 can be physically adjusted to correct for this deviation.

The heading output of the LV100 always follows the direction of the master antenna to the slave antenna, as illustrated in Figure 3-3, on page 17.

Figure 3-3. LV100 board

It may be useful to put a directional marking in the plastics design. This eases the installation when designing the enclosure.

Powering the LV100

Power Considerations

The LV100 is powered with an input voltage of between 9 and 36 VDC. The supplied power should be continuous and clean for best performance. Table 3-1 provides the power requirements of the LV100.

Table 3-1: Power Requirements

Input voltage	Input current	Input power
9 to 36 VDC	< 360mA @12 VDC	<5 W maximum

The LV100's power supply features reverse polarity protection, but will not operate with reverse polarity.

Connecting to a Power Source

The first step to powering the LV100 is to terminate the wires of the power cable. There are a variety of power connectors and terminals on the market to choose from, depending on your specific requirements.

Once the LV100 has been installed, the system is ready to be turned on. The LV100 smart antenna will start when an acceptable voltage is applied to the power leads of the extension cable.

Warning!

Do not apply a voltage higher than 36 VDC. This will damage the receiver and void the warranty.

Electrical Isolation

The LV100 features a power supply that is isolated from the communication lines.

Connecting the LV100 to External Devices

LV100 Pinouts

Table 3-2 and Table 3-3, on page 20, provide the J100 pinout and J101 pinout.

Table 3-2: J100 Pinout

Pin	Description
1	+ power input
2	- power input
3	Tx Port A, RS232
4	Rx Port A, RS232
5	Signal ground
6	Signal ground
7	CAN ground
8	CAN term
9	CAN low
10	CAN high

Table 3-3: J101 Pinout

Pin	Description
1	Alarm +
2	Alarm -
3	Tx Port B, +RS422
4	Tx Port B, -RS422

Table 3-3: J101 Pinout

Pin	Description
5	Signal ground
6	Signal ground
7	Tx Port D, RS232
8	Rx Port D, RS232
9	PPS
10	No connection

Figure 3-4 provides the LV100 I/O location.

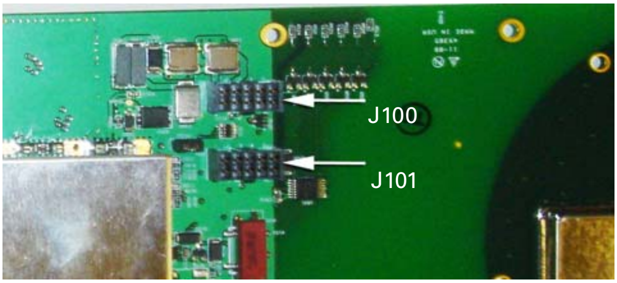

Figure 3-4. LV100 I/O locations

The LV100 board uses two input/output (I/O) locations. The primary I/O connector, J100, contains the main power and I/O functional signals. The secondary I/O connector, J101, contains supplementary signals. Depending on your application, you may not need to use the J101. (See Figure 3-4, on page 21.)

Hemisphere GPS strongly recommends using a shielded cable assembly to reduce system noise on the communications lines of the final assembly when designing a cable to connect to the LV100 board.

Any data or I/O pins that are not used should be left unterminated.

Signals

The LV100 uses six signals:

- Power
- I/O communications
- Can communications
- Alarm
- PPS signal
- LED indicator

Power - Pin 1 and Pin 2 of the J100 should be used for powering the unit.

I/O Communications - The LV100 offers position and heading data via both RS-232 and RS-422 level serial ports. The other electronics being used and the serial port level(s) they support will determine which serial port level you can use. The other electronics may need either the RS-232 or the RS-422 or a mixture of both.

Pin 3 and Pin 4 of J100 offer a bidirectional RS232 signal interface to the Vector™ OEM board housed on the LV100 board. Pins 3 and 4 are connected to Port A of the receiver.

Pin 7 and Pin 8 of J101 offer a RS232 signal interface to the Vector OEM board. However, this interface is on Port D, which can only be used for differential correction input at a 9600 baud rate. Consult the Crescent Vector OEM Integrator's Guide for additional information on the use of Port D.

When connecting an external cable to the LV100, always include a drain wire connected to signal ground, to suppress induced noise along the cable. This drain wire is mandatory in order to pass certain compliance testing.

Pin 5 and Pin 6 of J100 and J101 are all redundant signal ground pins for use with the RS-232 communications interface.

Pin 3 and Pin 4 of J101 offer a RS-422 signal interface to Port B of the Crescent Vector OEM board. The RS-422 standard allows for one device to communicate with many other devices simultaneously, therefore the RS-422 ports only transmit. This port complies with international marine standard IEC 61162. See Annex C of the international marine standard for a description.

