GLADIATOR TECHNOLOGIES

AS9100C & ISO9001:2008

G300D Triaxial Digital MEMS Gyro Technical User's Guide

Technical Support
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AS9100C &
ISO9001:2008

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3 SAFETY AND HANDLING INFORMATION

- **Always use caution when handling** the G300D Triaxial Digital Gyro!
- **Supplying too high an input voltage could permanently damage the unit.** Input Power is specified at +3.8 V to +5.5 V Maximum. The unit is specified at 5 V ± 0.3 V.
- The G300D Triaxial Digital Gyro is a sensitive scientific instrument containing shock and vibration sensitive inertial and other sensors**. Excessive shock and or vibration can damage these sensors and can adversely affect sensor performance and unit output**.
- **Avoid exposure to electrostatic discharge (ESD)**. Observe proper grounding whenever handling the G300D Triaxial Digital Gyro.
- **Properly attach connector and ensure that it has been wired correctly before applying power** to the G300D Triaxial Digital Gyro.

4 GETTING STARTED

This section contains directions and references for a quick start to using the G300D.

For additional support, please contact the distributor representing your location. If there isn't a local representative for your location, please contact our Headquarter office for assistance and someone from our Sales Team will assist you.

The G300D Triaxial Digital Gyro Software Development Kit (SDK) is an optional product to assist first-time users of the G300D Triaxial Digital Gyro. This kit provides the user everything they need to facilitate a rapid setup and test of the unit. The SDK (P/N SDK-IMU-8) includes display software with user defined options including the following components and is seen in Figure 1:

- Turn-Key Solution for G300D Triaxial Digital Gyro on User PC
- All Cabling, Interface Connectors, and Software Included and Ready for Use
- Easy Integration of Direct Gyro RS-422/RS485 to PC's USB Port
- Includes PC Display Software for Gyro
- Data Recording Capability
- Multiple User Selected Field Options for Programming and Initializing the Unit
- User Defined Bandwidth Settings and Data Output Rate on Gyro
- Self-Test Switch

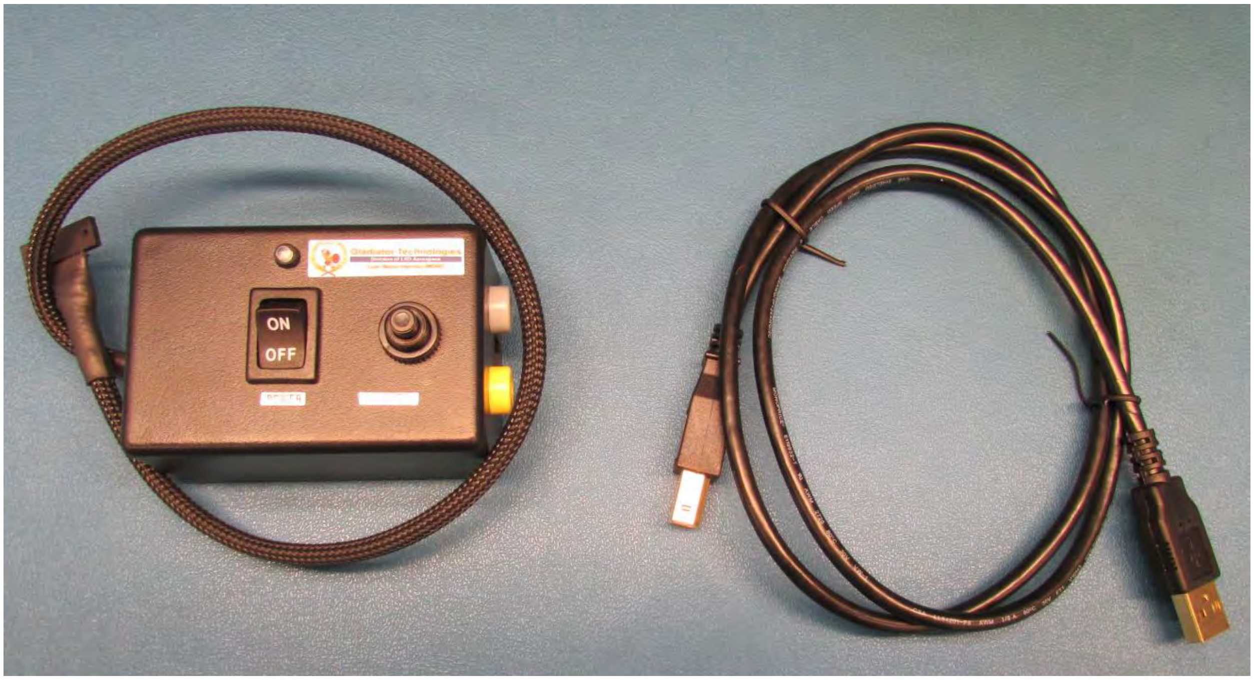


Figure 1 SDK Power Control/Self-Test, SDK to PC Cabling

The following steps will allow the user to quickly set up a G300D and interface it with its SDK.

1. Connect all units together per the User Guide under this section (Getting Started) to the PC. Do not turn on the power yet. Follow all steps in Section 4 carefully.
2. Follow the instructions from the enclosed disc under Linx SW labeled "STOP! Read This First - Installation Guide" to load the VCP drivers for the USB interface.
3. Copy the Glamr.msi software and setup.exe applications to the PC hard drive from the header file on the disc.
4. Run the Glamr.msi to install the Glamr and select the com port to LINX if not selected.
5. Apply power to the unit to see data on the screen. Turn the self-test switch to ON to see a change in the sensor data that ensures the unit is functioning. Then switch OFF.
6. Follow the instructions in the following sections of the User Guide Glamr Software Installation (Section 4.5) to change any factory settings for your application.

4.1 *RS-422/RS485 to USB Power Supply & Converter Cable*

Contained in the Software Development Kit (SDK) is a complete RS-422/RS485 to USB Converter cable including power supply and self-test switch (Fig. 1). The power supply uses USB power.

An RS-422/RS485 to USB converter is also included (requires additional drivers that are included in the CD-ROM).

This power supply converter cable enables the user to quickly connect the G300D Triaxial Digital Gyro to their PC to ease integration and testing. Connect the cables to the unit and the converter board to the PC with the USB cable. Do not turn on the power switch until the rest of the software is installed.

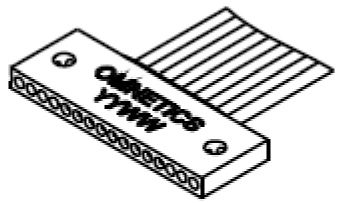


Figure 2 Unit Connector

4.2 G300D Triaxial Digital Gyro Mating Connector

The G300D Triaxial Digital Gyro mating connector and mating pins are contained in a separate package to enable customer-specific wiring options. If the SDK was purchased, then the customer also has an RS-422/RS485 Converter board, USB connector, and mating pins.

4.3 *STOP! Read This First*

You <u>must first install the USB drivers</u> from the enclosed USB Driver CD-ROM <u>before using Glamr</u> to read the unit. Look on the CD-ROM under Linx SW and perform the instructions in the PDF "Read Me First - Installation Guide" (Figure 5).

Note: This driver is designed for Windows programs only.

Figure 3 Read Me First Installation Guide

4.4 *Installing the LINX SDM-USB-QS-S Drivers*

4.4.1 *Introduction*

The LINX SDM-USB-QS-S module requires that device drivers be installed on the host PC before they can interact. The drivers tell the PC how to talk to the module. These drivers are for Windows 98, XP, NT, Windows 7, and Windows 8. For Windows 10 installation, please see the note. The set for Windows are the direct drivers, which offer program functions that allow a custom application to directly control the module through the USB port.

Figure 4 SDK Installation Disc

NOTE: This is for the installation on machines running the Windows 10 Operating System.

1. Install LINX driver first. This is updated for Windows 10 and is found here:

https://linxtechnologies.com/wp/wp-content/uploads/qs_driver_installer.zip

Do **NOT** use the FTDI device driver that Windows 10 provides. It does not work with the LINX product even though they are using the FTDI parts. The PID was changed so it is unique.

2. When installing Glamr, there will be an error message saying “Combined.OCX could not be registered.” This is due to missing some DLLs. To get these dependencies, you need to install a Microsoft Redistribution package. This package (language dependent for our foreign customers) can be found at:

https://www.microsoft.com/en-us/download/details.aspx?id=29

Figure 5 shows which files will be available to the user via the SDK Installation Disc. Test data for the units is also available for the user to view. User Guides for each product will also be located on the disc.

Name	Date modified	Type	Size
Linx SW	8/18/2017 10:04 A...	File folder	
Demo Read me	7/12/2011 1:02 PM	Text Document	1 KB
Glamr_13p3p72p4_2017-09-12	9/12/2017 7:15 PM	Application	658 KB
Read Me First - Installation Guide	11/23/2009 8:24 A...	Adobe Acrobat D...	558 KB
setup	9/12/2017 7:08 PM	Application	666 KB
SetupGlamr_13p3p72p4	9/12/2017 7:08 PM	Windows Installer ...	410 KB

Figure 5 Files on Installation Disc

4.4.2 *Installing the Direct Drivers*

The drivers are included in the Linx SW folder and should be saved onto the hard drive of a PC or onto a flash drive. Double click on the **QS_Driver_Installer.msi** for the Setup Wizard.

Click Next

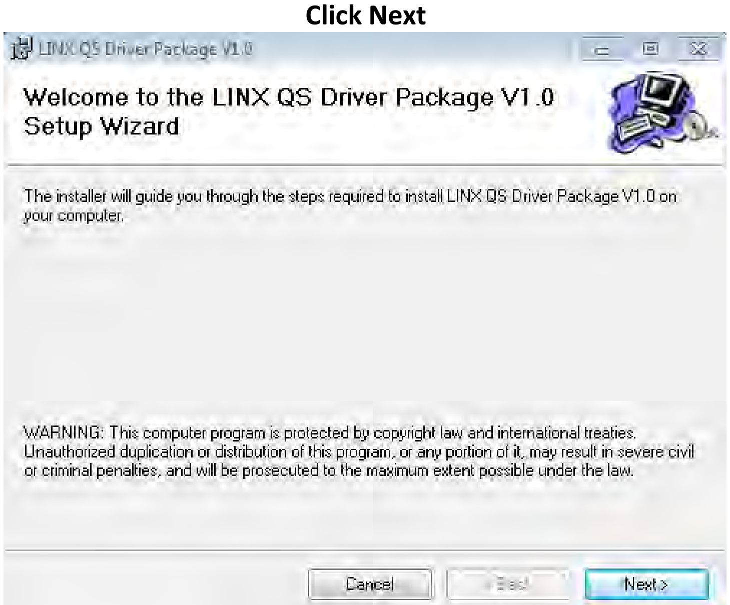


Figure 6 Driver Setup Wizard

Read License, click I Agree, then Next

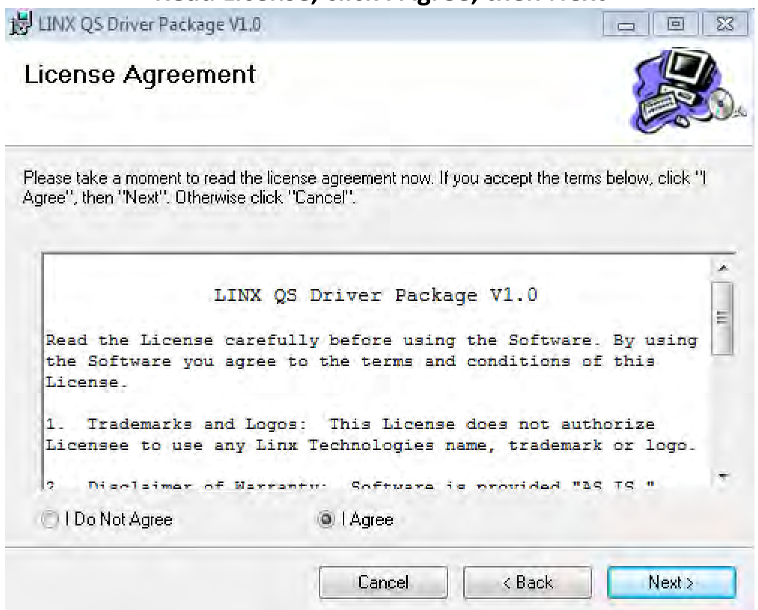


Figure 7 License Agreement Prompt

Click Next upon arrival at the Installation Folder prompt

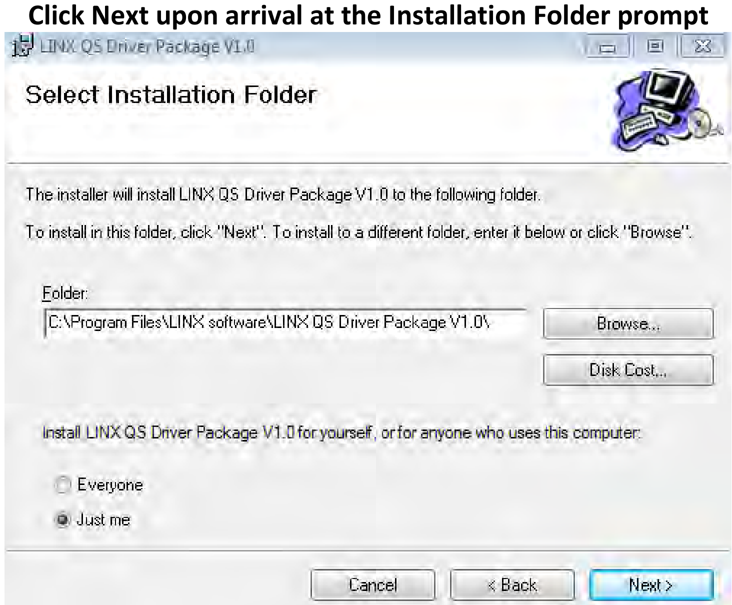


Figure 8 Installation Folder Prompt

Click Next at the Driver Package Information prompt

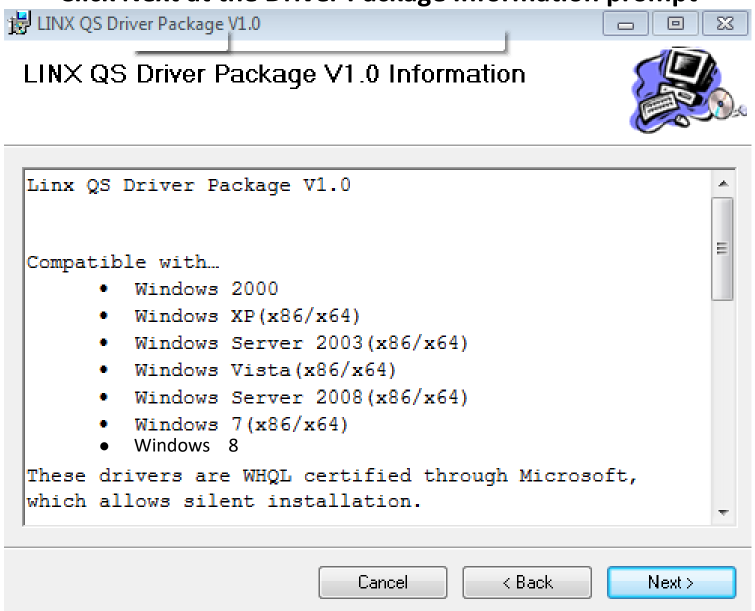


Figure 9 Driver Package Information Prompt

NOTE: Plug the connector cable into the USB port before you turn the device power on to avoid Windows loading as a mouse driver.

Allow driver installation to complete

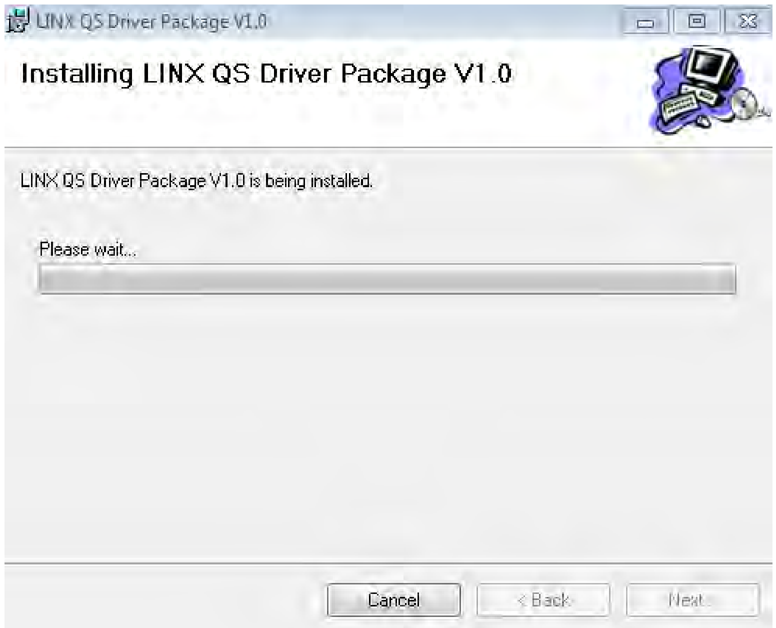
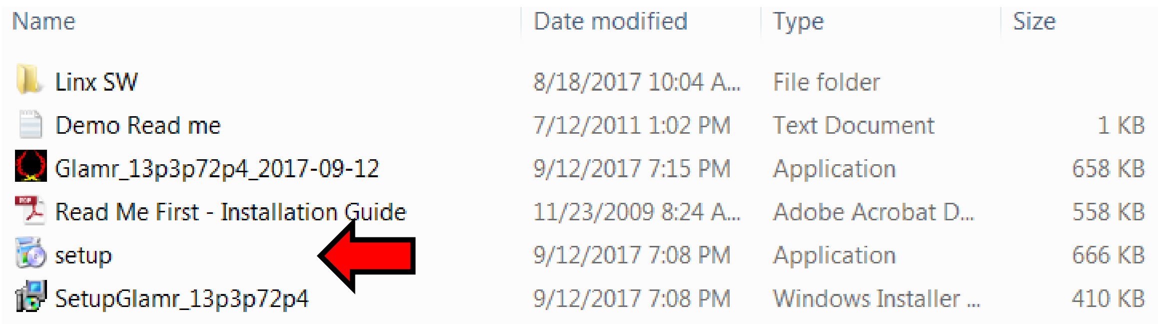


Figure 10 Driver Installation Status

4.5 *Glamr Software Installation*

Now install the Glamr application off of the CD-ROM. Open the Glamr file (Fig. 11) in the enclosed CD-ROM and install the application to the desired location on the hard drive. Note that the Glamr display has common software features for IMUs and Gyro Triax units.



Name	Date modified	Type	Size
Linx SW	8/18/2017 10:04 A...	File folder	
Demo Read me	7/12/2011 1:02 PM	Text Document	1 KB
Glamr_13p3p72p4_2017-09-12	9/12/2017 7:15 PM	Application	658 KB
Read Me First - Installation Guide	11/23/2009 8:24 A...	Adobe Acrobat D...	558 KB
setup	9/12/2017 7:08 PM	Application	666 KB
SetupGlamr_13p3p72p4	9/12/2017 7:08 PM	Windows Installer ...	410 KB

Figure 11 Glamr Location on SDK CD-ROM

Once Glamr is installed, create a shortcut on your desktop to the application. Right click on the Glamr Software icon on your hard drive file. Select create shortcut. Drag this shortcut file and drop on your desktop, as seen in Figure 12.

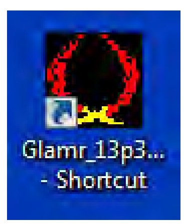


Figure 12 Glamr Shortcut Software Icon

Open the Glamr software and a window will appear as in Figure 13.

