Rugged, Highly Accurate INS and AHRS with Embedded GNSS

The GEO•FOG™ 3D INS uses sensor fusion to deliver reliable, high-accuracy navigation and control to a wide variety of unmanned, autonomous, and manned aerial, ground, marine, and subsurface marine applications and platforms. The KVH GEO•FOG 3D Inertial Navigation System (INS) is built upon the company’s landmark high-performance Fiber Optic Gyro (FOG)-based 1750 Inertial Measurement Unit (IMU). The advanced unit contains three KVH DSP-1750 gyros – the world’s smallest high-performance FOG – integrated with three very low noise MEMS accelerometers. The GEO•FOG 3D INS is an integration of the 1750 IMU with a pressure sensor, a 3-axis magnetometer, and a dual antenna RTK GNSS receiver.

High Accuracy, Intelligent Inertial Performance

Designed for demanding navigation and control applications, the GEO•FOG 3D INS has performance monitoring and instability protections to ensure stable and reliable data. Utilizing an innovative sensor fusion algorithm, its high performance filter is more intelligent than the typical Kalman filter used in many inertial solutions. The GEO•FOG 3D is capable of extracting significantly more information from the 1750 IMU core processor by using a cutting-edge artificial intelligence algorithm.

Designed for Mission Critical Control Applications

The rugged KVH GEO•FOG 3D INS is designed and tested to ensure that the hardware is both secure and reliable. It is protected from reverse polarity, overvoltage, surges, static and short circuits on all external surfaces. The embedded GNSS includes Receiver Autonomous Integrity Monitoring (RAIM) to assess the integrity of satellite signals. The system also contains a backup MEMS IMU providing seamless inertial data collection for redundancy and backup purposes.

Embedded RTK GNSS Receiver

The KVH GEO•FOG 3D contains a triple frequency GNSS receiver providing 8 mm positioning accuracy. It supports all of the current and future satellite navigation systems including GPS, GLONASS, GALILEO, and BeiDou. It also offers data rates up to 1000 Hz, and data can be output over a high-speed RS-422 interface or RS-232 interface.

Integrated North-seeking Gyrocompass

In addition to providing GNSS positioning backed with highly accurate inertial data, the GEO•FOG 3D features a north-seeking algorithm. This provides accurate heading as fast as 10 seconds after power-on from a hot start, and 10 minutes from a cold start. The north-seeking algorithm runs continuously while the INS is operating, and is unaffected by velocity or angular motion. This means the GEO•FOG 3D provides high accuracy heading in environments in which magnetometers and GPS-heading cannot be used.

Key Features

- Core processor: KVH 1750 IMU
- 6 DoF IMU consisting of integrated FOGs and accelerometers
- Triple frequency Trimble® GNSS receiver
- Cutting-edge sensor fusion algorithm delivering accurate, reliable data for navigation, orientation, and control
- North-seeking gyrocompass
- Attitude and Heading Reference System (AHRS)

Applications

- Navigation and control
- Unmanned systems
- Autonomous systems
- Manned systems
- AHRS
- Positioning and imaging
- Georeferencing
- Land surveying
- Robotics
- Underground navigation
- Stabilization and orientation
## GEO•FOG 3D INS

### IMU Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyro Technology</td>
<td>FOG</td>
</tr>
<tr>
<td>Input Rate (max)</td>
<td>±490°/sec</td>
</tr>
<tr>
<td>Bias Instability (25°C)</td>
<td>≤0.1°/h, 1° (max), ≤0.05°/h, 1°C (typical)</td>
</tr>
<tr>
<td>Bias vs. Temperature (±1°C/min)</td>
<td>≤1°/h, 1° (max), ≤0.7°, 1°C (typical)</td>
</tr>
<tr>
<td>Bias Offset (25°C)</td>
<td>±2°/hr</td>
</tr>
<tr>
<td>Scale Factor Non-linearity (max rate, 25°C)</td>
<td>±50 ppm, 1σ</td>
</tr>
<tr>
<td>Scale Factor vs. Temperature (±1°C/min)</td>
<td>±200 ppm, 1σ</td>
</tr>
<tr>
<td>Angle Random Walk (25°C)</td>
<td>±0.012°/sqrt(hr) (±0.7°/sqrt(hr/Hz))</td>
</tr>
<tr>
<td>Bandwidth (-3 dB)</td>
<td>≥440 Hz</td>
</tr>
<tr>
<td>Initialization Time (valid data)</td>
<td>≤1.5 secs</td>
</tr>
<tr>
<td>Data Interface</td>
<td>Asynchronous or Synchronous RS-422</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>Selectable 9.6 Kbps to 521.6 Kbps</td>
</tr>
<tr>
<td>Data Rate</td>
<td>User Selectable 1 to 1000 Hz</td>
</tr>
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</table>

