PRODUCT SPECIFICATION

VN-300 RUGGED DUAL GNSS/INS

Sensor Datasheet (Hardware v2.1)

VECTORNAV

HIGHLIGHTS

0.2° Dynamic Heading Accuracy (INS)	**0.15°** Static Heading Accuracy (GNSS-Compass)	**< 0.04 mg** Accel In-Run Bias Stability	**Up to 400 Hz** Position, Velocity and Attitude Data
0.03° Dynamic Pitch/Roll Accuracy	**5-7°/hr (typ.)** Gyro In-Run Bias Stability	**1.0 m / 1.5 m** Horizontal / Vertical Position Accuracy	**SWaP** 45 x 44 x 11mm; 30 grams; < 1.25 W

Product Overview

The VN-300 Rugged 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 attitude. The onboard GNSS-Compass enables accurate heading measurements without reliance on vehicle dynamics or magnetic sensors, providing unmatched performance under both static and dynamic conditions.

The VN-300 Rugged is the "plug and play" version of the VN-300 SMD. Enclosed in a clamshell precision anodized aluminum enclosure, the VN-300 Rugged offers additional protection of the internal inertial sensors, GNSS receivers and electronics.

Calibration and Testing

Each individual VN-300 Rugged sensor 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-300 Rugged

Features

GNSS-Compass for Static Heading

Two onboard GNSS receivers perform GPS-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; Ships in 1-2 days.

Automatic Heading Transition

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

Software Compatibility

The VN-300 SMD shares a common communication protocol with the entire VectorNav product line.

User Configurable Messages

ASCII, NMEA 0183, and VectorNav Binary messages.

Sensor Summary

- All VN-300 units are calibrated for bias, scale factor, misalignment and gyro g-sensitivity errors across the full temperature range of the sensor from -40˚C to +85˚C
- GNSS-Compass for static and low dynamic heading accuracy
- Automatic transitioning between AHRS, INS and GNSS-Compass
- Real-time gyro and accel bias tracking and compensation
- Hard/Soft Iron Compensation (Real-time and Manual 2D & 3D)
- Raw Pseudorange, Doppler and carrier phase outputs
- Coning and sculling integrals (ΔV's, Δθ's)

CONTENTS

VectorNav Support

Whether you are looking for details on the VN-300 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.

+1.512.772.3615 support@vectornav.com

1 INS PERFORMANCE

Attitude

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range (Heading/Yaw, Roll)	-180		180	deg	
Range (Pitch)	-90		90	deg	
Output Rate	1		400	Hz	User configurable.
Heading (Magnetic)		2		deg	RMS[1]
Heading (INS)		0.2		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)		0.5		deg	RMS
Pitch/Roll (INS)		0.03		deg	1 σ[2]
Heading Mounting Misalignment		0.15		deg	1 σ[4]
Pitch/Roll Mounting Misalignment		0.1		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 of other alignment processes.

TABLE 1

Position/Velocity

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Output Rate	1		400	Hz	User configurable.
Horizontal Position Accuracy		1		m	RMS[1]
Vertical Position Accuracy		1.5		m	RMS[1]
Free Inertial Position Drift		3		cm/s^2	[2]
Velocity Accuracy		0.05		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

