# Vector H102 GPS Compass OEM Board

## Integrator Guide

Part No. 875-0280-000 Rev D1

Hemisphere GPS®

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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Hemisphere GNSS, Inc.
8444 N 90th St, Suite 120
Scottsdale, AZ 85258 USA
Phone: (480) 348-9919
Fax: (480) 348-6370
precision@hemispheregps.com
www.hemispheregps.com

## Technical Support

If you need to contact Hemisphere GNSS Technical Support:

Hemisphere GNSS, Inc.
8444 N 90th St, Suite 120
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Phone: (480) 348-9919
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# Chapter 1: Introduction

Overview
Configuring the H102
Message Interface
Using VectorPC to Communicate with the H102

The purpose of this chapter is to help you get the H102 running quickly; however, it is not intended to replace the balance of this manual and it assumes a reasonable amount of knowledge of GPS navigation system installation. Novice GPS and SBAS users should consult Chapter 4, "Operation" and the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon) for further information on these services and technologies.

*Note: The term "machine" is used throughout this manual as a general term for a vessel, craft, boat, vehicle, etc.*

# Overview

The Vector H102™ GPS Compass OEM Board is based upon Hemisphere GPS' exclusive Crescent® and Crescent Vector™ II technologies.

*Note: Throughout this manual, the Vector H102 GPS Compass OEM Board is referred to simply as the H102.*

The H102 is a complete GPS compass and positioning system that requires only one power/data cable connection (see "Powering the H102" on page 16 and "Connecting to External Devices" on page 17 for more information). With its CAN support and ease of installation, the H102 is the perfect solution for both marine and land-based applications such as mine construction, earthworks, and machine guidance.

The H102, included in marketing kit part number 940-3050-000, is an integrated system comprised of the following:

- Crescent Vector II technology
- Dual integrated GPS antennas
- Power supply
- Single axis gyro
- Tilt sensor on each axis (X and Y axes)

The gyro and tilt sensors are present to improve system performance and to provide backup heading information in the event that a GPS heading is not available due to signal blockage.

Crescent Vector II technology supports multiple RF front ends—enabling tighter coupling of measurements from separate antennas for use in heading-based products. Users will achieve excellent accuracy and stability due to Crescent's more accurate code phase measurements, improved multipath mitigation, and fewer components.

The H102's GPS antennas are separated by 27.5 cm between their phase centers, resulting in better than 0.75° rms heading performance. The H102 provides heading and positioning updates of up to 20 Hz and delivers positioning accuracy of better than 1.0 m 95% of the time when using differential GPS corrections from Space Based Augmentation Systems (SBAS).

H102 also features Hemisphere GPS' exclusive COAST™ technology that enables Hemisphere GPS receivers to utilize aging differential GPS correction data for 40 minutes or more without significantly affecting positioning quality. H102 is less likely to be affected by differential signal outages due to signal blockages, weak signals, or interference when using COAST.

## Configuring the H102

The H102 offers either serial port or NMEA 2000 port functionality and comes preconfigured. You only need to do the following to begin using the H102:

- Connect the H102 to a power supply
  *See "Powering the H102" on page 16*
- Set up your COM ports
  *See "Ports" on page 20*
- Make sure the H102 has a clear view of the sky
- Connect the H102 to a PC running VectorPC and then set up VectorPC (to track satellites set up the GPGGA and GPGSV messages)
  *See "Using VectorPC to Communicate with the H102" below*

*Note: The H102 provides limited CAN support. For more information contact Hemisphere GPS Technical Support.*

## Message Interface

The H102 uses a NMEA 0183 interface, allowing you to easily make configuration changes by sending text-type commands to the receiver.

The H102 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, this information is available only in a binary format.

For more information on NMEA 0183 commands and messages as well as binary messages (and NMEA 2000 messages) refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon).

## Using VectorPC to Communicate with the H102

Hemisphere's VectorPC is a free utility program that runs on your Windows PC or Windows mobile device. Simply connect your Windows device to the H102 via the COM port and open VectorPC. The screens within VectorPC allow you to easily interface with the H102 to:

- Select the internal SBAS, beacon, or L-band correction source and monitor reception (beacon and L-band optional)
- Configure NMEA messages, Vector parameters, and port settings
- Monitor Vector performance and tracking information
- Review heading, pitch, and roll visually
- Automatically calculate heading bias

VectorPC is available for download from the Hemisphere GPS website (www.hemispheregps.com).

# Chapter 2: Layout and Connectors

Mechanical Layout

Connectors

# Mechanical Layout

Figure 2-1 shows the H102’s mechanical layout. All dimensions are in millimeters.

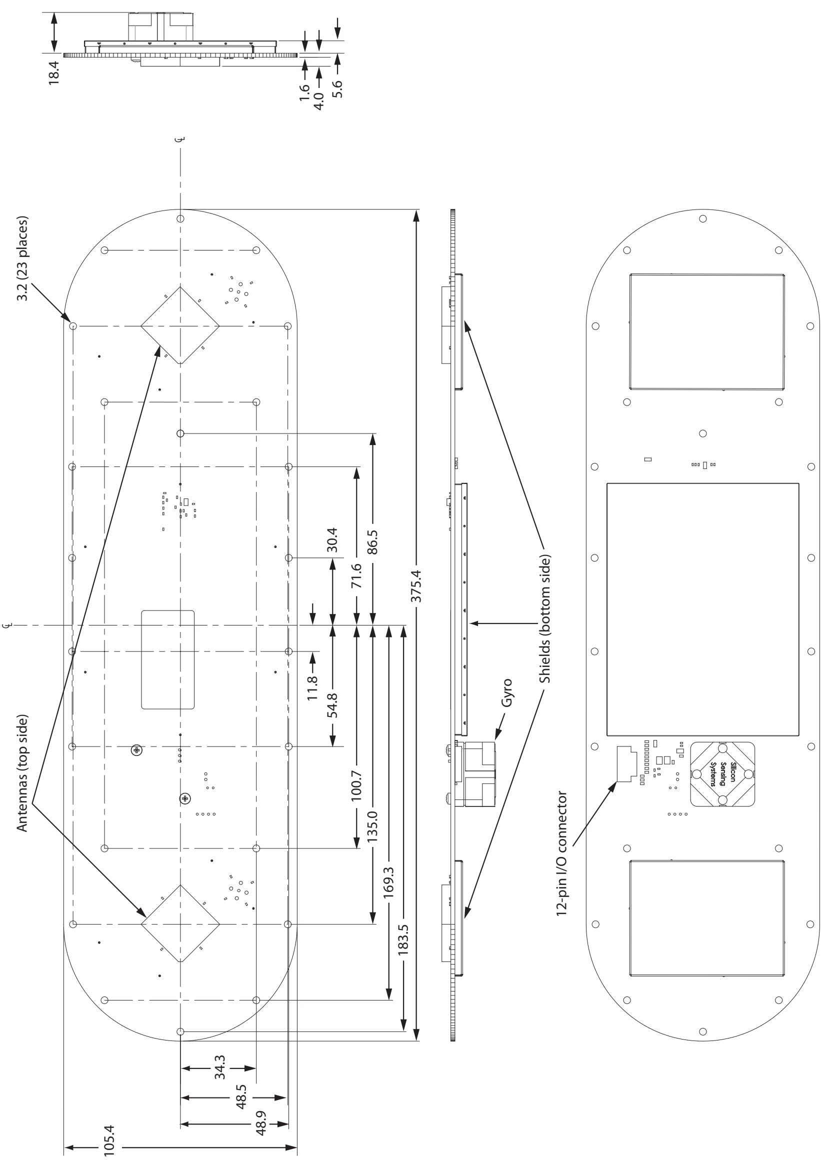



**Figure 2-1: H102 OEM board layout**

# Connectors

Table 2-1 provides information on the J60 connector as well as related mating connectors. You can use different compatible connectors; however, the requirements may be different.

