PRODUCT SPECIFICATION

VN-310E TACTICAL EMBEDDED DUAL GNSS/INS

Sensor Datasheet (Hardware v2.0)

VECTORNAV

HIGHLIGHTS

0.05°-0.1°	0.15°	Multi-band GNSS	External SAASM/MCODE
Dynamic Heading Accuracy (INS)	Static Heading Accuracy (GNSS-Compass)	Integrated L1/L2/E1/E5b GNSS Receiver	Support for External SASSM/MCODE
0.015°	**< 1°/hr**	**RTK/PPK Capable**	**Low SWaP**
Dynamic Pitch/Roll Accuracy (INS)	Gyro In-Run Bias Stability	External RTCM 3 Inputs; Exportable RINEX	31 x 31 x 12 mm; 15 grams; < 1.6 W

Product Overview

The VN-310E is a tactical-grade, high-performance Dual Antenna GNSS-Aided Inertial Navigation System. Incorporating the latest inertial sensor and GNSS technology, the VN-310E combines 3-axis accelerometers, 3-axis gyros, 3-axis magnetometers and two high-performance GNSS receivers into a compact embedded module to deliver a high-accuracy position, velocity, and attitude solution under both static and dynamic conditions.

The ultra compact VN-310E option delivers unprecedented size and weight advantages while still delivering tactical-grade inertial navigation performance.

Calibration and Testing

Each individual VN-310E undergoes a robust calibration and acceptance testing process at VectorNav's AS9100 certified manufacturing facility. Performance specifications are based on comprehensive field testing and results from real-world applications and are regularly tested to ensure continued conformance to such specifications.

VN-310E

Features

GNSS-Compass for Static Heading

Two onboard GNSS receivers perform GNSS-Compassing, providing highly accurate heading estimates under static and low dynamic conditions.

True Inertial Navigation System

No mounting orientation restrictions or configuration modes; Automatic filter initialization and dynamic alignment.

Ease of Availibility

ITAR-free and Made in the USA; short lead times.

Automatic Heading Transition

Automatic and seamless transition between magnetic heading, INS operation in dynamics, and GNSS-Compass in static conditions.

Software Compatibility

The VN-310E share a common communication protocol with the entire VectorNav product line.

User Configurable Messages

ASCII and VectorNav Binary messages.

Sensor Summary

- Continuous attitude solution over the complete 360° range of operation
- Hard/Soft Iron Compensation (Real-time and Manual 2D & 3D)
- Individually calibrated for bias, scale factor, misalignment, and gyro-sensitivity over full operating range (-40°C to +85 °C)
- RTK Capable: Support for External RTCM 3 Inputs
- Raw GNSS Data: Exportable RINEX Data for PPK; Raw Pseudorange, Doppler and Carrier Phase outputs
- Support for external RTK GNSS receivers & SAASM/M-Code GPS receivers
- Coning and sculling integrals (ΔV's, Δθ's)
- Data output format: ASCII (VectorNav), NMEA-0183, Binary (VectorNav)

CONTENTS

VectorNav Support

Whether you are looking for details on the VN-310 or assistance with your application, a wealth of information is available to assist you in product design and development. Check out the *Inertial Systems Primer* on our website, and be sure to register for access to a wide range of resources:

PRODUCT SPECIFICATIONS	TECHNICAL NOTES	APPLICATION NOTES
▪ User Manual	▪ Time Synchronization	▪ Gimbal Stabilization & Pointing
▪ Interface Control Document	▪ Hard & Soft Iron Calibration	▪ Satellite Communications
▪ Datasheet	▪ External GNSS Aiding	▪ Lidar Mapping
▪ Quick Start Guide	▪ Firmware Update	▪ Aerial Photogrammetry

All VectorNav products are backed by our customer-focused, robust and responsive support ecosystem. Our team is committed to supporting you through your entire product life-cycle, from concept design to in-field support. Please feel free to contact us by phone or email, our global team of engineers and representatives is ready to work with you through every challenge you know of, and every challenge you don't.