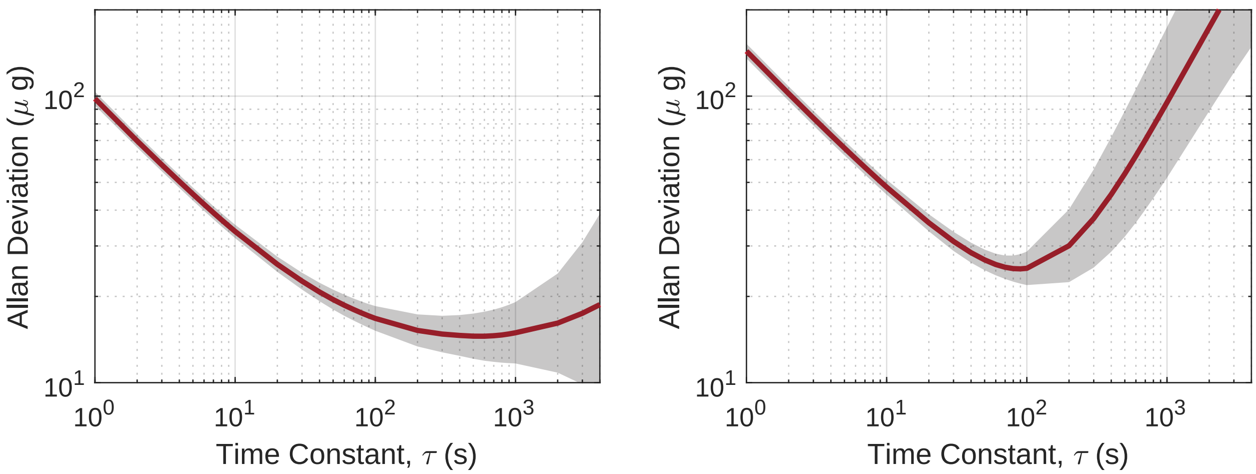
2.1 Accelerometer

Accelerometer

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range		±16		g	
In-Run Bias Stability			0.04	mg	
Noise Density		0.14		$mg/\sqrt{Hz}$	
Sample Rate		400		Hz	
Bandwidth		230		Hz	
Cross-Axis Sensitivity			0.05	deg	
Resolution		0.5		mg	

TABLE 3

Allan Deviation



(a) XY-Axis Allan Deviation

(b) Z-Axis Allan Deviation

FIGURE 1

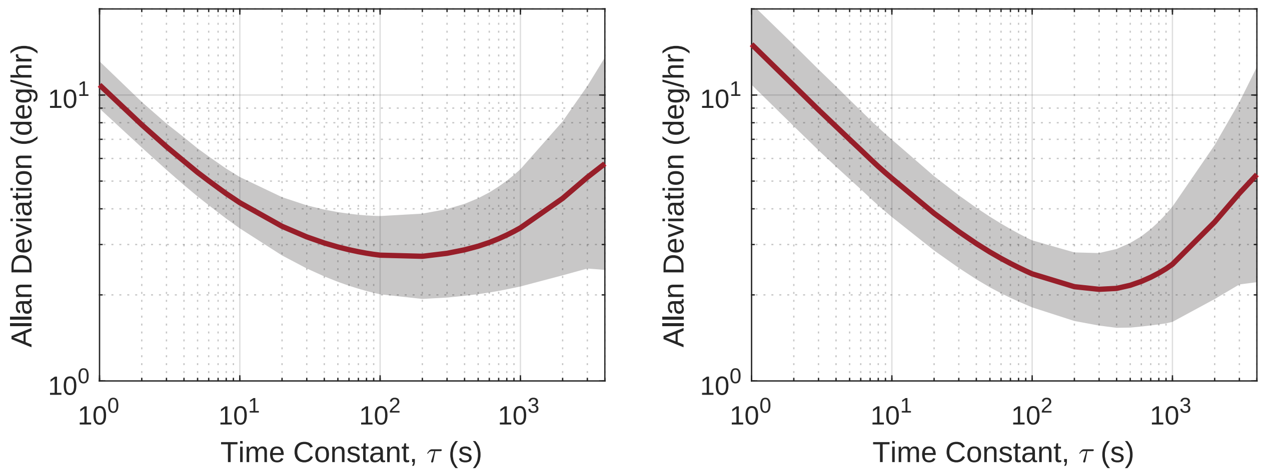
2.2 Gyroscope

Gyroscope

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range		±2000		°/s	
In-Run Bias Stability		5	10	°/hr	
Noise Density		0.0035		$^\circ/s/\sqrt{Hz}$	
Sample Rate		400		Hz	
Bandwidth		265		Hz	
Cross-Axis Sensitivity			0.05	deg	
Resolution		0.02		°/s	

TABLE 4

Allan Deviation



(a) XY-Axis Allan Deviation

(b) Z-Axis Allan Deviation

FIGURE 2

2.3 Magnetometer & Barometer

Magnetometer

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range		± 2.5		G	
Noise Density		140		$\mu G/\sqrt{Hz}$	
Sample Rate	200			Hz	
Cross-Axis Sensitivity			0.05	deg	
Resolution		1.5		mG	

TABLE 5

Barometer

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Range	10		1200	mbar	
Sample Rate		250		Hz	
Resolution		0.042		mbar	
Accuracy		1.5		mbar	$1\,\sigma$

TABLE 6

3 GNSS RECEIVER

3.1 Receiver Specifications

GNSS Receiver Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Solution Update Rate		5		Hz	
Time-to-First-Fix					
Cold Start		29		s	
Sensitivity					
Tracking		-167		dBm	
Reacquisition		-160		dBm	
Cold Start		-148		dBm	
Max RF Power			13	dBm	[1]
Altitude Limit			50000	m	
Velocity Limit			500	m/s	

[1] Measured at the GNSS connector.

