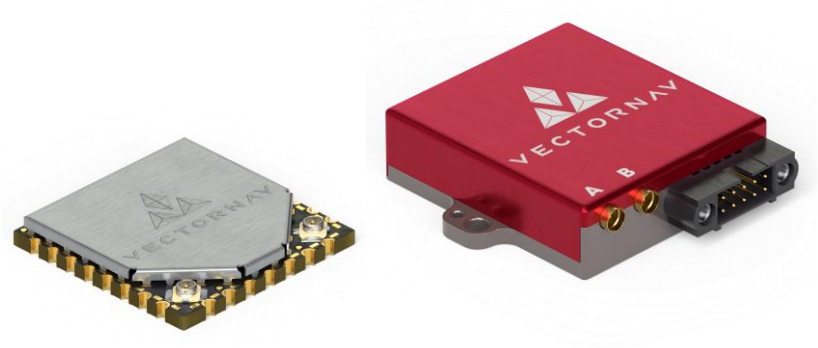
VN-300 DEVELOPMENT KIT

Quick Start Guide



10-0004-R5

Thank you for purchasing the VN-300 Development Kit from VectorNav Technologies. This Quick Start Guide will assist you in getting the VN-300 configured and operational. It will also introduce some common operations performed with the sensor. For more detailed information, please refer to the VN-300 User Manual, a copy of which is provided in the Development Kit and is also available online at www.vectornav.com/support.

Please do not hesitate to give us a call at +1.512.772.3615 or email us at support@vectornav.com if you have any questions.

1 VN-300 INTRODUCTION

The VN-300 is a miniature, high-performance Dual Antenna GNSS-Aided Inertial Navigation System (Dual GNSS/INS) that combines MEMS inertial sensors, two high-sensitivity GNSS receivers, and advanced Kalman filtering algorithms to provide optimal estimates of position, velocity, and orientation.

The VN-300 is able to accurately estimate heading (azimuth with respect to True North) in both static as well as dynamic conditions without any reliance on a magnetic compass. This is achieved by incorporating a GNSS Compass into the INS Filter.

The VN-300 GNSS Compass works by utilizing GNSS interferometry techniques, to precisely measure the relative position of two GNSS antennas separated by some distance (RTK moving baseline technique). This provides real-time, highly accurate heading of the vehicle or platform without any assumptions or requirements regarding the vehicle dynamics. This is a crucial feature for applications that require an accurate heading while stationary, or in situations where insufficient motion is present to perform dynamic alignment.

2 VN-300 INSTALLATION

2.1.1 Mounting the VN-300

You may mount the VN-300 to the vehicle or platform in any orientation. If the VN-300 axes do not align with the desired vehicle or platform axes then a Reference Frame Rotation will be required to remap the attitude, angular rates, acceleration, and other data to the desired frame (see page 9).

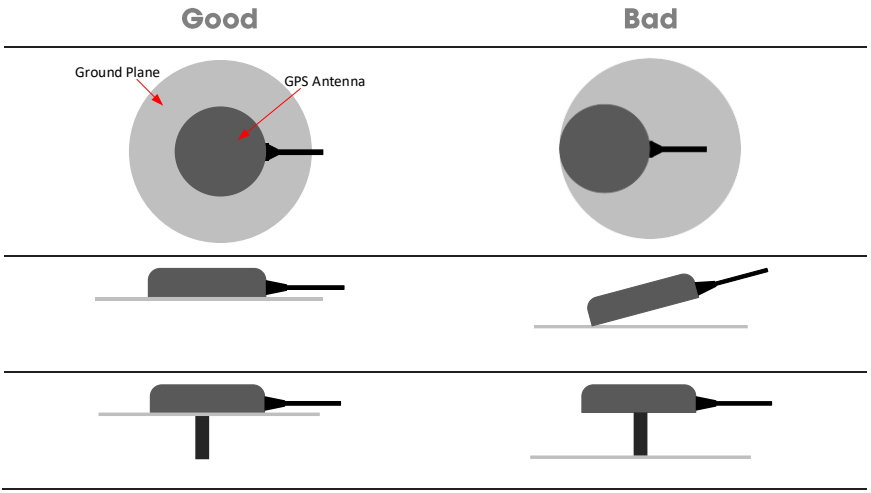
When installing the VN-300 to a vehicle or other platform, ensure that:

- The VN-300 is rigidly mounted with respect to the two GNSS antennas
- The VN-300 is rigidly mounted to the aircraft, vehicle or other platform.
  - Vibration dampeners or flexible mounts can degrade the VN-300 performance and are not recommended.
- All harnesses are properly secured and strain-relieved to avoid stress entering the VN-300 from the cabling.
- Great care is taken when connecting the GNSS antennas, as the connectors can sustain limited side loads and connecting cycles

2.1.2 Ground Planes

To prevent multipath ensure that the GNSS Antennas are mounted directly to a ground plane. Below are good and bad ground plane installation examples.

GNSS Antenna Ground Plane Installation



- Antennas shipped with the development kit have a manufacturer recommended 100 mm diameter ground plane included

There is no requirement for ground planes to be electrically grounded

- Ground planes can be any thin piece of metal (even foil)

2.1.3 Mounting GNSS Antennas

The VN-300 requires connection to two active GNSS antennas, both mounted with the same clear view of the sky for the GNSS Compass feature to function correctly.

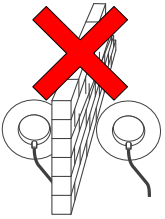
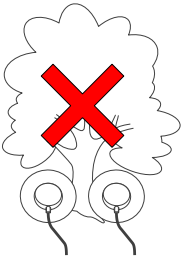
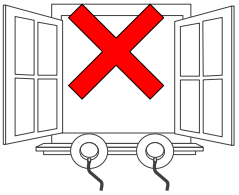
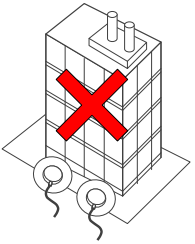
The two antennas must share at least 6 satellites (preferably 10 or more) in common with a direct line of sight (LOS) visibility for the GNSS Compass to operate.

In order for the GNSS Compass to function optimally both antennas must be mounted:

- With a clear view of the sky
- In the same orientation.
- Directly on top of ground plane or on a large metal surface
- As level as possible, minimize pitch/roll to < 10°
- Rigidly with respect to the VN-300

Avoid placing the GNSS antennas in conditions which would lead to degraded GNSS Compass operation such as illustrated in the table below.

Poor GNSS Compass Conditions

	
Objects or structures placed in between the antennas	Partial view of the sky
	
In a windowsill	Next to a large building

2.2 GNSS Compass Baseline and Heading Accuracy

The GNSS Compass baseline is the position of a point on GNSS Antenna B relative to the same point on GNSS Antenna A. The accuracy of the GNSS Compass heading measurements will depend on the distance between the two antennas, the baseline. Longer baseline distances will provide higher accuracy GNSS Compass heading estimates. We recommend an initial baseline distance between 0.25 meters and 2.0 meters.

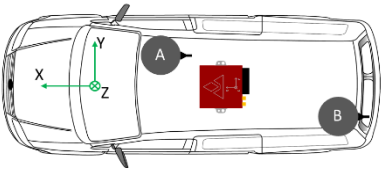
The table below details baseline length and corresponding heading accuracy.

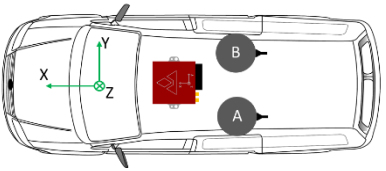
Baseline Length (m)	Heading Accuracy (° RMS)
0.3	1
0.5	0.6
1	0.3
2	0.15

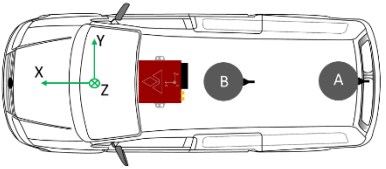
2.3 GNSS Antenna Position Examples

The two GNSS antennas can be mounted in many configurations to achieve the required GNSS Compass Baseline. Below are several examples including ground plane installation best practice.