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1 INS PERFORMANCE

Attitude

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range (Heading/Yaw, Roll)	-180		180	deg	
Range (Pitch)	-90		90	deg	
Output Rate		400		Hz	User configurable.
Heading (Magnetic)		2		deg	RMS[1]
Heading (INS)		0.05-0.1		deg	1 σ[2]
Heading (GNSS-Compass)					[3]
0.5 m Baseline		0.3	0.6	deg	RMS
1.0 m Baseline		0.15	0.3	deg	RMS
2.0 m Baseline		0.08	0.15	deg	RMS
Pitch/Roll (Static)		0.05		deg	RMS
Pitch/Roll (INS)		0.015		deg	1 σ[2]
Heading Mounting Misalignment			0.15	deg	1 σ[4]
Pitch/Roll Mounting Misalignment			0.05	deg	1 σ[4]
Angular Resolution		0.001		deg	
Heave Accuracy		5 or 5%		cm	
Delayed Heave Accuracy		2 or 2%		cm	

[1] With proper magnetic declination, suitable magnetic environment and valid hard/soft iron calibration.
[2] With sufficient motion for dynamic alignment.
[3] Dependent on SBAS, clear view of GNSS satellites, good multipath environment, compatible GNSS antenna, and measurement duration period.
[4] Constant on a per part basis. Can be calibrated out during system integration using boresighting or other alignment processes.

TABLE 1

Position/Velocity

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Output Rate		400		Hz	User configurable.
Horizontal Position Accuracy		1		m	RMS[1]
Vertical Position Accuracy		1.5		m	RMS[1]
RTK Position Accuracy		1 + 1 ppm		cm	CEP
Free Inertial Position Drift		0.5		cm/s^2	[2]
Velocity Accuracy		0.02		m/s	RMS

[1] Dependent on SBAS, clear view of GNSS satellites, good multipath environment, compatible GNSS antenna, and measurement duration period.
[2] Typical rate of growth in error of position estimates after loss of GNSS signal, provided INS full alignment prior to loss.

TABLE 2

2 IMU SPECIFICATIONS

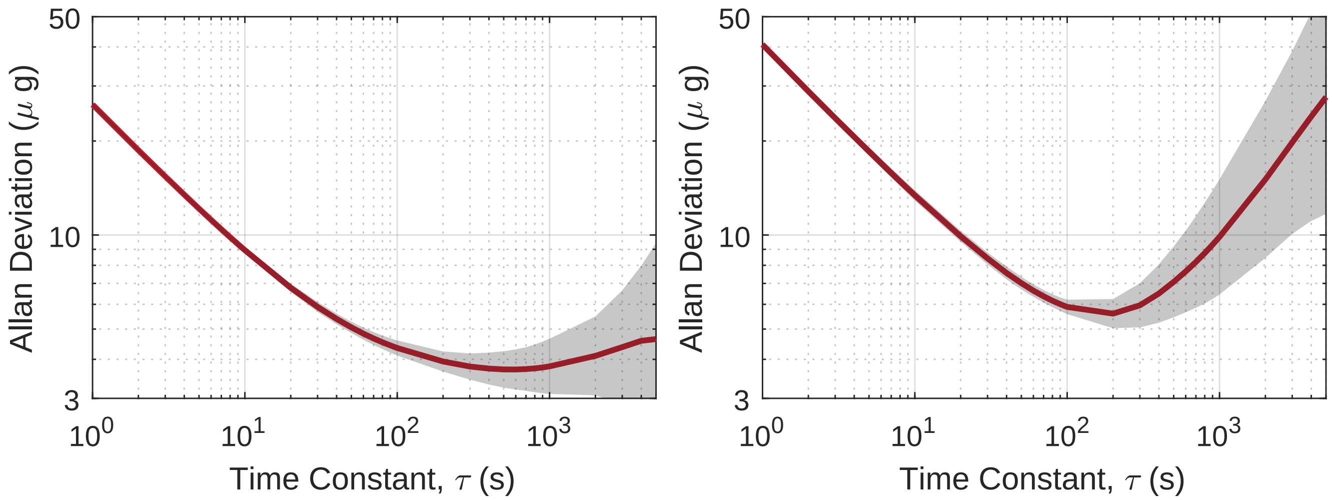
2.1 Accelerometer

Accelerometer

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range		± 15		g	
In-Run Bias Stability			10	μg	
Noise Density			0.04	$mg/\sqrt{Hz}$	
Sample Rate		800		Hz	
Bandwidth		200		Hz	
Cross-Axis Sensitivity			0.05	deg	
Resolution		0.1		mg	

