Hemisphere®

VS-i8 Inertial Navigation System

875-0470-10

User Guide
Revision: A1
December 5, 2022

Device Compliance, License and Patents

Device Compliance

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.

This product complies with the essential requirements and other relevant provisions of Directive 2014/53/EU. The declaration of conformity may be consulted at HTTPS://HEMISPHEREGNSS.COM/ABOUT-US/QUALITY-COMMITMENT.

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6539303	7292185	7689354	8138970
6549091	7292186	7808428	8140223
6711501	7373231	7835832	8174437
6744404	7388539	7885745	8184050
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2002244539	2002325645
2004320401	

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Table of Contents

Chapter 1: Introduction

Overview

Introduction

Chapter 1 provides the basic overview information you need to know about the VSi8 Receiver.

Contents

Product Overview

Product Introduction

The Hemisphere GNSS Vector VSi8 Inertial Navigation System combines a world class GNSS engine with Honeywell® IMU technology, providing a powerful dual-antenna, multi-frequency, multi-constellation RTK capability. Hemisphere's integration blends the IMU with GNSS data for an accurate, robust navigation service to your application with all the functionalities you need.

Note: Throughout the remainder of this manual, the Vector VSi8 Inertial Navigation System is referred to as the "VSi8".

The VSi8 output data includes a time stamped position, velocity, angular rate, linear acceleration, roll, pitch and heading information. In dual-antenna mode, the device supports GNSS-based heading measurements and initialization.

The Honeywell® HGUIDE DATA READER (HGDR) is a web-deployed software integration tool to configure Honeywell HGuide Products. It configures for message type (HGNSI or NMEA), baud rate, message information, installation set-up (antenna lever arms, vehicle frames, and odometer).

Continued on next page

Product Introduction, continued

All configurations should be completed using the HGDR software or other approved means[1].

Athena™ RTK - The VSi8 supports the use of Athena RTK (Real Time Kinematic) technology. Athena RTK requires the use of two separate receivers: a base station (stationary or RTK network primary receiver) that broadcasts corrections over a wireless link to the rover (secondary receiver). The localized corrections are processed on the rover to achieve superior accuracy and repeatability. Performance testing has shown positioning accuracy at the centimeter level. Alternatively, RTK corrections can be brought in over a GNSS network (NTRIP) if one is available in your area.

Athena RTK has the following benefits:

- Improved Initialization time - Performing initializations in less than 15 seconds at better than 99.9% of the time.
- Robustness in difficult operating environments - Extremely high productivity under the most aggressive of geographic environments.

[1] The VSi8 is not compatible with Hemisphere PocketMax® software.

Key Features

VSi8 Key Features

Key features of the VSi8 include:

- Athena GNSS engine-providing best-in-class RTK performance
- Extremely accurate dual antenna heading
- Atlas® L-band capable
- Non-ITAR controlled
- 0.03° heading, 0.015° pitch and roll accuracy on a 2m baseline
- Rugged IP68 enclosure
- Onboard data logging
- SDK, ROS drivers available

What's Included in Your Kit

Kit Contents

Table 1-1 provides the description and part numbers of each part in your kit. Table 1-2 lists the optional cables and accessory parts that are available for use with VSi8.

Table 1-1: Parts List

Part Name	Part Number	Qty
VSi8 INS Receiver	752-0079-10	1
USB to RS-485 Adapter (9-pin)	750-1187-10	1

Table 1-2: Optional Cables and Accessory Parts

Part Name	Part Number	Qty
IO1 Cable, 2 x DB9, DB15	051-0488-10	1
IO2 Cable, DB9, DB15, RJ45, PWR	051-0489-10	1
IO1 Cable, 2 x DB9, USB-A	051-0492-10	1
IO1 Cable, Unterminated, 1.8m	051-0493-10	1
IO2 Cable, Unterminated, 1.8m	051-0494-10	1
USB to RS-232 Adapter (9-pin)	750-1188-10	1

Chapter 2: Operating the VSi8

Overview

Introduction

Chapter 2 provides the information you need to power and operate your VSi8 INS receiver.

Contents

Powering the Receiver On/Off

Powering the receiver on/off

To power on the VSi8 you must connect to an external power supply. The VSi8 will power on automatically after it connects to the 16-pin power and communication cable and has a power supply.

After powering on, the LED indicators show the device status. For example, the power (PWR) LED illuminates if the power is on.

To power off the VSi8 disconnect the external power supply.

Figure 2-1: VSi8 LED Indicators

Powering the Receiver On/Off, Continued

Powering the receiver on/off, continued

Table 2-1 lists the VSi8 LED indicators by color and function.

Table 2-1: LED Indicators

LED	Description	LED OFF	LED Blinking	LED ON
PWR	Power	No Power Applied	N/A	Power Applied
POS	GNSS Status	No GNSS	Standalone, SBAS, or RTK FLOAT	RTK Fixed
INS	HGuide Navigation	Standby Awaiting Heading	Aided Navigation (Zero Motion Detected or Odometer Active)	Aided Navigation
LOG	On Device Storage	Not Logging Data	N/A	Logging Data

Ports

VSi8 ports

Figure 2-2 below shows the VSi8 communication ports and port name labels.

Figure 2-2: VSi8 power and communication ports

Table 2-2 lists the power and communication ports and a description of each function.

Table 2-2: VSi8 power and communication ports

	Port Name	Description
1	RF1	SMA, external GNSS primary antenna connector
2	RF2	SMA, external GNSS secondary antenna connector
3	IO1	One Power (+9.9VDC to +36VDC) Two RS-422 serial ports One RS-232 serial port One USB 2.0 interface (supports OTG) One PPS output interface One EVENT input interface
4	IO2	One Power (+9.9VDC to +36VDC) One 100M Ethernet port Two RS-232 serial port One PPS output interface One EVENT interface

Inertial Reference Frames

Inertial Reference Frames

Figure 2-3 below shows the IMU and Case Reference Frames. Table 2-3 lists the Frames and descriptions.