The RS-232 interface on Port A must be used to configure output on this port.

CAN Communications - Pins 7, 8, 9 and 10 offer an isolated Controlled Area Network (CAN) interface. This interface is a full NMEA 2000 certified interface.

Alarm - Pin 1 and Pin 2 of J101 are contact closure signals for the heading alarm. This is a 5 volt differential output signal. The alarm condition occurs when the LV100's heading output becomes unusable.

PPS Signal - There is a one Pulse Per Second (PPS) signal on this pin that may be useful for external timing applications or device synchronization. It is a 3.3 volt active low signal with rising edge synchronization, having a 1 millisecond pulse width.

LED Indicator - There are six LED indicators on the edge of the LV100 board. These indicators show power, master GPS antenna signal lock, slave GPS antenna signal lock, differential correction source signal lock, differentially corrected position solution and heading lock.

Shielding the LV100

There are five shields that are soldered to the LV100 board:

- Two shields over each of the antenna LNA circuitry
- One shield over the Crescent Vector OEM module
- One shield over the power supply circuitry
- One shield over the CAN processor circuitry

Warning!

Under NO circumstances should any of these shields be removed, mangled, destroyed, tampered with or otherwise pierced, punctured or opened. Doing so can dramatically reduce the performance of the receiver and will void the warranty.

Warning!

Always follow proper electrostatic discharge protocols when handling the device. Avoid touching the PCB, and its components, directly with your fingers. Always grab onto the large tin cans on the device when handling the board.

Serial Port Configuration

Port A or Port B of the GPS receiver may be configured to output any combination of data. Port A and Port B can have different data message outputs, data rates and baud rates. The ports can be independently configured to meet the user's needs. For instance, Port A may be configured to have GGA, VTG, GSV, ZDA and HDT all output at 1 Hz over a 9600 baud rate if one generalized port and one heading-only port is needed. Port B may need to be configured for HDT and ROT message output at their maximum rate of 20 Hz over a 19200 baud rate.

If the RS-422 baud rate and messages need to be changed, those commands need to go through the RS-232 port. Both RS-232 and RS-422 output signals may be used simultaneously.

Interfacing to a PC

PC computers typically use a DB9-male connector for RS-232 serial port communications. To terminate either port for connection to a PC serial port, connect the wires to a DB9 female connector according to Table 3-4 and Figure 3-5.

Table 3-4: Port A DB9 RS-232 Interface Configuration

Pin	Signal
2	Port A transmit RS-232
3	Port A receiver RS-232
5	Signal ground

Figure 3-5 displays the numbering scheme for a DB9 socket connector (female). The associated numbering for the plug connector (male) on a PC computer is a mirror reflection of Figure 3-5.

Figure 3-5. DB9 female socket numbering

Note: For successful communication, the baud rates for the LV100's serial ports and any connecting devices must match.

When interfacing to other devices, make sure that the transmit data output from the LV100 is connected to the data input of the other device. The signal grounds must also be connected.

Since RS-422 is a balanced signal with positive and negative signals referenced to ground, ensure that the correct polarity is maintained. For instance, when connecting the transmit data output positive signal to the receive line of the other device, it should be connected to the receive positive terminal. The negative transmit data signal from the LV100 is then connected to the receive data negative input of the other device.

There is no reason to connect the LV100's receive data input to another device unless the device can send configuration commands to the LV100. Unless they have a terminal setting with which they can manually change commands, the vast majority of electronic devices will not be able to configure their settings to work with the LV100. This is due to the fact that the LV100 is configured using proprietary NMEA 0183 commands.

Default Parameters

This section outlines the default parameters of the LV100. Table 3-5 to Table 3-11, on page 31, provide details on the default port settings, default NMEA 0183 messages, elevation mask, differential age mask, default differential mode and beacon receiver settings.

Note: Any changes made to the LV100 configuration need to be saved with the $JSAVE command in order to be present for a subsequent power-cycle.

Table 3-5: Default Port Settings

Port	Baud rate	NMEA 0183 messages	Default update rate
Port A (RS-232)	19200	GPGGA, GPVTG, GRGSV, GPZDA, GPHDT, GPROT	1 Hz
Port B (RS-422) output only	19200	GPGGA, GPVTG, GRGSV, GPZDA, GPHDT, GPROT	1 Hz
Port D (RS-232)	9600	None	
Power		9-36 V	

Note: The default update rate for NMEA 0183 messages is 1 Hz. 10 Hz is the standard maximum rate, but a subscription can be purchased to upgrade the output rate to 20 Hz.