TABLE 3

Allan Deviation



(a) XY-Axis Allan Deviation

(b) Z-Axis Allan Deviation

FIGURE 1

2.2 Gyroscope

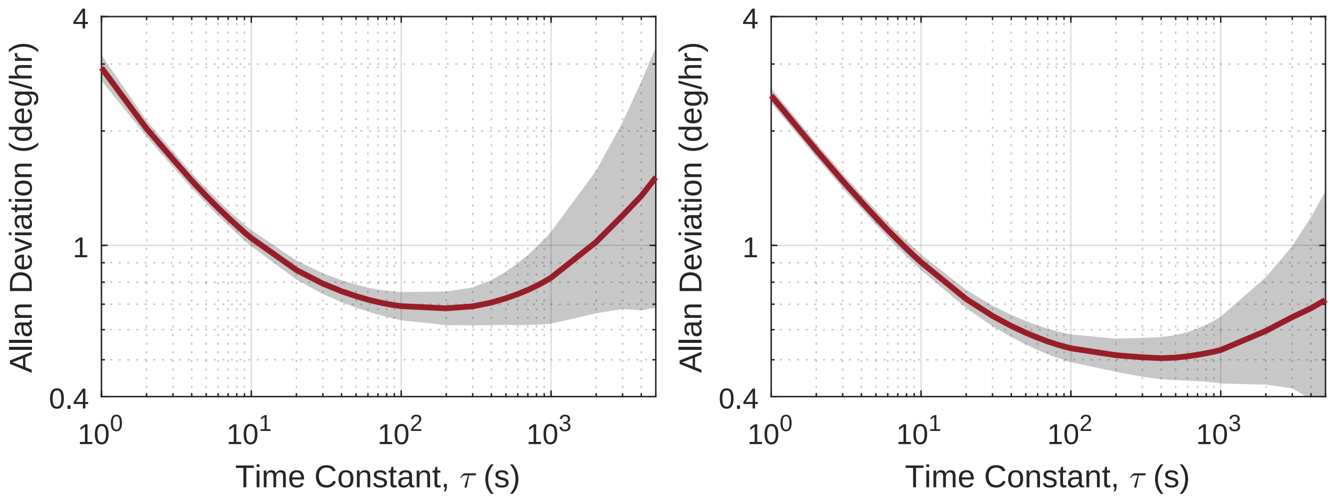
Gyroscope

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range		±490		°/s	[1]
In-Run Bias Stability		0.6	1	°/hr	
Noise Density		5		$°/hr/\sqrt{Hz}$	
Sample Rate		800		Hz	
Bandwidth		210		Hz	
Cross-Axis Sensitivity			0.05	deg	
Resolution		20		°/hr	

[1] Contact VectorNav for Extended Range Gyro option up to 2000 °/s.

TABLE 4

Allan Deviation



(a) XY-Axis Allan Deviation

(b) Z-Axis Allan Deviation

FIGURE 2

2.3 Magnetometer

Magnetometer

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range		± 2.5		G	
Noise Density		140		$\mu G/\sqrt{Hz}$	
Sample Rate		250		Hz	
Cross-Axis Sensitivity			0.05	deg	
Resolution		1.5		mG	

TABLE 5

3 GNSS RECEIVER

3.1 GNSS Receiver A

GNSS Receiver Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Solution Update Rate		5		Hz	
Time-to-First-Fix					
Cold Start		29		s	
Hot Start		1		s	
Sensitivity					
Tracking		-167		dBm	
Reacquisition		-160		dBm	
Cold Start		-148		dBm	
Max RF Power			10	dBm	[1]
Altitude Limit			50000	m	
Velocity Limit			500	m/s	

[1] Measured at the GNSS connector.

TABLE 6

Supported Frequencies

- GPS - L1C/A, L2C
- Galileo - E1-B/C, E5b
- GLONASS - L1OF, L2OF
- BeiDou - B1I, B2I
- QZSS - L1C/A & L2C
- SBAS - L1C/A

GNSS Antenna Electrical Requirements

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Voltage		5		V	
Current Draw			50	mA	Per antenna
Short-Circuit Current Limit Response Time		5		μs	
Gain	20		50	dB	
Noise			4	dB	

TABLE 7

Recommended Antennas

MANUFACTURER	MODEL	TYPE	NOTES
Tallysman	TW7882	Patch	General Purpose
Tallysman	TW8889	Patch	Smaller form factor
Tallysman	HC882	Helical	
ANTCOM	42GNSSA-XX-X	Patch	
ANTCOM	3GNSSA-XX-X	Patch	

TABLE 8

3.2 GNSS Receiver B

GNSS Receiver B Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Solution Update Rate		5		Hz	
Time-to-First-Fix					
Cold Start		29		s	
Hot Start		1		s	
Sensitivity					
Tracking		-159		dBm	
Reacquisition		-153		dBm	
Cold Start		-138		dBm	
Max RF Power			0	dBm	[1]
Altitude Limit			50000	m	
Velocity Limit			500	m/s	

[1] Measured at the GNSS connector.