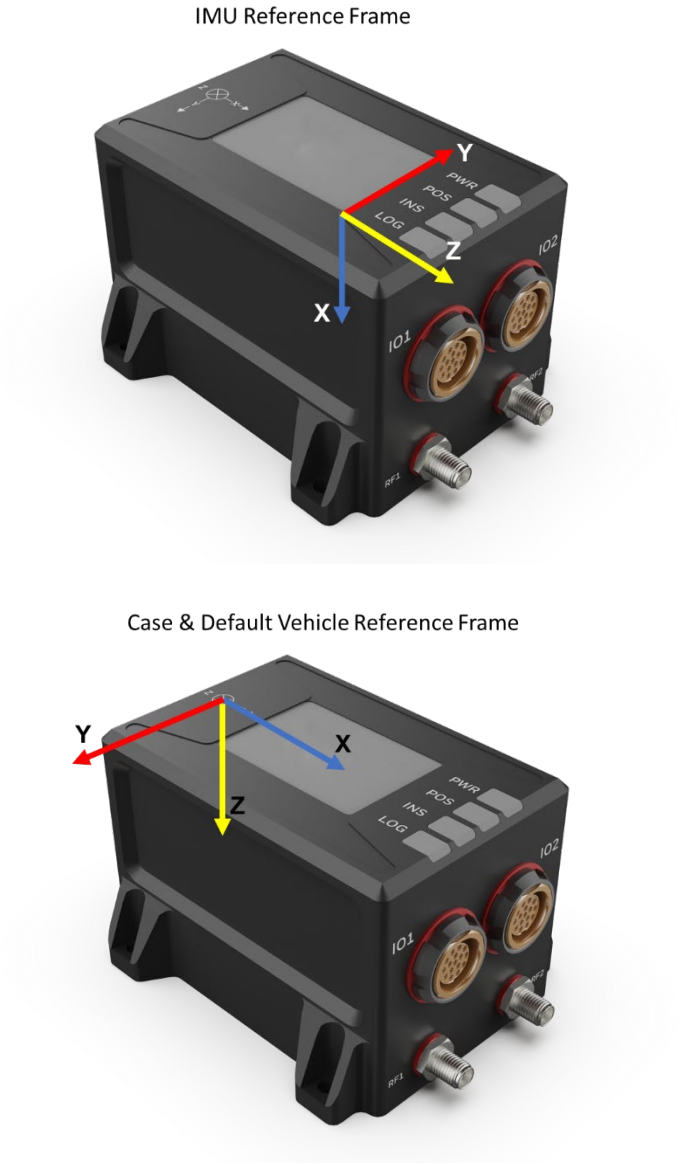

Figure 2-3: IMU and Case Reference Frames

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Inertial Reference Frames, continued

Table 2-3: HGuide Frames and Descriptions

Frame	Description
Vehicle or Platform	The **Output Frame** for most HGNSI navigation messages. These outputs blend data from the IMU, GNSS, odometer, user transmitted inputs (i.e., 0x1401), modes such as HGuide Motion Detect, Land Constraints, and other aiding information if available. The navigation data can include North-East-Down velocity, True Heading, Pitch (relative to local level), and roll. Heading / Pitch / Roll is an ordered "ZYX" Euler rotation.
Case	The **Lever Arms** (vehicle, antenna, odometer) and the distance to the IMU origin.
IMU	The **Reporting Frame** for the 0x2311 IMU message. Note the 0x6311 inertial data is oriented in the **Vehicle Frame** but reports acceleration magnitude relative to the IMU origin. The **IMU Frame** is used by internal navigation software and often referred to as the **"Nav" Frame**.
Antenna / GNSS	The **True heading / Pitch** relative to the Local Level (Dual Antenna Only).

Download and Install the HGDR and Driver

Download and install the HGDR and Driver

The Honeywell® HGDR is a web-deployed software integration tool used to configure Honeywell HGuide Products.

The software integration tool displays and records data, generates supporting message documentation, and includes an example Microsoft Windows executable file to parse and log data. The program also exports data to CSV format for easy plotting.

The HGDR provides software development support including C/C++ source code, header files, DLL, and essential functions. See the "Bit Stream" window to produce a Windows-based software development kit. Additional Linux and Unix support is available.

If using the HGDR, press the "scan/hunt" button on the introductory screen. The program automatically performs an initial search but will time-out if a device is not connected.

The software can be downloaded at https://www.hemispheregnss.com/firmware-software with software development support including C/C++ source code, header files, DLL, and essential functions.

To download and install the HGDR and driver, complete the steps in Table 2-3 below:

Table 2-3: Install the HGDR and Driver

Step	Action
1	Set up the USB HARDWARE PORT Run CDM21228_Setup.exe from the download site.
2	Open the Windows Device Manager.
3	Note Available Ports (COM & LPT1).
4	Plug the USB Cable into your PC. An additional port appears. Use this port for connection to the device.

Power-up and Connect the HGDR

Powerup and connect the HGDR

To power and connect the HGDR, use the steps in Table 2-4, below.

Table 2-4: Power and Connect the HGDR

Step	Action
1	Connect the cables and antennas.
2	Hook the IO1 connector to the i8 and connect COM1 DB9 to a RS485 to USB converter. **Note:** A DB9 adapter is required.
3	Attach the RF cables to the GNSS antennas, noting the primary and secondary antenna locations.
4	Power-up the device using the wall adapter and barrel connector on the IO1 cable.
5	Run the HGDR.
6	Click "Scan/Hunt" (after powering). Monitor ports / baud rate and protocols can be configured here.