**Table 2-1: H102 connectors**

| Connector | OEM Board Connector | Mating Connector |
|---|---|---|
| J60 | ZIF FPC 12-pin | Use flexible cable |

**WARNING:** Never add, remove, change, or short circuit any H102 jumpers. Doing so may cause undesirable effects and may damage the board. Always leave jumpers in their default positions, as shipped from the factory.

# Chapter 3: Installation

Creating an Enclosure
Mounting Location
Mounting Orientation
Shielding the H102
Powering the H102
Connecting to External Devices
Ports
Default Parameters

# Creating an Enclosure

## Mounting the Board

The H102 has multiple mounting holes (in the gold/yellow band) available for securing the H102 to its enclosure (see Figure 3-1). Use all the mounting holes to make sure the H102 is securely fastened to the enclosure and structurally rigid. Hemisphere GPS recommends using all the mounting holes for your installation.

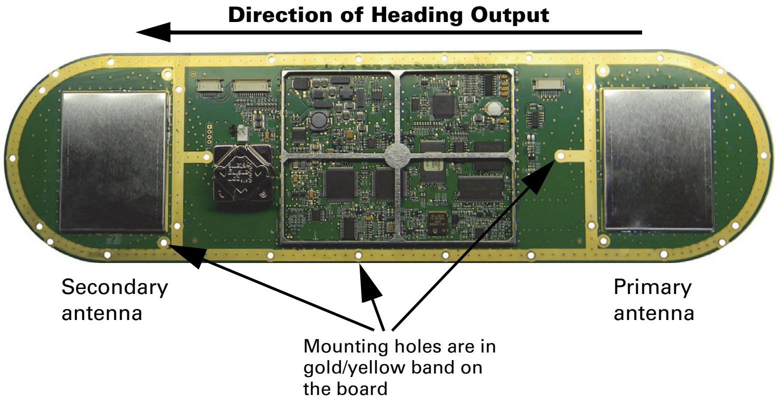



**Figure 3-1: Board mounting**

You can secure the board from the top or bottom. You must mount the board with the antennas facing upward (toward the sky).

Use self-tapping Plastite® Torx screws, 4-20 x 0.375, with a metal washer when securing the H102 to a plastic enclosure. If you are mounting the board to a material other than plastic, make sure you use an appropriate screw to properly secure the board.

*Note: Make sure you properly ground the board on the mounting holes to signal ground.*

## Plastic Cover

For the plastic cover, Hemisphere GPS recommends using a high quality ASA copolymer (with no metal) with excellent weatherability, good flow, aesthetics, and high impact resistance. You can paint the plastic, but do not use a metallic paint.

A plastic cover over the antennas is mandatory when designing the enclosure. The enclosure must be within the antennas' reactive near field (see Figure 3-2 on page 11). The plastic cover over the antennas shifts the center frequency of the antennas to the GPS L1 frequency. The H102's GPS antennas are tuned to a frequency higher than the GPS L1 central frequency and require the plastic cover to be placed over the antennas no closer than 5 mm, with plastic no thicker than 3 mm. With the appropriate plastic enclosure the H102 will be properly tuned to track GPS.

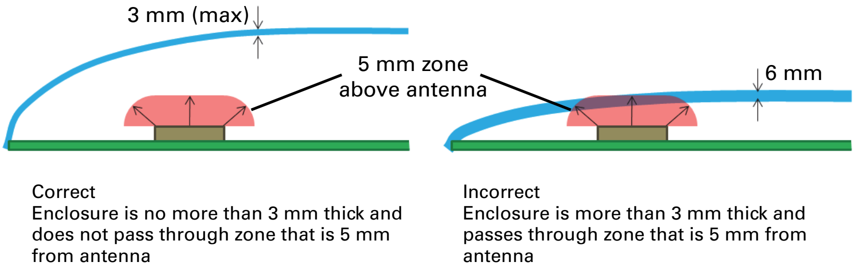



**Figure 3-2: Plastic cover**

In very benign RF environments, there may be no perceived positioning or heading performance difference between a system with or without a proper cover over the antennas. The broadcast GPS L1 signal has a 20 MHz bandwidth and the antennas capture 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.

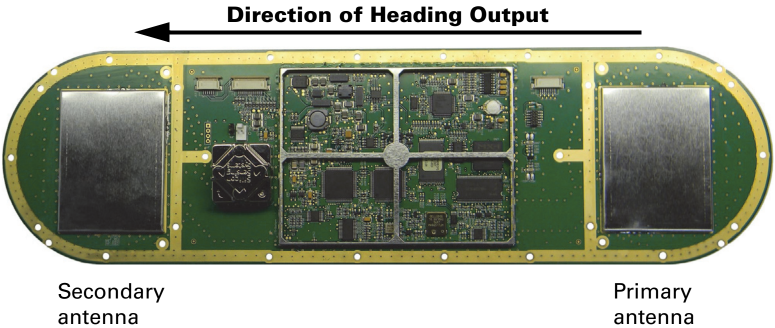
# Mounting Location

This section provides information on determining the best location for the H102.

## GPS Reception

When considering where to mount the H102, consider the following GPS reception recommendations:

- Consider GPS (and hence SBAS) reception, making sure the H102 has a clear view of the sky so the GPS and SBAS satellites are not masked by obstructions that may reduce system performance
- Since the H102 computes a position based on the internal primary GPS antenna element, mount the H102 where you desire a position with respect to the primary GPS antenna (it may be useful to put a directional marking in the plastics design of your enclosure to ease installation)




- Locate any transmitting antennas at least several feet away from the H102 to ensure tracking performance is not compromised, giving you the best performance possible
- Make sure there is enough cable length to reach a breakout box or terminal strip
- Do not locate the H102 where environmental conditions exceed those specified in Table B-5 on page 43

## H102 Environmental Considerations

The H102 is designed to withstand harsh environmental conditions; however, adhere to the following limits when storing and using the H102:

- Operating temperature: -30°C to +70°C (-22°F to +158°F)
- Storage temperature: -40°C to +85°C (-40°F to +185°F)
- Humidity: 95% non-condensing (when installed in an enclosure)

## VHF Interference

VHF interference from such devices as cellular phones and radio transmitters may interfere with GPS operation. When integrating with or near other transmitting RF devices consider interference from radio harmonics. For example, when integrating near marine radios consider the following:

- VHF marine radio working frequencies (Channels 1 to 28 and 84 to 88) range from 156.05 to 157.40 MHz. The L1 GPS working center frequency is 1575.42 MHz. The bandwidth is +/- 2 MHz to +/- 10 MHz, which is dependent on the GPS antenna and receiver design.
- VHF marine radios emit strong harmonics. The 10th harmonic of VHF radio, in some channels, falls into the GPS working frequency band, which may cause the SNR of GPS to degrade significantly.
- The radiated harmonic signal strength of different brands/models varies.
- Follow VHF radio manufacturers' recommendations on how to mount their radios and what devices to keep a safe distance away.
- Handheld 5 W VHF radios may not provide suitable filtering and may interfere with the H102's operation if too close.

Before installing your integrated H102 device use the following diagram to ensure there are no nearby devices that may cause VHF interference.

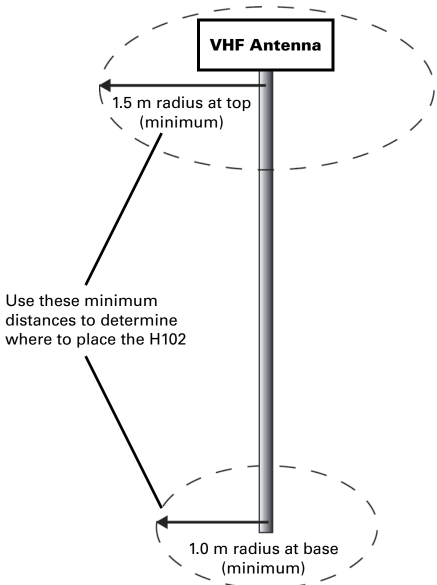



**Figure 3-3: H102 distance from nearby VHF radios**

# Mounting Orientation

Keep in mind your integrated H102 device and mounting location when determining your mounting orientation.