TABLE 9

Supported Frequencies

- GPS - L1C/A
- Galileo - E1-B/C
- GLONASS - L1OF
- BeiDou - B1I
- QZSS - L1C/A & L1 SAIF
- SBAS - L1C/A

GNSS Antenna B Electrical Requirements

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Voltage		3		V	
Current Draw			50	mA	
Short-Circuit Current Limit Response Time		5		µs	
Gain	20		30	dB	
Noise			2	dB	
U.FL Mating Cycles		10			

TABLE 10

Recommended Antennas

MANUFACTURER	MODEL	TYPE	NOTES
Tallysman	TW2712	Patch	General Purpose
Tallysman	TW4722	Patch	Smaller form factor
Tallysman	HC771	Helical	
ANTCOM	4G15AV	Patch	

TABLE 11

3.3 RTK/PPK

The VN-310E is able to accept RTCMv3 (Radio Technical Commission for Maritime Services) messages for RTK (Real-Time Kinematic) correction data on either UART-1 or UART-2. There are no requirements from the user to configure any settings prior to sending RTCM messages to the sensor. The sensor will automatically detect the RTCM messages and apply the corrections. It is recommended that the real-time link be capable of transferring correction data at an update rate of at least 1 Hz with minimal latency. It is also important that the communication baud rate be configured correctly.

The VN-310E is able to output raw carrier phase data including pseudorange and Doppler data. In order to produce RINEX (Receiver Independent Exchange Format) data for PPK (Post-Processed Kinematic) corrections the user will have to configure the VN-310E to output Raw GNSS data from Binary Group 4 GNSS1 Outputs, this logged data can then be converted to the RINEX data format using VectorNav's Control Center. Control Center is freely available from VectorNav's website: www.vectornav.com. Note that this data is available at 5 Hz.