### Magnetometers

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>8 G</td>
</tr>
<tr>
<td>Scale Factor Stability</td>
<td>&lt;0.05%</td>
</tr>
<tr>
<td>Non-linearity</td>
<td>&lt;0.05%</td>
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<tr>
<td>Noise Density</td>
<td>210 μG/Hz</td>
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<tr>
<td>Bandwidth</td>
<td>110 Hz</td>
</tr>
</tbody>
</table>

### Pressure

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>10 to 120 Kpa</td>
</tr>
<tr>
<td>Noise Density</td>
<td>0.56 Pa/VHz</td>
</tr>
<tr>
<td>Bias Instability</td>
<td>100 Pa/yr</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>50 Hz</td>
</tr>
</tbody>
</table>

### Connectors

GEO•FOG 3D features two general purpose input/output pins and two auxiliary RS-232/RS-422 ports that support an extensive number of peripherals, including odometric-based input for land vehicles, DVLs and USBLs for underwater navigation, NMEA input/output, and more.

### Communications

**Interface**
- RS-422 (RS-232 optional)
- AN Packet Protocol or NMEA
- 2x GPIO and 2x Auxillary, RS-232
- 5 V or RS-232

**GPIO Functions**
- 1PPS Odometer Stationary Pitot Tube
- NMEA input/output Nova/Trimble GNSS input Trimble GNSS input
- AN Packet Header input
- Packet Trigger input
- Teledyne DVL input
- Teledyne USBL input

### GNSS

**Model**
- Trimble BD930

**Supported Navigation Systems**
- GPS L1, L2, L5
- GLONASS L1, L2
- GALILEO E1
- BeiDou B1, B2

**Supported SBAS Systems**
- WAAS, EGNOS, MSAS, GAGAN, QZSS

**Update Rate**
- 20 Hz

**Cold Start First Fix**
- 30 s

**Hot Start Time**
- 2 s

**Orientation Range**
- Unlimited

**Vertical Position Accuracy (with RTK)**
- 0.008 m

**Vertical Position Accuracy (with SBAS)**
- 0.8 m

**Velocity Accuracy**
- 0.007 m/s

**Roll & Pitch Accuracy**
- 0.01*

**Heading Accuracy**
- 0.05°

**Heave Accuracy**
- 2% or 0.02 m (whichever is greater)

**Internal Filter Rate**
- 1000 Hz

**Output Data Rate**
- Up to 1000 Hz

### Typical Accuracy in Ground Vehicle

<table>
<thead>
<tr>
<th>Outage Duration</th>
<th>Position Accuracy (m)</th>
<th>Velocity Accuracy (m/s)</th>
<th>Roll &amp; Pitch Accuracy (°)</th>
<th>Heading Accuracy (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 s</td>
<td>0.008</td>
<td>0.007</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>10 s</td>
<td>0.05</td>
<td>0.009</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>30 s</td>
<td>0.15</td>
<td>0.012</td>
<td>0.01</td>
<td>0.051</td>
</tr>
<tr>
<td>1 m</td>
<td>0.6</td>
<td>0.014</td>
<td>0.01</td>
<td>0.052</td>
</tr>
<tr>
<td>5 m</td>
<td>2.9</td>
<td>0.025</td>
<td>0.01</td>
<td>0.062</td>
</tr>
<tr>
<td>10 m</td>
<td>5.8</td>
<td>0.048</td>
<td>0.01</td>
<td>0.075</td>
</tr>
<tr>
<td>30 m</td>
<td>17.4</td>
<td>0.05</td>
<td>0.01</td>
<td>0.125</td>
</tr>
<tr>
<td>60 m</td>
<td>34.8</td>
<td>0.05</td>
<td>0.01</td>
<td>0.2</td>
</tr>
</tbody>
</table>

### Other Specifications

- **Physical/Electrical/Environmental**
  - **Operating Voltage**: 9 to 36 V
  - **Input Protection**: -40 to 100 V
  - **Power Consumption**: 550 mA @ 12 V (typical)
  - **Hot Start Battery Capacity**: ≥48 hours
  - **Hot Start Battery Charge Time**: 30 minutes
  - **Hot Start Battery Endurance**: >10 years
  - **Operating Temperature**: -40°C to 75°C
  - **Environmental Protection**: IP67, MIL-STD-810G
  - **MTBF**: >36,000 hours
  - **Shock Limit**: 25 g
  - **Dimensions**: 90 x 90 x 88 mm
  - **Weight**: 655 grams

- **Trimble BD930**
  - **Supported SBAS Systems**: WAAS, EGNOS, MSAS, GAGAN, QZSS

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