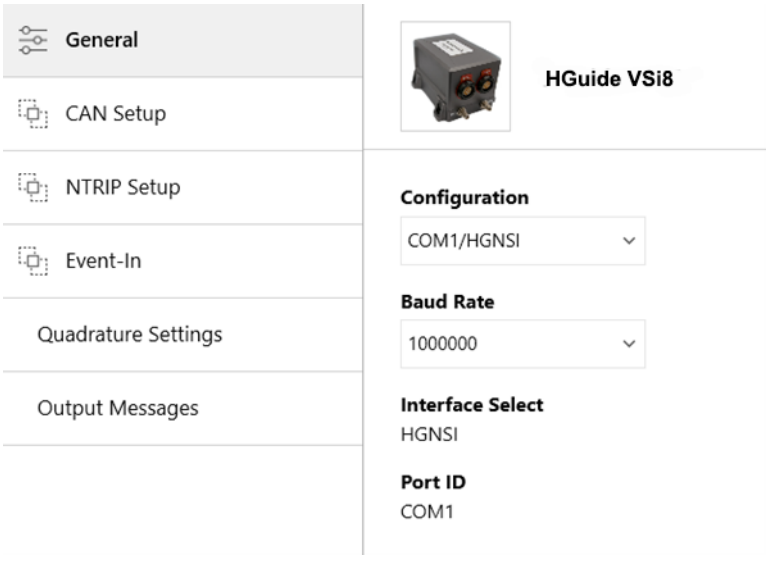

Figure 2-4: HGDR Setup

Configure Orientation, Alignment, and Data Collection

Configure orientation, alignment, and data collection

Use the installation worksheet (Appendix B), to configure the lever arms using the HGDR setup wizard. Once connected to the device, the status should report "Ready to Configure and Test".

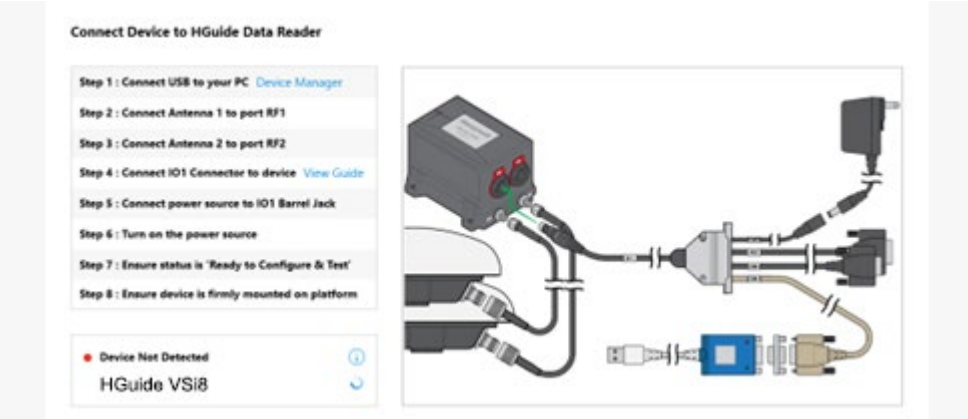

Figure 2-5: Connect Device to HGuide

Use the **Land Vehicle** wizard (Figure 2-6) to configure the lever arms. or complete a manual installation using **Advanced Settings** commands seen in Figure 2-8.

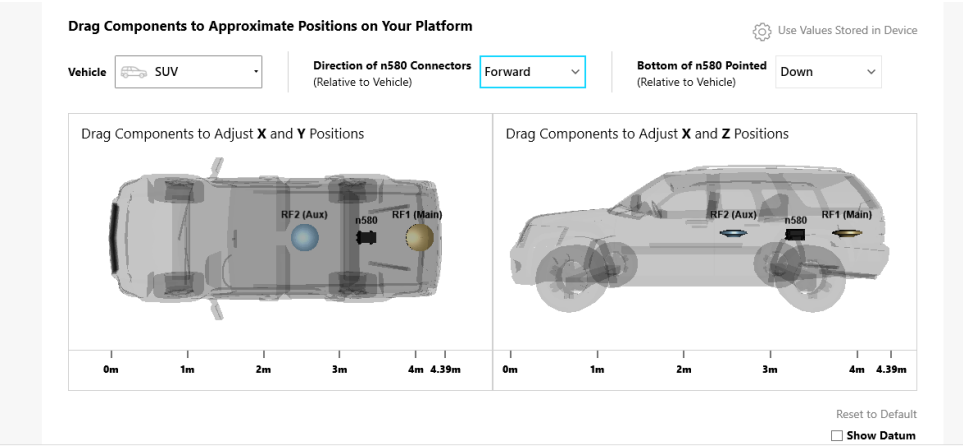

Figure 2-6: Land Vehicle wizard

Configure orientation, alignment, and data collection, continued

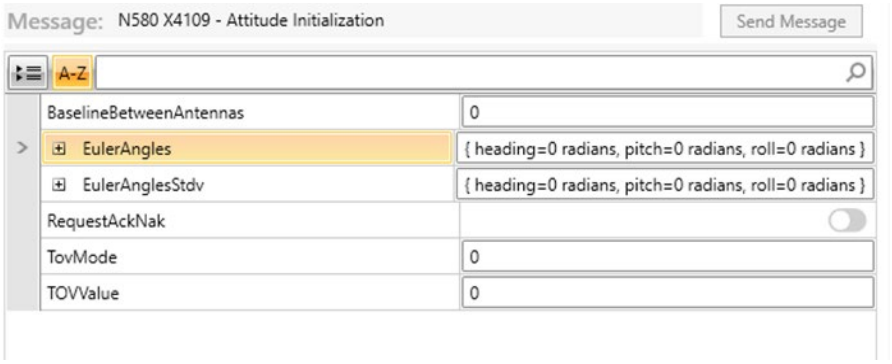

Figure 2-7: Advanced Settings

Check and Validate Calibration

Check and validate calibration

Start recording and perform the calibration according to the steps to achieve **IMU alignment**.