4 MECHANICAL

4.1 Size

Dimensions

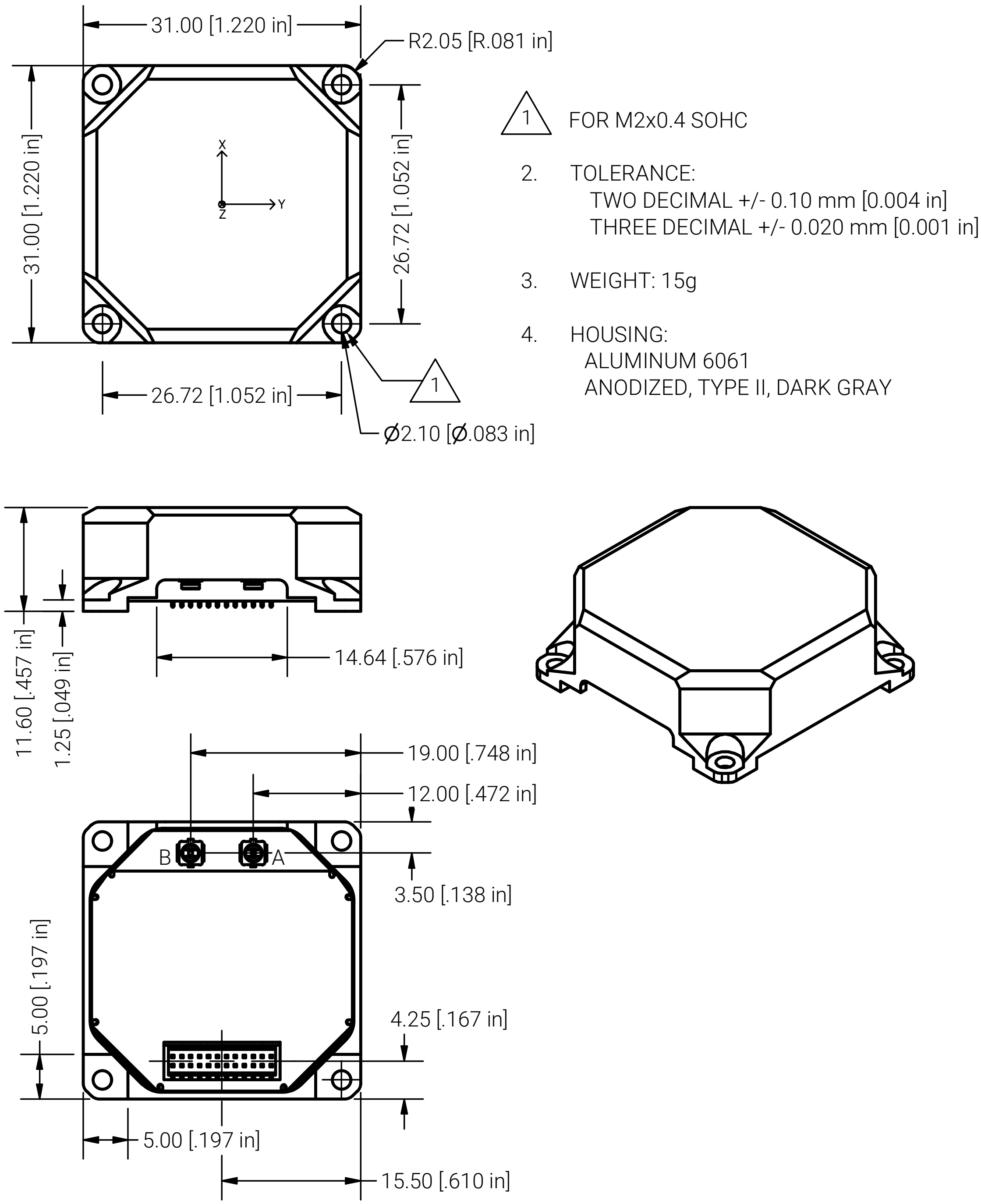


FIGURE 3

4.2 Environmental

Environmental

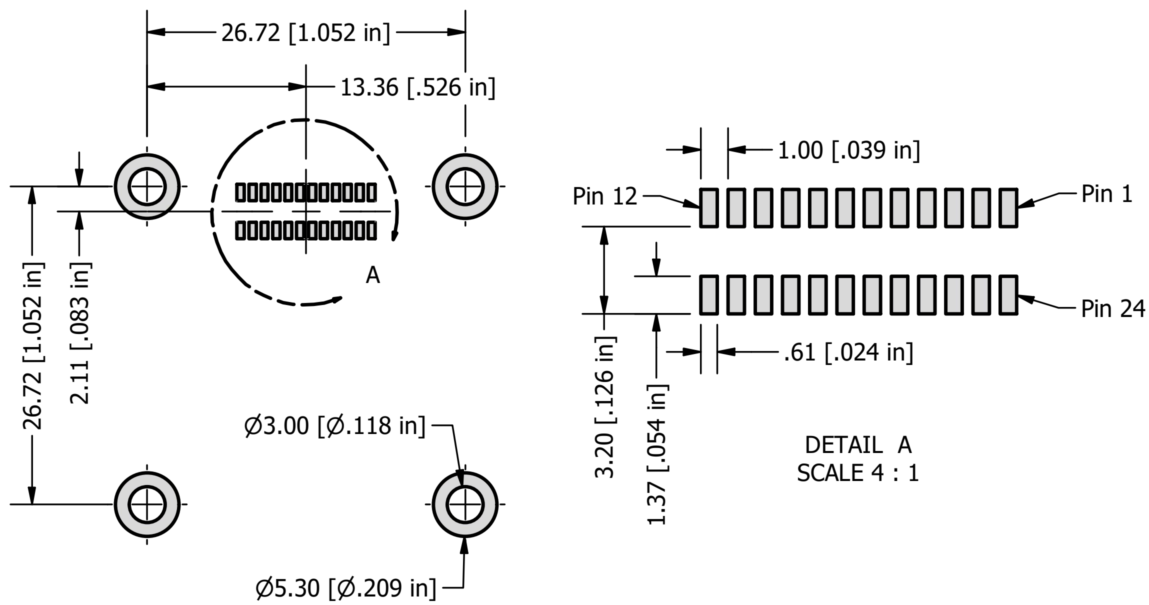
SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Operating Temperature	-40		85	°C	
Storage Temperature	-40		85	°C	
MTBF	22000			Hr	[1]

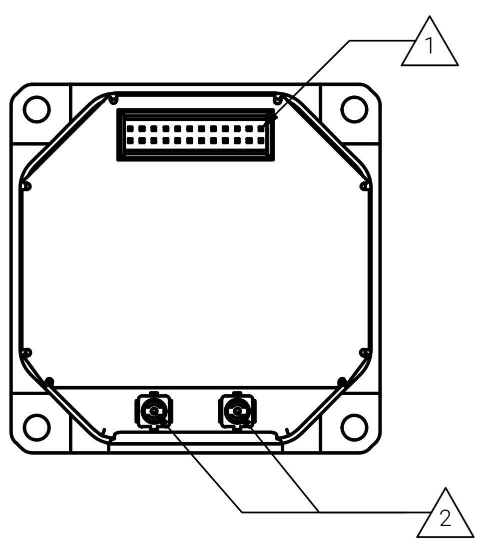
[1] The environment assumption was an Airborne Uninhabited Cargo (AUC) with 100 % duty cycle, which includes environmentally uncontrolled areas which cannot be inhabited by an aircrew during flight. Contact VectorNav for more information.