The H102 outputs heading, pitch, and roll readings regardless of antenna orientation. However, the relation of the antennas to the machine's axis determines whether you will need to enter a heading, pitch, or roll bias. The primary antenna is used for positioning and the primary and secondary antennas, working in conjunction, output heading, pitch, and roll values.

*Note: Regardless of which mounting orientation you use, the H102 provides the ability to output the heave of the machine via the $GPHEV message. For more information on this message refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon).*

***Parallel Orientation:*** The most common installation is to orient the H102 parallel to, and along the centerline of, the axis of the machine. This provides a true heading. In this orientation:

- If you use a gyrocompass, you can enter a heading bias in the H102 to calibrate the physical heading to the true heading of the machine.
- You may need to adjust the pitch/roll output to calibrate the measurement if the Vector is not installed in a horizontal plane.

***Perpendicular Orientation:*** You can also install the antennas so they are oriented perpendicular to the centerline of the machine's axis. In this orientation:

- You will need to enter a heading bias of +90° if the primary antenna is on the starboard side of the machine and -90° if the primary antenna is on the port side of the machine.
- You will need to configure the receiver to specify the GPS antennas are measuring the roll axis using $JATT,ROLL,YES.
- You will need to enter a roll bias to properly output the pitch and roll values.
- You may need to adjust the pitch/roll output to calibrate the measurement if the Vector is not installed in a horizontal plane.

Figure 3-4 and Figure 3-5 provide mounting orientation examples.

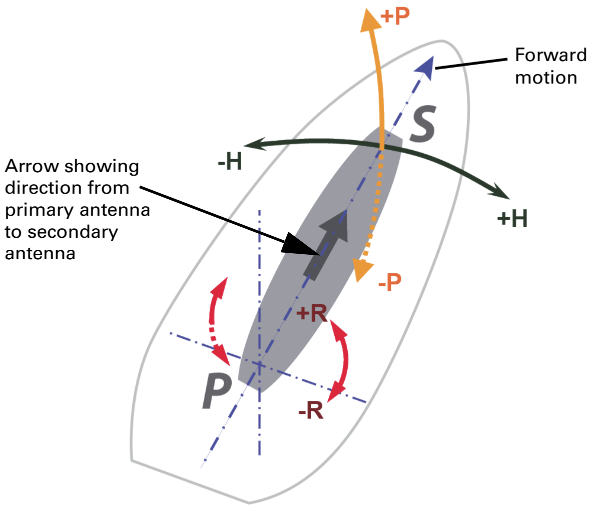



**Figure 3-4: Recommended orientation and resulting signs of HPR values**

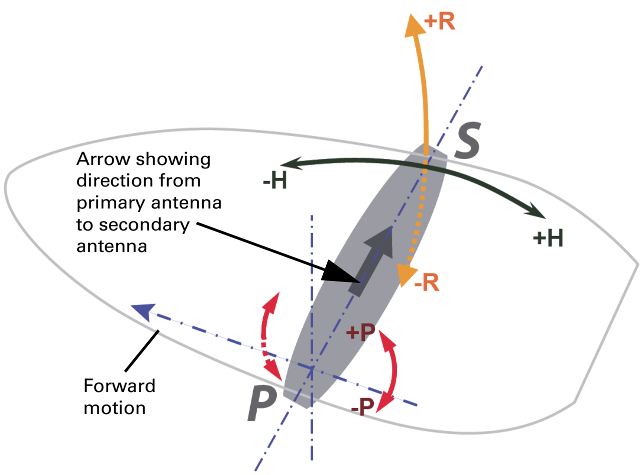



**Figure 3-5: Alternate orientation and resulting signs of HPR values**

# Shielding the H102

There are three shields that are soldered to the H102:

- Two shields (one over each antenna LNA circuitry)
- One shield over the main circuitry

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**WARNING:** Under NO circumstances should you remove, mangle, destroy, tamper with, or otherwise pierce, puncture, or open any of these shields. Doing so can dramatically reduce receiver performance and will void the warranty.

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**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 metal shields on the device when handling the board.

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# Powering the H102

## Power Considerations

For best performance use a clean and continuous power supply. The H102 power supply features reverse polarity protection but will not operate with reverse polarity.

See Table B-3 on page 43 for complete power specifications.

## Connecting to a Power Source

Perform the following steps to connect to a power source:

1. Build mating connector to J60 on the H102.
   - If you will be operating in NMEA 2000 mode, Hemisphere GPS recommends a flex connector with a 5-pin mini NMEA 2000 connector.
   - If you will be operating in serial mode, Hemisphere GPS recommends a Conxall style serial connector.
   - Keep in mind that power for serial and NMEA 2000 is shared power.
2. Connect your wire to mating connector.

The H102 will start when you apply an acceptable voltage to the power leads of the extension cable.

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**WARNING:** Do not apply a voltage higher than 36 VDC as this will damage the receiver and void the warranty.

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## Electrical Isolation

The H102 features a power supply that is isolated from the communication lines.

# Connecting to External Devices

This section provides information on connecting to other devices via J60.

## J60 Pinouts

Figure 3-6 shows a schematic of the section of the H102 OEM board related to J60.

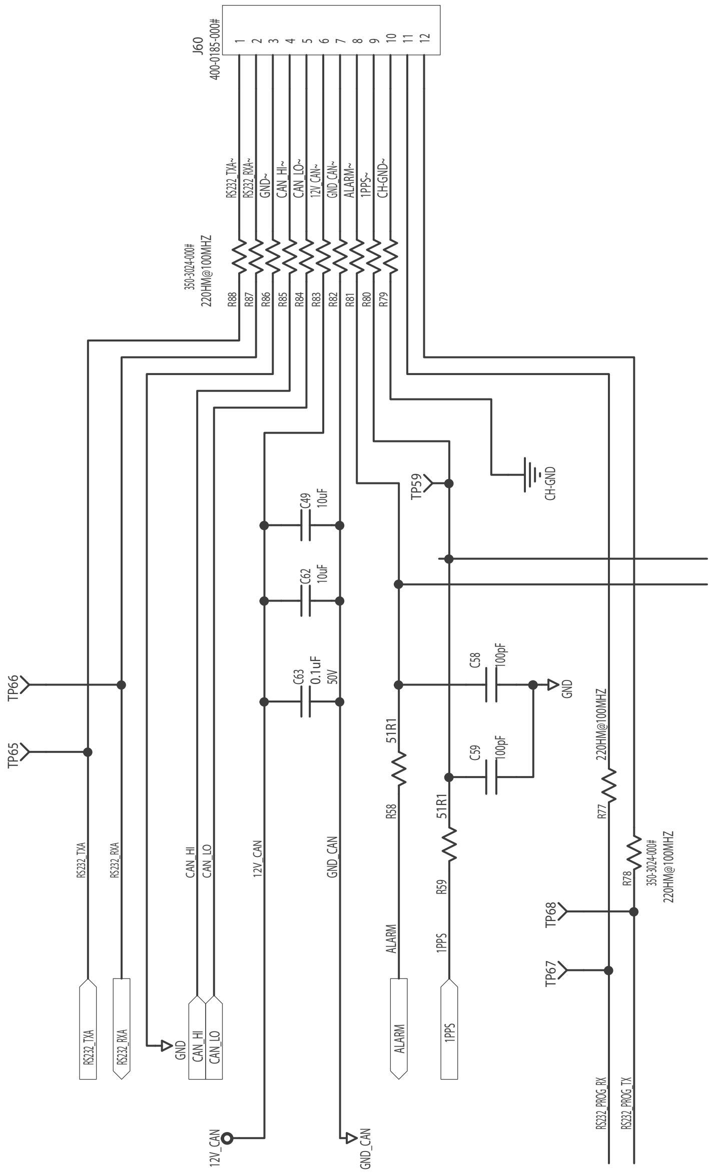


**Figure 3-6: H102 schematic (board section related to J60)**

Table 3-1 describes the J60 pinouts.