Important: This step is critical to achieve a stable IMU alignment and reduce gyro calibration errors in the remainder of the survey and should not be skipped.

The **INS Mode** should change to **Aided Navigation** status. A calibration file is recorded for validation.

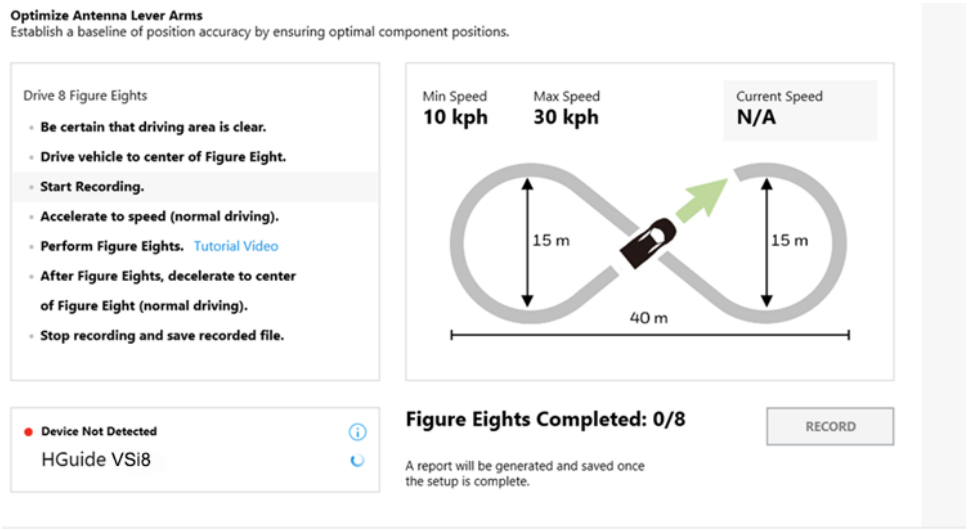

Figure 2-8: Calibration Diagram

Chapter 3: Installing the VSi8

Overview

Introduction

This chapter describes the steps to install and the equipment you need to install the VSi8.

Contents

Routing and Securing the Antenna Cable

Routing and securing the antenna cable

To route and secure the antenna cables, review the following guidelines.

Prior to selecting a cable, consider the attenuation of the cable. Attenuation of a cable is often specified at dB/100m and is related to the frequency of the signal being transmitted. GNSS signals are in the L-band frequency- which ranges from 1GHz –2GHz.

The VSi8 is designed to work with active GNSS antennas with an LNA gain range of 10 to 40 dB. The purpose of the range is to accommodate for losses in the cable system.

There is a maximum cable loss budget of 30 dB for a 40 dB gain antenna. The A45 antenna gain is 30 dB and has an antenna loss budget of 20 dB.

Measuring Antenna Dimensions

Antenna dimensions

Hemisphere offers two antennas available for purchase with your VSi8: the A45 (dual-frequency) antenna and the A25 (single-frequency) antenna.

The phase center measurements are important when using an RTK positioning solution with a dual frequency antenna (A45).

The phase center measurements for the A45 antenna are:
L1=45.8
L2=40.5

Figure 3-1 shows the antenna dimensions.

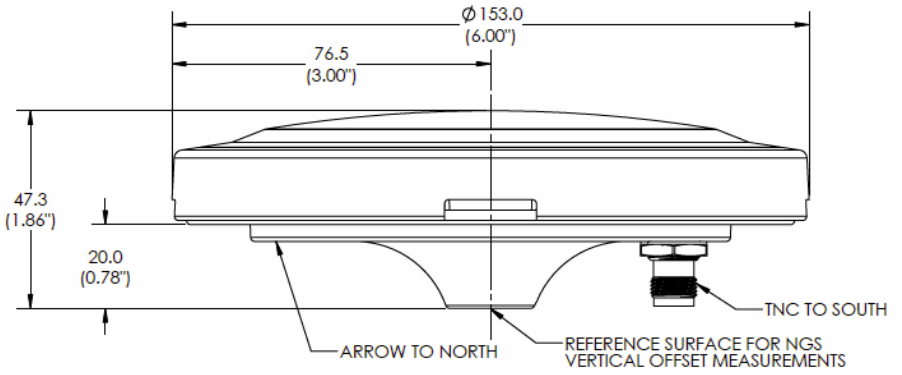

Figure 3-1: Antenna dimensions

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Measuring Antenna Dimensions, Continued

Antenna alignment

An arrow on the bottom of the antenna indicates the forward-facing direction for heading, and the marks on the side of the antenna provide a “zero” point for measuring the height of the antennas for the mounting surface. The height is relative to the accuracy of the RTK solution. Figure 3-2 shows the antenna arrow and alignment marks.