TABLE 12

5 ELECTRICAL

Pinout Schematic





1 — 24 PIN MALE CONNECTOR, 1mm PITCH

2 — GNSS CONNECTOR(S):
(PN: U.FL-R-SMT-1)

3. TOLERANCE:
TWO DECIMAL +/- 0.10 mm [0.004 in]
THREE DECIMAL +/- 0.020 mm [0.001 in]

FIGURE 4

Pin Assignments

PIN	PIN NAME	TYPE	DESCRIPTION
1	GPS_VANT	Supply	External Input voltage supply for antenna. 3 V to 5 V, 100 mA input
2	VIN	Supply	3.2 V to 3.5 V
3	VIN	Supply	3.2 V to 3.5 V
4	GND	Supply	Ground
5	GND	Supply	Ground
6	ENABLE	Input	Leave high for normal operation. Pull low to enter sleep mode. Internally pulled high with a 20 kΩ pull-up resistor.
7	SYNC_IN	Input	Input signal for synchronization purposes. Software configurable to either synchronize the measurements or the output with an external device
8	GPS_PPS	N/A	GPS time pulse. One pulse per second, synchronized on rising edge. Pulse width is 100 ms.
9	SYNC_OUT	Output	Output signal used for synchronization purposes. Software configurable to pulse when ADC, IMU, or attitude measurements are available.
10	UART1_RX	Input	Serial UART #1 data input (sensor)
11	UART1_TX	Output	Serial UART #1 data output (sensor)
12	AUX_SYNC	In/Out	User configurable auxiliary synchronization signal.
13	GPS_SYNC	N/A	GNSS sync output pulse. See the GNSS Sync Configuration Register for more details.
14	UART2_RX	Input	Serial UART #2 data input (sensor)
15	UART2_TX	Output	Serial UART #2 data output (sensor)
16	RESV	N/A	Reserved for internal use. Do not connect
17	RESV	N/A	Reserved for internal use. Do not connect
18	RESV	N/A	Reserved for internal use. Do not connect
19	RESV	N/A	Reserved for internal use. Do not connect
20	RESV	N/A	Reserved for internal use. Do not connect
21	RESV	N/A	Reserved for internal use. Do not connect
22	RESV	N/A	Reserved for internal use. Do not connect
23	RESV	N/A	Reserved for internal use. Do not connect
24	GPS_VBAT	Power	Optional GNSS RTC battery backup. 1.4 V to 3.6 V input.

TABLE 13

5.1 Power

Input Power Supply

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Voltage	3.2		3.5	V	
Power Consumption			1.6	W	[1]
Current (VIN @ 3.3 V)		480 165		mA µA	[1] ENABLE=Low
VANT	3		5 100	V mA	 Combined

[1] Not including active antenna power consumption

TABLE 14

VIN

The VN-310E module has a single input power supply (VIN). On the module a combination of both switching and linear regulators are used to supply power to the components.

GPS_VBAT

The GPS_VBAT pin provides external GNSS antenna power. This is an optional pin that is used if the GNSS antennas require higher input voltages than 3 V. If not connected, the VN-310E will power the antennas using an internal 3 V regulator.

GPS_VANT

The GPS_VANT provides power to the real time clock and backup RAM on the GNSS module. It provides GNSS the ability to recover in either HotStart or WarmStart config thereby providing a lower GNSS signal acquisition.

5.2 General Purpose I/O

SYNC_IN

The SYNC_IN pin is a 5 V tolerant input that drives SyncIn *Events*. It can be configured to detect either rising or falling edges. A SyncIn *Event* occurs when an internal counter exceeds a user defined SyncInSkipFactor. This allows SyncIn *Events* to occur at some multiple of the input signal such that a high-frequency input signal can be provided that is divided to the desired rate (eg. providing a 10 kHz signal that the sensor responds to only every 100 triggers will yield a 100 Hz response). At every SyncIn *Event* timeSyncIn is reset and syncInCount is incremented. SyncIn *Events* can also be configured to trigger several other actions (see the VN-310E Interface Control Document for more details).

SYNC_OUT

The SYNC_OUT pin is an output pin with configurable output polarity and pulse-width that is driven by SyncOut *Events*. A SyncOut *Event* occurs when an internal counter exceeds the user configurable SyncOutSkipFactor. The internal counter is incremented at a configurable rate defined by the SyncOutMode (See VN-310E Interface Control Document for more details).

GPS_PPS

The GPS_PPS pin is an output pin that is directly connected to the onboard GNSS receiver. It provides a very accurate timing reference that is aligned to the GPS signal. While the GPS has a valid time reference fix, the accuracy for the time pulse signal is better than 60 ns 99% of the time. The signal is a square wave, synchronized to the rising edge that pulses high for 100 ms.

GPS_SYNC

The GPS_SYNC pin outputs an accurate timing signal based on time derived from the internal receiver. In the default configuration, the pulse will only output while a valid time fix is maintained.