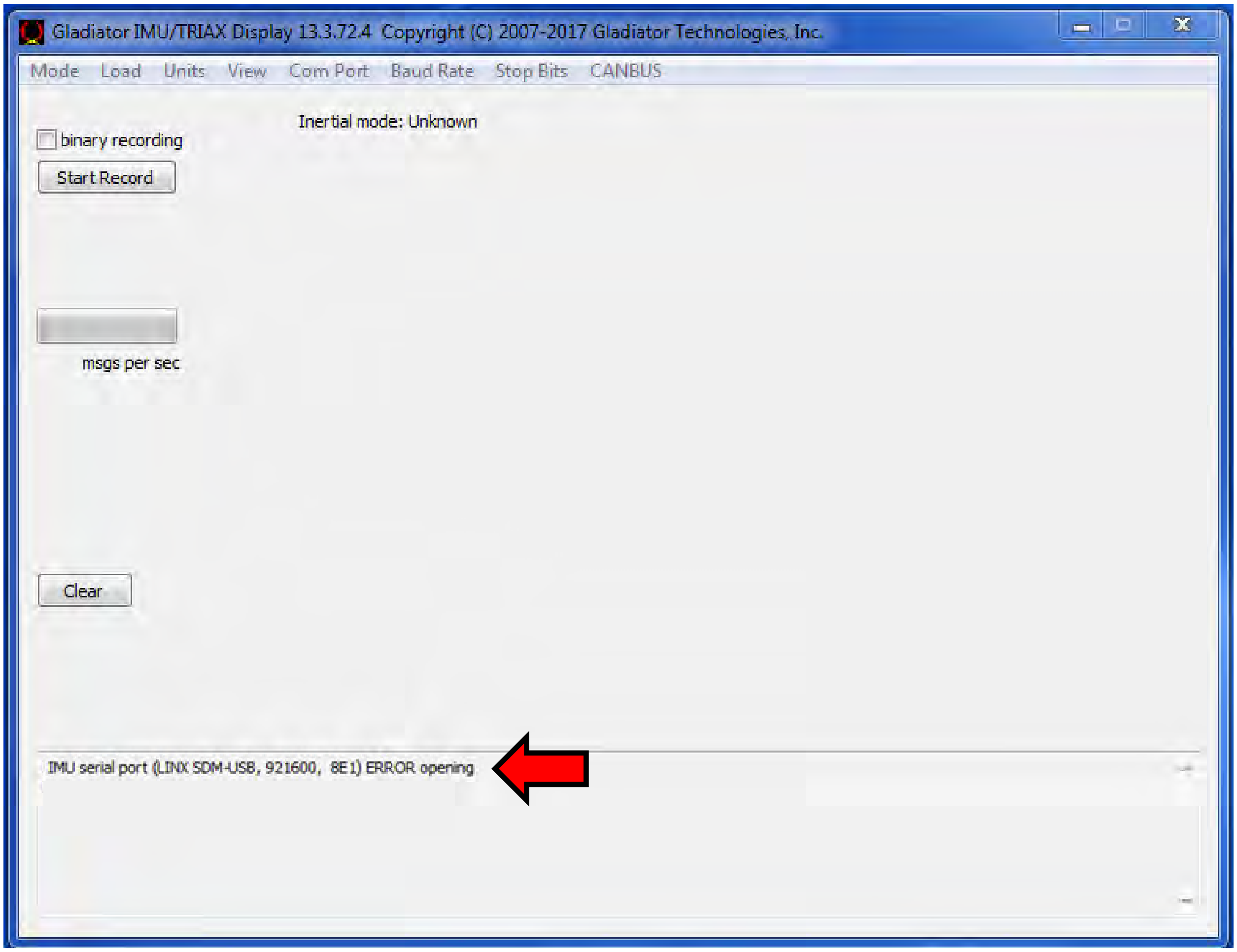


Figure 13 Glamr Screen before Selecting Correct COM Port Settings

The bottom of the Gladiator Gyro Display may read "IMU serial port (LINX SDM-USB, 115200, 8E1) ERROR opening."

Only one copy of Glamr can be open at a given time. Always make sure there is not another copy open on the task bar. If there are multiple copies of Glamr open, a message will appear at the bottom of the Gyro Display window.

Reconnect the USB plug to the SDK. The "LINX" port should have a checkmark next to it. The bottom of the window should now read "IMU serial port (LINX SDM-USB, 115200, 8E1) success", as shown in Figure 14.

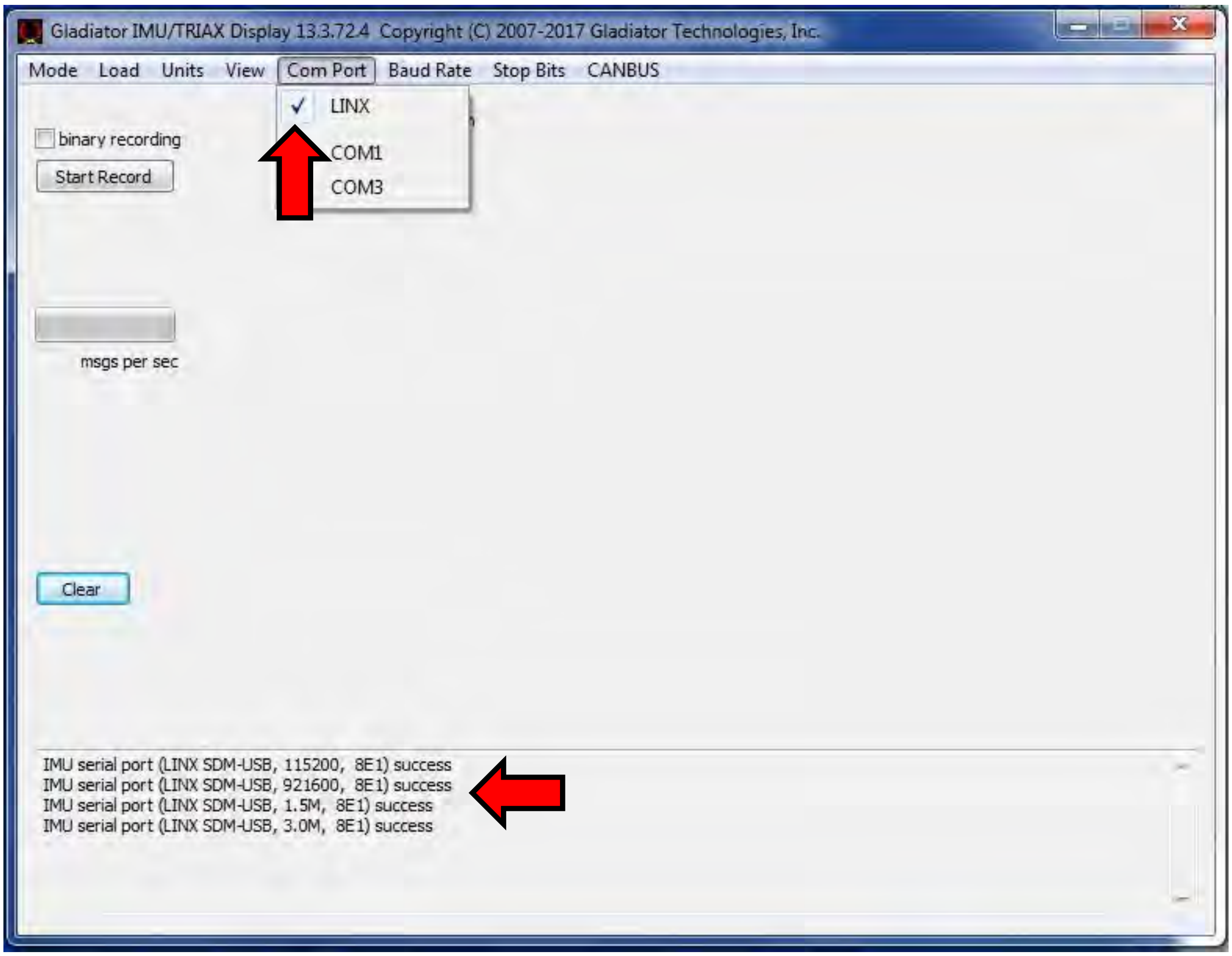


Figure 14 Confirmed Correct LINX Port with Message "success"

Turn on the power switch located on the SDK and data should appear in the window as seen in Figure 15 (blue box). Movement of the Gyro will see changes in rate and acceleration for each axis located within the Gyro. These changes are reflected on-screen. To see rapid change, the record function will capture real time data without the filter effect on the screen.

4.6 *Select Applicable Baud Rate*

		Baud Rate →				
Data Rate ↓		115200	921600	1.5 M	3.0 M	Bits/second
	100	Yes	Yes	Yes	Yes	19800
	200	Yes	Yes	Yes	Yes	39600
	500	*	Yes	Yes	Yes	99000
	1000		Yes	Yes	Yes	198000
	2500		Yes	Yes	Yes	495000
	5000			Yes	Yes	990000
	6000			Yes	Yes	1188000

Note that the 500 Hz Data Mode is a special case. Please refer to Section 4.7.1 for more details.

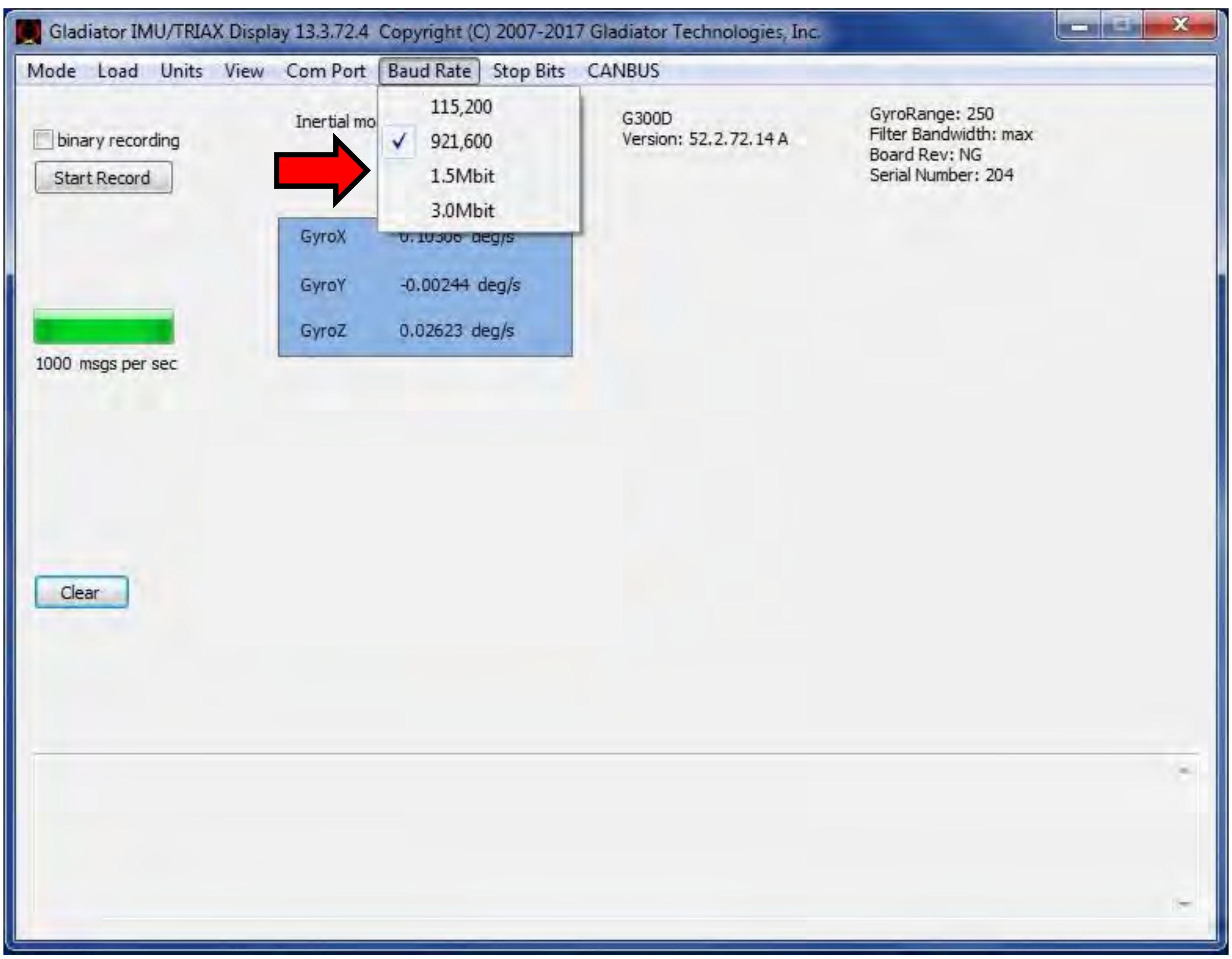


Figure 15 Baud Rate Selection for 1000 Hz Data Rate

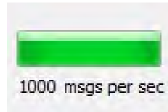


Figure 16 Gyro Data in Full Mode at 1000 Hz Data Rate

The message "Msg out-of-sequence: exp 0, act 96" may sometimes appear and indicates that the program saw a skip in the message count. This case will happen at start-up and can be ignored.

4.7 *Setting the Mode and Data Rate*

The SDK software also has data rate adjustment and data set selection. This feature is selected under Mode as shown in Figure 17. This allows a reduced data set in Spec mode.

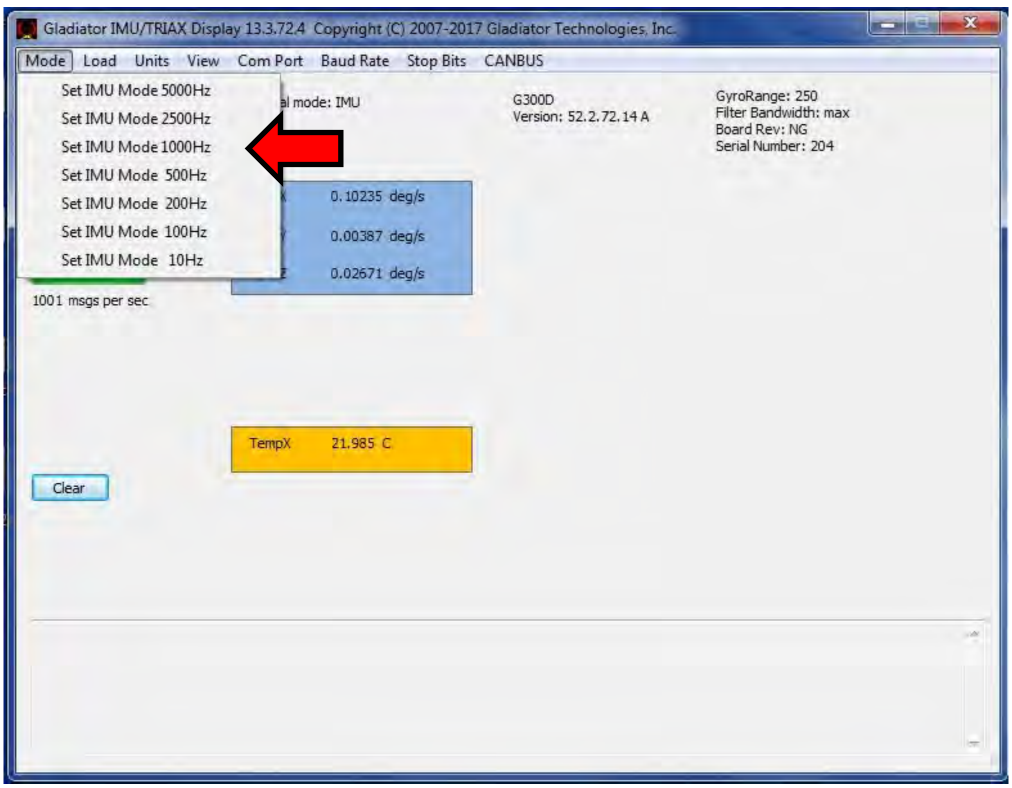


Figure 17 Mode Selection / Data Rate

4.7.1 *Set IMU Mode 500 Hz Data Rate*

All Gyros can be put into a 500 Hz data rate mode. This can be seen in Figure 18.

NOTE: To reset to another mode once in 500 Hz data rate mode, the unit requires a special procedure if at 115,200 baud rate.

Reverting the unit back to any other mode requires a mode click to the desired rate. This will command the unit to wait for a power recycle as per the screen instructions. To set the unit to the new mode upon powering up, turn on power and the new data rate will be shown under the green bar in the center-left "xxx msgs per sec."

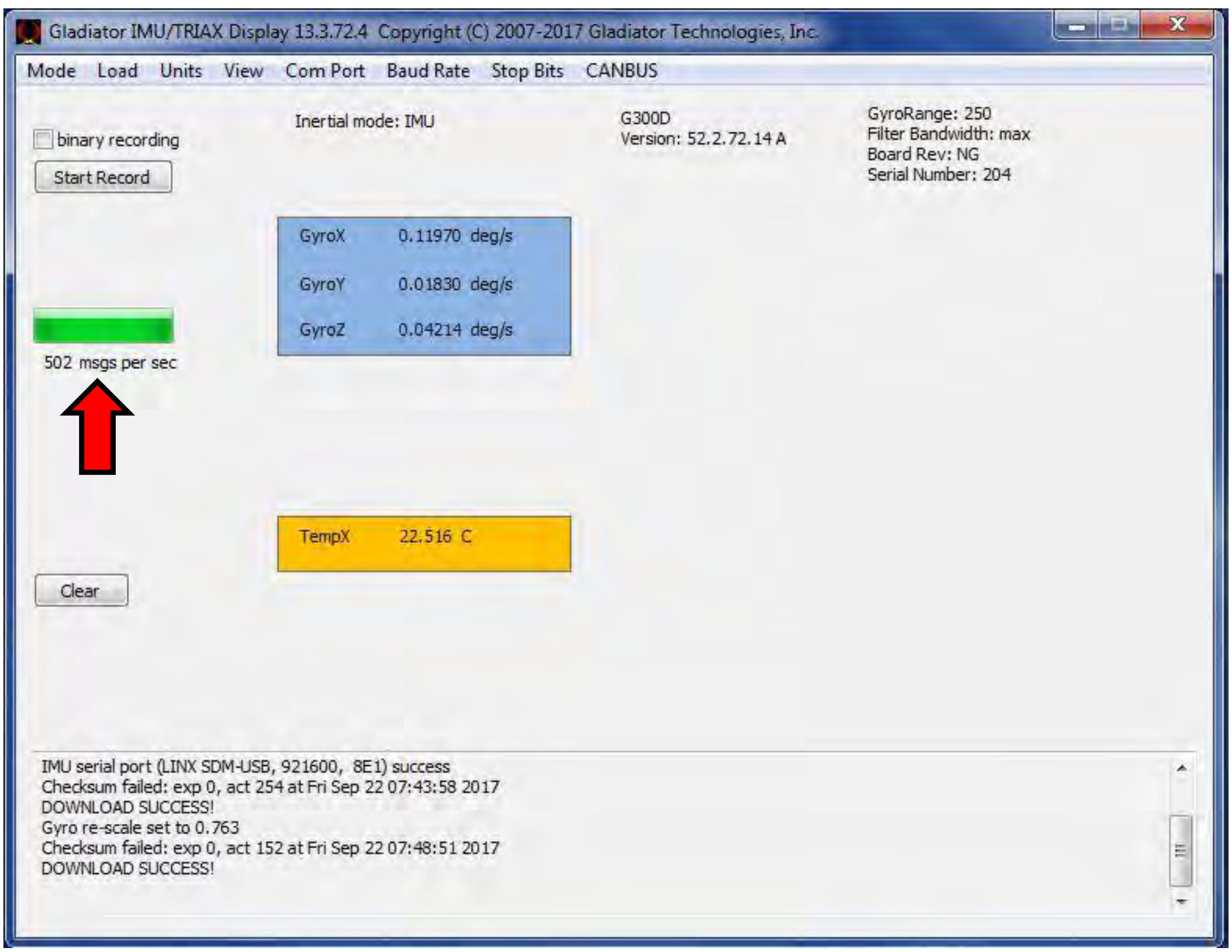


Figure 18 IMU Mode at 500 Hz Data Rate

4.8 *Self-Test in Glamr*

Glamr includes a self-test function. The user can initiate the self-test by the momentary switch (Fig. 19), contained within the switch box that is included in the G300D Triaxial Gyro SDK.