Port C is reserved exclusively for the NMEA 2000 CAN processor and internal communications. You should never change Port C’s baud rate of 57600 baud. None of the data logs being sent on Port C should be changed either. Changing or reconfiguring Port C’s default settings can cause the NMEA 2000 communications to output erroneous data. (Please refer to “Appendix C: NMEA 2000 Messaging Summary” on page 57 for a list of supported NMEA 2000 PGNs.)

Table 3-6: Default Configuration Commands

Command
$JATT,FLIPBRD,YES
$JATT,HTAU,2
$JATT,GYROID,YES

Table 3-6: Default Configuration Commands

Command
$JATT,EXACT,YES
$JATT,MSEP,0.35

The LV100 comes equipped with two different applications. The two applications are a specialized “marine” version of the Vector software and a standard version. The marine version can be identified with the letters “H2O” at the end of its name. The active applications can be seen by querying the receiver with the $JAPP command.

The marine version differs from the standard version in that it offers more robust in-band interference rejection capabilities. However, this improved capability may reduce the positional and heading accuracies. The marine version of the software will meet all defined specification numbers quoted in this guide. The standard version of the application exceeds these same requirements. However, the standard version of the application is more susceptible to in-band interference.

If the final integrated solution is to fulfill the requirements in IEC 61108-1:2003 - [Global Positioning System (GPS). Receiver Equipment. Performance standards, methods of testing and required test results (96/98/EC)], the marine version of the software must be used. The standard version will not pass the in-band interference requirements.

Table 3-7: IEC Approved Sentences

Sentence	Description	Output rate
GPDTM	Datum reference	0-20 Hz*
GPGBS	GNSS satellite fault detection	0-20 Hz*
GPGGA	GPS fix data	0-20 Hz*
GPGNS	GNSS fix data	0-20 Hz*

Table 3-7: IEC Approved Sentences

Sentence	Description	Output rate
GPRMC	Recommended minimum specific GNSS data	0-20 Hz*
GPVTG	Course over ground and ground speed	0-20 Hz*
GPZDA	Time and date	0-20 Hz*
GPGRS	GNSS range residuals	0-20 Hz*
GPGSA	GNSS DOP and active satellites	0-20 Hz*
GPGST	GNSS pseudorange error statistics	0-20 Hz*
GPGSV	GNSS satellites in view	0-20 Hz*
GPGLL	Geographic position - (latitude/longitude)	0-20 Hz*
GPRRE	Range residual message	0-20 Hz*
GPHDG	Command to provide magnetic deviation and variation for calculating magnetic or true heading	0-20 Hz*
GPHDT	Command to provide true heading of the vessel	0-20 Hz*
GPROT	Command that contains the vessel's rate of turn information	0-20 Hz*

*** Note:** 10 Hz is the standard maximum. A subscription can be purchased to upgrade the output rate to 20 Hz.

Note: The data bits, parity and stop bit are not adjustable. They are fixed with an 8-n-1 configuration.

Table 3-8: Other Sentences

Sentence	Description
$GPHDM	Magnetic heading (based on RTK-derived GPS and magnetic declination)
$J4STRING	Output, GPGGA, GPVTG, GPGSA and GPZDA (1 Hz max)
PSAT,HPR	Proprietary NMEA sentence that provides the heading, pitch/roll information and time in a single message
PSAT,INTLT	Proprietary NMEA sentence that provides the title measurement from the internal inclinomenter (in degrees)

Table 3-9: Available Baud Rates

Baud rates
4800
9600
19200
38400
57600
115200

Table 3-10: Correction Age and Elevation Mask Defaults

Max DGPS age	Elevation mask
2700 seconds	5°

Table 3-11: Default Differential Mode

LV100 differential mode
SBAS (WAAS/EGNOS)

4: LV100 Operation

GPS Overview

For added convenience, both the GPS and SBAS operation of the LV100 features automatic operational algorithms. When powered for the first time, the LV100 system will perform a "cold start," which involves acquiring the available GPS satellites in view and the SBAS differential service.

If SBAS is not available, an external source of RTCM SC-104 differential corrections may be used (using Port D only). If an external source of correction data is used, that external source needs to supports an eight data bit, no parity and one stop bit configuration (8-N-1).

GPS Operation

The GPS receiver is always operating, regardless of the DGPS mode of operation. The following sections describe the general operation of the LV100's internal GPS receiver.

Note: Differential source and status have no impact on heading. They only have an impact on positioning.

Automatic Tracking

The LV100's internal GPS receiver automatically searches for GPS satellites, acquires the signals and manages the navigation information required for positioning and tracking.