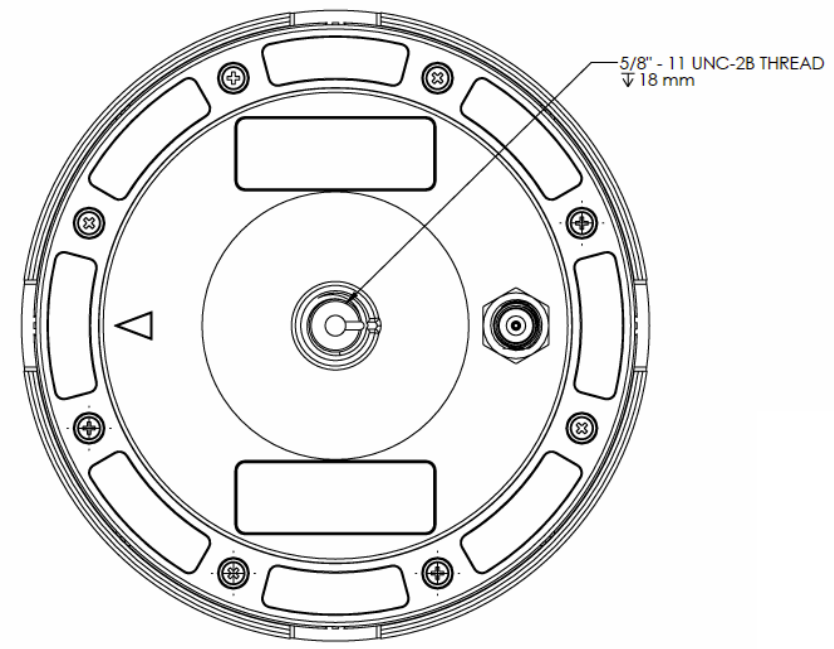

Figure 3-2: Antenna arrow and alignment marks

Mounting the Antennas

Default configuration	The default configuration is a single antenna position solution. The VSi8 can be upgraded to a dual antenna heading solution with the addition of an activation purchased from HGNSS or an HGNSS authorized dealer.
Parallel antennas orientation	The most common installation is to orient the antennas parallel to, and along the centerline of, the axis of the vessel with the primary antenna near the stern and the secondary antenna near the bow. This provides a true heading since heading is calculated from the primary to secondary antenna. If the primary antenna is near the bow and secondary antenna near the stern, you will need a heading bias of approximately 180°. In this orientation, you may need to enter a small heading bias in the VSi8 to calibrate the physical heading to the true heading of the vessel.
Perpendicular antenna orientation	You can also install the antennas, so they are oriented perpendicular to the centerline of the vessel's axis. In this orientation, you will need to enter a heading bias of +90° if the primary antenna is on the star side of the vessel, and -90° if the primary antenna is on the port side of the vessel.
Planning the optimal antenna placement	Proper antenna placement is critical to positioning accuracy. For the best results, orient the antennas so the antennas' connectors face the same direction. Place the antennas with a clear view of the horizon, away from other electronics and antennas, and along the vessel's centerline. When mounting the primary and secondary antennas, consider the following: • The recommended minimum separation is 0.5m. • The maximum separation is 10.0m if the receiver has a multi-frequency activation. If the receiver is only activated for single frequency, the maximum separation is 5.0m. • The position is calculated from the primary antenna. • Maintain at least 25cm distance from transmitting radios/antennas, as they may interfere with GNSS. • Maintain a clear view of the sky, avoiding metal obstructions at a higher elevation than the antenna (when possible).

Measuring VSi8 Dimensions

VSi8 dimensions Figures 3-3 through 3-6 show the dimensions of the VSi8 receiver.

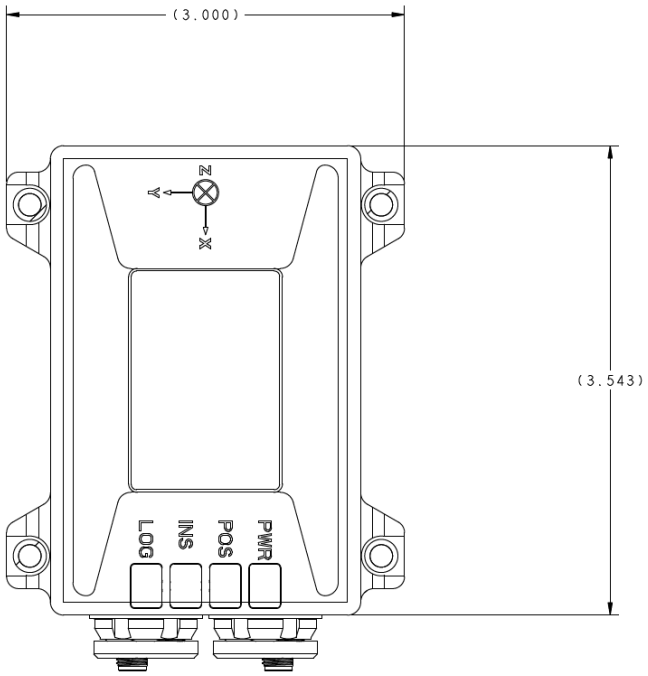

Figure 3-3: VSi8 receiver length and width

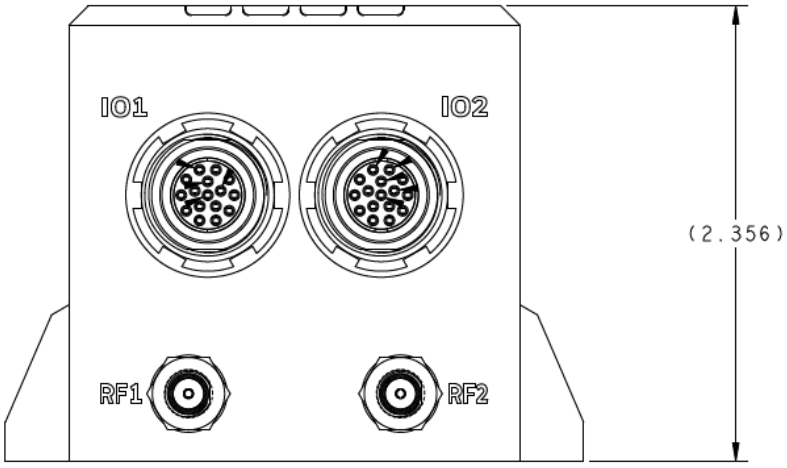

Figure 3-4: VSi8 receiver height

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Measuring VSi8 Dimensions, Continued