Press the switch button to activate self-test of the sensors. The Glamr display will now show "SELF-TEST" is activated while also showing the data outputs. This message is located just above the data rate status bar. You should see a delta change in the X, Y and Z sensor outputs when you initiate self-test per the data sheet (Fig. 20).

Figure 19 Power and Self-Test Momentary Switch

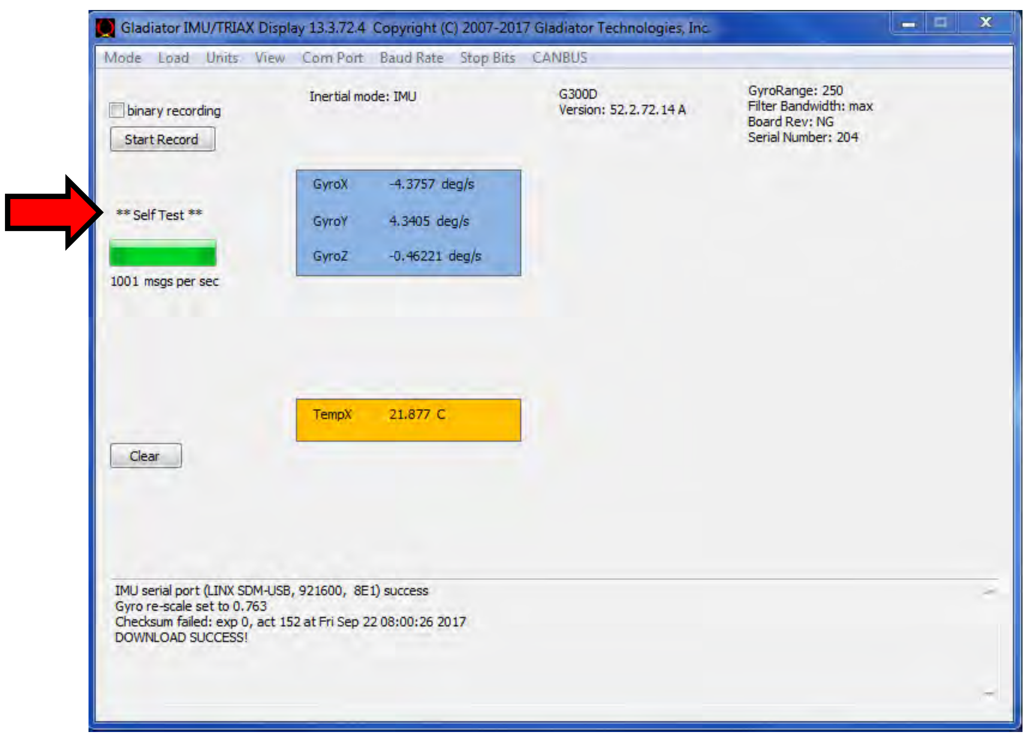


Figure 20 Self-Test Display when Activated

4.9 *Unit Display Options*

The SDK software can also set the dimensional units of the display. This is selected under Units, as seen in Figure 21.

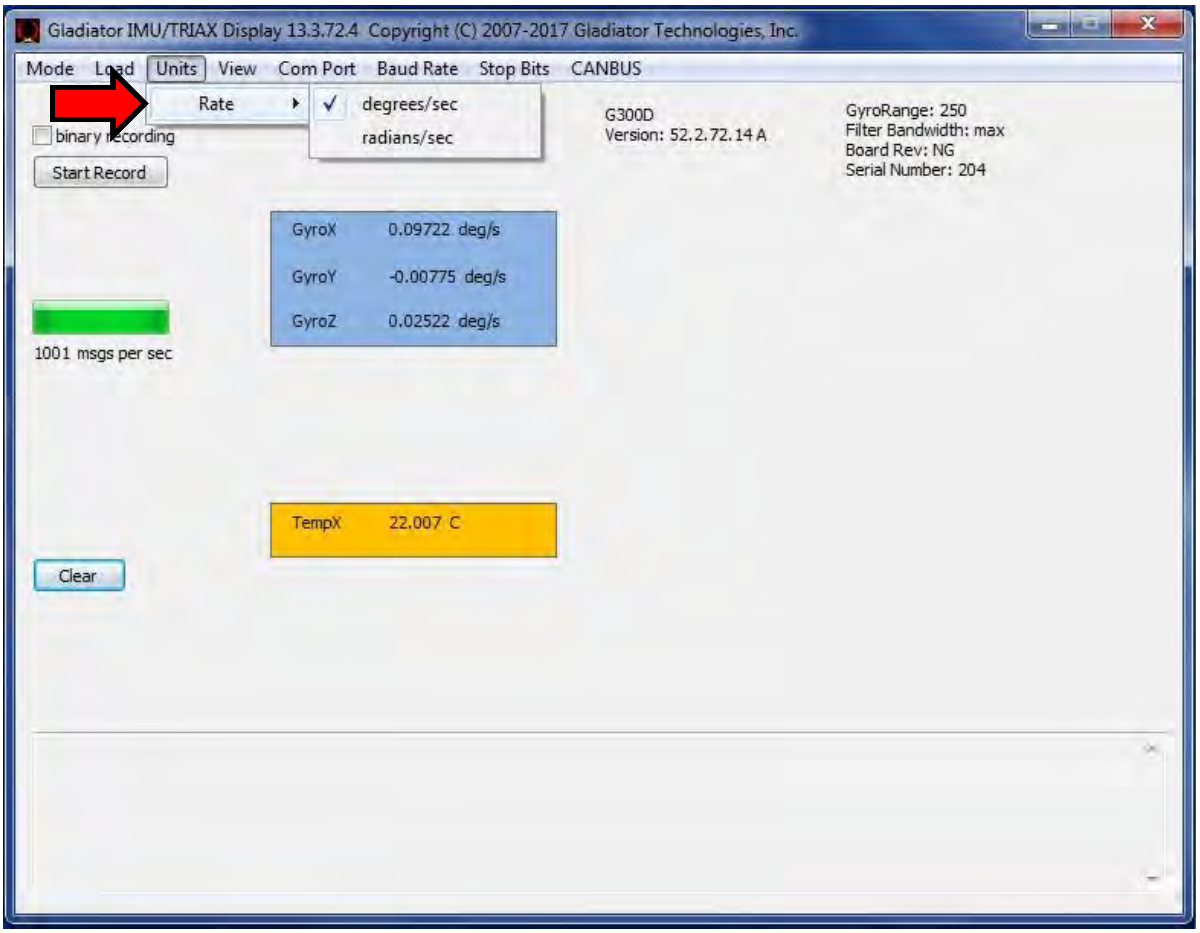


Figure 21 Gyro Units of Measure Selection Options

4.10 *Data Record Feature*

The SDK software also has a data record feature that captures data outputting from the Gyro and puts it into .csv format. This enables the user to easily convert these data files to Excel or database format. The user should click the Start Recording button (Fig. 22) to initiate the data record function. When they wish to stop recording, simply click the Stop Recording button.

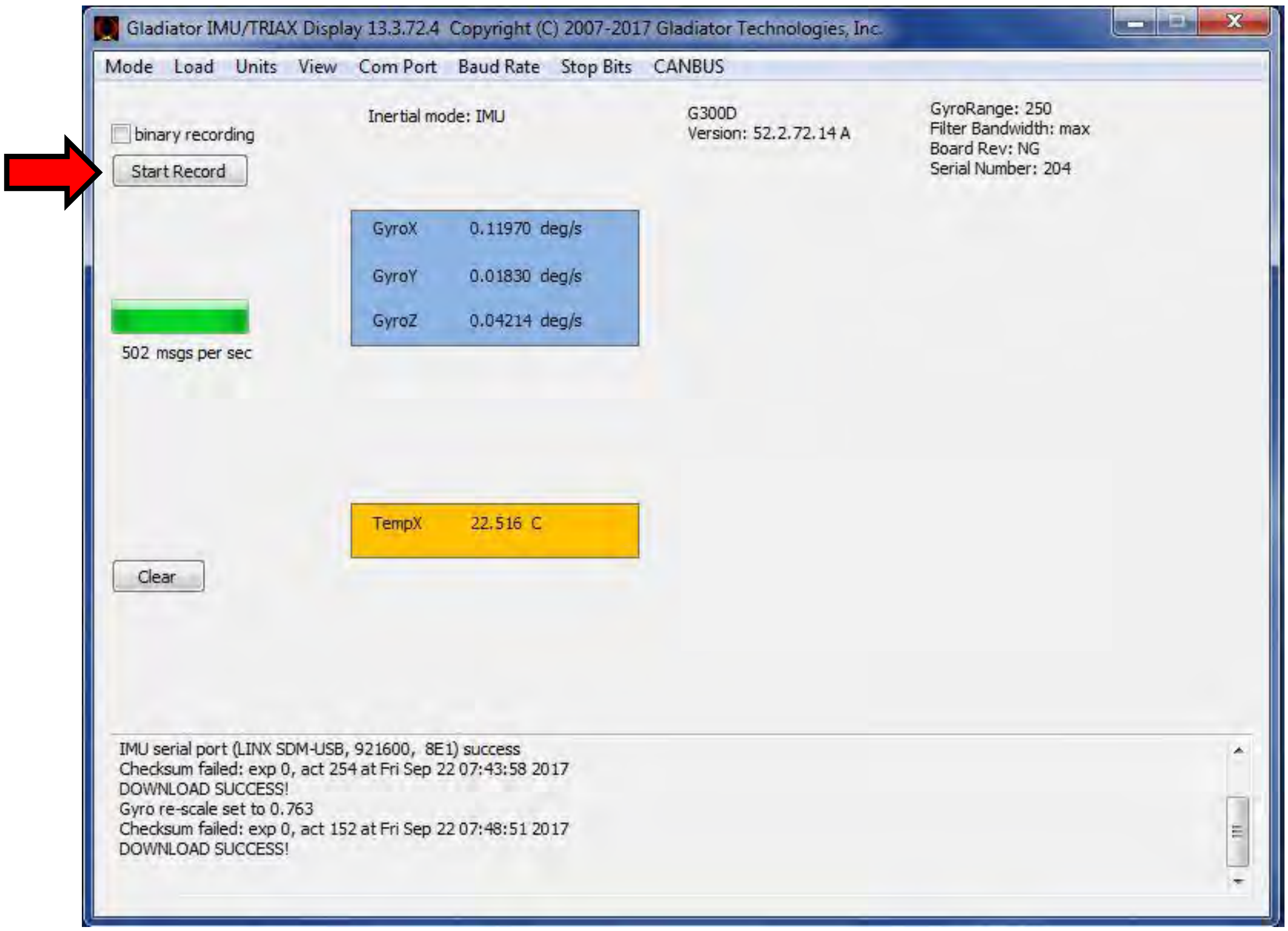


Figure 22 Data Record Capability

Select “Start Record” and designate the file name and location before the recording begins. To begin Data Record function, click on Open as per Figure 23. After the designated file is established, click the desired length of time to record then click OK (Fig. 24).

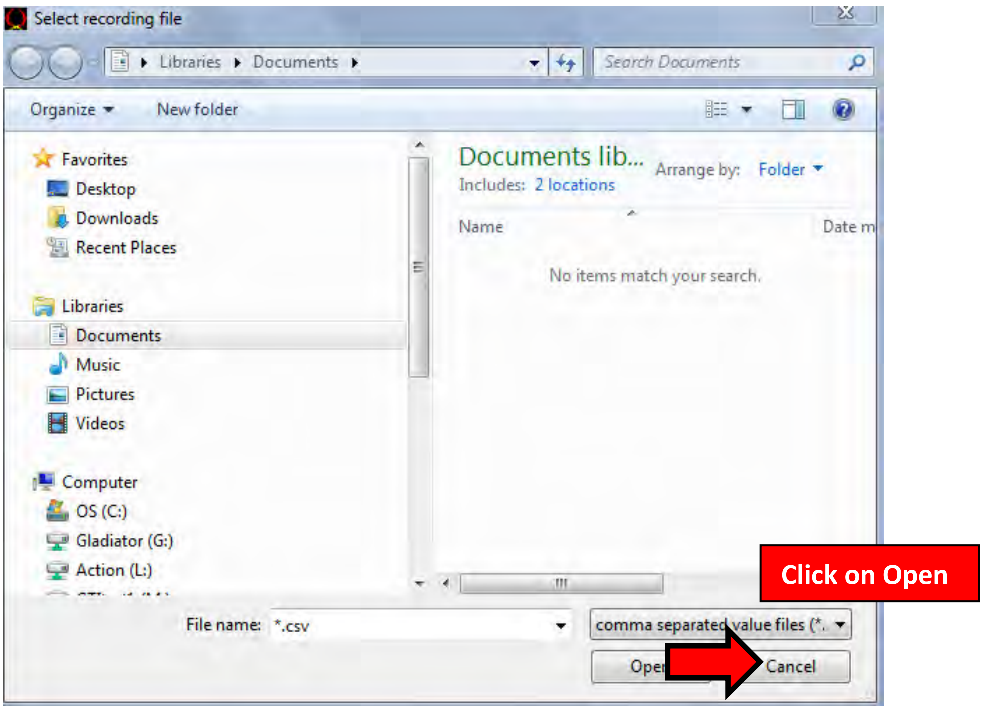


Figure 23 Start Record File Path

NOTE: Be sure to look at the Glamr message log to ensure file path is correct and file has successfully been opened for writing.

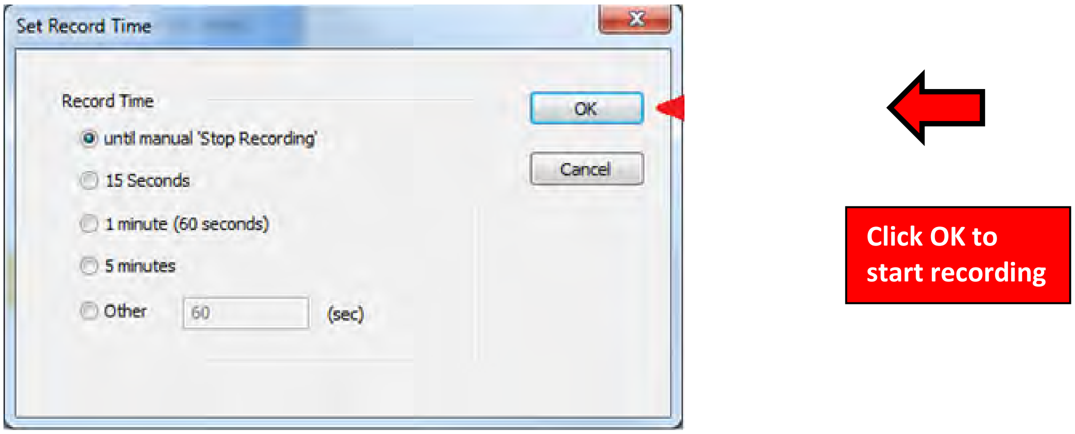


Figure 24 Saving Data Record Time

4.11 *Bandwidth Filtering Capability*

<u>Bandwidth vs. Noise</u>

The user should be aware that the standard G300D Triaxial Digital Gyro is optimized for high bandwidth, so the gyro bandwidth is set at 250 Hz. True bandwidth with the -3 dB point is approximately 250 Hz when the 2.5 kHz sample system is included. These are the settings for the standard unit when shipped and the noise may not be optimized for an end-user's specific application. The high bandwidth is ideal for dynamic applications where the high bandwidth would be required to close control loops in flight control in a UAV, for example. However, in UAV navigation, a lower bandwidth would be possible and there would be an improvement in noise. Laboratory uses, automotive monitoring, or stabilization applications would likely prefer improved noise and could tolerate reduced bandwidth.

Effective with G300D Triaxial Digital Gyro SDK, Gladiator Technologies offers the end-user the capability to set bandwidth filtering in permanent memory. This enables the end-user to set lower bandwidth levels than 250 Hz and benefit from the reduced peak-to-peak noise of the sensors in the G300D Triaxial Digital Gyro. To utilize this capability select Load from the drop down menu as seen in Figure 25.

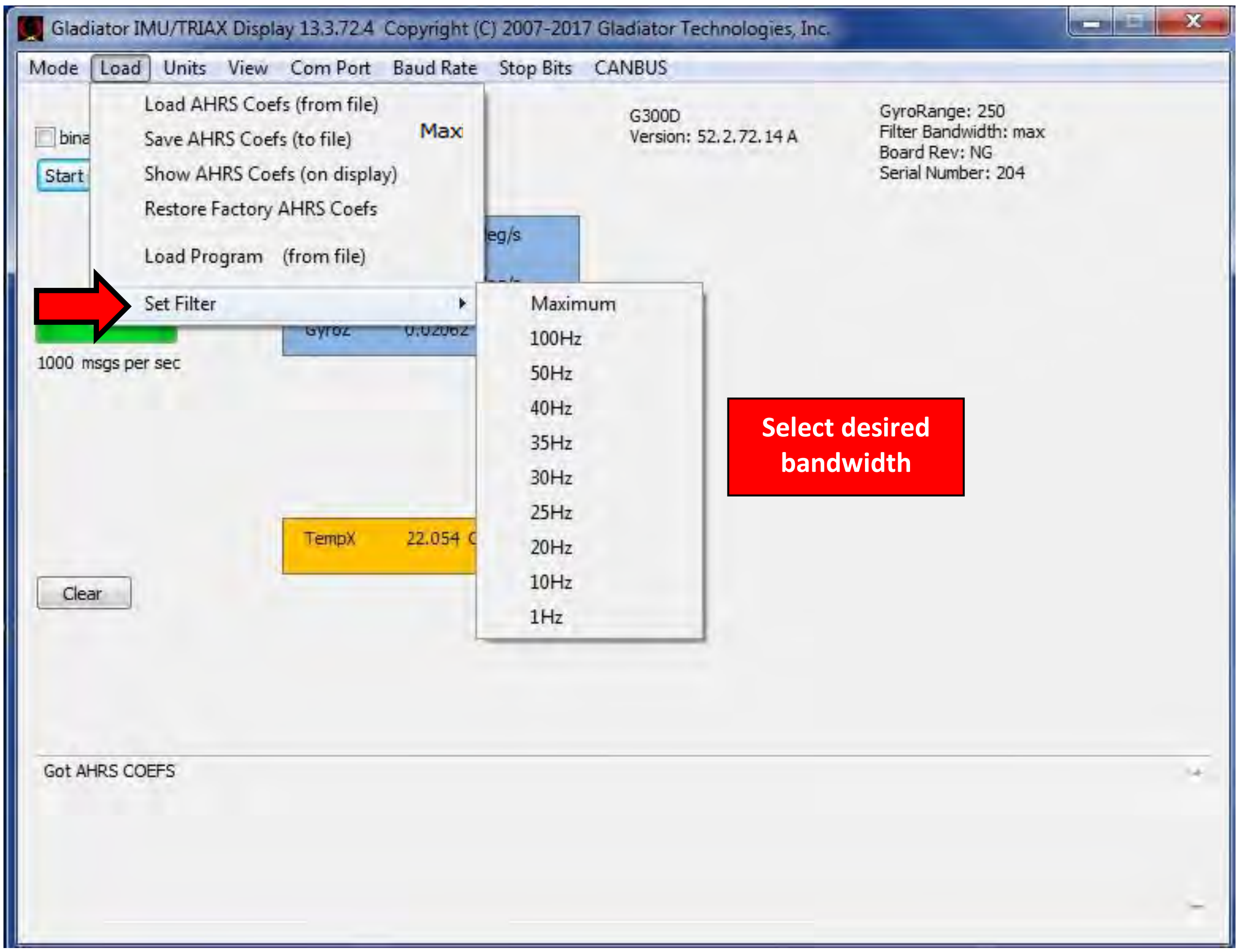


Figure 25 Select Desired Bandwidth Filter from Drop-Down Menu

Next select the desired true bandwidth of the gyros with the software filter. The user can select from Maximum (this is the full sensor bandwidth and standard units are shipped with this setting) or from the other bandwidth options all the way down to 1 Hz. Once this is set and the user takes and confirms data with this new setting, the G300D Triaxial Digital Gyro bandwidth filter setting will remain at the setting until the user changes it in the same manner as detailed in this section.