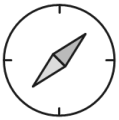
Various Antenna Layouts on Vehicle







3 VN-300 START UP SEQUENCE



Mode: 0 (NotTracking) No Fix Acquired No GPS Compass Aiding GPS Compass Not Active	Time: 0 sec The VN-300 is operating as an AHRS. Using the on-board magnetometer for coarse heading estimation

Mode: 0 (NotTracking) 3D Fix Acquired No GPS Compass Aiding GPS Compass Not Active	Time: 30 sec GNSS Fix acquired

Mode: 0 (NotTracking) 3D Fix Acquired No GPS Compass Aiding GPS Compass Active	Time: 35-40 sec GNSS Compass Flag will go high to indicate tracking carrier phase and calculating compass candidates

Mode: 1 (Aligning) 3D Fix Acquired No GPS Compass Aiding GPS Compass Active	Time: 120-180 sec GNSS Compass solution complete. VN-300 starts aligning INS Filter, smooth transition from AHRS to INS

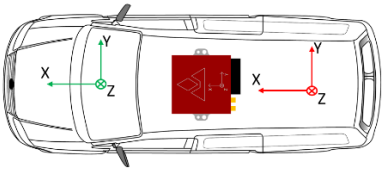
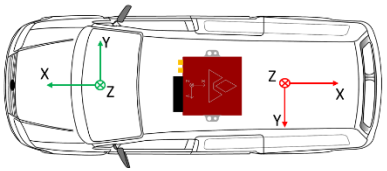
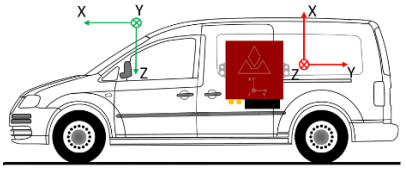
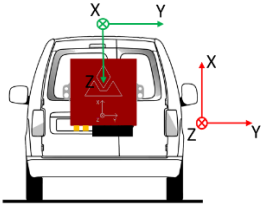
Mode: 2 (Tracking) 3D Fix Acquired No GPS Compass Aiding GPS Compass Active	Time: 180 - 600 sec VN-300 Heading uncertainty is now below 2 degrees. Sensor operating within specification

Mode: 2 (Tracking) 3D Fix Acquired GPS Compass Aiding GPS Compass Active	GPS Compass Aiding flag will go high indicating that the heading is tightly aligned to the GNSS Compass solution

4 VN-300 SETUP

4.1 Reference Frame Rotation

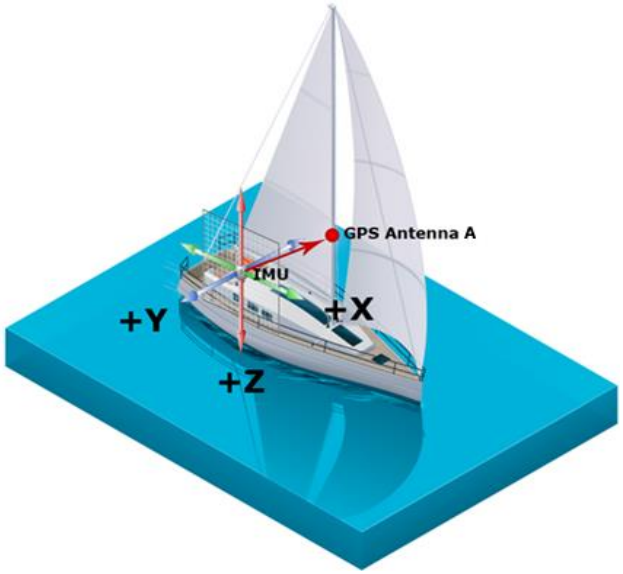
The VN-300 may be mounted in **any** orientation on the vehicle or platform. The Reference Frame Rotation is a 3 x 3 rigid rotation matrix that will map the sensor axes to the vehicle axes, which will enable the VN-300 to output attitude, angular rates, acceleration, and other data in the vehicle reference frame.

Sensor Orientation	Reference Frame Rotation
	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
	$\begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$
	$\begin{bmatrix} 0 & -1 & 0 \\ 0 & 0 & 1 \\ -1 & 0 & 0 \end{bmatrix}$
	$\begin{bmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{bmatrix}$
 Vehicle Frame	 Sensor Frame

4.1.1 GNSS Antenna A Offset

By default, the VN-300 assumes that GNSS Antenna A is mounted within 10 centimeters of the VN-300 module itself. If GNSS Antenna A is mounted farther away than 10 centimeters in any direction then the GNSS Antenna A Offset Register must be specified to properly account for the relative motion of the antenna with respect to the IMU. The VN-300 defines the Antenna A offset as the distance from the VN-300 to Antenna A in the X, Y, & Z directions defined by the Sensor Frame.