VSi8 dimensions, continued

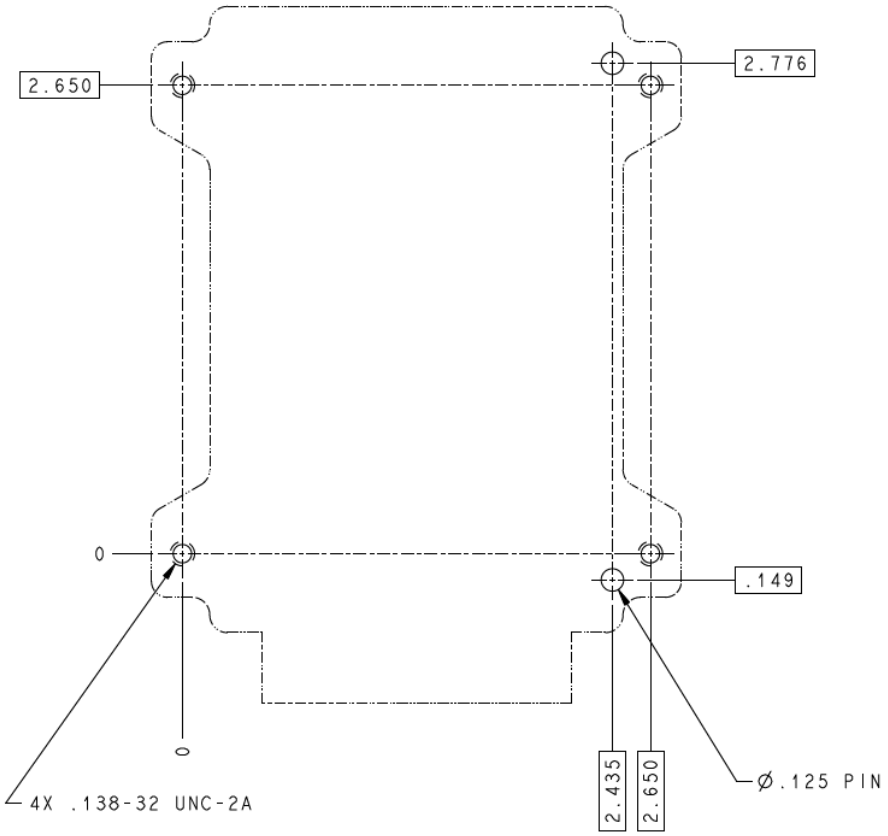

Figure 3-5: VSi8 mounting dimensions

Mounting the VSi8

Introduction

This section provides information on mounting the VSi8 in the optimal location, orientation considerations, environmental considerations, and other mounting options.

GNSS satellite reception

When considering where to mount the VSi8, consider the following satellite reception recommendations:

- Ensure cable length is adequate to route into the machine to reach a breakout box or terminal strip.
- Do not mount the receiver where environmental conditions exceed those specified in the technical specifications of this document.
- Route cables away from any potential source of mechanical damage. Do not locate the antenna where environmental conditions exceed those specified in Appendix C, Technical Specifications.

Environmental considerations

Hemisphere GNSS Receivers are designed to withstand harsh environmental conditions; however, adhere to the following limits when storing and using the VSI8:

- Operating temperature: -40°C to +70°C (-40°F to +158°F)
- Storage temperature: -40°C to +85°C (-40°F to +185°F)
- Humidity: IEC 16750-4:2010 Section 5.6 Humid heat, cyclic test

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Mounting the VSi8, Continued

Mounting option

The VSi8 should be mounted with bolts.

Power/Data cable considerations

Before mounting the VSi8, consider the following regarding power/data cable routing:

Do	Do not
Ensure cable reaches appropriate power source.	Run cables in areas of excessive heat.
Keep cable away from corrosive chemicals.	Run cables through a door or window jams.
Connect to a data storage device, computer, or other device that accepts GNSS data.	Crimp or excessively bend the cable.
Keep cable away from rotating machinery.	Place tension on the cable.
Remove unwanted slack from the cable at the VSi8 end.	
Secure along the cable route using plastic tie wraps.	

WARNING:
Improperly installed cable near machinery can be dangerous.

Connecting the serial and power cable

To connect the serial and power cable:

- Align the cable connector keyway with the VSi8 connector key.
- Push the connector in until it locks. The locking action is firm; you will feel a positive “click” when it has locked.

WARNING:
Do not apply a voltage higher than 36 VDC. This will damage the receiver and void the warranty. Also, do not attempt to operate the VSi8 with the fuse bypassed, as this will void the warranty.

Mounting Considerations

Mounting Considerations

The VSi8 is a precision instrument which measures angular rate and liner acceleration across a broad temperature range.

The device should be mounted on a rigid structure, relative to the vehicle body and the GNSS antenna locations. Motion on flexible structures is observed and coupled into the control solution. Any flexure on the mounting plate appears as real motion in the IMU.

Be aware of acoustic sources, energy can be coupled through the air or conducted mechanically through the structure. Common sources of excitation in this band are motors, actuators, turbines, hydraulic or pneumatic valves.

Devices are tested and rated to the temperature at the mounting feet.

Important: Use caution to ensure the thermal heating does not exceed the device temperature specifications.

Mount the device with four M3.5 socket head cap screws. Alternatively, a # 0.138-32 UNC socket head cap screw can be used. Torque the mounting screws to 1 +/- 0.05N-m (9 +/- 0.5 in-lbs.).

This device measures all motion, including any vibration / rotation of the mounting area. Installation on a flexible surface is not desirable and may degrade navigation performance. Placement at nodes maximizes angular rotation and minimizes linear displacement.

Mechanical offsets to sensors (lever arms), need to be measured accurately to within 1 cm, if possible, to maintain a stable IMU solution.