To help with troubleshooting, users can change what is displayed in the message section of Glamr. This is accessed through the View tab as shown in Figure 26.

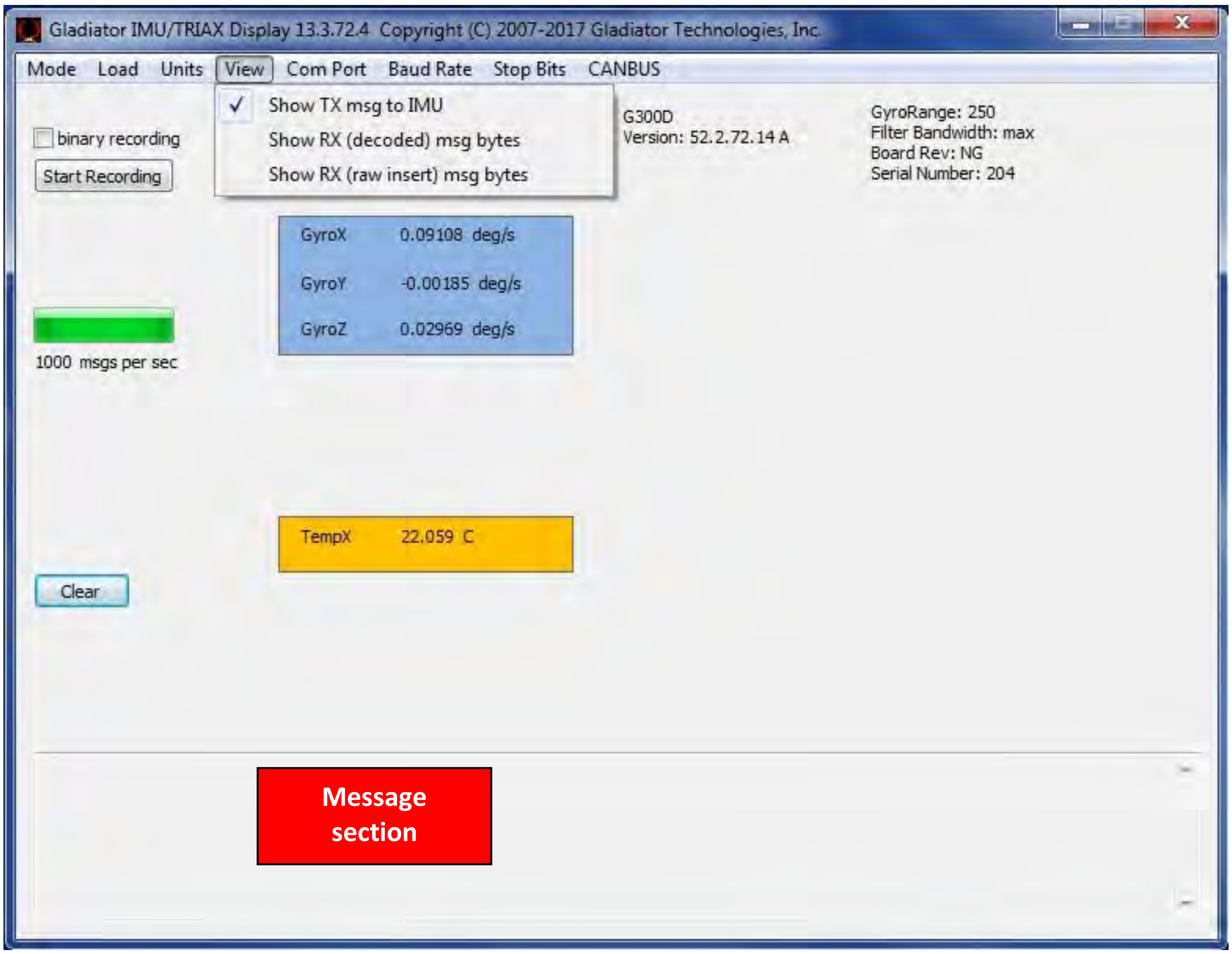


Figure 26 Message Options for Troubleshooting

5 PATENT AND TRADEMARK INFORMATION

The G300D Triaxial Digital Gyro is a newly developed unit containing significant intellectual property and is expected to be protected by United States of America (USA) and other foreign patents pending. LandMark™ is an official and registered Trademark that identifies the Gladiator Technologies brand name for our digital inertial and integrated GPS systems products.

6 APPLICABLE EXPORT CONTROLS

The G300D Triaxial Digital Gyro has been self-classified by Gladiator Technologies with pending Commodity Classification by the U.S. Department of Commerce under the Export Administration Regulations (EAR), as ECCN7A994 and as such may be exported without a license using symbol NLR (No License Required) to destinations other than those identified in country group E of supplement 1 to Part 740 (commonly referred to as the T-5 countries) of the Export Administration Regulations. Items otherwise eligible for export under NLR may require a license if the exporter knows or is informed that the items will be used in prohibited chemical, biological, or nuclear weapons or missile activities as defined in Part 774 of the EAR. Copies of official U.S. Department of Commerce Commodity Classifications are available upon request.

7 USER LICENSE

Gladiator Technologies grants purchasers and/or consignees of Gladiator's G300D Triaxial Digital Gyro a no cost, royalty-free license for use of the following software code for use with the G300D Triaxial Digital Gyro. Companies or persons not meeting the criteria as a purchaser or consignee are strictly prohibited from use of this code. Users in this category wanting to use the code may contact the factory for other user licensing options.

8 STANDARD LIMITED WARRANTY

Gladiator Technologies offers a standard one (1) year limited warranty with the factory's option to either repair or replace any units found to be defective during the warranty period. Opening the case, mishandling, or damaging the unit will void the warranty. Please see Gladiator Technologies' Terms and Conditions of sale regarding specific warranty information.

9 QUALITY MANAGEMENT SYSTEM

Gladiator Technologies' Quality Management System (QMS) is certified to AS9100 Rev. C and ISO9001:2008. UL DQS is the company's registrar and our certification number is 10012334 ASH09-1.

Please visit our website at www.gladiatortechnologies.com to view our current certificates.

10 THEORY OF OPERATION

The G300D Triaxial Digital Gyro is a digital 3 Degree of Freedom MEMS (Micro Electro-Mechanical System) IMU that provides delta theta information, as well as temperature. Utilizing Gladiator Technologies' proprietary thermal modeling process, this unit is fully temperature compensated, with temperature-corrected bias and scale factor, plus corrected misalignment and g-sensitivity.

The unit features:

- The RS-422/RS485 serial digital interface provides serial data outputs and enables the user to monitor the outputs during use. Internal sampling is done at 8 kHz. Oversampling is done on the Gyro output rate (2X) when set at 2.5 kHz and then averaged to improve the noise of the MEMS sensors. The nominal output rate in the G300D Triaxial Digital Gyro is 2.5 kHz ± 5%. An RS-422/RS485 to USB converter is available in Gladiator's G300D Triaxial Digital Gyro Software Development Kit (SDK) to enable quick G300D to PC integration and ease of use.
- Three MEMS gyro signals with active filtering and 2X oversampled when set at 2.5 kHz with a 16-bit A/D converter. The gyros are available in standard ranges of ± 250°/sec or ± 490°/sec.
- Two internal temperature sensor outputs are 2X oversampled when set at 2.5 kHz with a 16-bit converter. These temperature measurements are co-located with the x-, y-, and z-axis gyros to enable accurate temperature compensation of the gyro outputs.
- The calibration process measures temperature at a minimum of five set points from -40°C to +85°C and a nine-point correction table is generated that identifies temperature based offsets for each of the gyro data sets. Depending upon the variable, up to a 4^{th} order thermal model is used to create a correction model.
- Though a precision orthogonal mounting block is used in the G300D Triaxial Digital Gyro, misalignment error correction is also essential in enabling high performance navigation from a MEMS inertial sensor assembly. The calibration process also corrects and compensates for internal misalignment errors for all sensors in all three axes.
- In addition, "g-sensitivity" errors associated with the gyros are also modeled and calibrated to correct these performance errors associated with acceleration inputs in all three gyro axes.
- All of the calibration data is then loaded into an internal memory EEPROM enabling a look-up table for thermal modeling correction of the outputs during use.

The G300D Digital Triax MEMS Gyro data sheet is available to our gyro customers via download on our website. For more information please see Gladiator Technologies' website at www.gladiatortechnologies.com. Copies of product User's Guides are available upon request at support@gladiatortechnologies.com

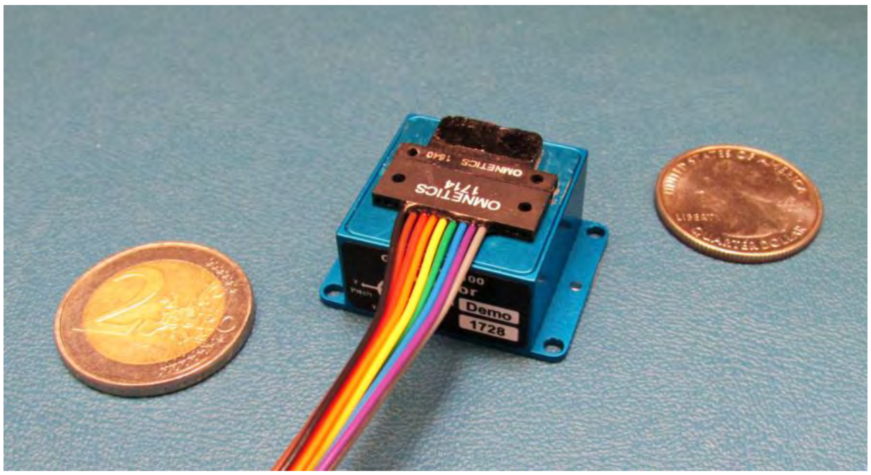


Figure 27 G300D Triaxial Gyro with Mating Connector vs. 2 Euro Coin & US Quarter

11 G300D TRIAXIAL DIGITAL GYRO PRODUCT DESCRIPTION

The G300D Triaxial Digital Gyro is our digital output triaxial gyro model featuring our lowest noise MEMS gyros that also offer outstanding bias in-run and bias over temperature. This high performance MEMS Triaxial Gyro provides internally temperature-compensated RS-422/RS485 output of delta thetas.

Designed for commercial stabilization and aircraft applications, the G300D Triaxial Digital Gyro is ideal for commercial applications requiring high inertial performance approaching “small RLG or open loop FOG-Class,” yet available at much lower cost. Other key advantages include low power consumption, small size, light weight and no inherent wear out modes for long life. The signature features of the G300D Triaxial Digital Gyro are the exceptionally low noise and bias performance.

- **Non-ITAR MEMS Digital Triaxial Gyro** *(0.6” Cube)*
- **Smallest Triaxial Gyro in its Performance Class**
- **Low Noise** *< 0.0028°/sec/√Hz*
- **Wide Sensor Bandwidth** *250 Hz, Low Latency*
- **Gyro Bias In-Run** *5°/hour 1σ*
- **Bias Over Temperature** *≤ 0.1°/sec 1σ*
- **Compensated Misalignment** *≤ 0.5 mrad 1σ*
- **G-Sensitivity** *≤ 0.001°/sec/g 2σ*
- **Full Temperature Calibration** *(Bias and SF)*
- **Vibration** *$8g_{rms}$*
- **Shock Resistant** *600g*
- **Light Weight** *≤ 18 grams*
- **Ultra-Low Power** *< 200 mW typical*
- **RS-422/485 Serial Data** *up to 6 kHz (selectable)*
- **CAN BUS 2.0B 1 MHz** *(-200 option)*
- **Low Voltage** *+3.8 V to +5.5 V*
- **External Sync Input** *up to 6 kHz*

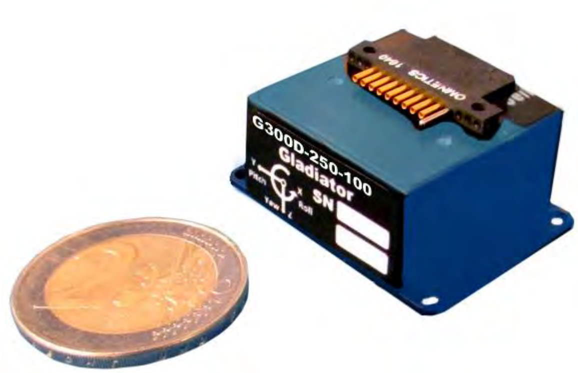


Figure 28 G300D Triax Gyro with 2 Euro Coin

The G300D’s ultra-low noise and low bias MEMS gyros enable precision measurement including excellent in-run bias and bias over temperature. The gyro’s performance is optimized with fully temperature compensated bias and scale factor, as well as compensated misalignment and g-sensitivity. The unit is environmentally sealed in a rugged enclosure and has a MIL-SPEC connector in order to withstand environmental vibration and shock typically associated with commercial aircraft requirements. The G300D Triaxial Digital Gyro is well suited for demanding commercial applications including: precision imaging, platform and antenna stabilization, rail track telemetry, navigation, flight control, flight testing, and laboratory use. Other standard custom ranges are available.

11.1 *Outline Drawing and 3D Solid Models*

Please go to the applicable product of interest on our website at www.gladiatortechnologies.com and download the 3D Solid Model, 2D outline drawing, and other product information.

11.1.1 *3D Solid Model*

Figure 29 shows the G300D Triaxial Gyro in a 3D environment.

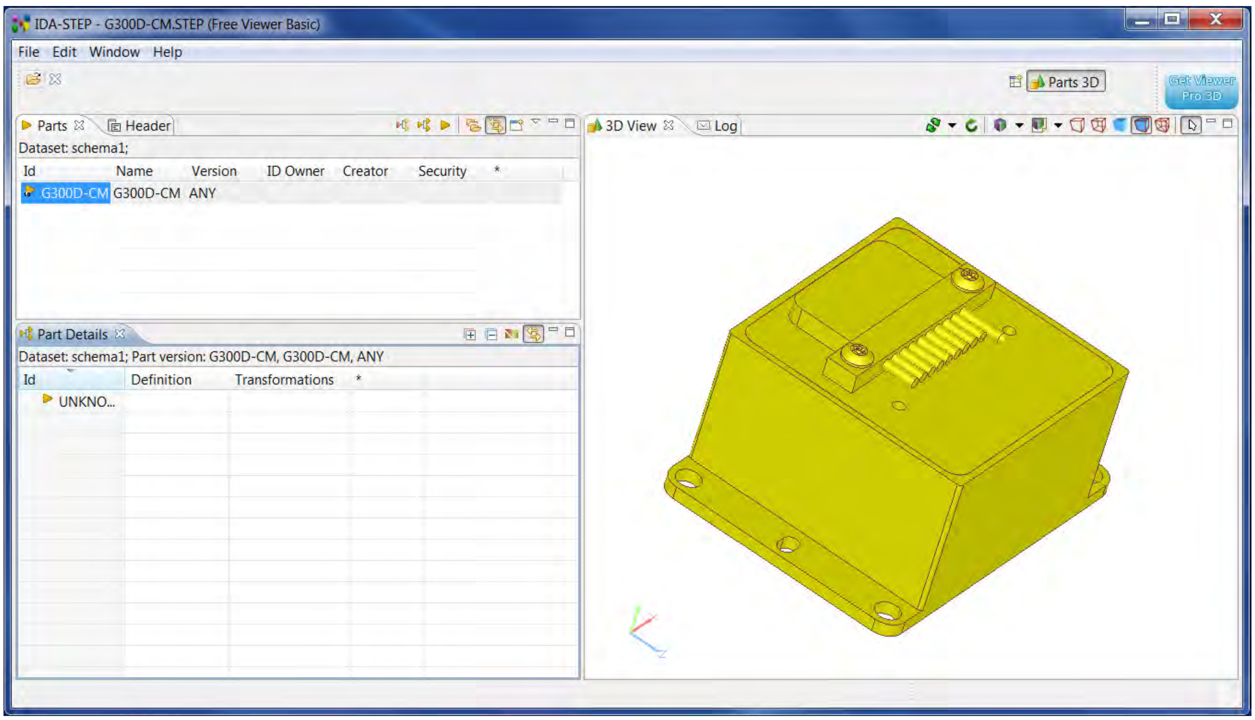


Figure 29 G300D Triaxial Digital Gyro 3D Model

11.1.2 *Outline Drawing*

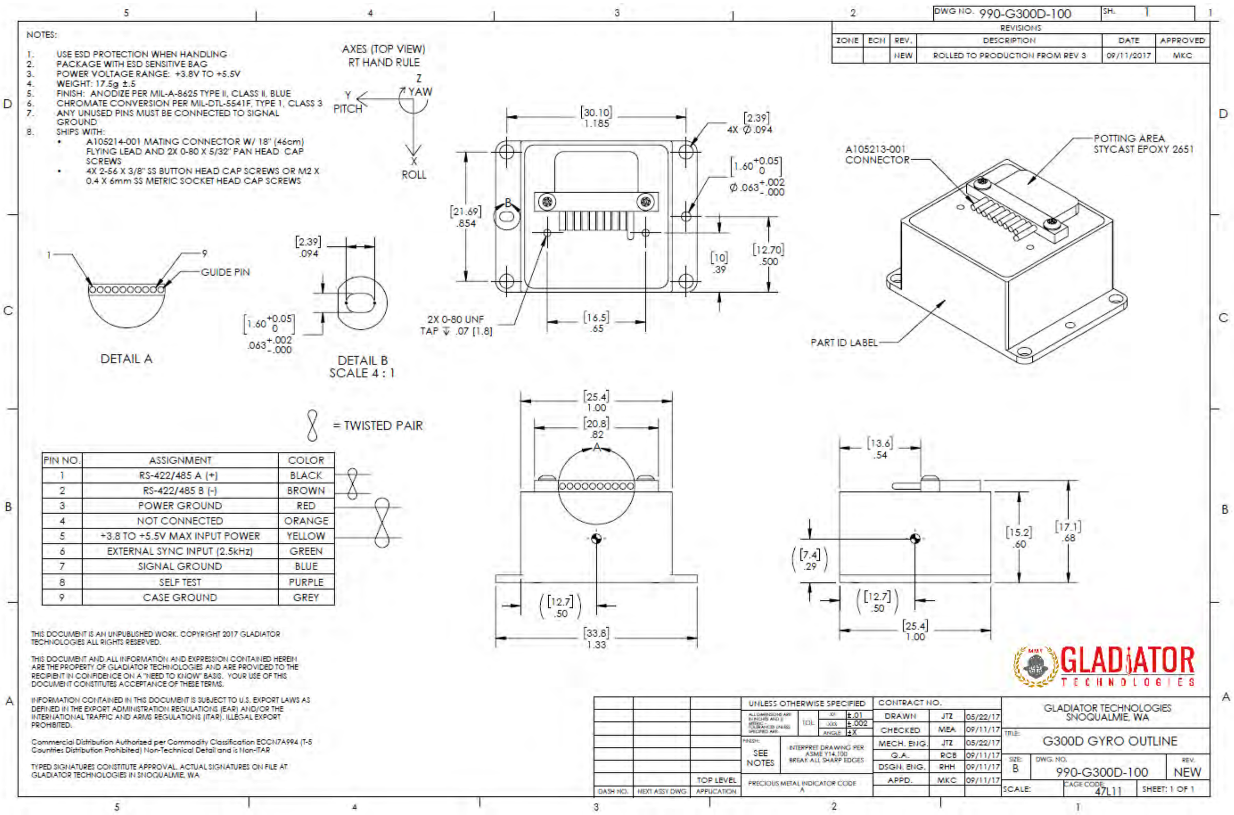


Figure 30 Standard G300D Triaxial Digital Gyro Outline Drawing

11.2 *Outline Exploded View & Axis Orientation*

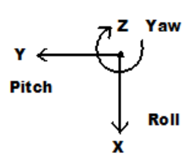
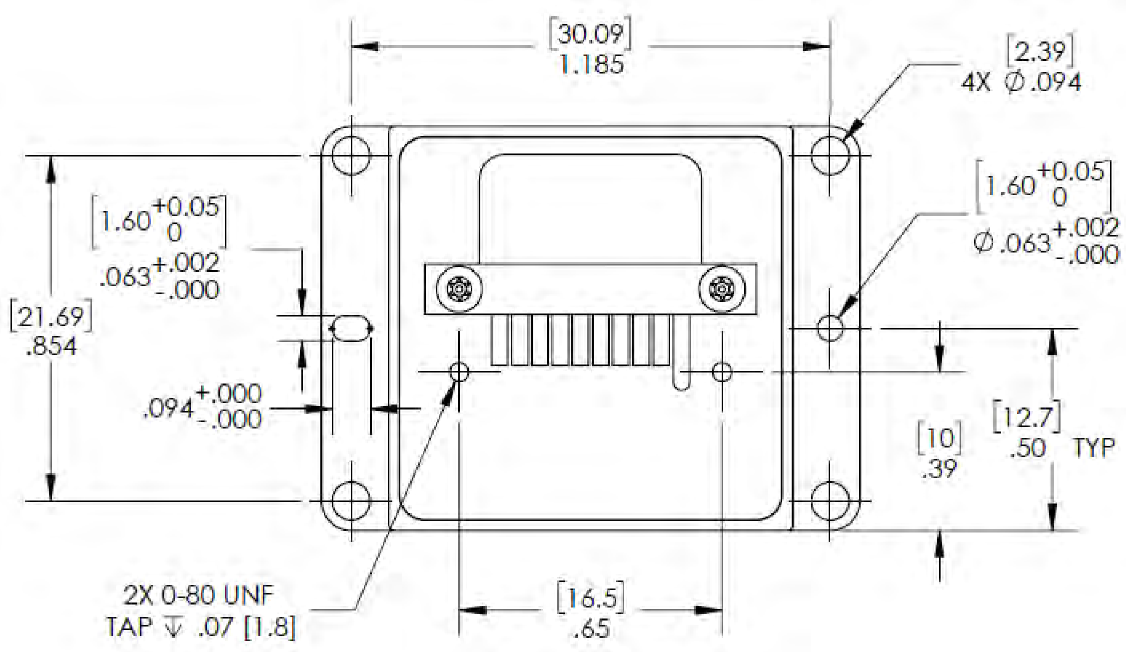