To configure the GNSS Antenna A Offset, use *Register ID 57* to input the X, Y, & Z position of Antenna A with respect to the VN-300.



If the Reference Frame Rotation is implemented, then the Antenna A offset must be specified in the X, Y, & Z directions of the Vehicle Frame as defined by the Reference Frame Rotation matrix.

4.1.2 GNSS Compass Baseline

The factory default baseline is {1, 0, 0}, this vector represents that GNSS Antenna B is positioned 1m in front of Antenna A relative to the x-axis in the Sensor Frame, as defined by the axes labeled on the top of the aluminum enclosure of the VN-300.

To configure a different GNSS compass baseline, use *Register ID 93* to input the X, Y, & Z position of Antenna B with respect to Antenna A as well as an estimate of the uncertainty of each of these values.

If the Reference Frame Rotation (RFR) is implemented, then the GNSS Compass Baseline must be specified in the X, Y, & Z directions of the Vehicle Frame as defined by the RFR matrix.

4.1.3 GNSS Compass Baseline Uncertainty

For the VN-300 to consistently converge on accurate GNSS compass heading estimates, it is important to provide measurement uncertainties that are greater than the largest expected measurement error. A rule of thumb is:

Baseline Uncertainty = 2.5% of the largest baseline measurement

The table below provides suggested baseline uncertainties for different baseline lengths.

Baseline Length (m)	Uncertainty (m)
0.3	0.0075
0.5	0.0125
1	0.025
2	0.05

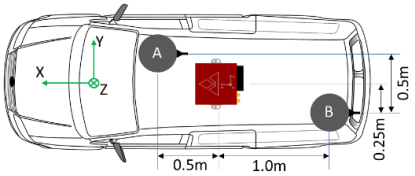
4.1.4 GNSS Compass Estimated Baseline Register

The VN-300 INS Filter will dynamically align when the platform is in motion and will use this solution to improve the estimate of the GNSS Compass Baseline. *Register ID 97* provides the output X, Y, & Z positions and uncertainties from the onboard calibration.

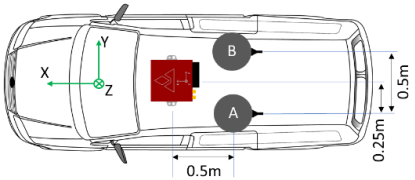
Issuing a Write Settings Command will save the calculated baseline and uncertainty estimates to nonvolatile memory for use in subsequent operations.

4.2 VN-300 Configuration examples

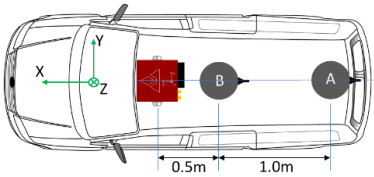
Various Antenna Layouts on Vehicle



Antenna A Offset:	[0.5, 0.25, 0.0]
GNSS Compass Baseline:	[-1.5, -0.5, 0, 0.0375, 0.0375, 0.0375]



Antenna A Offset:	[-0.5, -0.25, 0.0]
GNSS Compass Baseline:	[0.0, 0.5, 0, 0.0125, 0.0125, 0.0125]



Antenna A Offset:	[-1.5, 0.0, 0.0]
GNSS Compass Baseline:	[1.0, 0.0, 0.0, 0.025, 0.025, 0.025]

All inputs to the GNSS Compass Baseline and GNSS Antenna A Offset Registers should be specified in meters.

5 CONFIGURING THE VN-300 IN CONTROL CENTER

All VN-300 configuration registers can be set within Control Center using the various dropdown items in the Config Registers View and stored in non-volatile memory using the Write Settings command. The VN-300 will automatically startup in the configuration that was set when a Write Settings command was issued. A Restore Factory Settings command will reset the configuration to the default settings.