ENABLE

The ENABLE pin directly controls the output of all onboard regulators on the VN-310E module. Pulling this pin low will disable power to all onboard devices and will place the module into a ultra-low power mode. If not using this pin, leave as no connect.

SYNC_IN Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Logic-Low Voltage	-0.3		0.8	V	
Input Logic-High Voltage	2		5.5	V	
Pull-up/down Equivalent Resistor	30	40	50	kΩ	
Pulse Width	100			ns	
ESD Protection		±15		kV	

TABLE 15

SYNC_OUT Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Output Logic-Low Voltage	0		0.4	V	
Output Logic-High Voltage	2.4		3	V	
High to Low Fall Time			125	ns	
Low to High Rise Time			125	ns	
Output Frequency	1		1000	Hz	
Jitter			20	μs	
Sink/Source Current	-8		8	mA	
ESD Protection		±15		kV	

TABLE 16

GPS_PPS Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Output Logic-Low Voltage	0		0.4	V	
Output Logic-High Voltage	2.6		3	V	
Sink/Source Current	-2		2	mA	
Time Accuracy		30	60	ns	
ESD Protection		±15		kV	

TABLE 17

ENABLE Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Logic-Low Voltage	0		0.2	V	
Input Logic-High Voltage	1.1		VIN	V	
Pull-up Resistor		20		kΩ	
ESD Protection		±15		kV	

TABLE 18

5.3 Communication

The VN-310E has two completely indpendent Universal Asynchronous Receiver Transmitter (UART) serial interfaces. The serial interface on the VN-310E operates with 3 V TTL logic. The UARTS support baud rates from 9,600bps up to a maximum of 921,600bps. The VN-310E provides two separate communication interfaces on two separate serial ports. The main or primary port consists of UART1_TX and UART1_RX pins while the secondary or auxillary port consists of the UART2_TX and UART2_RX pins. Note that only the main serial port supports firmware updates.

Serial (TTL) Interface Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Logic-Low Voltage	-0.3		0.8	V	
Input Logic-High Voltage	2		5.5	V	
Output Logic-Low Voltage	0		0.4	V	
Output Logic-High Voltage	2.4		3	V	
Data rate	9600		921600	bps	
ESD Protection		±15		kV	

TABLE 19

6 PRODUCT HANDLING AND INSTALLATION

6.1 Mounting Requirements

The VN-310E is designed to mount directly to a printed circuit board (PCB) using M2 screws. A single 1 mm pitch 24-pin female board-to-board connector must be installed on the PCB to interface with the mating male connector on the VN-310E. VectorNav recommends the Samtec CLM-112-02-L-D-A connector.

There are two recommended ways in which the VN-310E can be secured to the PCB. The first method uses board mounted threaded standoffs, and the second method uses an aluminum x-bracket. Both methods are shown in the diagrams below.

Threaded Standoffs

The recommended method of mounting the VN-310E to the PCB is to use threaded standoffs that are soldered to the underside of the PCB. This approach provides the simplest installation, without requiring access to the underside of the PCB.

Recommended Standoff

Manufacturer: Wurth Electronik
Manufacturer Part #: 9774015243R
Material: Steel

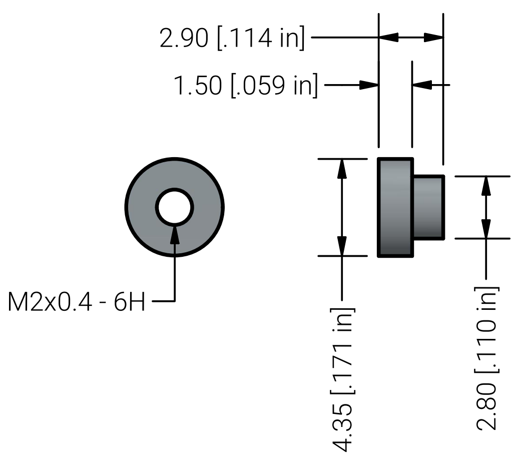


FIGURE 5

X-Bracket

A second method of mounting is to use an aluminum x-bracket manufactured by VectorNav. This bracket provides increased rigidity and does not require a two-sided PCB assembly operation, but it does require access to the underside of the PCB during installation.