*Note: Although a 12-pin connector is included with the H102 and the connector supports both CAN and serial, you can only use one mode at a time (CAN or serial) not both at the same time (this satisfies NMEA 2000 compliance).*

**Table 3-1: J60 pinouts**

| Pin | Description |
|---|---|
| 1 | Tx Port A, RS-232 (Output from H102) |
| 2 | Rx Port A, RS-232 (Input to H102) |
| 3 | GND (Power, RS-232) |
| 4 | CAN high |
| 5 | CAN low |
| 6 | 12 V (Power In, NMEA 2000) |
| 7 | CAN ground |
| 8 | Alarm |
| 9 | PPS |
| 10 | No connect, or unterminated drain wire |
| 11 | Rx Port C, RS-232 (Input to H102) |
| 12 | Tx Port C, RS-232 (Output from H102) |

Figure 3-7 shows the H102 I/O location (J60 as marked on the board).

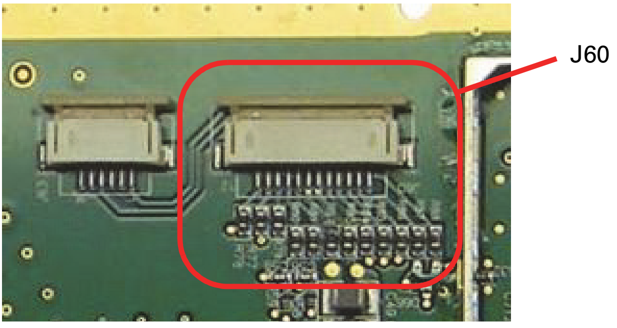


**Figure 3-7: H102 I/O locations**

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 H102. Any data or I/O pins that are not used should be left unterminated.

## J60 Signals

Table 3-2 describes the signals provided by the J60 connector of the H102.

**Table 3-2: J60 signals**

| Signal | Description |
|---|---|
| Power | Pin 3 (GND) and Pin 6 (12 V) of the J60 should be used for powering the unit. |
| I/O communications (port A, port C) | The H102 offers position and heading data via RS-232 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.<br>The RS-232 interface on Port A must be used to configure output on Port C. |
| Alarm (non-differential) | Pin 8, non-differential, non-IMO certifiable. The alarm condition occurs when the H102’s heading output becomes unusable. |
| PPS signal (3.3V CMOS) | There is a one pulse per second (PPS) signal on Pin 9 that may be useful for external timing applications or device synchronization. It is a 3.3 V CMOS active high signal with rising edge synchronization, having a 1 ms pulse width. |
| LED indicators (2) | Located on the edge of the H102 (one for heading, one for power) |
| CAN High | Pins 3, 4, and 5 offer an isolated Controlled Area Network (CAN) interface (you have to only use CAN connector ports from J60—you cannot mix serial and CAN together). This interface is a full NMEA 2000-certified interface. |
| CAN Low | |
| CAN Ground | |
| CAN Power | Shared with H102 main power supply, Pin 6 |

# Ports

The H102 offers either serial port or NMEA 2000 port functionality.

## Serial Ports

The H102 offers position and heading data via two full-duplex (bidirectional) RS-232 serial ports. These ports are also used for firmware upgrades.

### Selecting Baud Rates and Message Types

When selecting your baud rate and message types use the following formula to calculate the bits/sec for each message and then sum the results to determine the baud rate for your required data throughput.

> Message output rate * Message length (bytes) * bits in byte = Bits/second
> (1 character = 1 byte, 8 bits = 1 byte, use 10 bits/byte to account for overhead)

See “Common Commands and Messages” on page 33 for a calculation example. For information on message output rates refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon).

### Configuring the Ports

You may configure Port A or Port C of the GPS receiver to output any combination of data you want. Port A can have a different configuration from Port C in terms of data message output, data rates, and the port baud rate; this allows you to configure the ports independently based upon your needs.

*Note: The CAN processor that controls Port C is by default programmed into NMEA 2000 mode. You must configure Port C as a serial port to use the H102 with two serial ports. Port A, which is the main configuration port, is always a serial port. To configure Port C as a serial port refer to Table 3-4 on page 21.*

For example, if you want one generalized port and one heading-only port, you can configure the ports as follows:

- Port A to have GPGGA, GPVTG, GPGSV, GPZDA, and GPHDT all output at 1 Hz over a 9600 baud rate
- Port C to have GPHDT and GPROT output at their maximum rate of 20 Hz over a 19200 baud rate

*Note: For successful communications use the 8-N-1 protocol and set the baud rate of the H102’s serial ports to match that of the devices to which they are connected. Flow control is not supported.*

### Recommendations for Connecting to Other Devices

When interfacing to other devices, ensure the transmit data output from the H102 is connected to the data input of the other device. The signal grounds must also be connected.

There is likely little reason to connect the receive data input of the H102 to another device unless it is able to send configuration commands to the H102. Since the H102 uses proprietary NMEA 0183 commands for control over its configuration, the vast majority of electronics will not be able to configure its settings unless the other device has a terminal setting where you can manually issue commands.

### Interfacing to a PC

PCs 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 per Table 3-3 and Figure 3-8.

**Table 3-3: Port A and Port C RS-232 interface configuration**

| J60 Pin | Signal (Port A) |
|---|---|
| 2 | Port A transmit RS-232 |
| 1 | Port A receive RS-232 |
| 3 | Signal ground |

| J60 Pin | Signal (Port C) |
|---|---|
| 11 | Port C transmit RS-232 |
| 12 | Port C receive RS-232 |
| 3 | Signal ground |

Figure 3-8 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 3-8.

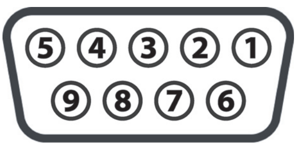


**Figure 3-8: DB9 female socket numbering**

## NMEA 2000 Port

By default, Port C is configured as a NMEA 2000 port with the default baud rate of 57600.

Table 3-4 lists the commands used to configure Port C back to serial or NMEA 2000 when necessary. You can only send these commands using Port A.

**Table 3-4: Commands for changing Port C (must be sent through Port A)**

| Command | Reply | Description |
|---|---|---|
| $JRELAY,PORTC,$JSERIALMODE | $>JSERIALMODE,ENABLED<br>$>resetting | Switch Port C to serial |
| $JRELAY,PORTC,$JN2KMODE | $>JN2KMODE,ENABLED<br>$>resetting | Switch Port C to NMEA 2000 |

Table 3-5 shows the requested PGNs with the H102 in NMEA 2000 mode.

**Table 3-5: Received messages based on a request**

| PG No. (PGN) | Description | Level | Default Update Rate (msec) | Freq (Hz) |
|---|---|---|---|---|
| 059392 | ISO Acknowledgement<br>Used to acknowledge the status of certain requests addressed to a specific ECU. | B | On Request | On Request |
| 059904 | ISO Request<br>Request the transmission of a specific PGN, addressed or broadcast. | B | On Request | On Request |
| 060928 | ISO Address Claim<br>Used to identify to other ECUs the address claimed by an ECU. | B | On Request | On Request |
| 126996 | Product Information<br>NMEA 2000 database version supported, manufacturer’s product code, NMEA 2000 certification level, Load Equivalency number, and other product-specific information. | B | On Request | On Request |
| 126464 | Receive/Transmit PGNs group function<br>The Transmit / Receive PGN List Group type of function is defined by first field. The message will be a Transmit or Receive PGN List group function. | B | On Request | On Request |
| 129538 | GNSS Control Status<br>GNSS common satellite receiver parameter status. | B | On Request | On Request |
| 129545 | GNSS RAIM Output<br>Used to provide the output from a GNSS receiver's Receiver Autonomous Integrity Monitoring (RAIM) process. The Integrity field value is based on the parameters set in PGN 129546 GNSS RAIM Settings. | B | On Request | On Request |
| 129546 | GNSS RAIM Settings<br>Used to report the control parameters for a GNSS Receiver Autonomous Integrity Monitoring (RAIM) process. | B | On Request | On Request |

Table 3-6 shows the transmitted PGNs with their default update rate with the H102 in NMEA 2000 mode.