Figure 31 Axis Orientation



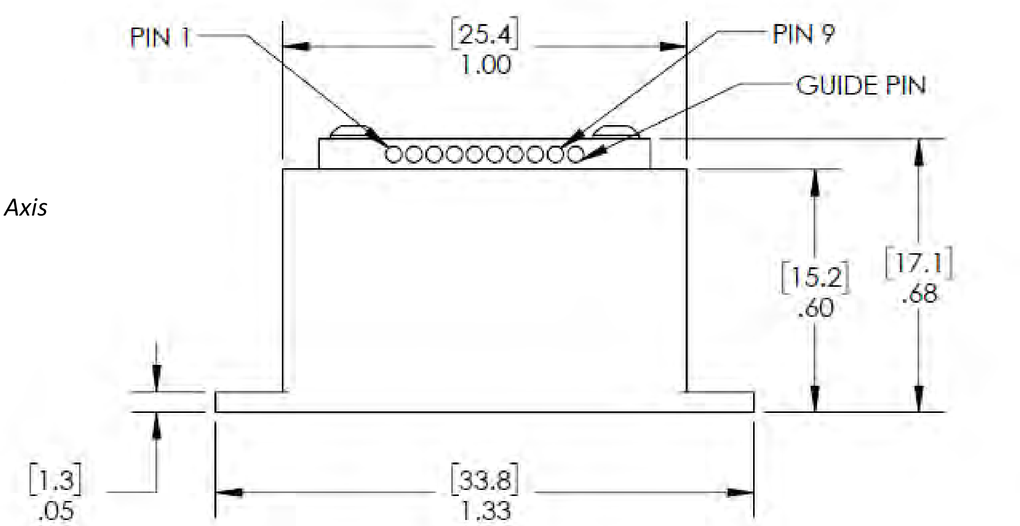


Figure 32 G300D Triaxial Digital Gyro Exploded Outline Drawing (metric in [mm])

11.3 *Center of Gravity*

Some applications need to know the CG (center of gravity) of the package, which is simply the mass center. The CG is near the center line of the package, located at the midpoint along the z-axis above the base plate and with the following offsets:

- X offset = 0 inches (0 mm) along the centerline
- Y offset = 0 inches (0 mm) along the centerline
- Z offset = +0.29 inches (7.4 mm) above the case mounting plane

11.4 *G300D Triaxial Digital MEMS Gyro Block Diagram*

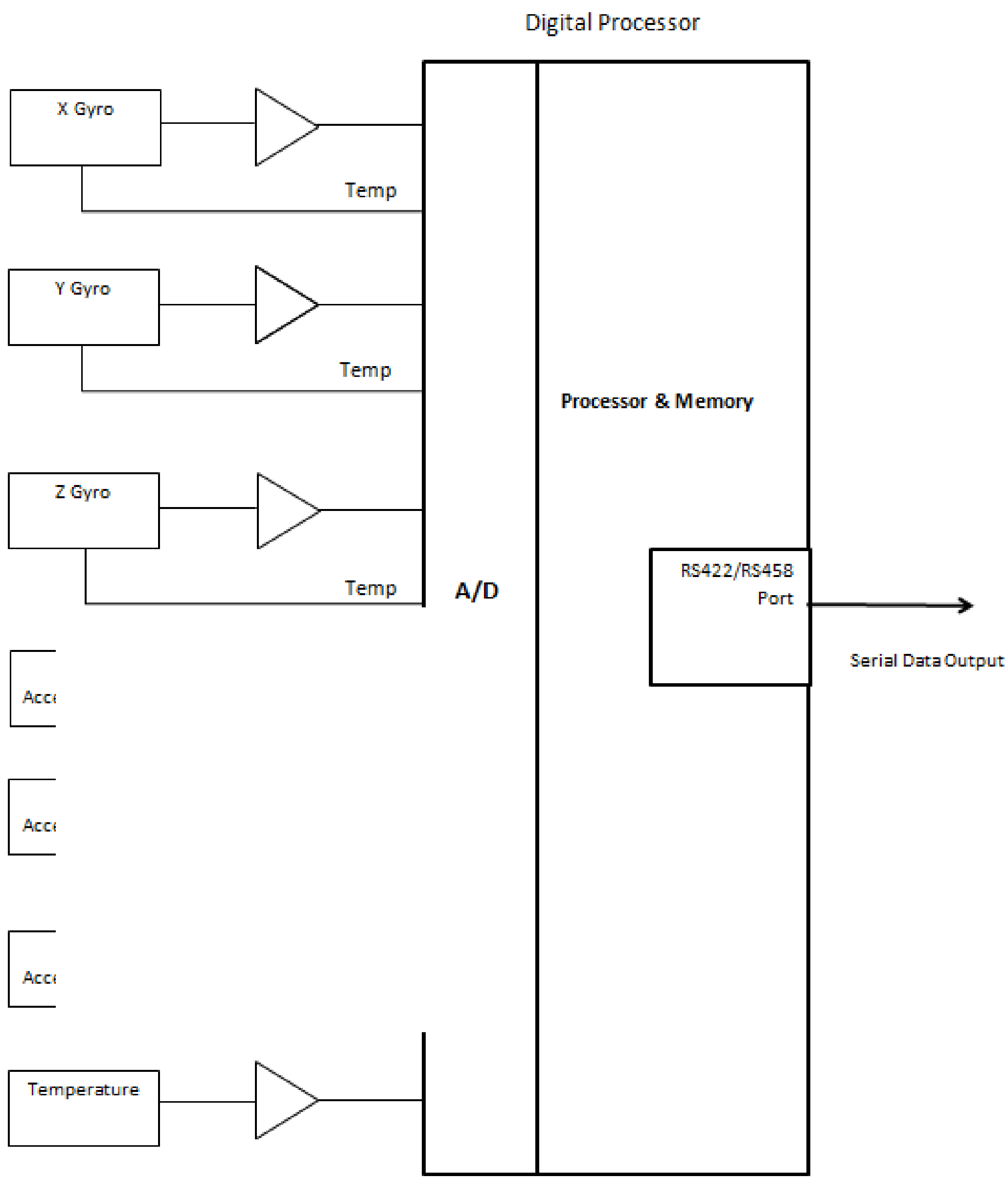


Figure 33 G300D Triaxial Digital Gyro Block Diagram

11.5 *G300D Triaxial Digital Gyro Part Naming Convention & Part Numbers*

G300D-250-100

G300	**D**	**250**	**100**
Product Make *"Gyro"*	**Product Model** *"Digital"*	**Gyro Rate Range** *"250°/sec"*	**Specific Unit Configuration** "100" (Triax)

Figure 34 Gladiator Technologies Part Naming Convention

G300D Digital Gyro
G300D-250-100 Triax 250°/sec
G300D-490-100 Triax 490°/sec

Figure 35 G300D Triaxial Digital Gyro Part Number Configurations

Please note that the G300D Triaxial Digital Gyro is also available in the -200 unit configuration.

11.6 *G300D Triaxial Digital Gyro Pin Assignments*

The G300D Triaxial Digital Gyro has a nine pin MIL-SPEC connector interface which provides the electrical interface to the host application. Be aware that the signal pin-outs differ slightly between the -100 and -200 versions.

11.6.1 *G300D-100*

Pin No.	Assignment
1	RS-422/485 A (+) (Twisted Pair)
2	RS-422/485 B (-) (Twisted Pair)
3	Power Ground
4	N C
5	+3.8 V to +5.5 V Max Input Power
6	External Sync Input (up to 6 kHz)
7	Signal Ground
8	Self Test Input (3.3 V logic)
9	Case

If Pin 6 is not used, connect to Pin 8.

Outputs	Serial Sequence at 1 kHz
1	Roll Gyro (X)
2	Pitch Gyro (Y)
3	Yaw Gyro (Z)
4	Temperature ± 0.5°C *typical*

Figure 36 G300D-250-100 Triaxial Digital Gyro Pin Assignments and Outputs

11.6.2 *G300D-200*

Pin No.	Assignment
1	RS-422/485 A (+) (Twisted Pair)
2	RS-422/485 B (-) (Twisted Pair)
3	Power Ground
4	External Sync Input (up to 6 kHz)
5	+3.8 V to +5.5 V Max Input Power
6	CAN L
7	CAN H
8	Signal Ground
9	Case

If Pin 4 is not used, connect it to Pin 8.

Outputs	Serial Sequence at 1 kHz
1	Roll Gyro (X)
2	Pitch Gyro (Y)
3	Yaw Gyro (Z)
4	Temperature ± 0.5°C *typical*

Figure 37 G300D-250-200 Triaxial Digital Gyro Pin Assignments and Outputs

NOTE: If the input pins have long wires with no termination, they can pick up noise in a high EMI environment and upset the proper operation of the Gyro. Pin 4 is particularly vulnerable to noise pickup and can cause data drops and is OK if connected to a logic level 5 kHz signal source, otherwise connect to Pin 8.

11.7 *G300D Triaxial Digital Gyro Performance Specification*

See applicable current revision data sheet available on our website at www.gladiatortechnologies.com.

12 G300D Triaxial Digital Gyro MESSAGE PROTOCOL (≥ V72)

12.1 *Serial Communication Settings*

Parameter	Value
Bits/second:	115200, 921600, 1.5 Mbit, 3.0 Mbit
Data bits:	8
Parity:	E
Stop bits:	1

Figure 38 Serial Communication Settings

12.2 *Triaxial Gyro Message Packet Format*

At power-up, the Gyro enters operational mode using the last commanded mode setting. Please refer to the Gladiator Technologies Software Reference for additional information.

12.3 *Sample Data Format*

Figure 39 provides a sample Gyro data output in Excel. The real output includes both the header information and data (see rows with MSGCOUNT) that contain actual output data. Also included are the multiplier information, averages, and units of measure for additional clarity for the user. The Gyro Software Development Kit also includes the actual Excel file as in Figure 39, so that the user can quickly identify the formulas to use in their system integration directly from the sample data file.

1	MSGCOUNT	GYRX (°/s)	GYRY (°/s)	GYRZ (°/s)	TEMPX (C)
236	69	-3.174	-3.456	249.875	24.98
237	70	-2.365	2.579	249.875	24.95
238	71	-2.953	1.869	249.875	24.94
239	72	2.594	3.151	249.875	24.95
240	73	-0.603	5.73	249.875	24.98
241	74	-3.54	-3.403	249.875	24.96
242	75	-0.557	6.417	249.875	24.95
243	76	-3.35	-2.907	249.875	24.94
244	77	4.265	-0.053	249.875	24.94
245	78	-9.705	-1.48	249.875	24.94
246	79	5.776	3.99	249.875	24.96
247	80	3.09	-2.808	249.875	24.98
248	81	-6.302	1.358	249.875	24.95
249	82	0.61	-3.334	249.875	24.95
250	83	-0.45	-0.313	249.875	24.95
251	84	0.862	-3.968	249.875	24.94
252	85	2.258	0.694	215.83	24.94
253	86	-1.511	-3.662	179.488	24.92

Figure 39 Screenshot of G300D Triaxial Digital Gyro Sample Data

Please note that when a customer uses the Glamr interface it automatically rescales the gyros. This is displayed in Figure 39, as well as the sample Excel file included in the G300D Triaxial Digital Gyro Software Development Kit (SDK). However, if the user is not using Glamr and inputting directly into their system then they should use the LSB's noted above (LSB 0.00763°/sec for 250°/sec rate range gyros and 0.01 degrees for temperature).

12.4 *Sync Input (2.5 kHz)*

The optional input to the Gyro is a sync square wave to Pin 6. This allows the data stream to be synchronized to an external clock. For example, if the user wants to supply and sync an external GPS to the Gyro, the GPS can generate a 2.5 kHz square wave which is sent to the Gyro when the GPS signal is valid. However, any external 2.5 kHz clock of logic level can be used to synchronize the data.

12.4.1 *Specification*

- Clock 2.5 kHz ± 5% square wave (40 - 60 duty cycle not critical)
- Data sample starts on rising edge only
- 3.3 V logic is suggested (-0.3 V < "0" < 0.8 V and 2.0 V < "1" < 5.3 V) with respect to signal ground
- Input has diode protection for levels below -0.7 V or above 5.5 V to 10.5 V to protect the CPU, but excessive levels may cause performance problems

12.4.2 *Status Bit*

The Gyro will operate on an internal 5 kHz clock (which is internally counted down to 2.5 kHz for output) until an external clock is detected. Then the Gyro will automatically switch over and set Status Bit 1 to true. It should be noted that as the internal and external clocks are asynchronous, the first transition to Ext Sync will take a few clock periods to align. The Status Bit will be set true for that period even if there is only one sample. However, the next data package will all be samples on the external clock. Refer to the timing diagram to see the relationship between external clock and data transmission (Fig. 40). The Gyro will revert to the internal clock if the external clock is removed.

12.4.3 *Timing Diagram*

Timing (2.5kHz)	0.2 msec	0.4 msec	0.6 msec	0.8 msec	1.0 msec	1.2 msec	1.4 msec	1.6 msec	1.8 msec	2.0 msec
Data Reads	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS	GYROS ACCELS
Processor samples		1		2		3		4		5
Average delay Gyro			12µs±62.5µs							
Accel		-110µs±125µs								
Processor Starts										Samples
Process Ends			40µs±9µs							Repeat
Transmission Starts										
3M baud Ends			52µs							
Total Delay Gyro			92µs±62.5µs	=	154.5	µsec max				
Accel			202µs±125µs	=	327	µsec max				
Degrees at 2500Hz = Gyro						360*0.1545/0.4	139.05	degrees		
Accel						360*0.247/0.4=	294.3	degrees		
Degrees at 50 Hz = Gyro						139.05/50=	2.8	degrees		
Accel						222.30/50=	5.9	degrees		
250Hz Single Pole							11.3	degrees		
Accel										
349Hz Single Pole								8.2	degrees	
N=3							Gyro	Accel		
Total Degrees at 50Hz							14.1	14.1	degrees	

Figure 40 2.5 kHz Timing Diagram

12.5 *Bandwidth vs. Noise*

Note that our standard G300D Triaxial Digital Gyro is optimized for high bandwidth, so the gyros are set at 200 Hz. True bandwidth includes the data sampling effects and has the -3 dB point, which is approximately half of the sample frequency. These are the settings for the standard unit when shipped and the noise may not be optimized for an end-user's specific application. The high bandwidth is ideal for dynamic applications where the high bandwidth would be required to close control loops in flight control in a UAV, for example. However, in UAV navigation, a lower bandwidth would be possible and the unit would output an improvement in peak-to-peak noise. Laboratory uses, automotive monitoring, or stabilization applications would likely prefer improved (lower) noise and could tolerate reduced bandwidth.

The G300D Triaxial Digital Gyro Software Development Kit offers the end-user the ability to set bandwidth filtering in permanent memory. This enables the end-user to set lower bandwidth levels than the sensor bandwidth in order to benefit from the reduced peak-to peak noise of the sensors in the IMU.

			Output Data Rate			
Bandwidth Hz	100Hz	200Hz	500Hz	1000Hz	2500Hz	5000Hz
250	N/A	N/A	1	1	1	1
100	N/A	1	0.715	0.4665	0.2222	0.12
50	0.957	0.792	0.467	0.2692	0.1181	0.061
40	0.92	0.715	0.395	0.222	0.0957	0.049
35	0.89	0.667	0.356	0.1974	0.0842	0.043
30	0.848	0.61	0.314	0.1718	0.0726	0.037
25	0.792	0.544	0.27	0.14536	0.0609	0.031
20	0.715	0.47	0.222	0.1181	0.049	0.025
10	0.46	0.27	0.118	0.0609	0.0248	0.0125
1	0.061	0.031	0.0125	0.0062	0.00251	0.00125

Figure 41 Bandwidth Frequency and Output Data Rate

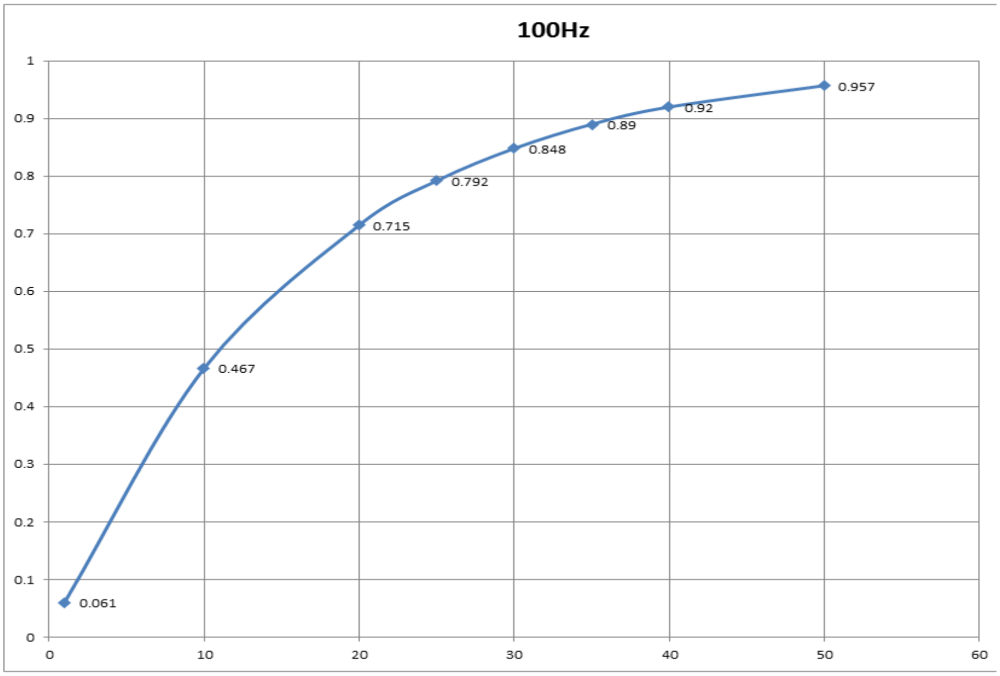


Figure 42 Gyro Bandwidth vs. Peak-to-Peak Noise 100 Hz

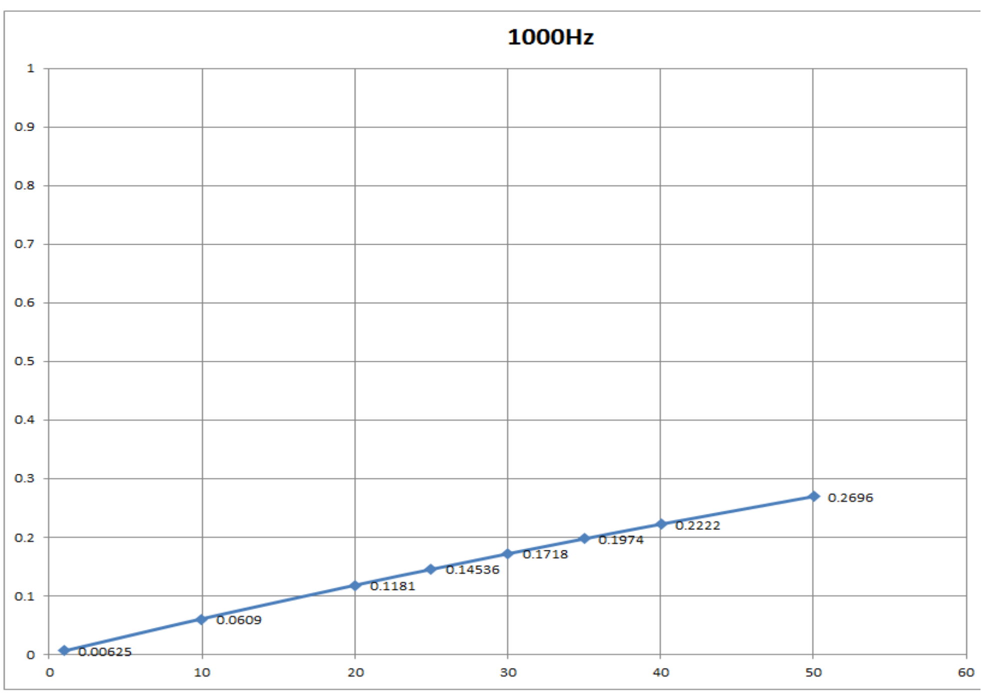


Figure 43 Gyro Bandwidth vs. Peak-to-Peak Noise 1 kHz

13 SAMPLE TEST DATA & TEST METHODS

13.1 *Gladiator ATP Explanation*

13.1.1 *Rate Spin Test*

Data is captured at 100 Hz data rate. The unit is mounted on an orthogonal test fixture and spun at about half of the full scale rate range. Only the rate scale factors and gyro misalignments are measured. The data comes across as a raw number with an LSB of 0.01 deg/sec. This means that all the data has to be divided by 100 to get into degrees/second units. The spin rate in the data seen in Figure 55 is 72°/sec. Each column is the data taken for the axis name at the top of the column during the test at the left. The final values printed in green fall within the "passing" values for the unit (note that all passed).

