3DM-GX1® FAQs

Revised: 5 October 2009

1. What's the main advantage of MicroStrain's gyro enhanced inclinometers and orientation sensors?

MicroStrain's gyro enhanced products are specified when orientation must be measured in the face of vibration, and a good static & dynamic response is needed. 3DM-GX1® is a good example of a sensor that makes use of the best characteristics of different MEMs sensing technologies. The accelerometers provide good static response but are subject to inertial influences, while the angular rate sensors provide good dynamic response but are prone to drift. Our built-in algorithm combines these sensor's outputs on the fly to prevent gyro drift, and to eliminate the inertial influences on the accelerometers, which provides high performance in both static & dynamic conditions. The combination of multiple MEMs sensors with our proprietary software algorithms (running on a tiny microprocessor) allows us to enhance performance and simplify our sensor's outputs, and still keep things small.

2. What hyperlinks can I use to get information on 3DM-GX1®?

On-line data sheets for gyro-enhanced orientation sensors:
http://www.microstrain.com/3dm-gx1.aspx
List of supporting documentation:
http://www.microstrain.com/3dm-gx1_docs.aspx
Detailed specifications:
http://www.microstrain.com/pdf/3DM-GX1%20Detailed%20Specs%20-%20Rev%201%20-%20070723.pdf
Product data sheet:
http://www.microstrain.com/pdf/3DM-GX1%20Datasheet%20Rev%201.pdf
Data communications protocol:
http://www.microstrain.com/manuals/3DM-GX1%20Data%20Communication%20Protocol%203101.pdf
Software manual:
http://www.microstrain.com/pdf/3DM-GX1%20Version%20204%20Help.pdf
Enclosure mechanicals:
http://www.microstrain.com/pdf/3017-0008.pdf
White papers listing
http://www.microstrain.com/white-papers.aspx
Pricing:
http://www.microstrain.com/3dm-gx1_buy.aspx

3. What hyperlinks are available to make gyro & accelerometer comparisons?
Analog Devices accelerometers:
http://www.analog.com/en/prod/0%2C2877%2CADXL203%2C00.html
We are now using a custom 5G implementation of this accelerometer.

Analog Devices gyros:
http://www.analog.com/en/prod/0%2C2877%2CADXRS300%2C00.html

4. How is 3DM-GX1® different from the 3DM®?
3DM® includes three orthogonal MEMs accelerometers and three orthogonal magneto-resistive magnetometers. It will measure orientation over 360 degrees about any axis, but is suitable for static and quasi-static environments only, because the accelerometers cannot accurately measure inclination in the face of inertial influences, without heavy low pass filtering, which introduces a lag in the response to angular change.

5. Can the 3DM-GX1® be used as a vertical gyro?
Yes. The vertical gyro mode allows the end user to place the unit in an operating mode which disables the magnetometers but preserves the complementary filter's advantages by combining three accelerometers and three gyros to give good static & dynamic response. In this mode, 3DM-GX1® will report only two angles (pitch and roll), over a range of +/- 180 degrees in roll and +/- 90 degrees in pitch. Note that the in vertical gyro mode, compass heading (or azimuth) is reported but may not be accurate.

6. What software support do you provide for 3DM-GX1®?
We provide applications for Windows 2000/XP/Vista operating systems that read data from the serial output (RS-232 or RS- 485) of 3DM-GX1®, display data in vector, matrix, quaternion, or Euler angle modes, and save these data to the hard drive of the host PC. We also supply some sample code in C, VB and LabVIEW.

7. What's the difference between the 3DM-GX1-M and the 3DM-GX1-SK?
3DM-GX1-M is the gyro enhanced module only: it has nine sensors (three magnetometers, three accelerometers, and three angular rate sensors). 3DM-GX1-SK includes one module, cable assembly, external power supply and software.

8. What test methods are used to calibrate and what calibration documentation are provided with 3DM-GX1®?

The system for static and dynamic calibration of our orientation sensors is an optical indexing head mounted to a servo-motor controlled rotary stage. The stage includes a precision optical rotary encoder providing a resolution of 630,000 counts per revolution (0.0006 degrees), and an absolute accuracy of 0.01 degrees.

Every 3DM-GX1® is provided with serial number and associated certificate of calibration. This certificate details test results for each of the nine sensors, including the residual measurement errors for each of the nine sensors, over 360 degrees, for three orthogonal axes of motion.

9. What are the typical nonlinearity, hysteresis, and non-orthogonality errors for the magnetometers and accelerometers, and rate gyros on 3DM-GX1®?