A copy of the Control Center GUI is included on the CD in the VN-300 Development Kit. Please also regularly check our website for the latest version of the software.

http://www.vectornav.com/support/downloads

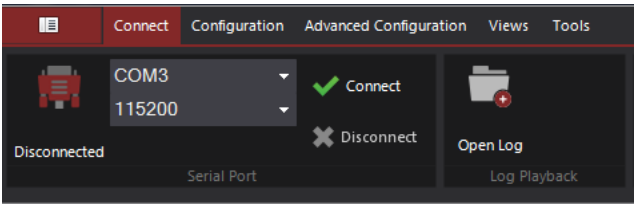
The following steps provide an example of how to connect to the VN-300, configure the VN-300 output data, input the GNSS Compass measurements, and view the VN-300 INS Status message through startup and operation.

Some INS Filter configuration settings require a Reset command after issuing a Write Settings command before taking effect.

5.1.1 Connecting to the VN-300

When first working with the VN-300, we recommend connecting the sensor to a PC running our Control Center GUI to gain familiarity with the available configuration options and features.

1. Attach the USB or Serial Adapter Cable to the VN-300 using the cable tool provided in the Development Kit. For the VN-300 Development Board, you can connect and power the sensor through USB1 (J2 connector) or alternatively use the USB2 (J3) for power and the DB-9 (J4) for communication.



2. Connect to the VN-300 by selecting the correct COM port and baudrate and clicking on the Connect button. The default baudrate for the VN-300 is 115200.

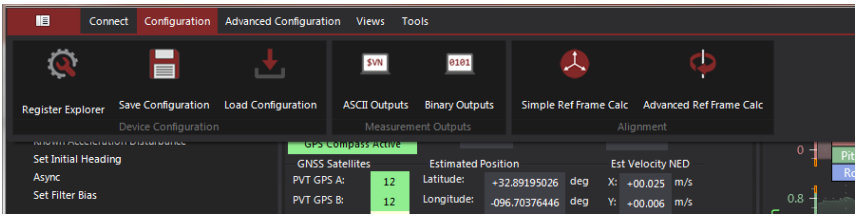
The VN-300 can pull up to 250mA of current when both GNSS antennas are connected. Ensure USB port compatibility prior to use.

5.1.2 Reference Frame Rotation Configuration

As mentioned earlier, the VN-300 can be mounted in any orientation. In order to align the output axes with that of the vehicle frame you need to configure the Reference Frame Rotation. The changes can be input by either using the:

1. Simple Ref Frame Calc Tool
2. Advanced Ref Frame Cal Tool
3. Reference Frame Rotation Register located in:
   Config Registers -> IMU -> Reference Frame Rotation

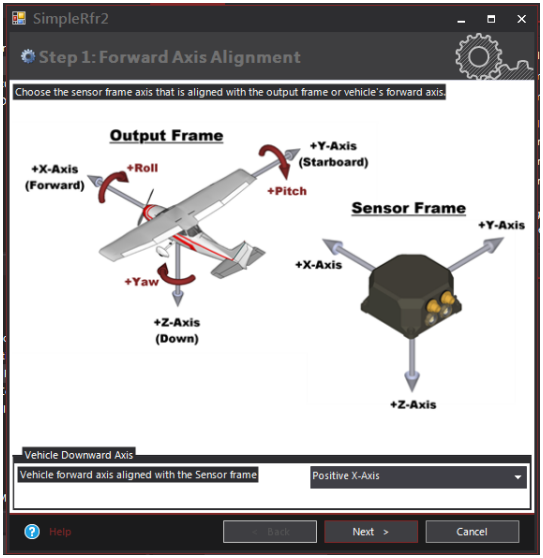
The simplest tool to use for the RFR configuration is the Simple Ref Frame Calc tool that can be found under the Configuration menu item.