Receiver Performance

The LV100 works by finding four or more GPS satellites in the visible sky. It uses information from the satellites to compute a position (within 2.5 meters (2.7 yards)). Since there is some error in the GPS data calculations, the LV100 also tracks a differential correction. The LV100 uses these corrections to improve its position to less than 1 meter (1 yards). The LV100 has an accuracy of 2.5 meters (2.7 yards) with no differential corrections and 1 meter (1 yard) with differential corrections.

There are two main aspects of GPS receiver performance, positioning and satellite acquisition.

When the LV100 is properly positioned, the satellites transmit coded information to the antenna on a specific frequency. This allows the receiver to calculate a range to each satellite. GPS is essentially a timing system. The ranges are calculated by timing how long it takes for the signal to reach the GPS antenna. The GPS receiver uses a complex algorithm incorporating satellite locations and ranges to each satellite to calculate the geographic location. Reception of any four or more GPS signals allows the receiver to compute 3-dimensional coordinates.

Differential Operation

The purpose of differential GPS (DGPS) is to remove the effects of selective availability (SA), atmospheric errors, timing errors and satellite orbit errors, while enhancing system integrity. Autonomous positioning capabilities of the LV100 will result in positioning accuracies of 2.5 meters (2.73 yards) (95%). In order to improve positioning quality to sub-meter levels, the LV100 is able to use differential corrections received through the internal SBAS demudulator.

Refer to Hemisphere GPS' GPS Technical Reference for more information on the differential services and the associated commands.

Automatic SBAS Tracking

The LV100 automatically scans and tracks SBAS signals without the need to tune the receiver. The LV100 features two-channel tracking that provides an enhanced ability to maintain a lock on a SBAS satellite when more than one satellite is in view. This redundant tracking approach results in more consistent tracking of a SBAS signal in areas where signal blockage of a satellite is possible.

Understanding the LV100

The LV100 provides accurate and reliable heading and position information at high update rates. To accomplish this task, the LV100 uses a high performance GPS receiver and two antennas for GPS signal processing. One antenna is designated as the primary GPS antenna, and the other is the secondary GPS antenna. Positions computed by the LV100 are referenced to the phase center of the primary GPS antenna. Heading data references the vector formed from the primary GPS antenna phase center to the secondary GPS antenna phase center.

Moving Base Station RTK

The LV100's internal GPS receivers use both the L1 GPS C/A code and carrier phase data. The LV100 uses this information to compute the location of the secondary GPS antenna in relation to the primary GPS antenna with a very high sub centimeter level of precision. The technique of computing the location of the secondary GPS antenna with respect to the primary antenna, when the primary antenna is moving, is often referred to as moving base station Real Time Kinematic (or moving base station RTK).

Generally, RTK technology is very sophisticated and requires a significant number of possible solutions to be analyzed where various combinations of integer numbers of L1 wavelengths to each satellite intersect within a certain search volume. The integer number of wavelengths is often referred to as the "ambiguity" as they are initially ambiguous at the start of the RTK solution.

The LV100 restricts the RTK solution. It does this knowing that the secondary GPS antenna is 0.350 meters (1.15 feet) from the primary GPS antenna. This defines the search volume of the secondary antenna as the surface of a sphere with radius 0.350 meters (1.15 feet) centered on the location of the primary antenna. (See Figure 4-1 on page 38.)

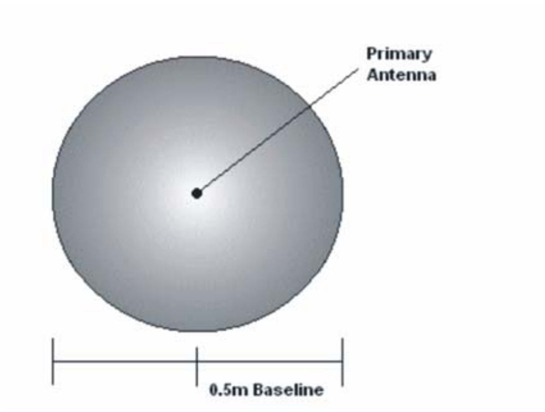

Figure 4-1. Secondary antenna's search receiver

Note: The LV100 moving base station algorithm only uses GPS to calculate heading. Differential corrections are not used in this calculation and will not affect heading accuracy.

Supplemental Sensors

The LV100 has an integrated gyro and tilt sensor. The gyro is enabled by default. The tilt sensor is disabled by default. Each supplemental sensor may be individually turned on or off. Both supplemental sensors are mounted on the printed circuit board inside the LV100.

The sensors act to reduce the RTK search volume, which improves heading startup and reacquisition times. This improves the reliability and accuracy of selecting the correct heading solution by eliminating other possible, erroneous solutions.