Temperature Compensation of Orthogonal Gyros, Accelerometers, and Magnetometers: 3DM-GX1® undergoes a full calibration over the temperature range of -20 to +70 degrees C. The correction coefficients needed for each and every sensor on every 3DM-GX1® are burned into each individual module's non-volatile memory. An example of the results from our embedded temperature compensation algorithm is provided in this hyperlink:
http://www.microstrain.com/pdf/Comparision%20With%20and%20Without%20Temp%20Comp.pdf

Linearity & Hysteresis: 3DM-GX1®'s sensors exhibit a combined non-linearity and hysteresis of approximately +/- 0.2% typical.

Orthogonality of Axes: Non-orthogonality of the sensor placement is corrected through robotic rate table calibration about each axis and subsequent software compensation. When 3DM-GX1® reports scaled vector quantities (acceleration vector, magnetic vector, rotation rate vector), these are all expressed in a single right handed coordinate system with orthogonality better than 0.05 degrees.

Alignment of Axes w/ Package Reference Frame: 3DM-GX1®'s standard case is made of injection molded ABS plastic. The limiting factor in establishing a package reference frame is that there are no precisely defined reference edges or points on that case. If the package reference is critical to your application, we can fabricate custom made aluminum cases which incorporate a reference edge. During calibration, we can align the package reference frame to the sensor's reporting frame to 0.05 degrees.

10. Do you have more detailed specifications about the angular rate measurements (bias stability, bias repeatability, etc)?

The gyros can handle maximum angular rates of +/- 300 degrees per second. However, these specifications pertain to the "raw" angular rate sensor, so these do not apply our 3DM-GX1®'s static and dynamic performance. We have developed a unique complementary filter, which is embedded within 3DM-GX1®'s microprocessor, and that is used to "blend" the response of the static sensors (accelerometers & magnetometers), with the response of the dynamic sensors (gyros). In this way, drift of the gyros is eliminated, but their fast dynamic response is preserved.

Please refer back to question #3 for hyperlinks to the gyros performance specs.

11. What orientation output formats are available with 3DM-GX1®?

The following orientation outputs formats are available: vectors, quaternion, matrix, & Euler angles.

12. Will 3DM-GX1® output the nine sensor readings?

Yes. You can place 3DM-GX1® in raw sensor bits mode and the module will continually stream the nine orthogonal sensor readings in scaled units over the serial port. You may also ask 3DM-GX1® to return the bias drift compensated signals from the three orthogonal angular rate gyros.

Please refer to the communications protocols document for a detailed listing of the operating modes available:
http://www.microstrain.com/manuals/3DM-GX1%20Data%20Communication%20Protocol%203101.pdf

13. What is the bandwidth of the accelerometers, gyros, and magnetometers?

The sampling rate of the 3DM-GX1® is 75 Hz when reading the vector quantities (the nine scaled sensor readings). This rate limits our ability to measure dynamic signals. Assuming that you would want to capture, at minimum, 10 samples for a given mechanical motion input, than you could measure motions from 0 to 7.5 Hz. When reading the matrix, Euler Angle, or quaternion quantities, the sampling rate drops to 50Hz. Assuming that you would want to capture, at minimum, 10 samples for a given angular motion, than you could measure angular motion from 0 to 5 Hz.

In regards to the bandwidth of the nine sensors, we limit this on some of the sensors by the use of hardware anti-aliasing filters. We use hardware anti-aliasing filters on the accelerometers; this is a two pole low pass filter which is -3dB down at 50 Hz. We use hardware anti-aliasing filters on the gyros; this is a single pole low pass filter which is -3dB down at 50 Hz. We do not use hardware anti-aliasing filters on the magnetometers; their inherent frequency response is ~5 MHz.

14. What is the frequency response of the accelerometers, gyros, and magnetometers, and will this change depending on the operating mode?

In scaled sensor output mode, the frequency response of these sensors is primarily limited by the anti-aliasing hardware filters in 3DM-GX1®; this response is described above in question 13. In quaternion, matrix, or Euler angles mode, the dynamic response is primarily dominated by the gyro frequency response, while the static response represents the long term output from the heavily filtered accelerometers and magnetometers. You can modify this response by changing the setting of the complementary filter.

15. What do you exactly mean for "Accuracy" in the specification data sheet? Does "+/-0. 5 degrees typical ...." mean that if I roll the unit by (for example) exactly 90 degrees from horizontal, the measure that I will get is 90 +/-0.5 degrees?