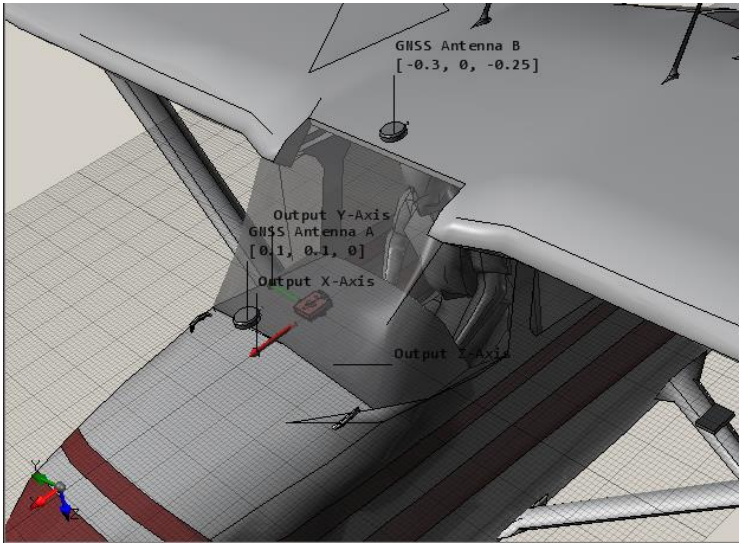
The Simple Ref Frame Calc will step you through aligning the VN-300 axes with the vehicle axes. There are three (3) steps:

a. What axis of the VN-300 aligns with the forward axis of the vehicle?
b. What axis of the VN-30 0 aligns with the downward axis of the vehicle?
c. Click Finish to write the new RFR to the sensor and reset

The RFR will only take affect after a reset. Ensure that you issue Write Settings to save the configuration for the next power up and then reset.

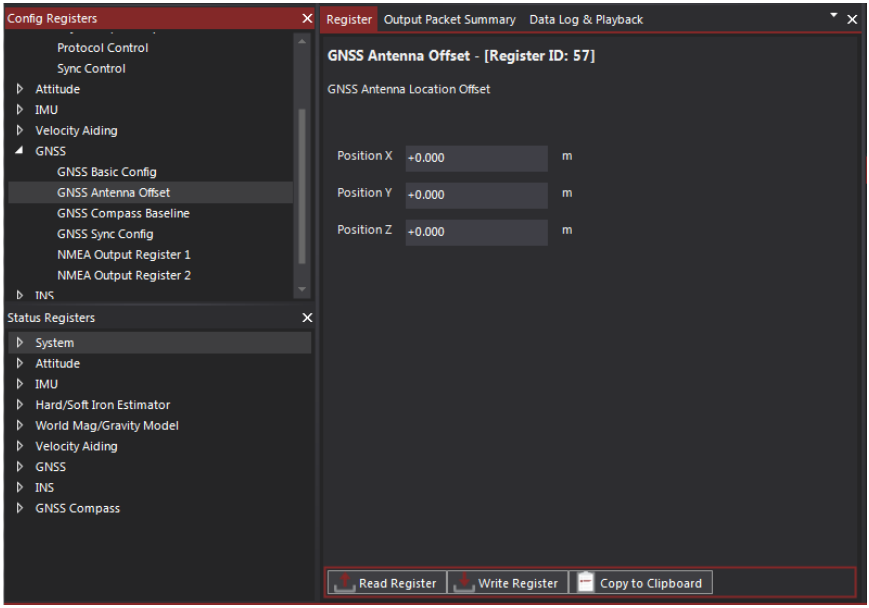


Use the 3D View to confirm the orientation of the VN-300 matches your physical installation.