Hemisphere GPS' GPS Technical Reference describes the commands and methodology required to recalibrate, query or change the sensors status

Tilt Aiding

The LV100's accelerometer (internal tilt sensor) is not enabled by default. However, it is factory calibrated. This constrains the RTK heading solution beyond the volume associated with just a fixed antenna separation. This is because the LV100 knows the approximate inclination of the secondary antenna with respect to the primary antenna. The search space defined by the tilt sensor will be reduced to a horizontal ring on the sphere's surface by reducing the search volume. This considerably decreases startup and reacquisition times. (See Figure 4-2 on page 39.)

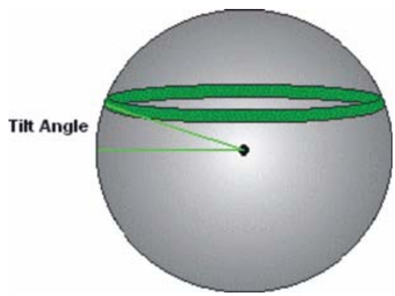

Figure 4-2. LV100's tilt aiding

Gyro Aiding

The LV100's internal gyro offers several benefits. It reduces the sensor volume for an RTK solution. This shortens reacquisition times when a GPS heading is lost because the satellite signals are blocked. The gyro provides a relative change in angle since the last computed heading, and, when used in conjunction with the tilt sensor, defines the search space as a wedge-shaped location. (See Figure 4-3.)

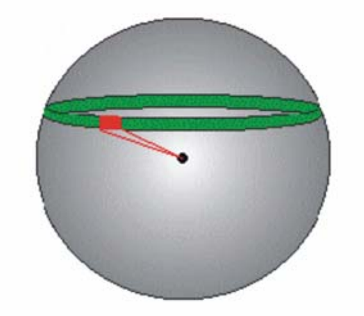

Figure 4-3. LV100's gyro aiding

The gyro aiding accurately smoothes the heading output and the rate of turn. It provides an accurate substitute heading for a short period depending on the roll and pitch of the vessel, ideally seeing the system through to reacquisition. The gyro will provide an alternate source of heading, accurate to within 1 degree for up to 3 minutes in times of GPS loss for either antenna. If the outage lasts longer than three minutes, the gyro will have drifted too far and the LV100 will begin outputting null fields in the heading output messages. There is no user control over the time-out period of the gyro.

The gyro will initialize itself at power-up and during initialization, or can be calibrated by the user as outlined in Hemisphere GPS' GPS Technical Reference. When the gyro is first initializing, it is important that the dynamics that the gyro experiences during this warm-up period are similar to the regular operating dynamics. For example, if the LV100 is used on a high speed, maneuverable craft, it is essential that when gyro aiding in the LV100 is first turned on and is used in an environment that has high dynamics for the first 5 to 10 minutes instead of sitting stationary.

With the gyro enabled, the gyro is also used to update the post HTAU smoothed heading output from the moving base station RTK GPS heading computation. This means that if the HTAU value is increased while the gyroid is enabled, there will be little to no lag in heading output due to vehicle maneuvers. Hemisphere GPS’ GPS Technical Reference includes information on setting an appropriate HTAU value for the application.

Time Constants

The LV100 incorporates user-configurable time constants that can provide a degree of smoothing to the heading, course over ground and speed measurements. These parameters may be adjusted depending on the expected dynamics of the vessel. For instance, increasing the time is reasonable if the vessel is very large and is not able to turn quickly or would not pitch quickly. The resulting values would have reduced “noise,” resulting in consistent values with time. However, if the vessel is quick and nimble, increasing this value can create a lag in measurements. Formulas for determining the level of smoothing are located in Hemisphere GPS’ GPS Technical Reference. If you are unsure on how to set this value, it is best to be conservative and leave it at the default settings.

The heading time constant allows the level of responsiveness of the true heading measurement provided in the $GPHDT message to be adjusted. The default value of this constant is 2.0 seconds of smoothing when the gyro is enabled. The gyro is enabled by default, but can be turned off. By turning the gyro off, the equivalent default value of the heading time constant would be 0.5 seconds of smoothing. This is not automatically done and therefore must be manually entered. Increasing the time constant will increase the level of heading smoothing and increase lag.

The pitch time constant allows you the level of responsiveness of the pitch measurement provided in the $PSAT,HPR message to be adjusted. The default value of this constant is 0.5 seconds of smoothing. Increasing the time constant will increase the level of pitch smoothing and increase lag.

The heading rate time constant allows the level of responsiveness of the rate of heading change measurement provided in the $GPROT message to be adjusted. The default value of this constant is 2.0 seconds of smoothing. Increasing the time constant increases the level of heading smoothing.