**Table 3-6: Transmitted messages**

| PG No. (PGN) | Description | Level | Default Update Rate (msec) | Freq (Hz) |
|---|---|---|---|---|
| 126992 | System Time<br>The purpose of this PGN is twofold: To provide a regular transmission of UTC time and date and to provide synchronism for measurement data. | B | 1000 | 1 |
| 127250 | Machine Heading<br>Heading sensor value with a flag for True or Magnetic. If the sensor value is Magnetic, the deviation field can be used to produce a Magnetic heading, and the variation field can be used to correct the Magnetic heading to produce a True heading. | B | 100 | 10 |
| 127251 | Rate of Turn<br>Rate of change of the Heading. | B | 100 | 10 |
| 127257 | Attitude<br>Provides a single transmission that describes the position of a machine relative to both horizontal and vertical planes. This would typically be used for machine stabilization, machine control and onboard platform stabilization. | B | 1000 | 1 |
| 127258 | Magnetic Variation<br>Message for transmitting variation. The message contains a sequence number to allow synchronization of other messages such as Heading or Course over Ground. The quality of service and age of service are provided to enable recipients to determine an appropriate level of service if multiple transmissions exist. | | 1000 | 1 |
| 128259 | Speed<br>Provides a single transmission that describes the motion of a machine. | B | 1000 | 1 |
| 129025 | Position, Rapid Update<br>Provides latitude and longitude referenced to WGS84. Being defined as single frame message, as opposed to other PGNs that include latitude and longitude and are defined as fast or multi-packet, this PGN lends itself to being transmitted more frequently without using up excessive bandwidth on the bus for the benefit of receiving equipment that may require rapid position updates. | B | 100 | 10 |

**Table 3-6: Transmitted messages (*continued)***

| PG No. (PGN) | Description | Level | Default Update Rate (msec) | Freq (Hz) |
|---|---|---|---|---|
| 129026 | COG & SOG, Rapid Update<br>Single frame PGN that provides Course Over Ground (COG) and Speed Over Ground (SOG). | B | 250 | 4 |
| 129027 | Position Delta, High Precision Rapid Update<br>Intended for applications where very high precision and very fast update rates are needed for position data. This PGN can provide delta position changes down to 1 mm with a delta time period accurate to 5 msec. | B | 100 | 10 |
| 129028 | Altitude Delta, High Precision Rapid Update<br>Intended for applications where very high precision and very fast update rates are needed for altitude and course over ground data. This PG can provide delta altitude changes down to 1 millimeter, a change in direction as small as 0.0057°, and with a delta time period accurate to 5 msec. | B | 100 | 10 |
| 129029 | GNSS Position Data<br>Conveys a comprehensive set of Global Navigation Satellite System (GNSS) parameters, including position information. | B | 1000 | 1 |
| 129033 | Time & Date<br>Single transmission that provides UTC time, UTC Date, and Local Offset. | B | 1000 | 1 |
| 129539 | GNSS DOPs<br>Provides a single transmission containing GNSS status and dilution of precision components (DOP) that indicate the contribution of satellite geometry to the overall positioning error. There are three DOP parameters reported: horizontal (HDOP), Vertical (VDOP), and time (TDOP). | B | 1000 | 1 |
| 129540 | GNSS Sats in View<br>GNSS information on current satellites in view tagged by sequence ID. Information includes PRN, elevation, azimuth, SNR, defines the number of satellites; defines the satellite number and the information. | B | 1000 | 1 |

# Default Parameters

Port C is reserved exclusively for the NMEA 2000 CAN processor and internal communications and is configured by default as a NMEA 2000 port.

To switch Port C to serial:

- Send `$JRELAY,PORTC,$JSERIALMODE`

To switch Port C back to NMEA 2000 mode:

- In version 1.3.0 and earlier, send:
  `$JRELAY,PORTC,$JSWITCHN2KMODE14325`

  The receiver response is:
  ```
  $>JSWITCHN2KMODE14325,ENABLED
  $>resetting
  ```
- In version 1.3.1 and later, send:
  `$JRELAY,PORTC,$JN2KMODE`

  The receiver response is:
  ```
  $>JN2KMODE,ENABLED
  $>resetting
  ```

To change the mode of operation to serial pass-through mode:

- Send the following command from Port A:
  `$JRELAY,PORTC,$JSERIALMODE`

  The receiver response is:
  ```
  $>JSERIALMODE,ENABLED
  $>resetting
  ```

## Standard Configuration

The following represents the standard configuration for the H102. For more information on these commands refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon).

```
$JRELAY,PORTC,$JN2KMODE
$JOFF,PORTA
$JOFF,PORTB
$JOFF,PORTC

$JBAUD,19200,PORTA
$JBAUD,19200,PORTB
$JBAUD,19200,PORTC

$JAGE,2700
$JLIMIT,10
$JMASK,5
$JNP,5
$JWAASPRN,AUTO
$JDIFF,WAAS
$JPOS,59.0,18.0
$JSMOOTH,LONG
$JTAU,COG,0.00
$JTAU,SPEED,0.00
$JAIR,AUTO
$JALT,NEVER

$JATT,HTAU,2.0
```

```
$JATT,HRTAU,2.0
$JATT,COGTAU,0.0
$JATT,MSEP,0.275
$JATT,GYROAID,YES
$JATT,TILTAID,YES
$JATT,LEVEL,NO
$JATT,EXACT,NO
$JATT,HIGHMP,NO
$JATT,FLIPBRD,YES
$JATT,HBIAS,0.0
$JATT,NEGTILT,NO
$JATT,NMEAHE,0
$JATT,PBIAS,0.0
$JATT,PTAU,0.5
$JATT,ROLL,NO
$JATT,SPDTAU,0.0

$JASC,GPGGA,1,PORTA
$JASC,GPGLL,1,PORTA
$JASC,HEHDT,5,PORTA
$JASC,GPRMC,5,PORTA
$JASC,GPROT,5,PORTA
$JASC,GPVTG,1,PORTA
$JASC,GPZDA,1,PORTA
$JASC,GPHPR,1,PORTA
```

# Chapter 4: Operation

GPS Overview
H102 Overview
Common Commands and Messages

# GPS Overview

For your convenience, both the GPS and SBAS operation of the H102 features automatic operational algorithms. When powered for the first time, the H102 performs a ‘cold start’ that involves acquiring the available GPS satellites in view and the SBAS differential service.

If SBAS is not available in your area, an external source of RTCM SC-104 differential corrections may be used. If you use an external source of correction data, it must support an eight data bit, no parity, one stop bit configuration (8-N-1).

## GPS Operation

The GPS receiver is always operating, regardless of the DGPS operation mode. The following sections describe the general operation of the H102’s internal GPS receiver.

*Note: Differential source and status have no impact on heading, pitch, or roll. They only have an impact on positioning and heave.*

### Automatic Tracking

The H102’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 H102 works by finding four or more GPS satellites in the visible sky. It uses information from these satellites to compute a position within 2.5 m 95%. Since there is some error in the GPS data calculations, the H102 also tracks a differential correction. The H102 uses these corrections to improve its position accuracy to better than 1.0 m 95%.

There are two main aspects of GPS receiver performance:

- Satellite acquisition
- Positioning and heading calculation

When the H102 is properly positioned, the satellites transmit coded information to the antennas on a specific frequency. This allows the receiver to calculate a range to each satellite from both antennas. 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 and heading. Reception of any four or more GPS signals allows the receiver to compute three-dimensional coordinates and a valid heading.

---

**⚠WARNING:** If you are using a reradiator to rebroadcast GPS signals indoors, the H102 may be able to calculate a position solution but it will not be able to compute an accurate heading solution. This is due to the heading algorithms essentially receiving the same measurements at both antennas and is unrelated to the quality or operation of either the H102 or the reradiator.

---

## 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 H102 will result in positioning accuracies of 2.5 m 95% of the time. In order to improve positioning quality to better than 1.0 m 95%, the H102 is able to use differential corrections received through the internal SBAS demodulator or externally-supplied RTCM corrections.