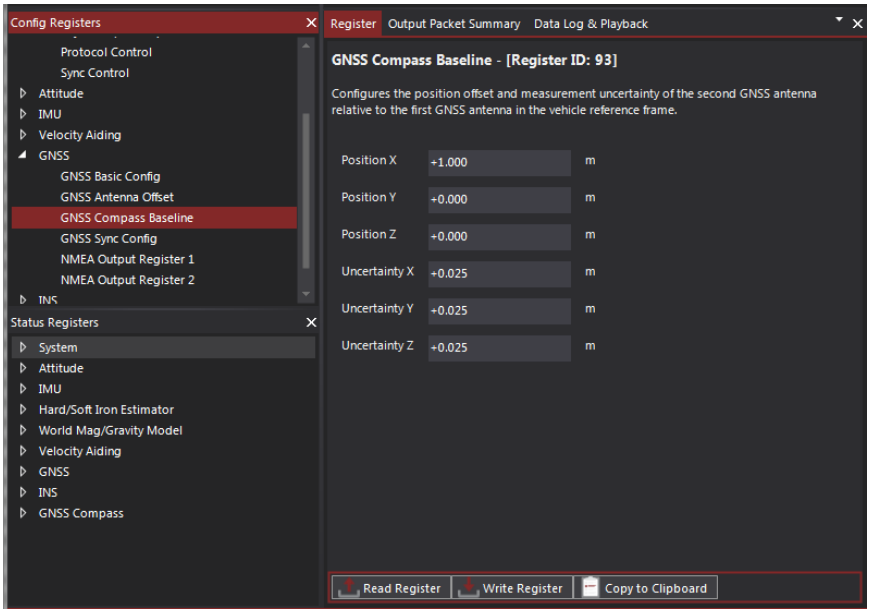
5.1.3 Antenna A Offset Configuration

Input the X, Y, & Z GNSS Antenna A Offset measurements by expanding the GNSS Antenna A Offset item under Config Registers -> GNSS.
Click the Write Register button in order to write the new configuration to the sensor.



5.1.4 GNSS Compass Baseline Configuration

Input the X, Y, & Z GNSS Compass Baseline measurements and uncertainties by expanding the GNSS Compass Baseline item in Config Registers -> GNSS -> GNSS Compass Baseline.
Click the Write Register button in order to write the new configuration to the sensor.



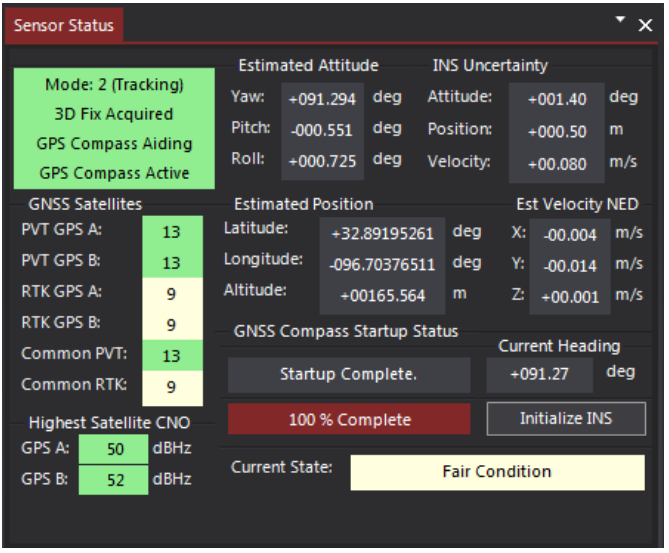
It is important to issue a Write Settings followed by a Reset command after inputting the GNSS Compass Baseline measurements to ensure the VN-300 initializes on the correct values. Right-click on Write Settings in the *Commands Window* and then click Execute Command. Next, right-click on Reset and then click Execute Command.

5.2 Monitoring VN-300 Startup

Control Center will poll the VN-300 and display the INS Mode, GNSSFix, GNSS Compass Aiding, and GNSS Compass Active status flags in the Sensor Status window. It will also provide details of the number of satellites used from Position, Velocity and Timing (PVT) solution and also the number of common satellites used for the GNSS Compass (RTK).

It is important to monitor these status messages during the startup sequence to ensure that both the GNSS Compass and INS Filter calculations initialize properly.

The Sensor Status window provides a comprehensive overview of the VN-300 status.



Please refer to Section 7.3.3 – GPS Compass Signal Heath Status for further details on Excellent, Fair and Poor GPS Compass Condition

6 TROUBLESHOOTING

1. The GPS Compass Active flag does not go green.

The GNSS receivers are not tracking the carrier phase and there are no GNSS Compass candidates being calculated.

- ☐ Check for clear sky visibility.
- ☐ Possible multipath, ensure grounds planes are installed.
- ☐ Ensure antennas are clear of large obstructions or buildings.
- ☐ A minimum of 6 common satellites are required for the GNSS Compass (Check Common RTK status).
- ☐ Improper Compass Baseline configuration (bad measurements or too tight uncertainties).
- ☐ Check for potential sources of interference near the GPS frequency of 1575 MHz.

2. GNSS Compass Startup Status takes >10min to achieve 100% complete or it never completes.

This indicates poor GNSS conditions (multipath) or incorrect GPS Compass Configuration.