The gyro misalignment is first transformed into degrees per second by dividing by 100. The first row has the term for the X-Axis gyro, "Diff/2" for X while the Y Axis is spun. The second term for the X Axis gyro, "Diff/2" for the X Axis while the Z Axis is spun. The same is done for the next two rows. The result is converted into milliradians by dividing the spin rate, 72° per second, and dividing by 1000.

Test	gyroX	gyroY	gyroZ	temp X
PX	143.9818	0.013266	-0.01593	2571.992
NX	-143.968	0.01727	-0.01433	2571.686
Diff/2	143.9747	-0.002	-0.0008	0.153
Ave	0.007052	0.015268	-0.01513	2571.839
PY	0.009355	143.9924	-0.01854	2577.073
NY	0.005935	-143.961	-0.0148	2576.088
Diff/2	0.00171	143.9767	-0.00187	0.4925
Ave	0.007645	0.015702	-0.01667	2576.581
PZ	-0.00096	0.018796	143.93	2583.618
NZ	0.006401	0.013186	-143.972	2582.081
Diff/2	-0.00368	0.002805	143.9508	0.768618
Ave	0.002721	0.015991	-0.02078	2582.85
RSF Norm	0.999824	0.999838	0.999658	Temp °C
				25.77
Gyro Mis-Align deg/sec				
x		0.0017	-0.0037	
y	-0.0020		0.0028	
z	-0.0008	-0.0019		
Gyro Mis-align mrad				
x		0.012	-0.026	
y	-0.014		0.019	
z	-0.006	-0.013		

Figure 44 Rate Spin Test

13.1.2 *1g Tumble Test*

Data is captured at 100 Hz data rate. The unit is mounted on an orthogonal test fixture and placed in ± 1g and ± 0g in this test. During this test both the gyro biases and g-sensitivity are measured.

Test	gyroX	gyroY	gyroZ	temp X
PX	0.00913	0.00977	-0.01421	2577.99
NX	0.00673	0.01408	-0.01611	2578.16
Diff/2	0.0012	-0.00216	0.00095	-0.0885
Ave	0.00793	0.01193	-0.01516	2578.07
PY	0.00696	0.01177	-0.01397	2572.85
NY	0.00653	0.0139	-0.01547	2572.58
Diff/2	0.00022	-0.00106	0.00075	0.1305
Ave	0.00675	0.01284	-0.01472	2572.71
PZ	0.00814	0.01421	-0.01531	2572.66
NZ	0.00636	0.01101	-0.01448	2573.25
Diff/2	0.00089	0.0016	-0.00041	-0.29275
Ave	0.00725	0.01261	-0.0149	2572.95
Bias °/s,mg	0.0073	0.0125	-0.0149	25.75
ASF Norm				Temp °C

			Input g =	
Gyro °/s /g				
x	0.0012	0.0002	0.0009	
y	-0.0022	-0.0011	0.0016	
z	0.0010	0.0008	-0.0004	

Figure 45 1g Tumble Test Data

13.2 *Angle Random Walk (ARW) and Allan Deviation*

The unit is mounted on an orthogonal fixture and is turned on with no input. Data is captured at 200 Hz data rate. The white noise due to angular rate is measured. ARW is typically expressed in our datasheets in degrees per second per square root hertz (°/sec/√Hz), which is standard for most MEMS gyros. However, our performances are now commensurate with higher performing small open loop FOG's and small RLG's, so we also denote ARW in degrees per square root hour [°/√*h*].

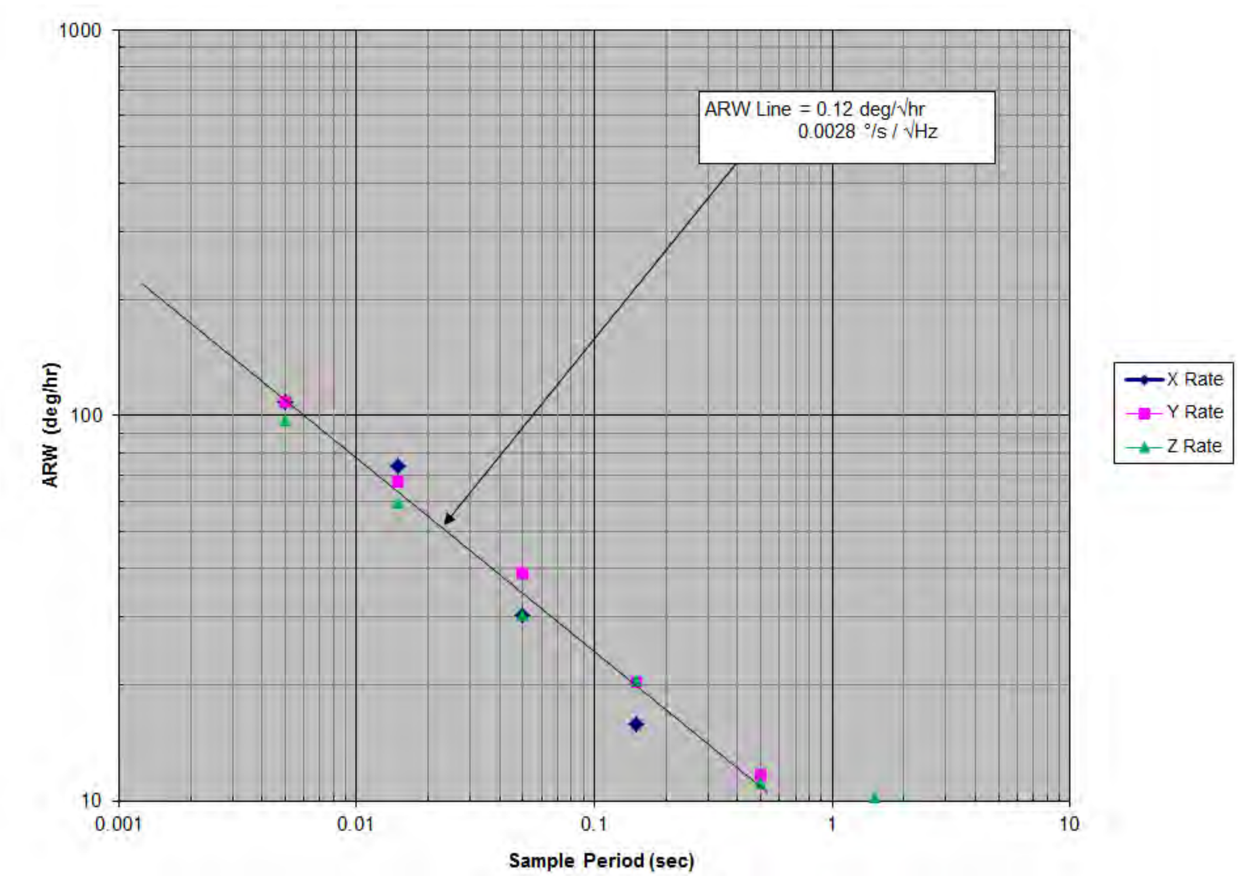


Figure 46 Angle Random Walk (ARW)

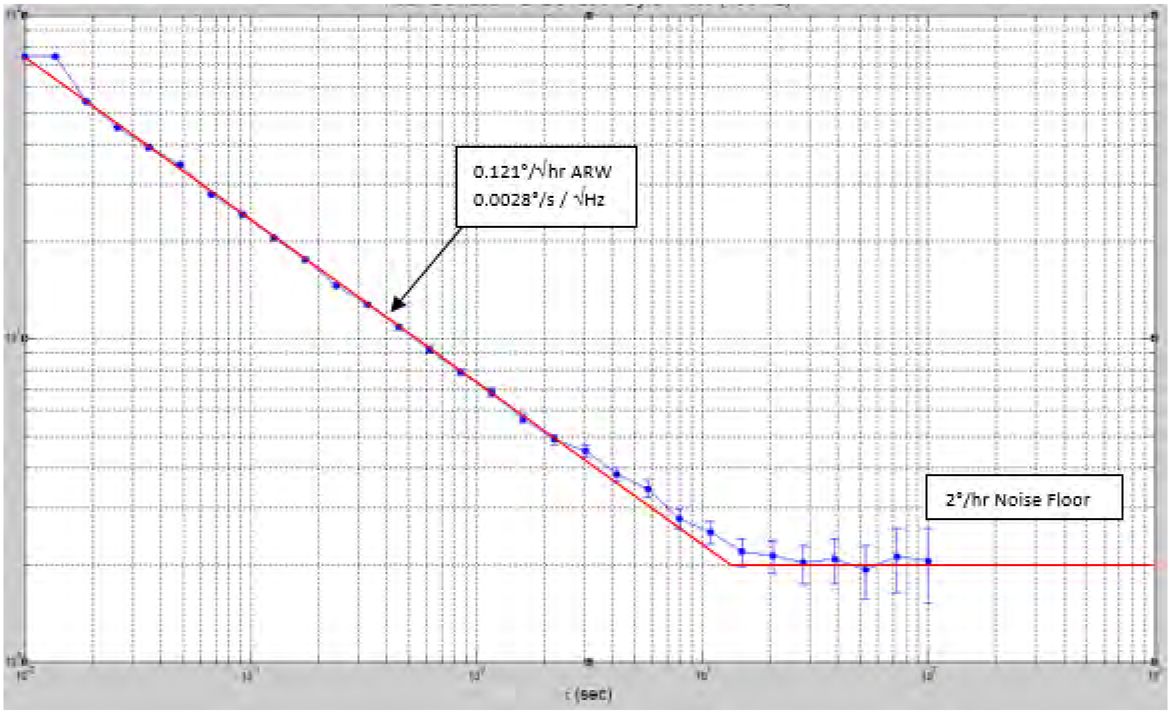


Figure 47 Gyroscope Allan Deviation

13.3 *Bias In-Run*

The unit is placed on an orthogonal test fixture. Data is captured at 100 Hz data rate. Then the bias of the gyros are measured at 1 Hz average. After a five minute warm-up period, data is taken for five minutes at ambient temperature. The test conditions should be similar to that of a user during initial setup approximately within five minutes after turn-on.