VectorNav X-Bracket

Manufacturer: VectorNav
Manufacturer Part #: TE-BRACKET-1
Material: Aluminum 6061
Weight: 1.3g

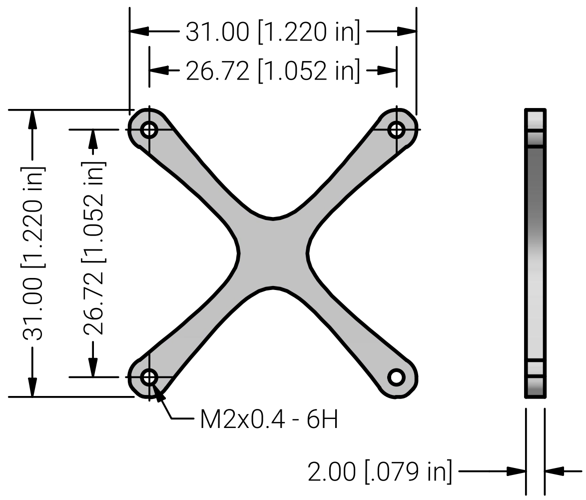


FIGURE 6

6.2 Board Stress Precautions

Flexing of the carrier board for the VN-310E can impact the sensor's performance. Consideration should be given to avoid stresses and strains from entering the module. Consider the various accelerations that the application will experience and that these can deflect heavy cables. Proper strain relief can mitigate this as can avoiding large connectors to be PCB mounted near the module. Avoid having heavy components installed without proper support close to the module for this same reason. For best performance, we recommend 3.2 mm thick PCBs, though 1.6 mm boards can be used if properly supported.

6.3 GNSS Antenna Considerations

The VN-310E requires an active antenna to be connected. For long cable runs we recommend using LMR-400 cable. In most dynamic applications, some vibration and shock will be present—it is important to secure the U.FL connector with staking compound to prevent it from disconnecting. Do this after the RF path has been verified. It is also important to avoid the U.FL jumper cable crimps from touching the EMI shield on the device. Depending on the lay of the U.FL jumper cable this can be avoided. If they lay of the cable is such that the metal crimps must cross over the EMI shield, some Kapton tape and staking compound is recommended to guarantee that the metal never physically touches the shield. Because U.FL connectors are rated for a relatively low connect/disconnect cycles, VectorNav recommends using a U.FL to bulkhead adapter.

6.4 Magnetic and Vibration Considerations

Magnetic disturbances and vibration are two forms of interference that can reduce performance and accuracy for an orientation sensor. In most applications it is not possible to avoid magnetic and vibration interference entirely, so the effect of these disturbances on the navigation sensor need to be minimized by careful design.

Magnetic Interference

Magnetic interference occurs when nearby objects emit either a static or time-varying magnetic field that interferes with the navigation sensor's ability to measure the background Earth's magnetic field which is used to estimate heading. Components such as electric motors, iron-core inductors, and current carrying wires can emit a magnetic field which will interfere with the VN-310E.

Static magnetic fields do not vary with time. This type of static interference can be compensated for by performing a hard/soft iron calibration of the magnetometer on the VN-310E if the component creating the interference rigidly rotates with the sensor and always maintains the same distance and direction with respect to the sensor. If the source of the magnetic field rotates separately from the sensor, for instance is installed on a separate moving platform or arm, then it cannot be compensated for using a hard/soft iron calibration. Where possible attempt to locate the sensor as far away from sources of magnetic interference as possible.

Dynamic magnetic fields vary with time and are created by items such as electric motors or current carrying wires. This form of magnetic distortion is very difficult for the sensor to handle without adverse effect on navigation performance. When designing the navigation sensor into your product pay careful attention to the location of current carrying conductors and their location with respect to the sensor. Where possible move these wires as far away from the sensor as possible to reduce its effect on the sensor's performance.

Vibration

The VN-310E has been incorporated into numerous helicopter, racing vehicles, and fixed winged aircraft applications. Whether your application is one of the aforementioned or another use case, there are a few important considerations with regard to vibration when using the VN-310E.

VectorNav recommends rigidly mounting the sensor with no vibration isolation. Vibration isolation is difficult to implement correctly and can degrade the performance of the sensor if done incorrectly. However, if isolation is determined to be necessary, the best practice is to isolate the subsystem that the VN-310E is on or isolate the source of vibration.

Note that random vibrations on the order of 4.5 g RMS will saturate the accelerometers, causing significant performance degradation of the navigation filters.

Electrostatic Discharge (ESD) Precautions

Electrostatic discharge (ESD) is the sudden and momentary electrical current that flows between two objects at different electrical potentials when they come in contact or very close proximity to each other. This discharge is the same effect that occurs when you walk across the carpet and touch a door knob. ESD has the potential to damage and possibly destroy electronic equipment due to the very high voltages that can be reached during the discharge of current between the two devices. Proper ESD precautions should be taken while handling the VN-310E to avoid the risk of possible damage to the device.

- Leave the module in its anti-static packaging until it is ready to be installed.
- Follow standard ESD practices when handling and working directly with the module.

Maintenance

There is no recommendation for returning the unit for recalibration. The factory calibrations are effective over the life of the part.

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Version 25-310E-20-R1-R1