- ☐ Ensure ground planes are installed.
- ☐ Move away from large structures or trees.
- ☐ Check GPS Compass Baseline Measurements are correct in Register 93 – both correct values and correct axes.
- ☐ Check GPS Compass Baseline Uncertainty values are scaled to 2.5%.

3. The VN-300 never gets out of INS Mode 1 when stationary.

The INS is not able to align to the GNSS Compass. This indicates that there is a configuration error.

- ☐ Check GPS Compass Baseline Measurements are correct in Register 93.
- ☐ GPS Compass Baseline Uncertainties values should be set to 2.5% of largest baseline measurement.

4. The VN-300 is in INS Mode 2 when stationary but drops to INS Mode 1 when the vehicle starts moving.

- ☐ Check that Antenna A and B are connected to the correct ports.
- ☐ Check that the Reference Frame Rotation is configured correctly.

5. During high dynamics the INS Mode switches between Mode 2 and Mode 1.

- ☐ Ensure that the Antenna A Offset (lever arm) is configured correctly.

6. During high dynamics the GPS Compass Aiding flag toggles

This indicates that the carrier phase tracking is lost. When high dynamics cease tracking will resume.

- ☐ If INS Mode is 2 then sensor is performing within spec.

7. The VN-300 altitude is incorrect

The VN-300 reports altitude above ellipsoid (WGS84) and not above Mean Sea Level (MSL).

8. VN-300 reported heading is 180° offset

This indicates that the GPS Compass Baseline configuration settings do not match the actual installation.

- ☐ Ensure antenna A and B are not switched compared to the GPS Compass Baseline inputs.

7 VN-300 INSTALLATION AND SETUP CHECKLIST

VN-300 Mounting	
Is the VN-300 rigidly mounted?	☐
Are the cables strain relieved?	☐
Do you need a reference frame rotation?	☐

$$\begin{bmatrix} \_ & \_ & \_ \\ \_ & \_ & \_ \\ \_ & \_ & \_ \end{bmatrix}$$

GNSS Antenna Mounting	
Are both antennas rigidly mounted?	☐
Are both antennas on flat and level surface?	☐
Is GNSS Antenna A mounted directly to a ground plane?	☐
Is GNSS Antenna B mounted directly to a ground plane?	☐
Do both antennas have a clear view of the sky?	☐
Do both antennas see the same sky?	☐
Are GNSS Antenna A and B in the same orientation?	☐

Measurements			
Are the Antenna A Offset measurements in the *Vehicle Frame*?			☐
X:	Y:	Z:	☐
Are the GNSS Compass Baseline measurements in the *Vehicle Frame*?			☐
X:	Y:	Z:	☐
Are the Baseline Uncertainties correct for the baseline length?			☐
X:	Y:	Z:	☐

VN-300 Setup	
Start Control Center	☐
Connect Control Center to VN-300	☐
Input Reference Frame Rotation into Control Center	☐
Input GNSS Antenna A Offsets (X, Y, & Z)	☐
Input GNSS Compass Baseline and Uncertainties (X, Y, &Z)	☐
Set COM Baudrate to: 115200	☐
Set Async Data Output Type to: INS LLA	☐
Set Async Data Output Frequency to: 40	☐
Write Settings to Sensor Memory	☐
VN-300 Startup Sequence	
Are you outside?	☐
Are you away from tall buildings?	☐
Do you have a clear view of the sky?	☐
Connect the VN-300 to Control Center	☐
Is GNSS Fix: True	☐
Is GNSS Compass: True	☐
Is INS Mode: 1	☐
Is GNSS Heading: True	☐
Is INS Mode: 2	☐

8 ADDITIONAL REFERENCES

- VectorNav VN-300 User Manual (UM0005)

  www.vectornav.com/support/manuals

- VN-300 GNSS Compass – INS Initial Setup (AN017)

- VectorNav Development Tools
  - Control Center
  - C/C++ Library
  - .NET Library
  - Embedded Firmware Library
  - MATLAB Development Library
  - EAGLE PCB Parts Library

  www.vectornav.com/support/downloads

- Overview of Inertial Sensor Technology

  www.vectornav.com/support/library

- Contact us

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