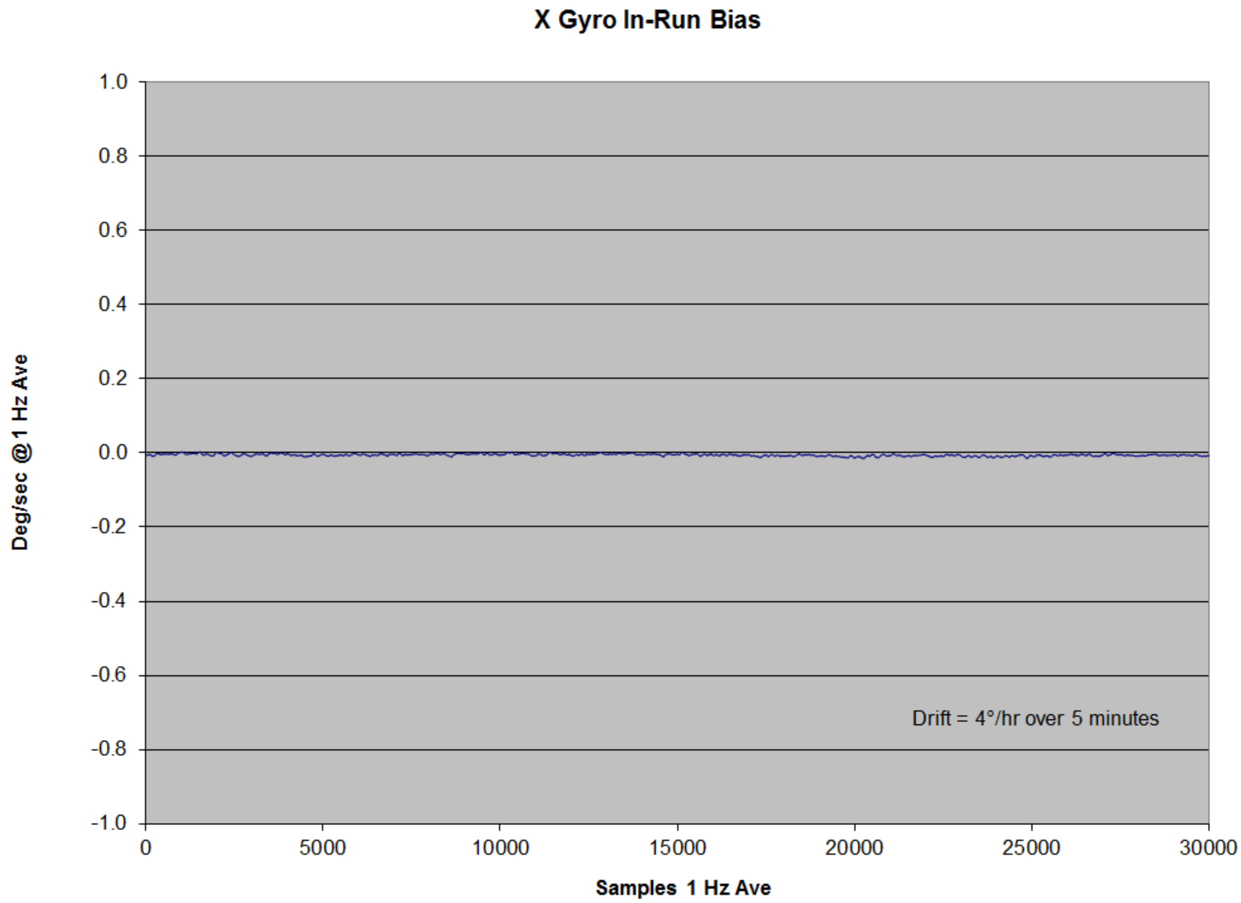


Figure 48 X Gyro Bias In-Run

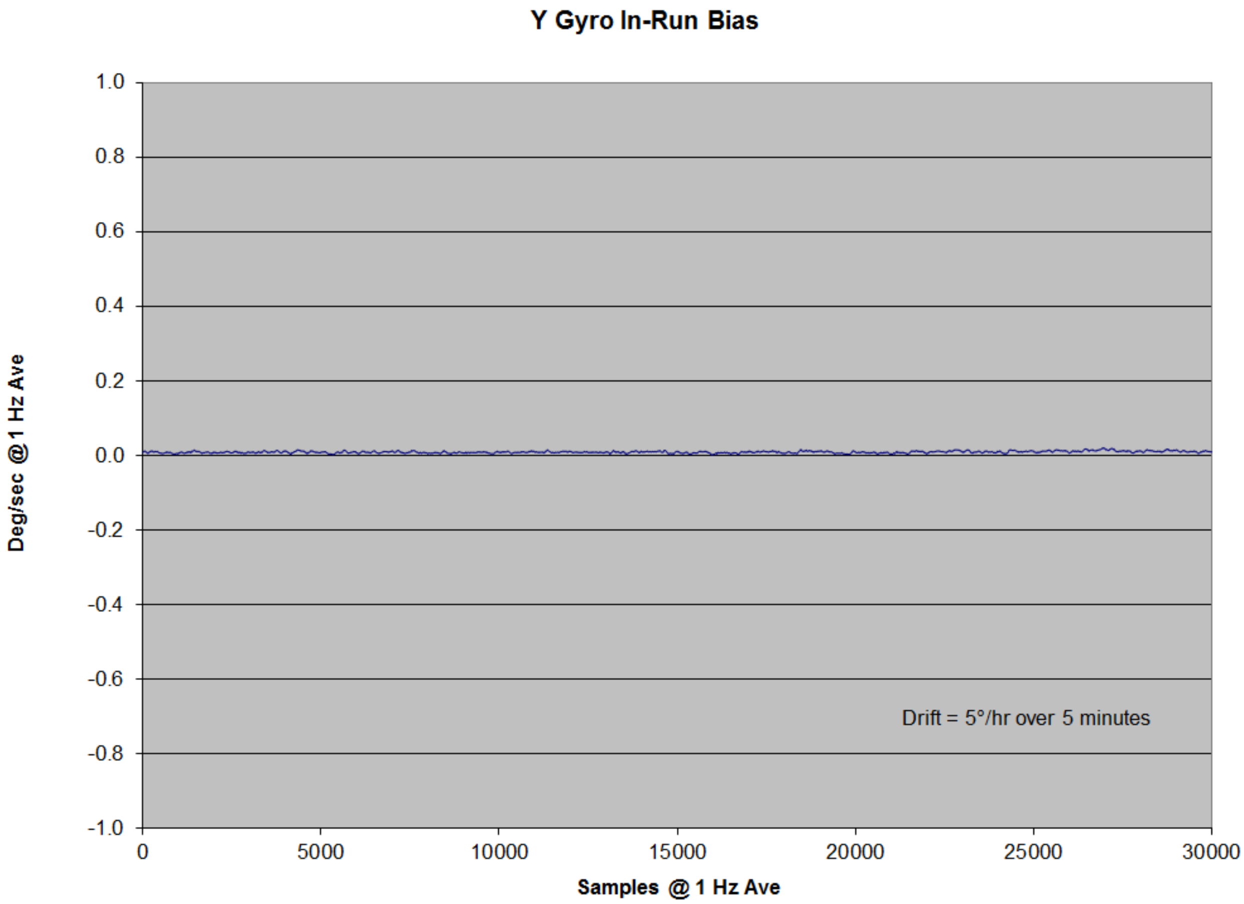


Figure 49 Y Gyro Bias In-Run

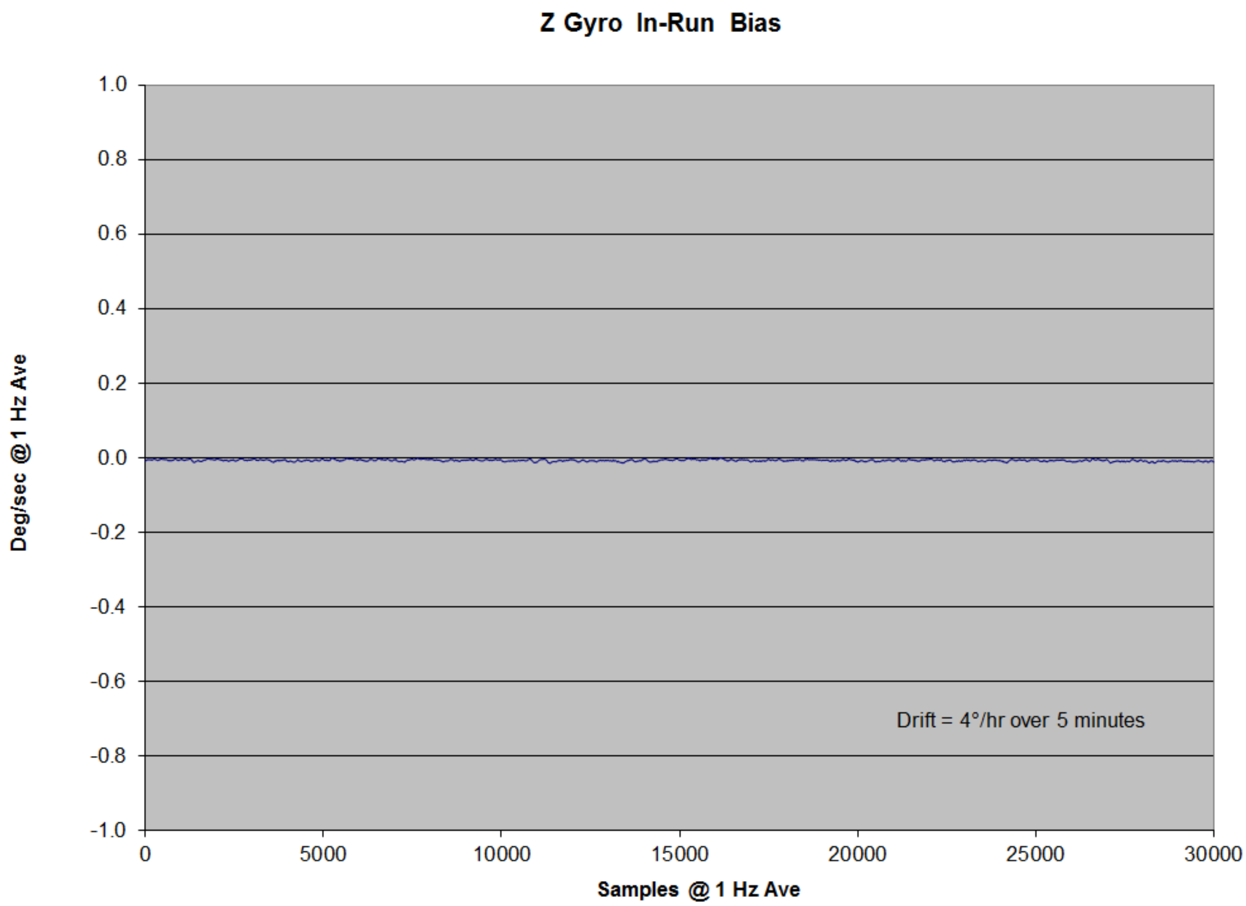


Figure 50 Z Gyro Bias In-Run

13.4 *Bias and Scale Factor over Temperature*

Data is captured at 100 Hz data rate. The temperature calibration process measures temperature at a minimum of five set points from -40°C to +85°C at a slew rate of approximately 1-2°/minute. A nine point correction table is generated that identifies temperature-based offsets for each of the gyro data sets. Depending upon the variable, up to a 4th order thermal model is used to create a correction model.