The course over ground (COG) time constant allows the level of responsiveness of the COG measurement provided in the $GPVTG message to be adjusted. The default value of this constant is 0.0 seconds of smoothing. Increasing the time constant increases the level of COG smoothing. COG is computed using only the primary GPS receiver and its accuracy is dependant upon the speed of the vessel (noise is proportional to 1/speed). This value is invalid when the vessel stationary.

The speed time constant allows the level of responsiveness of the speed measurement provided in the $GPVTG message to be adjusted. The default value of this parameter is 0.0 seconds of smoothing. Increasing the time constant will increase the level of speed measurement smoothing.

Alarm Functionality

A relay is located on the LV100 circuit board. The relay contacts are isolated. If the LV100 loses power or heading, the coil loses voltage, the relay opens and the notification (set by the user) is activated. When the heading is valid, the relay contacts remain closed. This completes the circuit and the LV100 is operational.

Alarm Signal

There are two pins on the I/O header J101 that are used for the external alarm function.

Watchdog

The watchdog is a timer that is controlled by the software which monitors if the heading is lost. The watchdog software is in compliance with IEC 60945.

Common Commands and Messages

Table 4-1 to Table 4-5, on page 46, provide the common commands and brief description of what they do. Refer to Hemisphere GPS' GPS Technical Reference for more details.

Note: The messages have a default update rate of up to 10 Hz and optional 20 Hz with a subscription. The GPGSA, GPGST, GPGSV and GPRRE messages are only output at 1 Hz.

Table 4-1: Application Information

Command	Description
$JAPP	Primary application 1

Table 4-2: Differential Commands

Command	Description
$JDIFF	Differential mode
$JLIMIT	DGPS LIMIT distance
$JAGE	Max DGPS (COAST) age (6 to 8100 seconds)
$JWAASPRN	Configure for specific SBAS PRN numbers
$JGEO	Query SBAS for current location and SBAS satellites
$JASC,D1	Request SBAS diagnostic information

Table 4-3: Serial Port Settings Commands

Command	Description
$JBAUD	RS-232C, RS-422 (output) communication rate

Table 4-4: NMEA 0183 Commands

Command	Description
$GPGGA	GPS fix data
$GPGLL	Geographic position - lat/long
$GPGSA	GNSS DOP and active satellites
$GPGST	GNSS psuedo range error statistics
$GGSV	GMSS satellites in view
$GRMC	Recommended minimum specific GNSS data
$GPRRE	Range residual message
$GPVTG	COG and ground speed
$GPZDA	Time and date
$GPGBS	Satellite fault detection used for RTCM
$GPGNS	GNSS fix data
$GPGRS	GNSS range residual
$GPHDG	Provides magnetic deviation and variation for calculating magnetic or true heading
$GPHDT	RTK-derived GPS heading
$GPROT	RTK-derived GPS rate of turn
$PSAT,HPR	Heading, pitch/roll and time in single message
$GPHDM	Magnetic heading (based on RTK-derived GPS and magnetic declination)
$J4STRING	Output GPGGA, GPVTG, GPGSA and GPZDA (1 Hz maz)

Note: The GP of the message is the talker ID.

Note: The $GPRRE and $GPHDM commands do not comply with the current IEC 61162 standard.

Table 4-5: Binary Commands

Message	Description
$JBIN1	GPS position
$JBIN2	GPS DOP's
$JBIN80	SBAS
$JBIN93	SBAS ephemeris data
$JBIN94	Ionosphere and UTC conversion parameters
$JBIN95	Ephemeris
$JBIN96	Code and carrier phase
$JBIN97	Process statistics
$JBIN98	Satellite and almanac
$JBIN99	GPS diagnostics

Table 4-6: General Commands

Command	Description
$JATT,CSEP	Query antenna separation
$JATT,MSEP	Manually set/query antenna separation
$JASC,Dx	Turn on/off diagnostics message x
$JQUERY,GUIDE	Query accuracy acceptableness
$JRESET	Reset unit's configuration to firmware defaults

Table 4-6: General Commands

Command	Description
$JSAVE	Save session's configuration changes
$JSHOW	Shows current configuration
$JOFF	Turn off all data messages
$JT	Query receiver type
$JI	Query unit's serial number and firmware versions
$JATT,SEARCH	Force a new RTK heading search
$JATT,SUMMARY	Show current TAU configuration

Table 4-7: Heading Commands

Command	Description
$JATT,TILTAID	Enable/disable accelerometer, pre-calibrated
$JATT,TILTCAL	Calibrate accelerometer
$JATT,GYROAID	Enable/disable gyro
$JATT,LEVEL	Enable/disable level operation
$JATT,HTAU	Set/query heading time constant (0.0 to 3600.0 seconds)
$JATT,PTAU	Set/query pitch time constant (0.0 to 3600.0 seconds)
$JATT,HRTAU	Set/query time constant (0.0 to 3600.0 seconds)
$JATT,COGTAU	Set/query COG time constant (0.0 to 3600.0 seconds)