### Automatic SBAS Tracking

The H102 automatically scans and tracks SBAS signals without the need to tune the receiver. The H102 features two-channel tracking that provides an enhanced ability to maintain a lock on an SBAS satellite when more than one satellite is in view. This redundant tracking approach results in more consistent tracking of an SBAS signal in areas where signal blockage of a satellite is possible.

# H102 Overview

The H102 provides accurate and reliable heading and position information at high update rates. To accomplish this task, the H102 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 H102 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.

The heading is defined by the orientation from primary to secondary antenna. See Figure 3-1 on page 10 for locations of the primary and secondary antennas.

## Fixed Baseline Moving Base Station RTK

The H102's internal GPS receiver uses both the L1 GPS C/A code and carrier phase data 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 H102 restricts the RTK solution. It does this knowing that the secondary GPS antenna is 27.5 cm from the primary GPS antenna. This is called a fixed baseline and it defines the search volume of the secondary antenna as the surface of a sphere with radius 27.5 cm centered on the location of the primary antenna (see Figure 4-1 on page 30).

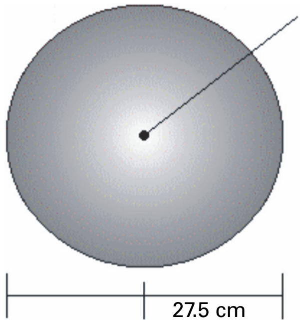


**Figure 4-1: Secondary antenna's search volume**

*Note: The H102 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 H102 has three supplemental sensors (gyro and two tilt sensors) that are integrated into the unit's carrier board. The supplemental sensors are enabled by default. You can enable/disable the gyro and both tilt sensors (you cannot enable/disable each tilt sensor separately).

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. Table 4-1 provides a sensor operation summary.

**Table 4-1: Sensor operation summary**

| Feature | Normal Operation | Coasting (no GPS) |
|---|---|---|
| Heading | GPS | Gyro |
| Heave | GPS | None |
| Pitch | GPS | Inertial sensor |
| Roll | Inertial sensor | Inertial sensor |

Refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon) for the commands and methodology required to recalibrate, query, or change a sensor's status.

### Tilt Aiding

The H102's accelerometers (internal tilt sensors) are factory calibrated and enabled by default. This constrains the RTK heading solution beyond the volume associated with just a fixed antenna separation. This is because the H102 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 as well as instances of incorrect heading solutions (see Figure 4-2).

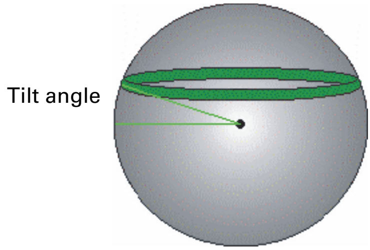


**Figure 4-2: H102's tilt aiding**

### Gyro Aiding

The H102'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 were blocked. The gyro provides a relative change in angle since the last computed heading, and, when used in conjunction with the tilt sensors, defines the search space as a wedge-shaped location (see Figure 4-3).

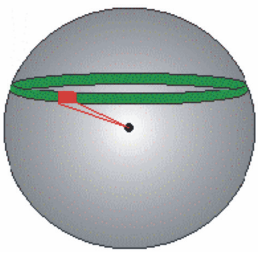

**Figure 4-3: H102's gyro aiding**

The gyro aiding accurately smoothes the heading output and the rate of turn. It provides an accurate substitute heading for a short period, accurate to within 1° per minute for up to three 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 H102 begins outputting null fields in the heading output messages. There is no user control over the timeout period of the gyro.

Calibration, which is set at the factory, is required for the gyro to remove latency from the heading solution as well as provide backup heading when GPS is blocked. The receiver will calibrate itself after running for a while but it may be important to follow the manual calibration instructions if you want to guarantee performance quickly after powering up the receiver.

The gyro initializes itself at powerup and during initialization, or you can calibrate it as outlined in the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon). When the gyro is first initializing, it is important that the dynamics that the gyro experiences during this warmup period are similar to the regular operating dynamics. For example, if you use the H102 on a high speed, maneuverable craft, it is recommended that when gyro aiding in the H102 is first turned on, use it in an environment that has high dynamics for the first five to ten minutes instead of sitting stationary.

When enabled, the gyro is also used to update the post HTAU smoothed heading output from the moving base station RTK GPS heading computation—if the HTAU value is increased while gyro aiding is enabled, there will be little to no lag in heading output due to machine maneuvers. The Hemisphere GPS Technical Reference includes information on setting an appropriate HTAU value for the application.

## Time Constants

The H102 incorporates user-configurable time constants that can provide a degree of smoothing to the heading, pitch, rate of turn (ROT), course over ground (COG), and speed measurements. You can adjust these parameters depending on the expected dynamics of the machine. For example, increasing the time is reasonable if the machine 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 machine is quick and nimble, increasing this value can create a lag in measurements. Formulas for determining the level of smoothing are located in the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon). If you are unsure on how to set this value, it is best to be conservative and leave it at the default setting.

*Note: For heading and rate of turn there is no lag once the gyro is calibrated and enabled.*

***Heading time constant:*** Use the $JATT,HTAU command to adjust the level of responsiveness of the true heading measurement provided in the $GPHDT message. The default value of this constant is 10.0 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 so you must manually enter it. Increasing the time constant increases the level of heading smoothing and increases lag.

***Pitch time constant:*** Use the $JATT,PTAU command to adjust the level of responsiveness of the pitch measurement provided in the $PSAT,HPR message. The default value of this constant is 0.5 seconds of smoothing. Increasing the time constant increases the level of pitch smoothing and increases lag.

***Rate of Turn (ROT) time constant:*** Use the $JATT,HRTAU command to adjust the level of responsiveness of the ROT measurement provided in the $GPROT message. The default value of this constant is 2.0 seconds of smoothing. Increasing the time constant increases the level of ROT smoothing.

***Course Over Ground (COG) time constant:*** Use the $JATT,COGTAU command to adjust the level of responsiveness of the COG measurement provided in the $GPVTG message. 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 antenna and its accuracy depends upon the speed of the machine (noise is proportional to 1/speed). This value is invalid when the machine is stationary, as tiny movements due to calculation inaccuracies are not representative of a machine's movement.

***Speed time constant:*** Use the $JATT,SPDTAU command to adjust the level of responsiveness of the speed measurement provided in the $GPVTG message. The default value of this constant is 0.0 seconds of smoothing. Increasing the time constant increases the level of speed measurement smoothing.

## Watchdog

The watchdog is a timer that is controlled by the software that monitors if the heading is lost. The watchdog software is compliant with IEC 60495.

# Common Commands and Messages

*Note: When selecting your baud rate and message types use the following formula and example to calculate the bits/sec for each message and then sum the results to determine the baud rate for your required data throughput.*

*The V103/113 has maximum baud rate of 38400.*

*Message output rate * Message length (bytes) * bits in byte = Bits/second*
*(1 character = 1 byte, 8 bits = 1 byte, use 10 bits/byte to account for overhead)*

*Example:*

| *Message* | *Rate* | *Bytes* | *Bits in byte* | *Bits/sec* |
|---|---|---|---|---|
| *GPHDT* | *10* | *20* | *10* | *2000* |
| *GPROT* | *5* | *18* | *10* | *900* |
| *GPHDG* | *1* | *33* | *10* | *330* |
| *GPGGA* | *1* | *83* | *10* | *830* |
| *GPZDA* | *1* | *38* | *10* | *380* |
| | | | *Total* | *4440* |

For information on message output rates refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon).

Table 4-2 below through Table 4-5 provide brief descriptions of common commands and messages for the H102. Refer to the Hemisphere GPS Technical Reference for more detailed information.