Measurements are always taken in the VSi8 Case Reference Frame, and measured FROM the IMU TO the GNSS antenna, and FROM the IMU TO the body reference frame. The cartesian coordinate system on the device is defined as:

- X Axis: + Forward from connector face
- Y Axis: + To the right of the X Axis in plan view
- Z Axis: + Down to complete the right-hand-rule

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Mounting Considerations, continued

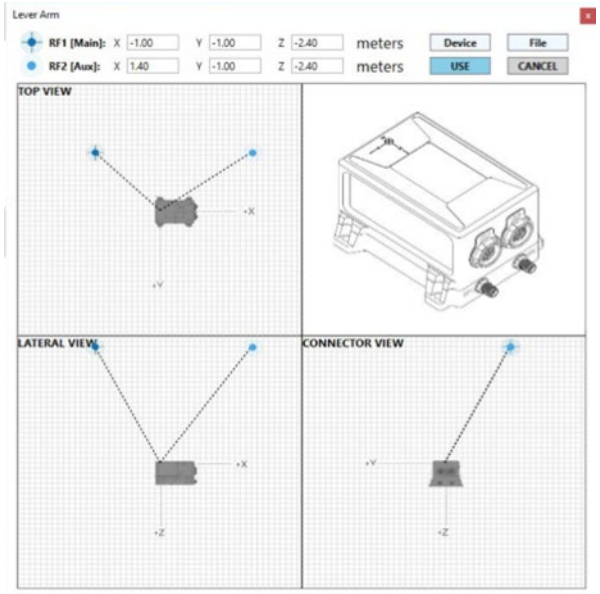

Figure 3-6: GNSS Antenna Offsets

The primary GNSS antenna location should always be the rearward antenna, with the secondary GNSS antenna in the forward location. This provides a geodetic heading from the primary to the secondary matching the primary axis of the vehicle.

Note: Any slight offset in this heading can be resolved in the HGDR software.

Mounting Considerations

The following tables show the pinouts for IO1 and IO2 power and communication connectors on the VSi8.

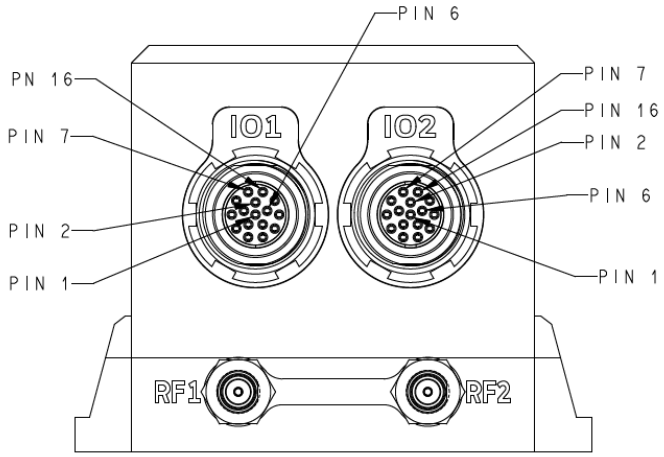

Figure 3-7: I01 and I02 pinouts

Table 3-1: IO1 Connector

Pin #	Function	Input/Output	Electrical
1	No Connect	Output	N/A
2	COM2_RX-	Input	RS-422
3	COM1_RX-	Input	RS-422
4	COM1_TX-	Output	RS-422
5	SYSTEM TOV Mark (100 Hz)	Output	+3.3 VDC BiCMOS
6	COM2_TX-	Output	RS-422
7	COM2_TX+	Output	RS-422
8	COM2_RX+	Input	RS-422
9	GPS TOV (PPS) Mark	Output	+5 VDC TTL
10	EVENT IN “1” Time Mark	Input	+3.3 to 5.5 VDC LVCMOS
11	COM1_RX+	Input	RS-422
12	COM1_TX+	Output	RS-422
13	COM3_RX	Input	RS-422
14	COM3_TX	Output	RS-422
15	Current Return	N/A	Ground
16	+9VDC to +_36VDC	N/A	VDD

Continued on next page

Mounting Considerations continued

Table 3-2: IO2 Connector

Pin #	Function	Input/Output	Electrical
1	No Connect	No Connect	N/A
2	ETH_RX+	Input	BASE 100
3	No Connect	No Connect	N/A
4	COM3_RX	Output	+3.3 to 5.5 VDC LVCMOS
5	SYSTEM TOV Mark (100 Hz)	Output	+3.3 VDC BiCMOS
6	ETH_TX-	Output	BASE 100
7	ETH_TX+	Output	BASE 100
8	ETH_RX-	Input	BASE 100
9	GPS TOV (PPS) Mark	Output	+5 VDC TTL
10	EVENT IN "1" Time Mark	Input	+3.3 to 5.5 VDC LVCMOS
11	No Connect	No Connect	N/A
12	COM3_TX	Output	+5 VDC BiCMOS
13	COM4_RX	Input	+3.3 to 5.5 VDC LVCMOS
14	COM4_TX	Output	+5 VDC BiCMOS
15	Current Return	N/A	Ground
16	+9VDC to +_36VDC	N/A	VDD

Appendix A: Terminology and References

Terminology and Resources

HGuide Navigation Software Interface (HGNSI) - Proprietary format messages used by Honeywell® to receive and transmit. See the **Commands Software** manual for more information.

HGuide Data Reader (HGDR) – The Honeywell® program that operates and configures the VS-i8 hardware.

Primary RF GNSS Antenna – The GNSS antenna providing position updates.

Secondary RF GNSS Antenna – The GNSS Antenna providing heading reference.

Event In Time Marks - User provided electrical signal which triggers the VS-i8 to send navigation messages. The trigger can be based on the rising or leading edge – or both edges. Rate must be < 100 Hz. Use the HGDR to configure.