Table 4-7: Heading Commands

Command	Description
$JATT,SPDTAU	Set/query speed time constant (0.0 to 3600.0 seconds)
$JATT,HBIAS	Set/query heading bias (-180 to 180 degrees)
$JATT,EXACT	Enable/disable internal filter reliance on the entered antenna separation
$JATT,PBIAS	Set/query pitch/roll bias (-15 to 15 degrees)
$JATT,NEGTILT	Enable/disable negative tilt
$JATT,ROLL	Configure for roll or pitch output
$JATT,NMEAHE	Changed the HDT and ROT, HDM and HDG message headers between GP and HE (and HC)

Appendix A: Troubleshooting

Troubleshooting

Table A-1 provides troubleshooting for common problems.

Table A-1: Troubleshooting

Symptom	Possible Solution
Receiver fails to power	• Verify polarity of power leads • Check integrity of power cable connectors • Check power input voltage (9 to 36 VDC) • Check current restrictions imposed by power source (minimum available should be > 1.0 A)
No data from LV100	• Check receiver power status to ensure that the receiver is powered (an ammeter can be used for this) • Verify that desired messages are activated (this can be done through PocketMAX or with $JSHOW in any terminal program) • Ensure that the baud rate of the LV100 matches that of the receiving device • Check integrity and connectivity of power and data cable connections
No GPS lock	• Verify LV100 has a clear view of the sky • Verify the lock status of GPS satellites (this can be done with PocketMAX)

Table A-1: Troubleshooting

Symptom	Possible Solution
Random data from LV100	• Verify that the RTCM or binary messages are not being output accidentally (send a $JSHOW command) • Verify baud rate settings of LV100 and remote device match correctly • Potentially, the volume of data requested to be output by the LV100 could be higher than the current baud rate supports. Try using 19,200 as the baud rate for all devices or reduce the amount of data being output
No heading or incorrect heading value	• Check CSEP value is fairly constant without varying more than 1 cm (0.39 in). Larger variations may indicate a high multipath environment and require moving the receiver location • Recalibrate the tilt sensor with $JATT,TILTCAL command if heading is calculated then lost at consistent time intervals
No SBAS lock	• Verify LV100's clear view of the sky • Verify the lock status of SBAS satellites (this can be done with PocketMAX - monitor BER value) • Set SBAS mode to automatic with the command $JWAASPRN,AUTO

Table A-1: Troubleshooting

Symptom	**Possible Solution**
No heading or incorrect heading value	• Heading is from primary to secondary antenna, so the arrow on the underside of the LV100 should be directed to the bow side • $JATT,SEARCH command forces the LV100 to acquire a new heading solution (unless gyro is enabled) • Enable GYROAID as this will give heading for up to 3 minutes in times of GPS signal loss • Enable TILTAID to reduce heading search times • Monitor the number of satellites and SNR values for both antennas within PocketMAX. At least 3 satellites should have SNR values above 20
No DGPS position in external RTCM mode	• Verify that the baud rate of the RTCM input port matches the baud rate of the external source • Verify the pin-out between the RTCM source and the RTCM input port (transmit from the source must go to receive of the RTCM input port and grounds must be connected) • Ensure corrections are being transmitted to the correct port. Using the $JDIFF,PORTD command on Port A will cause the receiver to expect the corrections to be input through Port D

Appendix B: Specifications

Specifications

Table B-1 to Table B-5, on page 54, provides the LV100's communication, power, GPS sensor, mechanical and environmental specifications.

Table B-1: Communication Specifications

Item	Specification
Serial ports	2 full duplex RS-232 and 1 half duplex RS-422
Baud Rate	4800 to 115200
Correction I/O protocol	RTCM SC-104, L-Dif (Hemisphere GPS proprietary)
Data I/O protocol	NMEA 0183, NMEA 2000, binary, L-Dif (Hemisphere GPS proprietary)
Heading warning I/O	Open relay system indicates invalid heading

Table B-2: Power Specifications

Item	Specification
Input voltage	9 to 36 VDC
Power consumption	< 5.0 W
Current consumption	< 360 mA @ 12 VDC
Isolation	Power supply isolated from serial ports
Reverse polarity protection	Yes

Table B-3: GPS Sensor Specifications

Item	Specification
Receiver type	L1, C/A code with carrier phase smoothing
Channels	Two 12-channel, parallel tracking (two 10-channel when tracking SBAS)
Update Rate	Standard 10 Hz, optional 20 Hz (position and heading)
Horizontal accuracy	< 1.0 m (< 1.0 yd) 95% confidence (DGPS)* < 2.5 m (< 2.7 yd RMS) (autonomous, no SA)**
Heading accuracy	< 0.75° RMS
Pitch/roll accuracy	< 1.5° RMS
Rate of turn	90°/s max
Start up time	< 60 s typical
Heading fix	< 30 s
Satellite reacquisition	< 1 s

***Note:** Depends on multipath environment, number of satellites in view, satellite geometry, baseline length (for local services) and ionospheric activity.