**Table 4-2: Commands**

| Command | Description |
|---|---|
| $JAGE | Specify maximum DGPS (COAST) correction age (6 to 8100 seconds) |
| $JAPP | Query or specify receiver application firmware |
| $JASC | Specify ASCII messages to output to specific ports (see ASCII messages in Table 4-3) |
| $JBAUD | Specify RS-232, RS-422 (output) communication rate |
| $JBIN | Specify binary messages to output to specific ports (see Table 4-4) |
| $JDIFF | Query or specify differential correction mode |
| $JGEO | Query or specify SBAS for current location and SBAS satellites |
| $JI | Query unit’s serial number and firmware versions |
| $JOFF | Turn off all data messages |
| $JQUERY,GUIDE | Query accuracy suitability for navigation |

**Table 4-2: Commands (*continued)***

| Command | Description |
|---|---|
| $JRESET | Reset unit's configuration to firmware defaults<br>**Note:** $JRESET clears all parameters. For the H102 you will have to issue the $JATT, FLIPBRD,YES command to properly redefine the circuitry orientation inside the product once the receiver has reset. Failure to do so will cause radical heading behavior.<br>You can also issue the $JRESET command with an optional field as follows:<br>• $JRESET,ALL does everything $JRESET does, plus it clears almanacs<br>• $JRESET,BOOT does everything $JRESET,ALL does, plus clears use of the real-time clock at startup, clears use of backed-up ephemeris and almanacs, and reboots the receiver when done |
| $JSAVE | Save session's configuration changes |

In Table 4-3 the Info Type value is one of the following:

- P = Position
- V = Velocity, Time
- H = Heading, Attitude
- S = Sats, Stats, Quality

**Table 4-3: NMEA 0183 and other messages**

| Message | Info Type | Max Output Rate | Description | IEC Approved Message |
|---|---|---|---|---|
| $GPDTM | P | 1 Hz | Datum reference | Yes |
| $GPGGA | P | 20 Hz | GPS position and fix data | Yes |
| $GPGLL | P | 20 Hz | Geographic position - lat/long | Yes |
| $GPGNS | P | 20 Hz | GNSS position and fix data | Yes |
| $GPGRS | S | 1 Hz | GNSS range residual (RAIM) | Yes |
| $GPGSA | S | 1 Hz | GNSS DOP and active satellites | Yes |
| $GPGST | S | 1 Hz | GNSS pseudo range error statistics and position accuracy | Yes |
| $GPGSV | S | 1 Hz | GNSS satellites in view | Yes |
| *$GPHDG | H | 20 Hz | Provides magnetic deviation and variation for calculating magnetic or true heading<br>*see last bullet in Note at end of this table | Yes |
| *$GPHDM | H | 20 Hz | Magnetic heading (based on GPS-derived heading and magnetic declination)<br>*see last bullet in Note at end of this table | No |
| *$GPHDT | H | 20 Hz | GPS-derived true heading<br>*see last bullet in Note at end of this table | Yes |
| $GPHEV | H | 20 Hz | Heave value (in meters) | Yes |

**Table 4-3: NMEA 0183 and other messages (*continued)***

| Message | Info Type | Max Output Rate | Description | IEC Approved Message |
|---|---|---|---|---|
| $GPRMC | P | 20 Hz | Recommended minimum specific GNSS data | Yes |
| *$GPROT | H | 20 Hz | GPS-derived rate of turn (ROT)<br>*see last bullet in Note at end of this table | Yes |
| $GPRRE | S | 1 Hz | Range residual and estimated position error | Yes |
| $GPVTG | V | 20 Hz | COG and ground speed | Yes |
| $GPZDA | V | 20 Hz | Time and date | Yes |
| $PASHR | H | 20 Hz | Time, heading, roll, and pitch data in one message | No |
| $PSAT,GBS | S | 1 Hz | Satellite fault detection (RAIM) | Yes |
| $PSAT,HPR | H | 20 Hz | Proprietary NMEA message that provides heading, pitch, roll, and time in single message | No |
| $PSAT,INTLT | H | 1 Hz | Proprietary NMEA message that provides the pitch and roll measurements from the internal inclinometers (in degrees) | Yes |
| $RD1 | S | 1 Hz | SBAS diagnostic information | Yes |
| $TSS1 | H | 20 Hz | Heading, pitch, roll, and heave message in the commonly used TSS1 message format | No |

**Notes:**

- The GP of the message is the talker ID.
- GPGRS, GPGSA, GPGST, and GPGSV support external integrity checking. They are to be synchronized with corresponding fix data (GPGGA or GPGNS).
- For information on outputting roll, pitch, and heave data in one message refer to the Hemisphere GPS Technical Reference (go to www.hemispheregps.com and click the GPS Reference icon).
- *You can change the message header for the HDG, HDM, HDT, and ROT messages to either GP or HE using the $JATT,NMEAHE command.
  - To preface these messages with GP, issue the following command: $JATT,NMEAHE,0<CR><LF>
  - To preface these messages with HE, issue the following command: $JATT,NMEAHE,1<CR><LF>

  For more information on the $JATT,NMEAHE command refer to the Hemisphere GPS Technical Reference.

**Table 4-4: Binary messages**

| $JBIN Message | Description |
|---|---|
| 1 | GPS position |
| 2 | GPS DOPs |
| 80 | SBAS |
| 93 | SBAS ephemeris data |
| 94 | Ionosphere and UTC conversion parameters |

**Table 4-4: Binary messages (*continued)***

| $JBIN Message | Description |
|---|---|
| 95 | Satellite ephemeris data |
| 96 | Code and carrier phase |
| 97 | Processor statistics |
| 98 | Satellites and almanac |
| 99 | GPS diagnostics |

**Table 4-5: Parameters specific to $JATT command**

| Parameter | Description | Query | Specify |
|---|---|---|---|
| COGTAU | Set/query COG time constant (0.0 to 3600.0 sec) | X | X |
| CSEP | Query antenna separation | X | |
| EXACT | Enable/disable internal filter reliance on the entered antenna separation | X | X |
| FLIPBRD | Turn the flip feature on/off | X | X |
| GYROAID | Enable/disable gyro | X | X |
| HBIAS | Set/query heading bias (-180.0° to 180.0°) | X | X |
| HELP | Show the available commands for GPS heading operation and status | X | |
| HIGHMP | Set/query the high multipath setting for use in poor GPS environments | X | X |
| HRTAU | Set/query ROT time constant (0.0 to 3600.0 sec) | X | X |
| HTAU | Set/query heading time constant (0.0 to 3600.0 sec) | X | X |
| LEVEL | Enable/disable level operation | X | X |
| MSEP | Manually set or query antenna separation | X | X |
| NEGTILT | Enable/disable negative tilt | X | X |
| NMEAHE | Change the HDG, HDM, HDT, and ROT message headers between GP and HE | X | X |
| PBIAS | Set/query pitch/roll bias (-15.0° to 15.0°) | X | X |
| PTAU | Set/query pitch time constant (0.0 to 3600.0 sec) | X | X |
| ROLL | Configure for roll or pitch GPS orientation | X | X |
| SEARCH | Force a new GPS heading search | | X |
| SPDTAU | Set/query speed time constant (0.0 to 3600.0 sec) | X | X |
| SUMMARY | Display current Crescent Vector settings summary | X | |
| TILTAID | Enable/disable accelerometer, pre-calibrated | X | X |
| TILTCAL | Calibrate accelerometers | | X |

# Appendix A: 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<br>• Check integrity of power cable connectors<br>• Check power input voltage (6 to 36 VDC)<br>• Check current restrictions imposed by power source (minimum available should be > 1.0 A) |
| No data from H102 | • Check receiver power status to ensure the receiver is powered (an ammeter can be used for this)<br>• Verify desired messages are activated (using VectorPC or $JSHOW in any terminal program)<br>• Ensure the baud rate of the H102 matches that of the receiving device<br>• Check integrity and connectivity of power and data cable connections |
| Random data from H102 | • Verify the RTCM or binary messages are not being output accidentally (send a $JSHOW command)<br>• Ensure the baud rate of the H102 matches that of the remote device<br>• Potentially, the volume of data requested to be output by the H102 could be higher than the current baud rate supports (try using 19200 as the baud rate for all devices or reduce the amount of data being output) |
| No GPS lock | • Verify the H102 has a clear view of the sky<br>• Verify the lock status of GPS satellites (this can be done with VectorPC) |
| No SBAS lock | • Verify the H102 has a clear view of the sky<br>• Verify the lock status of SBAS satellites (this can be done with VectorPC - monitor BER value)<br>• SBAS lock can only get if you are in an appropriate SBAS region (currently, there is limited SBAS availability in the southern hemisphere)<br>• Set SBAS mode to automatic with the $JWAASPRN,AUTO command |