Yes. In Euler, matrix, or quaternion modes, and in static test conditions, our test results as well as independent reports by our customers indicate an absolute accuracy of +/- 0.5 degrees, over 360 degrees full scale, on all three axes. Under dynamic conditions, the accuracy will degrade. We cannot test our modules under all dynamic conditions but under most conditions, the accuracy is +/- 2.0 degrees.

The 3DM-GX1® calibration sheet which ships with every 3DM-GX1® provides the test results from calibration of each sensor, and should be used as a benchmark for performance of the 3DM-GX1® in scaled sensor units mode. The residual errors as shown in our calibration reports are typically less that +/- 50 counts over the full operating range of 65,536 counts for the magnetometers, +/- 40 counts over 65,536 counts for the accelerometers, and +/- 20 counts over 65,536 counts for the angular rate gyros.

16. Can distortions of Earth's magnetic field degrade system accuracy?

Yes. The presence of strong magnetic fields or large magnetic materials will twist Earth's field and this will be reported by our magnetometers. However, we do support hard iron field calibration using algorithms built into the embedded firmware. These algorithms require rotation of the 3DM-GX1® about two or three axes over 360 degrees for optimum accuracy. The algorithms also require that all distorting influences remain fixed in position relative to the 3DM-GX1® during calibration and during subsequent operation

17. Can linear acceleration degrade system accuracy?
Yes. Vibratory or oscillating linear accelerations do not significantly affect 3DM-GX1® performance, because our complementary filter will remove those influences.

However, sustained inertial influences, such as during long duration (30 seconds) coordinated turns at velocity in an aerial vehicle, or during an interstate "on" ramp acceleration in an automobile will generate errors. The 3DM-GX1®, because its improved gyro bias stability, allows the time constant for drift correction by the complementary filter to be increased (in essence, we can place greater "trust" in the gyros over longer periods of time). We note, however, that when these sustained centrifugal or linear accelerations are no longer present, 3DM-GX1® will self correct for the errors that were present during the maneuver.

18. What is the range of angular velocity measurement for 3DM-GX1®?
The gyros we deploy in 3DM-GX1® are rated for +/- 150 degrees/sec minimum to up to 4 times that (+/- 600 degrees/sec) maximum full scale. We set them up & calibrate them over +/- 300 degrees/sec full scale and allocate the range of our A/D converter (16 bits) for +/- 300 degrees/sec.

19. How will the 3DM-GX1® improved gyro option reduce gyro drift rates & overall system accuracy?
The gyros exhibit a relatively low angular rate bias as compared to other miniaturized gyros. 3DM-GX1® uses the embedded temperature sensor within each gyro to provide temperature compensation for gyro drift (at no extra cost). This compensation improves the dynamic response of the system, because the gyros are more stable.

In static environments, 3DM-GX1® exhibits an accuracy of +/- 0.5 degrees in static applications. Under most dynamic conditions, we specify 3DM-GX1®'s accuracy at +/- 2.0 degrees.

20. I need more range of measurement from the accelerometers, how can you help?
We set up our standard 3DM-GX1®'s to operate over +/- 3.0 G's over the full scale measurement range of our 16 bit A/D, using the standard issue +/- 2 G rated ADXL203 accelerometers. However, we can replace the standard issue ADXL203's with the pin-for-pin compatible +/- 10 G range ADXL210's. Please contact us for current pricing and delivery for this custom option.

21. What are the dimensions of the 3DM-GX1®?
3DM-GX1® uses the same enclosure and is essentially the same weight as our 3DM® and earlier 3DM-G® products. In fact, the GX1 module is actually a bit smaller in size; without the enclosure, GX1 modules are more compact by a few mm in each linear dimension. 3DM-GX1®'s PCB assembly is 15 mm by 42 mm by 40 mm.

22. Can 3DM-GX1®'s serial communications cable be relatively long in length?
3DM-GX1® has two serial operating modes, RS-232 and RS-485. This mode is software selectable, but we build a cable for RS-485 which is different from the standard serial cable, when customers require RS-485 communications. The maximum communication distances are:

- RS-232 50-100 feet (roughly 16 to 30 meters)
- RS-485 4000 feet (roughly 1300 meters)

23. Is it possible to use the unit with a serial port emulator (i.e., with a USB to serial adapter)?
Yes, we have also had good success with several types of off-the-shelf USB to serial port adaptors, such as those from IOGear and Keyspan, which may be purchased through consumer products distributors such as Best Buy or Circuit City.

24. At what baud rates can the 3DM-GX1® be operated?
Serial baud rates also software selectable (choose 19.2 kbaud, 38.4 kbaud, 115.2 kbaud).