****Note:** Depends on multipath environment, number of satellites in view and satellite geometry.

Table B-4: Mechanical Specifications

Item	Specification
Dimensions (not including mounts)	45.811 cm L x 11.316 cm W x 3.782 cm H (18.036 in L x 4.455 in W x 1.489 in H)
Weight	350 g (12.35 oz)

Table B-5: Environmental Specifications

Item	Specification
Storage temperature	-40° C to 85° C (-40° F to 185° F)
Operating temperature	-32° C to 74° C (-25.6° F to 165.2° F)
Humidity	95% non-condensing

Appendix C: NMEA 2000 Messaging Summary

NMEA 2000 Messaging Summary

Table C-1 to Table, C-2 on page 59, provides the LV100's NMEA 2000 transmit and receive messages. Table C-3 and C-4 provides the Request and Command Group Functions for PGN 126208.

Table C-1: Transmit Messages

PGN	Description
059392	ISO acknowledge
060928	Address claim
126208	NMEA – request group function
126464	PGN list (TX and RX)
126992	System time
126996	Product information
127250	Vessel heading
127251	Rate of turn
127257	Altitude
127258	Magnetic variation
129025	Position, rapid update
129026	COG and SOG, rapid update
129027	Position delta, high precision, rapid update
129028	Altitude, high precision, rapid update
129029	GNSS position data
129033	Time and date

Table C-1: Transmit Messages

PGN	Description
129044	Datum
129538	GNSS control status
129539	GNSS DOP's
129540	GNSS DOP's

Table C-2: Receive Messages

PGN	Description
059392	ISO acknowledge
059904	ISO request
060928	Address claim
126208	NMEA – Request group function

Table C-3: PGN 126208 Support - Request Group Function Messages

NMEA 2000 allows messages to be requested by specified fields contained with the message.			
PGN	**Description**	**Field**	**Description**
060928	ISO Address Claim	1,2,3,4,5,7,8,9	Unique Number, Manufacturer Code, Device Instance Lower, Device Instance Upper, Device Function, Device Class, System Instance, Industry Group
126464	PGN List	1	Transmitted PGN Group Function Code
126992	System Time	2	Source

Table C-3: PGN 126208 Support - Request Group Function Messages

NMEA 2000 allows messages to be requested by specified fields contained with the message.			
126996	Product Information	1,2,7,8	NMEA 2000 Database Version, NMEA Manufacturer's Product Code, NMEA 2000 Certification Level, Load Equivalency
127258	Magnetic Variation	2	Variation Source
129026	COG and SOG, Rapid Update	2	COG Reference
129028	Altitude, high precision, rapid update	3,4	GNSS Quality, Direction
129029	GNSS Position Data	7,8,9	System Type, Method GNSS, Integrity
129538	GNSS Control Status	5,6,7	GNSS Mode, DGNSS Mode, Position/Velocity Filter
129539	GPS DOPs	2,3	Set Mode, Op Mode
129540	GNSS Satellites in View	2	Mode
PGNs not listed above: N/A			

Table C-4: PGN 126208 Support - Command Group Function Message

NMEA 2000 allows command messages in which the user can set values and initialize actions at the receiving device.

PGN	Description	Field	Description
060928	ISO Address Claim	3,4,8	Device Instance Lower, Device Instance Upper, System Instance
129026	COG and SOG, Rapid Update	2	COG Reference

Table C-4: PGN 126208 Support - Command Group Function Message

NMEA 2000 allows command messages in which the user can set values and initialize actions at the receiving device.			
129028	Altitude, high precision, rapid update	4	Direction
129033	Time and Date	3	Local Offset, minutes
129538	GNSS Control Status	1,9,10	SV Elevation, Antenna Altitude for 2D Mode, Use Antenna for 2D Mode
PGNs not listed above: Not supported			

The LV100 does not support Read or Write Field Request Groups.

Appendix D: Parts List

Table D-1 provides the LV100 equipment list.

Table D-1: LV100 Equipment

Part number	Description	Quantity
720-0041	LV100 OEM GPS Compass	1
875-0211	LV100 Integrator's Guide (Available at www.hemispheregps.com)	1

Hemisphere GPS®

www.hemispheregps.com
e-mail: info@hemispheregps.com