**Table A-1: Troubleshooting (*continued)***

| **Symptom** | **Possible Solution** |
|---|---|
| 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<br>• Ensure MSEP is set to 0.275 m<br>• Verify all the settings in the $JSHOW and $JATT,SUMMARY command responses with the parameters shown in "Standard Configuration" on page 25<br>• Recalibrate the tilt sensor with $JATT,TILTCAL command if heading is calculated then lost at consistent time intervals<br>• Do not use the H102 under a reradiator; the H102 must be outside to provide heading with good GPS visibility (see Warning on page 28)<br>• Heading is from primary GPS antenna to secondary GPS antenna, so the arrow on the underside of the H102 should be directed to the bow side<br>• $JATT,SEARCH command forces the H102 to acquire a new heading solution (unless gyro is enabled)<br>• Enable GYROAID to provide heading for up to three minutes during GPS signal loss<br>• Enable TILTAID to reduce heading search times<br>• Monitor the number of satellites and SNR values for both antennas within VectorPC—at least four satellites should have strong SNR values<br>• Potentially, the volume of data requested to be output by the H102 could be higher than the current baud rate supports (try using 19200 as the baud rate for all devices or reduce the amount of data being output) |
| No DGPS position in external RTCM mode | • Verify the baud rate of the RTCM input port matches the baud rate of the external source<br>• Verify the pinout 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)<br>• Ensure corrections are being transmitted to the correct port—using the $JDIFF,PORTC command on Port A will cause the receiver to expect the corrections to be input through Port C |

# Appendix B: Technical Specifications

Table B-1 through Table B-5 provide the H102's GPS sensor, communication, power, mechanical, and environmental specifications.

**Table B-1: GPS sensor specifications**

| Item | Specification |
|---|---|
| Receiver type | L1, C/A code with carrier phase smoothing |
| Channels | Two 12-channel, parallel tracking<br>(Two 10-channel when tracking SBAS) |
| SBAS tracking | 2-channel, parallel tracking |
| Update rate | Standard 10 Hz, optional 20 Hz (position and heading) |
| Horizontal accuracy | < 1.0 m 95% confidence (DGPS[1])<br>< 2.5 m 95% confidence (autonomous, no SA[2]) |
| Heading accuracy | < 0.75° rms<br>Normal operation: GPS<br>Coasting (no GPS): Gyro |
| Heave accuracy | < 30 cm rms[3]<br>Normal operation: GPS<br>Coasting (no GPS): None |
| Pitch accuracy | < 1.5° rms<br>Normal operation: GPS<br>Coasting (no GPS): Inertial sensor |
| Roll accuracy | < 1.5° rms using accelerometer<br>Normal operation: Inertial sensor<br>Coasting (no GPS): Inertial sensor |
| Rate of turn | 90°/s maximum |
| Cold start | < 60 s typical (no almanac or RTC) |
| Warm start | < 20 s typical (almanac and RTC) |
| Hot start | < 1 s typical (almanac, RTC, and position) |
| Heading fix | < 10 s typical (valid position) |
| Compass safe distance | 30 cm[4] (when installed in an enclosure) |
| Maximum speed | 1,850 kph (999 kts) |
| Maximum altitude | 18,288 m (60,000 ft) |

**Table B-2: Communication specifications**

| Item | Specification |
|---|---|
| Serial ports | 2 full-duplex RS-232 |
| Baud rates | 4800, 9600, 19200, 38400, 57600, 115200 |
| Correction I/O protocol | RTCM SC-104 |
| Data I/O protocol | NMEA 0183, Crescent binary[5], NMEA 2000 |
| Timing output | 1PPS, CMOS, active high, rising edge sync, 10 kΩ, 10 pF load |

**Table B-3: Power specifications**

| Item | Specification |
|---|---|
| Input voltage | 6 to 36 VDC |
| Power consumption | 3 W nominal |
| Current consumption | 320 mA @ 9 VDC<br>240 mA @ 12 VDC<br>180 mA @ 16 VDC |
| Power isolation | Isolated to ground |
| Reverse polarity protection | Yes |

**Table B-4: Mechanical specifications**

| Item | Specification |
|---|---|
| Dimensions<br>(not including mounts) | 37.5 L x 10.5 W x 2.5 H (cm)<br>14.8 L x 4.1 W x 1.0 H (in) |
| Weight | 250 g (8.8 oz) |

**Table B-5: Environmental specifications**

| Item | Specification |
|---|---|
| Operating temperature | -30°C to +70°C (-22°F to +158°F) |
| Storage temperature | -40°C to +85°C (-40°F to +185°F) |
| Humidity | 95% non-condensing (when installed in an enclosure) |
| Vibration | IEC 60945 (when mounted in an enclosure with screw mounting holes utilized) |
| EMC | FCC Part 15, Subpart B, CISPR22, CE |

[1]Depends on multipath environment, number of satellites in view, satellite geometry, ionospheric activity, and use of SBAS

[2]Depends on multipath environment, number of satellites in view, satellite geometry, and ionospheric activity

[3]Based on a 40-second time constant

[4]This is the minimum safe distance measured when the product is placed in the vicinity of the steering magnetic compass. The ISO 694 defines “vicinity” relative to the compass as within 5 m (16.4 ft) separation.

[5]Hemisphere GPS proprietary

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**THE PURCHASER IS RESPONSIBLE FOR OPERATING THE VEHICLE SAFELY.** The purchaser is solely responsible for the safe operation of the vehicle used in connection with the Product, and for maintaining proper system control settings. UNSAFE DRIVING OR SYSTEM CONTROL SETTINGS CAN RESULT IN PROPERTY DAMAGE, INJURY, OR DEATH. The purchaser is solely responsible for his/her safety and for the safety of others. The purchaser is solely responsible for maintaining control of the automated steering system at all times. THE PURCHASER IS SOLELY RESPONSIBLE FOR ENSURING THE PRODUCT IS PROPERLY AND CORRECTLY INSTALLED, CONFIGURED, INTERFACED, MAINTAINED, STORED, AND OPERATED IN ACCORDANCE WITH HEMISPHERE GNSS' RELEVANT USER'S MANUAL AND SPECIFICATIONS. Hemisphere GNSS does not warrant or guarantee the positioning and navigation precision or accuracy obtained when using Products. Products are not intended for primary navigation or for use in safety of life applications. The potential accuracy of Products as stated in Hemisphere GNSS literature and/or Product specifications serves to provide only an estimate of achievable accuracy based on performance specifications provided by the satellite service operator (i.e. US Department of Defense in the case of GNSS) and differential correction service provider. Hemisphere GNSS reserves the right to modify Products without any obligation to notify, supply or install any improvements or alterations to existing Products.

**GOVERNING LAW.** This agreement and any disputes relating to, concerning or based upon the Product shall be governed by and interpreted in accordance with the laws of the State of Arizona.

**OBTAINING WARRANTY SERVICE.** In order to obtain warranty service, the end purchaser must bring the Product to a Hemisphere GNSS approved service center along with the end purchaser's proof of purchase. Hemisphere GNSS does not warrant claims asserted after the end of the warranty period. For any questions regarding warranty service or to obtain information regarding the location of any of Hemisphere GNSS approved service center, contact Hemisphere GNSS at the following address:

**Hemisphere GNSS**
8444 N. 90th Street, Suite 120
Scottsdale, AZ 85258
Phone: 480-348-9919 Fax: 480-348-6370
techsupport@hemispheregps.com

Hemisphere GPS

www.hemispheregps.com