TABLE 7

Supported Frequencies

- GPS - L1C/A
- Galileo - E1B/C
- GLONASS - L1OF
- BeiDou - B1I
- QZSS - L1C/A & L1 SAIF
- SBAS - L1C/A

3.2 Antenna Requirements

GNSS Antenna Electrical Requirements

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Voltage		5		V	
Current Draw			50	mA	Per antenna
Gain	20		40	dB	
Noise			1.5	dB	
MMCX Mating Cycles		500			

TABLE 8

Recommended Antennas

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

TABLE 9

VectorNav does not recommend using a multi-frequency antenna with the VN-300 Rugged. Other frequencies will appear as noise on the L1 band, slightly degrading GNSS performance.

4 MECHANICAL

4.1 Size

Dimensions

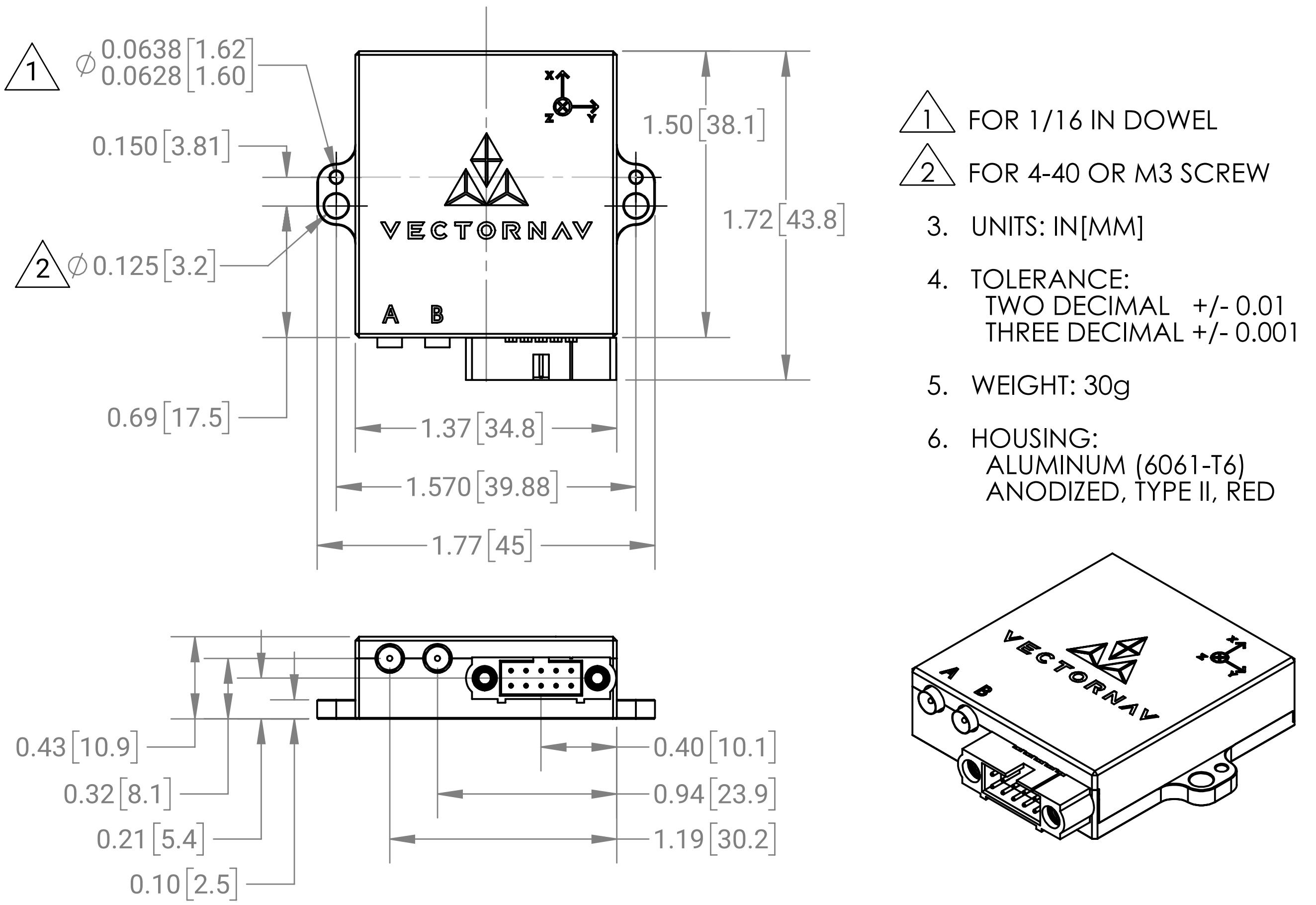


FIGURE 3

4.2 Environmental

Environmental

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Operating Temperature	-40		85	°C	
Storage Temperature	-40		85	°C	
MTBF	125000			Hr	[1]
Dust & Humidity Classification		IP 51			

[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 10

Shock and Vibration

The VN-300 Rugged has been designed such that when embedded into a larger system it passes standard MIL-STD-810 shock and vibration testing. Ultimately, conforming to MIL-STD-810 is up to the system designers, but several customers using VectorNav Industrial Series sensors have been qualified to date.

The VN-100 SMD has experienced the most shock and vibration testing, and shares an identical IMU core with the VN-300 Rugged.