Post Processing Time Mark - User provided electrical signal which triggers the VS-i8 to send a message via COM2 with other GNSS data. Triggers on leading edge.

Appendix B: Worksheet

Overview

Use this worksheet to document the VSi8 setup regarding orientation and offsets.

Worksheet

VS-i8 Orientation	
Direction of Connectors Relative to Vehicle (Ex. Forward)	
Direction of Bottom of i8 Relative to Vehicle (Ex. Down)	

Primary Antenna Offset (From IMU To Antenna)	
X	
Y	
Z	

Secondary Antenna Offset (From IMU To Antenna)	
X	
Y	
Z	

Vehicle Datum Offset (from IMU to Vehicle Reference) (Leave Blank for Datum Reference to IMU)	
X	
Y	
Z	

Appendix C: Technical Specifications

Overview

Introduction

Appendix C lists the technical specifications of your VSi8 INS receiver.

Contents

VSi8 Technical specifications

Table C-1: Receiver

Item	Specification
Receiver Type	INS with Multi-Frequency GPS, GLONASS, BeiDou, Galileo, QZSS, NavIC (IRNSS), and Atlas L-band
Signals Received	GPS L1CA/L1P/L1C/L2P/L2C/L5 Received: GLONASS G1/G2/G3, P1/P2 BeiDou B1i/B2i/B3i/B1C/B2a/B2b/ AceBOC GALILEO E1BC/E5a/E5b/E6BC/ AltBOC QZSS L1CA/L2C/L5/L1C/L6 NavIC (IRNSS) L5 Atlas
Channels	1,100+
GPS Sensitivity	-142 dBm
SBAS Tracking	3-channel, parallel tracking
Atlas L-band Channels	Dual-Channel
Atlas Satellite Selection	Manual and Automatic

Continued on next page

VSi8 Technical specifications, continued

Table C-2: Communications

Item	Specification
Ports	2x Power / Data
Interface Levels	2x RS-422, 1x RS-232, 5V CMOS, USB, Ethernet, CAN ISO 11898-2
Correction I/O Protocol	Hemisphere GNSS proprietary ROX format, RTCM v2.3, RTCM v3.2, CMR, CMR+
Output Rate	GNSS 10 Hz Standard / Optional 20 Hz, INS up to 100 Hz Standard
Data I/O Protocol	NMEA 0183, Hemisphere GNSS binary
Timing & Event I/O	2x Event In, Direct Quadrature Encoder Input, 2x PPS
Sensor Input, Optional	Odometer (DMI)
Onboard Logging	16 GB With USB 2.0 Access

Continued on next page

VSi8 Technical specifications, continued

Table C-3: Mechanical

Item	Specification
Weight	<0.5 kg (<1.1 lb.)
Dimensions	9.0 L x 6.0 W x 6.0 H (cm) 3.5 L x 2.4 W x 2.4 H (in)
Status Indicators (LED)	Power, GNSS, Navigation, Data
Antenna Connector	2 x SMA
Power/Data	2x Fischer Core 16 Contact DBPU 104 A086

Table C-4: Environmental

Item	Specification
Operating temperature	-40°C to +71°C (-40°F to +160°F)
Storage temperature	-40°C to +85°C (-40°F to +185°F)
Enclosure	IP68 per IEC 60529
Mechanical Shock	40g for 11 msec (MIL-STD-810G)
Humidity	95% non-condensing
Vibration	Random 7.7g RMS 20-2000 Hz
MTBF	>50,000 hours, ground mobile 25°C
EMC, Certifications	RoHS, WEEE, FCC Part 15, ICES-003, CISPR 32, CE Mark Compliant

Continued on next page

VSi8 Technical specifications, continued

Table C-5: Electrical

Item	Specification
Input Voltage	9 to 36 V DC
Power Consumption	7.5W nominal
Antenna Voltage Output	5 V DC maximum

GNSS Outage Performance[5,6,7,8]							
		Position Accuracy (RMS)		Velocity Accuracy (RMS)		Heading	Pitch & Roll
Outage Duration	Mode	Horizontal	Vertical	Horizontal	Vertical	(RMS)[4]	(RMS)
0 Seconds	SBAS	<0.30 m	<0.60 m	<0.015 m/s	<0.01 m/s	<0.03°	0.015°
0 Seconds	RTK	<0.01 m	<0.025 m	<0.015 m/s	<0.01 m/s	<0.03°	0.015°
10 Seconds	RTK	0.10 m	0.10 m	0.04 m/s	0.01 m/s	0.06°	0.015°
30 Seconds	RTK	1.0 m	0.30 m	0.06 m/s	0.02 m/s	0.07°	0.015°
60 Seconds	RTK	3.5 m	0.70 m	0.15 m/s	0.03 m/s	0.08°	0.015°

1. With a future firmware update.
2. CMR and CMR+ do not cover proprietary messages outside of the typical standard.
3. Excludes mounting tabs.
4. Using dual antennas with a 2m antenna separation. Longer baselines improve heading performance. Performance shown based on Hemisphere antennas, other antenna selection may impact final performance.
5. DMI pulse count aiding through direct quadrature encoder RS422 input. Motion Detect and Land Vehicle Constraints improve performance for land vehicles during GNSS outages independently of optional DMI input.
6. Typical Horizontal RMS error of ~0.25% of distance travelled with no Velocity Aiding source (DMI, DVL etc.).
7. Statistics are calculated by taking the RMS of the maximum error over multiple complete GNSS outages in a Land Vehicle application.
8. Horizontal and vertical RMS errors shown are based on starting from a fixed RTK solution before and after the GNSS outage. Autonomous, SBAS, and Atlas error growth will be similar, but absolute accuracy will be reduced.

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