25. Are the sampling rates adjustable and what are the fastest sampling rates of the 3DM-GX1®?
Yes, the sampling rates are adjustable. Please read these two technical notes for more details.
http://www.microstrain.com/tech_notes/TechNote_3DM-GX1_Timer_Tick_Intervals.pdf
http://www.microstrain.com/tech_notes/TechNote_3DM-GX1_Fastest_Rates.pdf

26. Is the data output of the 3DM-GX1 time-stamped?
The 3DM-GX1® has its own internal clock which tracks time. All of the data acquisition functions, whether in continuous mode or polled mode, provide elapsed timer ticks in the data return. This capability provides the user with accurate time stamping independent of the computer operating system.

27. Can 3DM-GX1® be installed in any orientation?
Yes, there are no limitations.

28. Will 3DM-GX1® output analog voltages?
Analog voltage outputs which reflect various data quantities can be provided as an option for 3DM-GX1®. Pricing is $195 for the Analog Output option; please call for lead times on this option. Please review this technical note:
http://www.microstrain.com/pdf/3DM-GX1%20Analog%20Output%20Option.pdf

29. Is it possible to receive an Adobe Acrobat (PDF) version of the user manual?
An electronic copy of the 3DM-GX1® software manual is provided on our web site, hyperlink: http://www.microstrain.com/pdf/3DM-GX1%20Version%20204%20Help.pdf

30. What are the power requirements, and what supplies are included with the starter kits?

Supply voltage: 5.2 VDC min, 12 VDC max. (3DM-GX1® is internally regulated at 5 VDC). Supply current is ~65 milliamps. Starter kits include a UL approved 'switching' power supply which may receive an input from 100 to 240 Volts AC. It outputs +9 Volts DC. A set of 4 plug adapters are provided to accommodate most countries' electrical services.

31. What are the dimensions of the 3DM-GX1®'s printed circuit board assembly without the enclosure?

There are actually three printed circuit boards (PCB's) within each 3DM-GX1® module. The three PCB's are secured to one another, so they can be removed from the housing without becoming disconnected from one another. This preserves their relative mechanical position so that the orthogonality matrix correction will still be valid, even when the PCB assembly is removed from the package. The dimension of the (three PCB) assembly is 15 mm by 42 mm by 40 mm. The keyed connector is 7 mm in diameter and protrudes from the PCB by 8 mm.

32. Is it possible to use 3DM-GX1® on a trial basis?

We encourage users to test this new product in their specific application(s). If you want to return the unit for any reason, you may do so within 30 days of its receipt. However, we require that you pay the shipping charges. A copy of our written return/warranty policy is available on our web site.

33. How soon can you ship 3DM-GX1® products?

Standard 3DM-GX1®s often ship from stock, within 2-3 days after receipt of written purchase orders.

34. What is the angular measurement range of the 3DM-GX1®?

MicroStrain's 3DM-GX1® is a 3-axis orientation sensor capable of measuring:

- -180˚ to + 180˚ of yaw (heading)
- -180˚ to +180˚ of roll
- -90˚ to +90˚ of pitch (see note following)

Note: The 3DM-GX1® has a pitch range of +/-90˚. It will measure pitch accurately within this range. However, due to a mathematical singularity in the Euler theorem, as pitch exceeds either -70˚ or +70˚, the yaw and roll measurements of the 3DM-GX1® will become numerically unstable. So to put it another way, if you are just measuring pitch with the device, all measurement between -90˚ and +90˚ will be accurate. If you are measuring pitch and roll at the same time (for example), pitch measurements beyond -70˚ or + 70˚ will effect the accuracy of the roll.

35. How does the analog output option work on the 3DM-GX1®?

Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I001_3DM-GX1_Analog_Output_Option.pdf

36. How does the Bluetooth work with the 3DM-GX1®?
Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I002_3DM-GX1_Bluetooth.pdf

37. What are the fastest data rates of the 3DM-GX1®?
Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I003_3DM-GX1_Fastest_Rates.pdf

38. Can hard iron calibration be performed on the 3DM-GX1®?
Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I004_3DM-GX1_Hard_Iron_Calibration.pdf

39. What are the addressing limitations with the 3DM-GX1 on an RS-485 network®?
Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I005_3DM-GX1_RS-485.pdf

40. Explain the timer ticks, calculation cycle and data output rates of the 3DM-GX1®.
Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I006_3DM-GX1_Timer_Tick_Intervals.pdf

41. What formulas are used to convert between the various orientation data quantities?
Here is a link to a detailed technical note:
http://www.microstrain.com/NumberedTechNotes/Inertial/TN-I0017_Orientation_Conversion_formulas.pdf