The VN-100 SMD has been tested with powered shock levels at 500 g without significant changes in gyro/accel bias, scale factors, or misalignments. Similar results were seen with the VN-100/200 SMD unpowered with shock levels up to 10,000g. Through all shock testing to date, the gyroscopes recovered immediately after the shock event while the accelerometers recovered in a few milliseconds. The VN-100 SMD has also successfully operated through sinusoidal vibration tests ranging from 10 Hz to 2 kHz at amplitudes of 6 g.

5 ELECTRICAL

Pinout Schematic

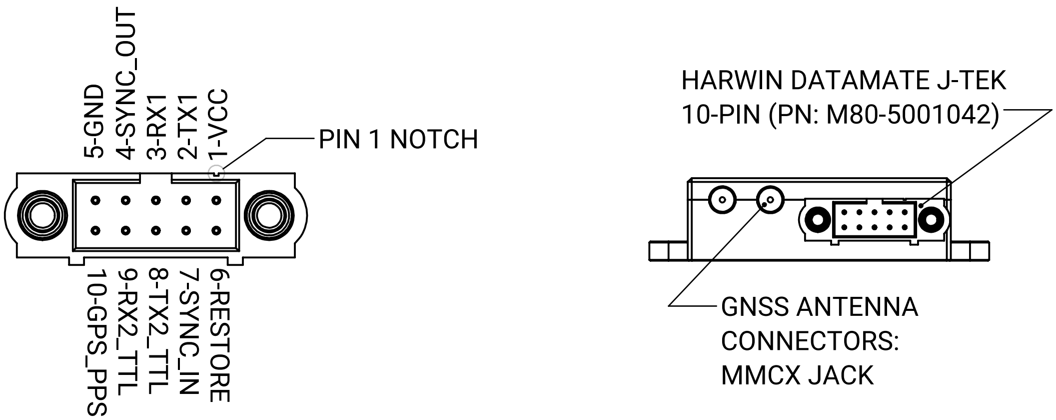


FIGURE 4

PIN ASSIGNMENTS

PIN	PIN NAME	TYPE	DESCRIPTION
1	VCC	Supply	3.3 V to 14 V
2	TX1	Output	RS-232 voltage levels data output from sensor. (Serial UART-1)
3	RX1	Input	RS-232 voltage levels data input to sensor. (Serial UART-1)
4	SYNC_OUT	Output	Output signal used for synchronization purposes. Software configurable to pulse when ADC, IMU, or attitude measurements are available.
5	GND	Supply	Ground
6	RESTORE	Input	During power on or device reset, holding this pin high will cause the module to restore the default factory settings. Internally held low with a 10 kΩ 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	TX2_TTL	Output	Serial UART-2 data output from the device at TTL voltage level (3 V)
9	RX2_TTL	Input	Serial UART-2 data into the device at TTL voltage level (3 V)
10	GPS_PPS	Output	GPS pulse per second output. This pin is a TTL voltage level (3 V) output directly connected to the PPS (pulse per second) pin on GNSS receiver A.

TABLE 11

5.1 Power

Power Supply Specifications

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Voltage (VIN)	3.3		14	V	
Power Consumption			1.25	W	[1]
Current (VIN @ 5 V)		150		mA	[1]

[1] Not including active antenna power consumption

TABLE 12

VIN

The VN-300 Rugged 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.

5.2 General Purpose I/O

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 13

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 14

RESTORE 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-down Resistor		10		kΩ	
ESD Protection		±15		kV	

TABLE 15

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	-4		4	mA	
Time Accuracy		30	60	ns	
ESD Protection		±15		kV	

TABLE 16

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-300 Rugged ICD 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-300 Rugged ICD for more details).

RESTORE

The RESTORE pin allows the sensor to be reset via hardware. At startup, if the state of this pin is high, the sensor will restore all of its configuration registers to their factory default state. This functionality serves as a fail-safe mechanism to avoid the situation that could possibly arise where invalid parameters are accidentally written to the device which could result in a loss of communication to the device. This pin needs to be held high for at least 5 ms after power-on to successfully restore factory settings. If not using this pin, leave as no connect.

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.

5.3 Communication

UART-1 Interface Specifications (RS232)

SPECIFICATION	MIN	TYP	MAX	UNITS	NOTES
Input Logic-Low Voltage	-25			V	
Input Logic-High Voltage			25	V	
Output Logic-Low Voltage		-5.4	-5	V	
Output Logic-High Voltage	5	5.5		V	
Data Rate	9600		921600	bps	
ESD Protection		±15		kV	

TABLE 17

UART-2 Interface Specifications (TTL)

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

TABLE 18

UART-1 & UART-2

The VN-300 Rugged has two fully separate and independently configurable Universal Asynchronous Receiver Transmitter (UART) serial interfaces. The TX1 and RX1 pins are the main serial port and TX2_TTL and RX2_TTL are the secondary serial port. Note that only the main serial port supports Firmware updates.

6 PRODUCT HANDLING AND INSTALLATION

6.1 Alignment and Fastening

When designing the installation location of the sensor, alignment pins can be used to precisely align the sensor to the installation location. We recommend 1/16in dowel pins PN:97395A405 from McMaster-Carr. VectorNav recommends fastening the sensor to 0.7 N m and 0.5 N m for steel and aluminum bases, respectively.

6.2 GNSS Antenna Considerations

The VN-300 Rugged requires an active antenna to be connected. In most dynamic applications some vibration and shock will be present—it is important to strain relieve the MMCX connector and/or secure the MMCX connector with staking compound to prevent it from ever coming undone. Do this after the RF path has been verified. If the sensor needs to be connected/disconnected frequently, we recommend a MMCX to SMA adapter be connected to the sensor. This will ensure no additional wear and tear is placed on the MMCX connector when connecting/disconnecting antennas.

6.3 Magnetic and Vibration Considerations

Magnetic disturbances and vibration are two forms of interference that can reduce performance and accuracy of 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 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-300 Rugged.

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-300 Rugged 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, 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 disturbance is 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-300 Rugged 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-300 Rugged.

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-300 Rugged 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.

6.4 Environmental Protection

The VN-300 Rugged's Dust & Humidity Classification is IP51. Precautions must be taken based on the environment the sensor is expected to operate in.

6.5 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-300 Rugged 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.

6.6 Maintenance

There is no recommendation for returning the unit for recalibration. The factory calibrations are effective over the life of the part. However, biases do drift over the life of the part regardless of the quality of the factory calibration. In rare circumstances the biases may drift enough to elicit a user calibration. Contact VectorNav support for more information if you believe a bias calibration is necessary for your sensor.

6.7 Cabling

The VN-300 Rugged uses a 10-Pin Harwin Datamate J-Tek connector. VectorNav manufactures various cables at various lengths, including cables terminated in: (a) a DB9, (b) USB, or (c) a pigtail cable. Contact VectorNav for the full suite of manufactured cables. When building cables, VectorNav uses the connector *Harwin M80-4861005*. Customers building their own cable should contact Harwin directly for additional connector options.

VectorNav Technologies, LLC
10501 Markison Rd
Dallas, TX 75238, USA

Tel: +1.512.772.3615
Email: sales@vectornav.com
Web: vectornav.com

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