13.4.1 *Gyro Bias over Temperature*

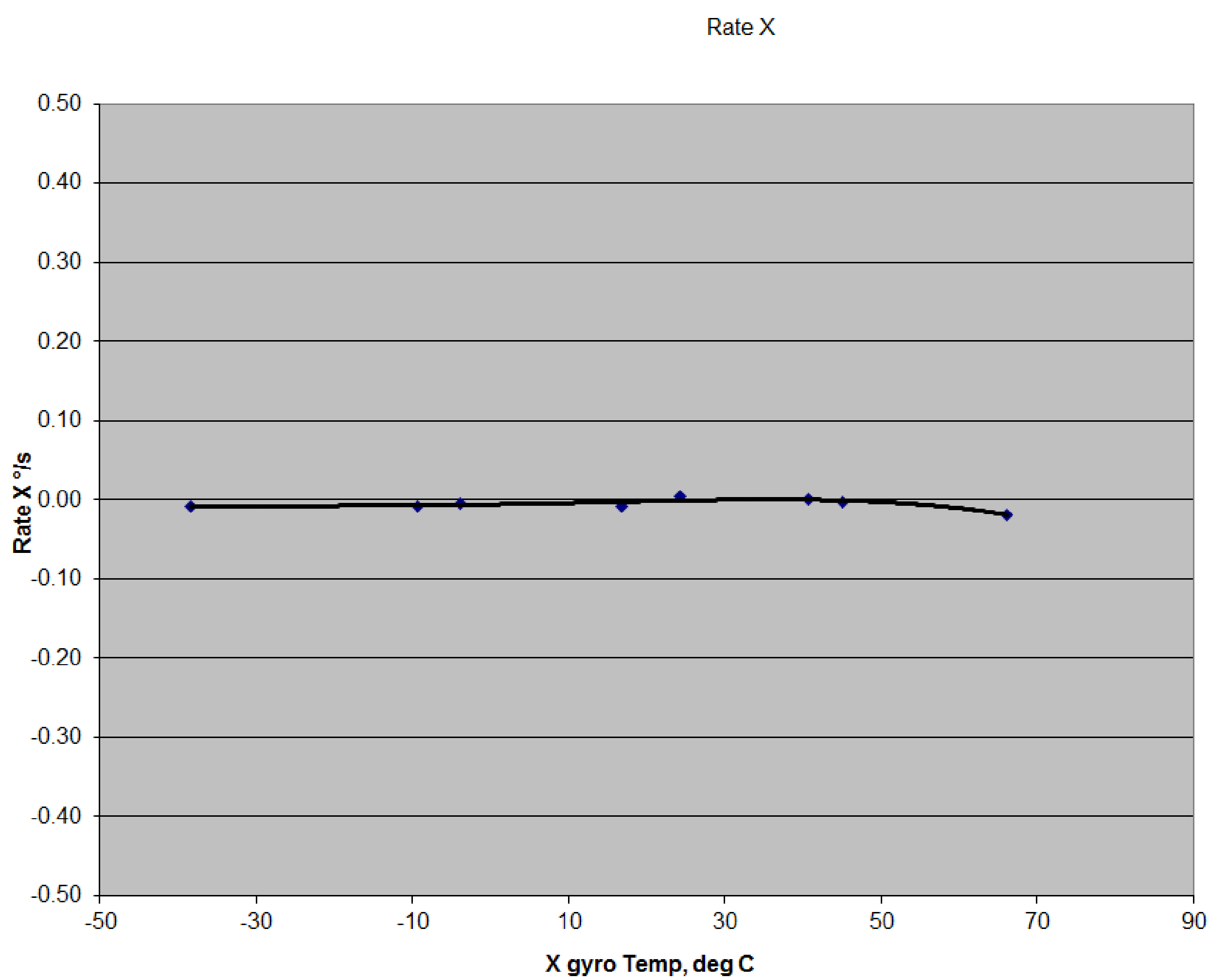


Figure 51 X Gyro Bias over Temperature

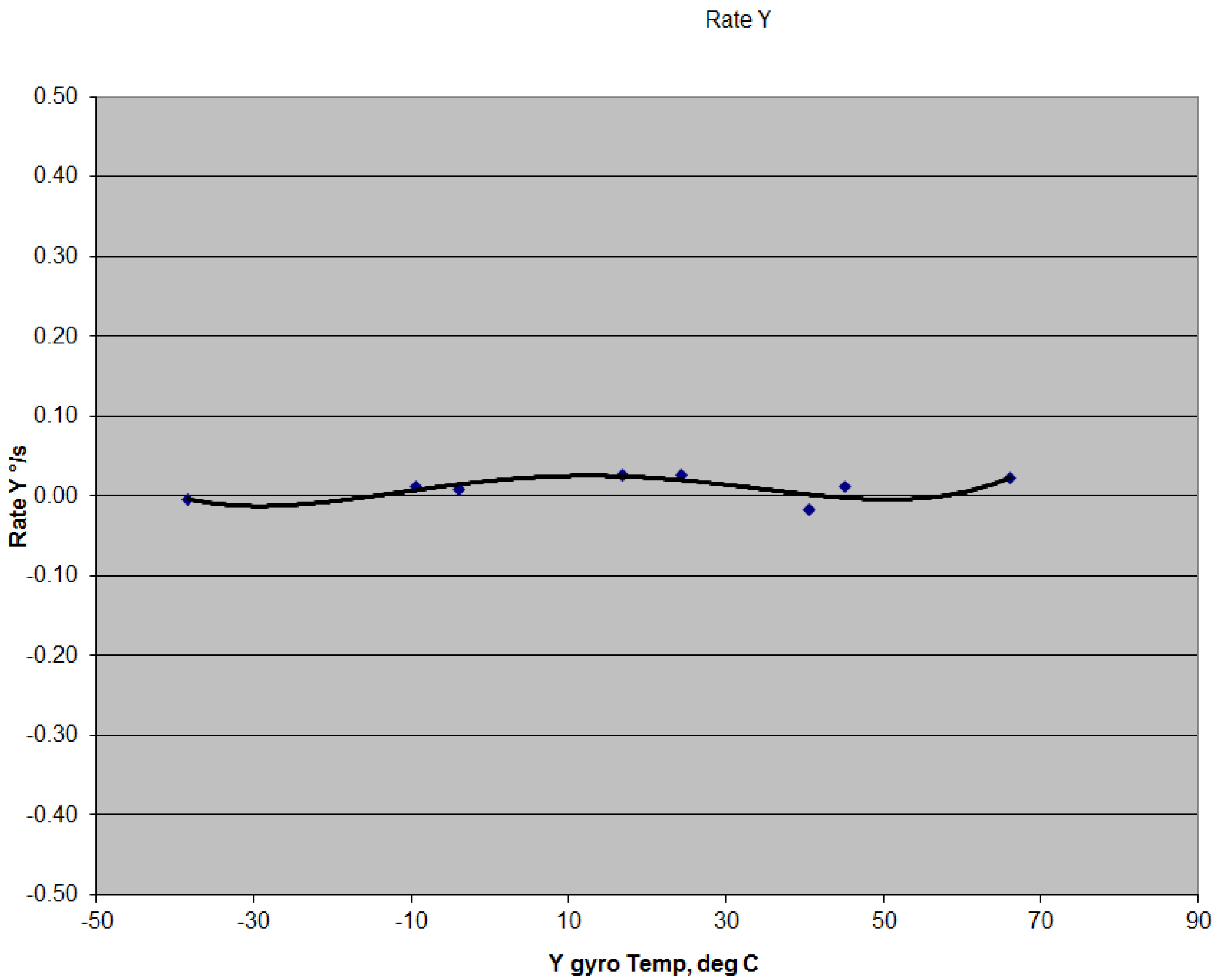


Figure 52 Y Gyro Bias over Temperature

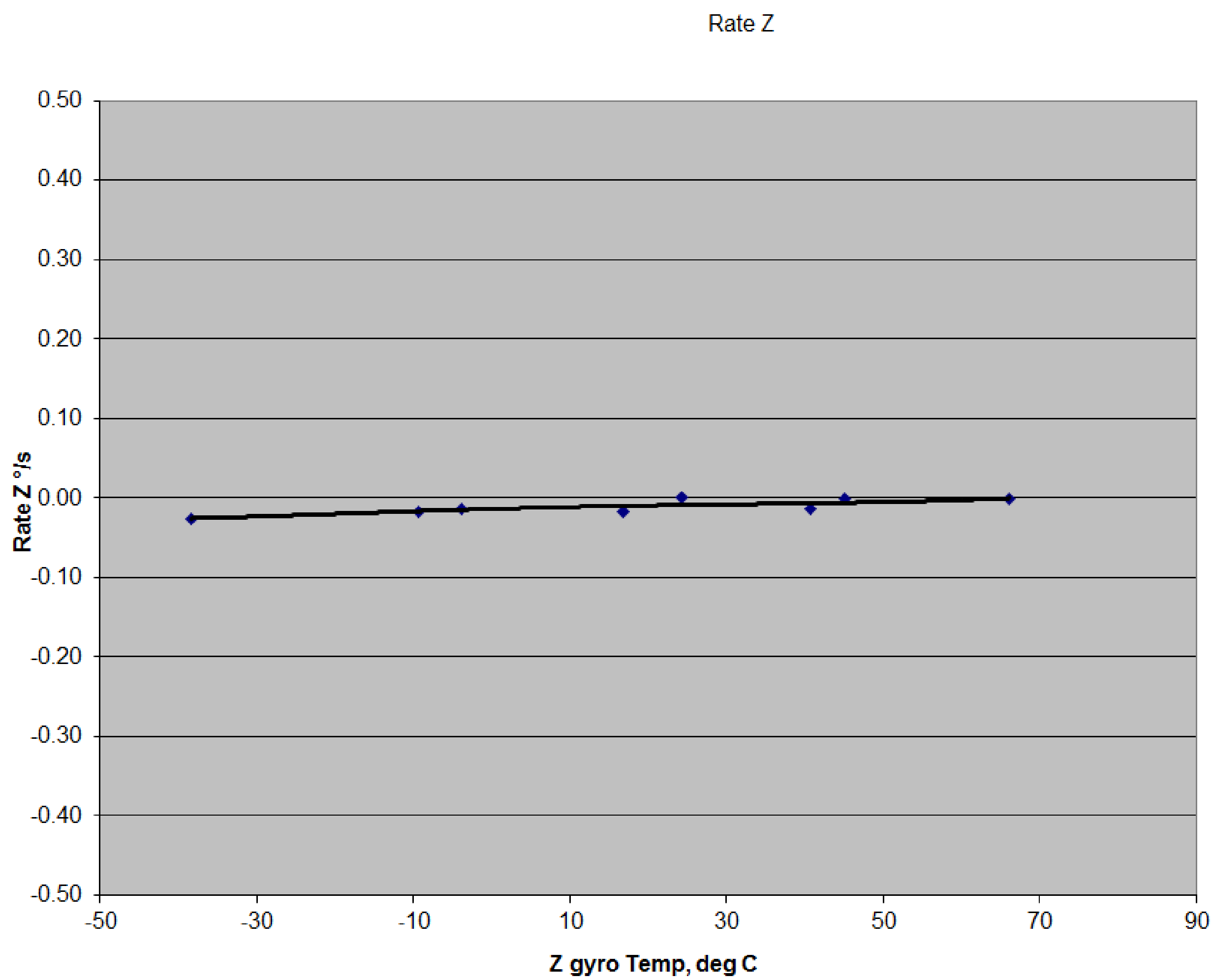


Figure 53 Z Gyro Bias over Temperature

13.4.2 *Gyro Scale Factor over Temperature*

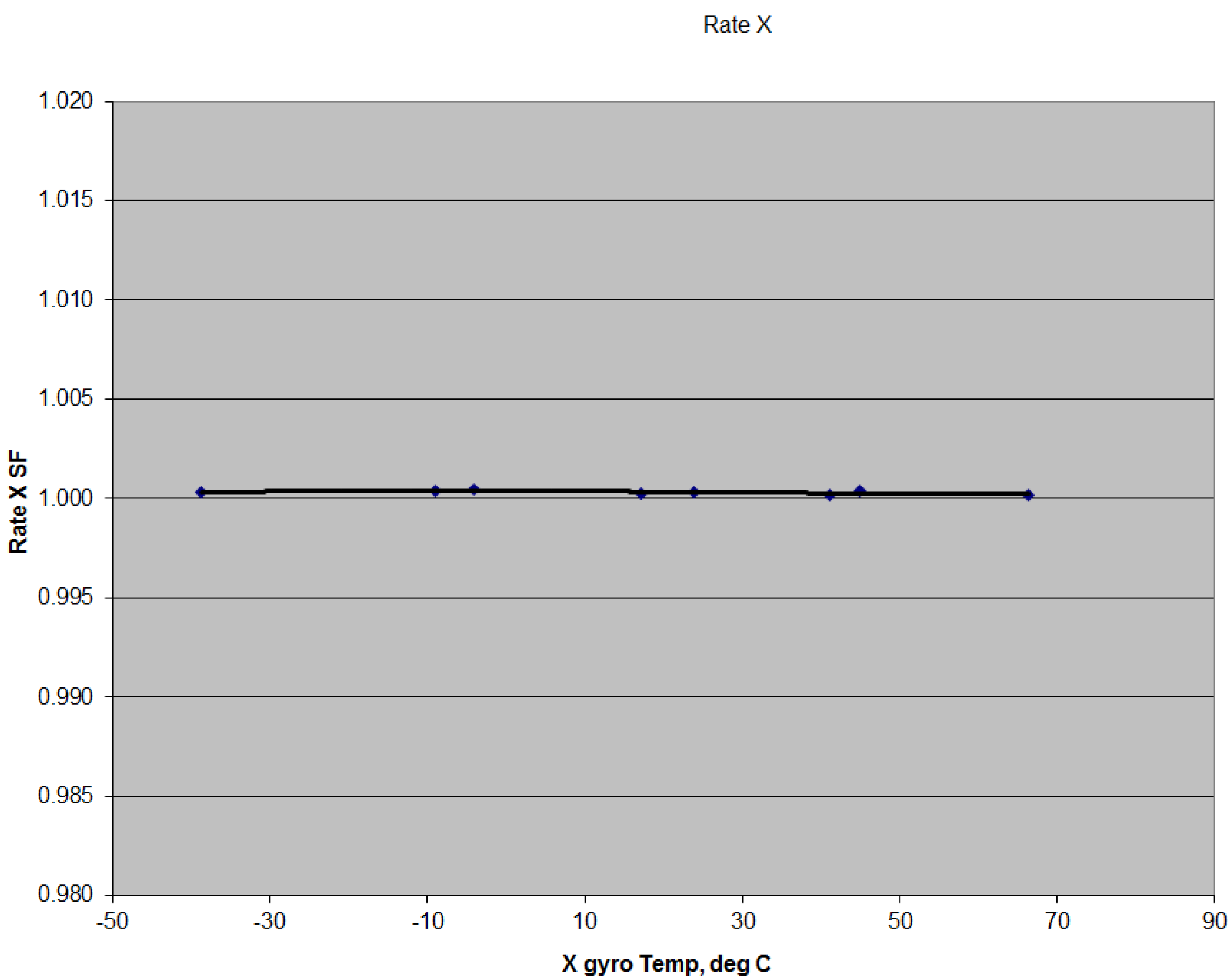


Figure 54 X Gyro Scale Factor over Temperature

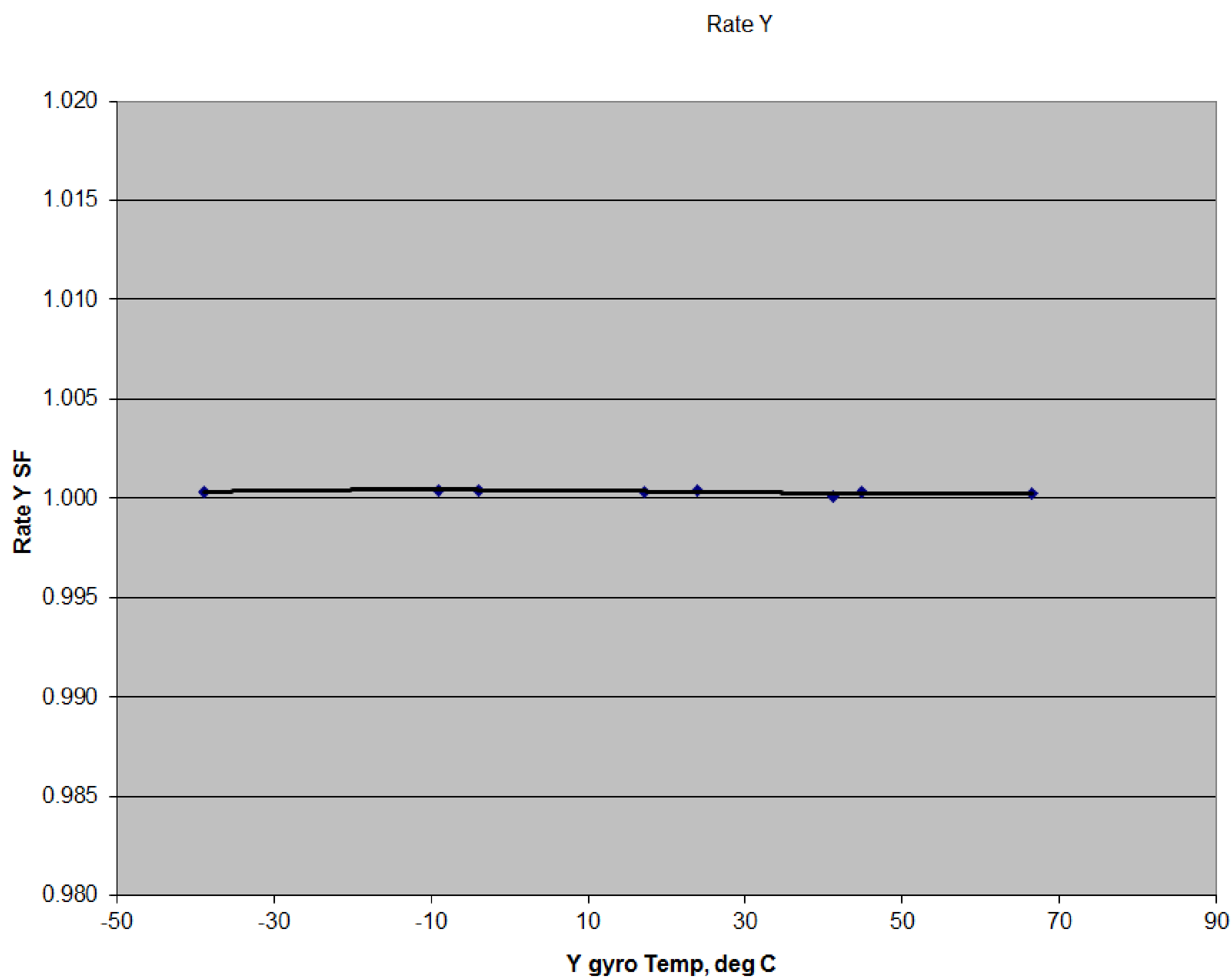


Figure 55 Y Gyro Scale Factor over Temperature

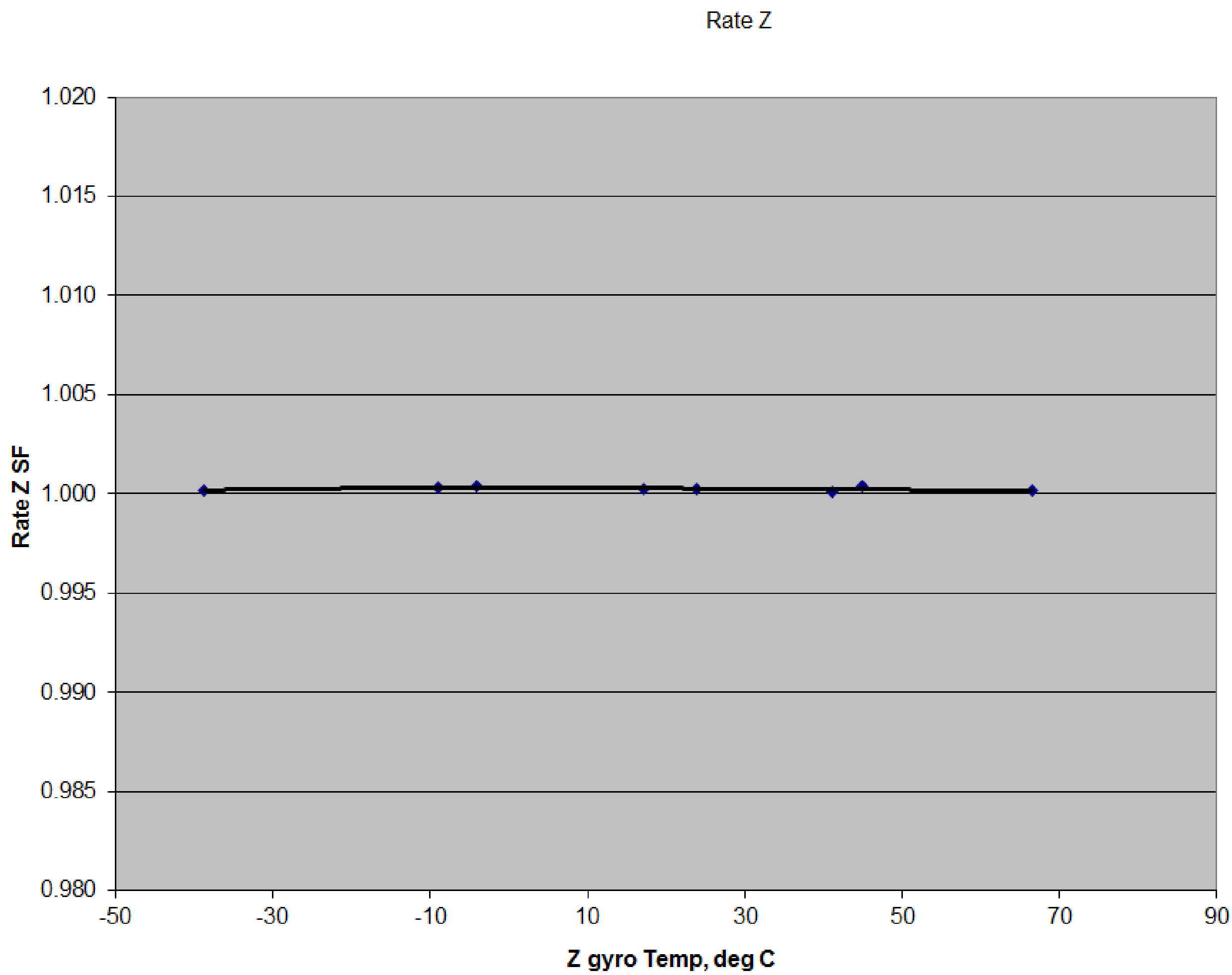


Figure 56 Z Gyro Scale Factor over Temperature

13.5 Bias Turn-On (from a Cold Start)

The G300D Triaxial Digital Gyro is **NOT** specified for this condition. This data is supplied for customer reference only. Data is captured at 100 Hz sample rate for 25 minutes (one second average data can be seen in Figures 57-59). Test conditions assume a unit has been powered off for five minutes. At this point, data is taken at ambient temperature from initial power-on to determine sample turn-on transient performance. It should be noted that most of the turn-on transient occurs during the initial two minutes after power-on and after that it performs near the specified Bias In-Run performance level.

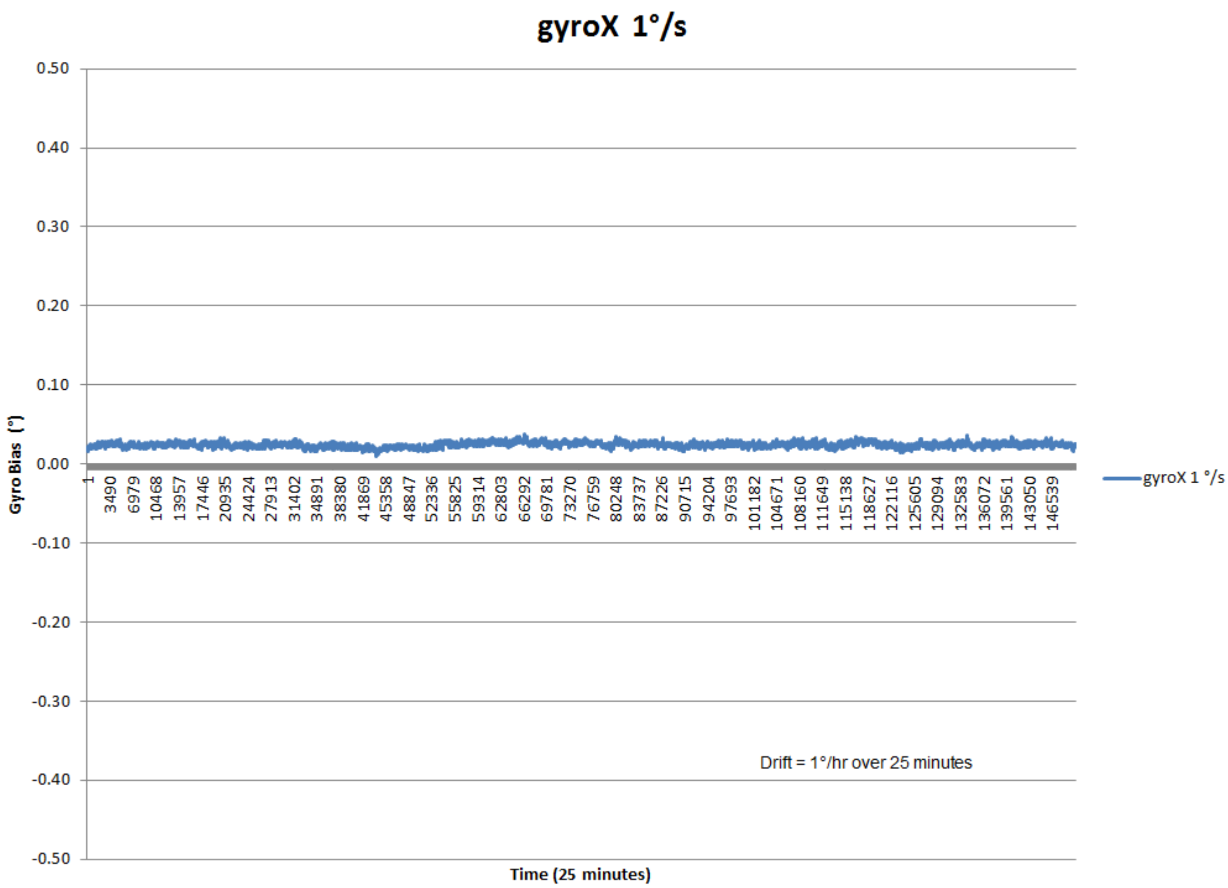


Figure 57 X Gyro Bias Turn-On

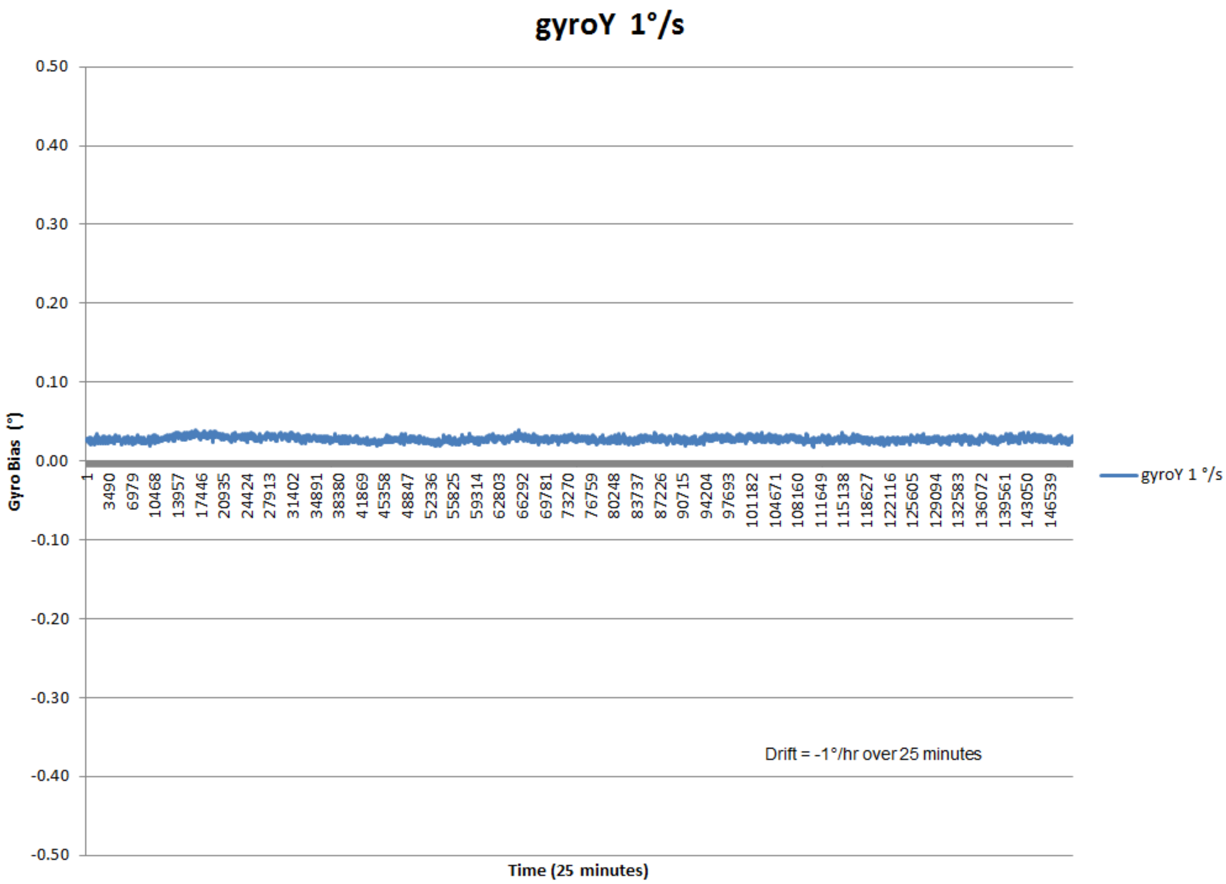


Figure 58 Y Gyro Bias Turn-On

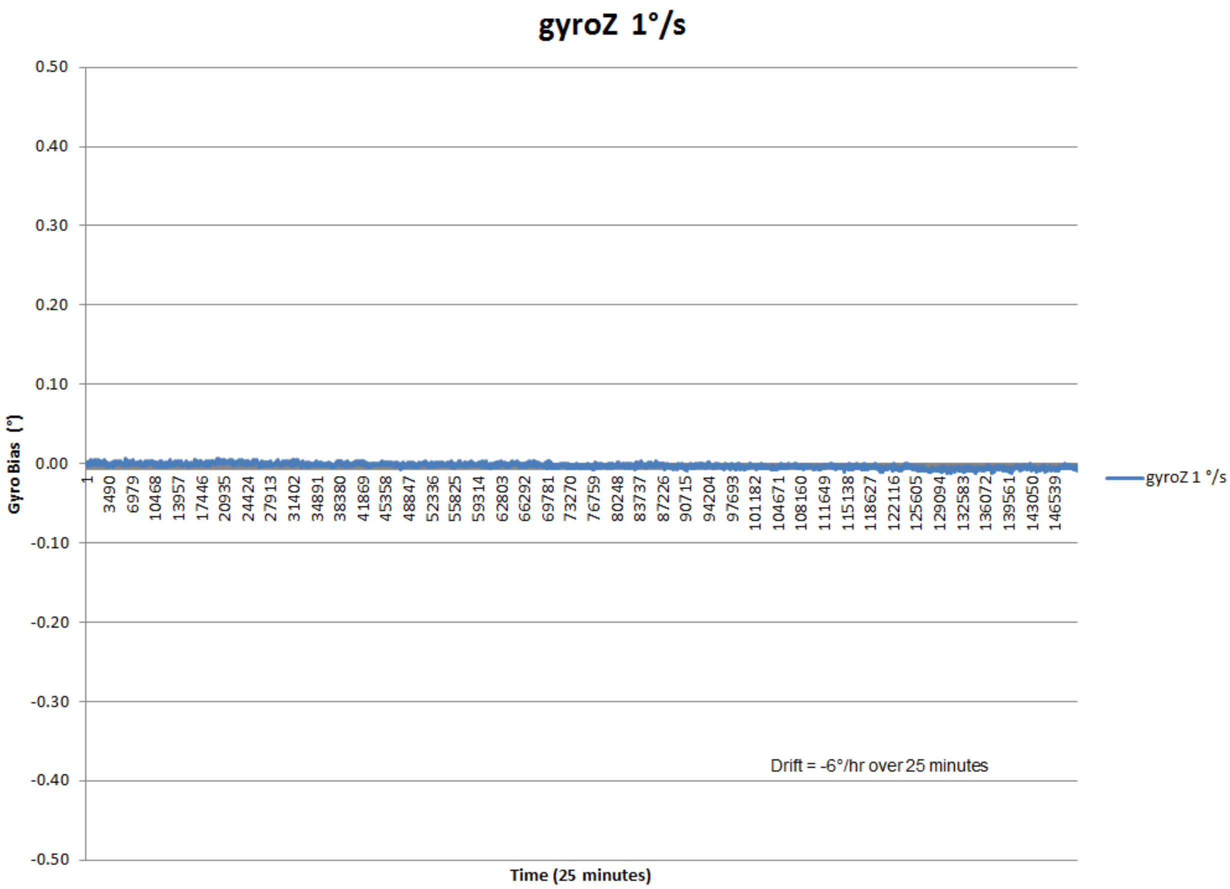


Figure 59 Z Gyro Bias Turn-On

13.6 Random and Sine Vibration

13.6.1 *Random Vibration*

Data is captured at 200 Hz data rate on a factory shaker. The unit is subject to random frequencies with total energy contained in the vibration profile of $5.74g_{rms}$. The delta shift for each gyro is measured before and after the run. Also measured during this portion of the Vibration test is the Vibration Rectification Coefficient (VRC) of the unit.

Axis	**Sensor**		**Gyro**					**Gyro**
	Test Units	X-G	Y-G	Z-G				**Abs Ave**
X Input	1 sigma on (deg/sec or mg)	0.1059						
	Shift (deg/sec or mg)	**0.0004**						0.0004
	VRE (deg/sec or mg)	-0.0053						
	VRC (°/hr or µg/grms^2)	**-0.6**						0.6
Y Input	1 sigma on (deg/sec or mg)		0.2543					
	Shift (deg/sec or mg)		**-0.0014**					0.0014
	VRE (deg/sec or mg)		0.0042					
	VRC (°/hr or µg/grms^2)		**0.5**					0.5
Z Input	1 sigma on (deg/sec or mg)			0.0450				
	Shift (deg/sec or mg)			**0.0011**				0.0011
	VRE (deg/sec or mg)			-0.0015				
	VRC (°/hr or µg/grms^2)			**-0.2**				0.2
								°/hr
	5.75 grms Random PSD					**Abs Ave**	**Shift =**	3.4
	0.02 g^2/Hz 50-1000 Hz, -3dB/octave to 2kHz					**Stdev**	**Shift =**	4.5
						Abs Ave	**VRC =**	0.4
	grms=	5.74				**Stdev**	**VRC =**	0.5
								°/hr/grms^2

Figure 60 Random Vibration Test Data

13.6.2 *Sine Vibration Test*

Data is captured at 200 Hz rate on a factory shaker. The unit is subject to a sine sweep of various frequencies from 30 Hz to 3000 Hz and delta shifts are calculated before and after the run. Also measured during vibe is the Vibration Rectification Coefficient (VRC) of the unit.

13.6.3 *Gyro Sine Vibration Response*

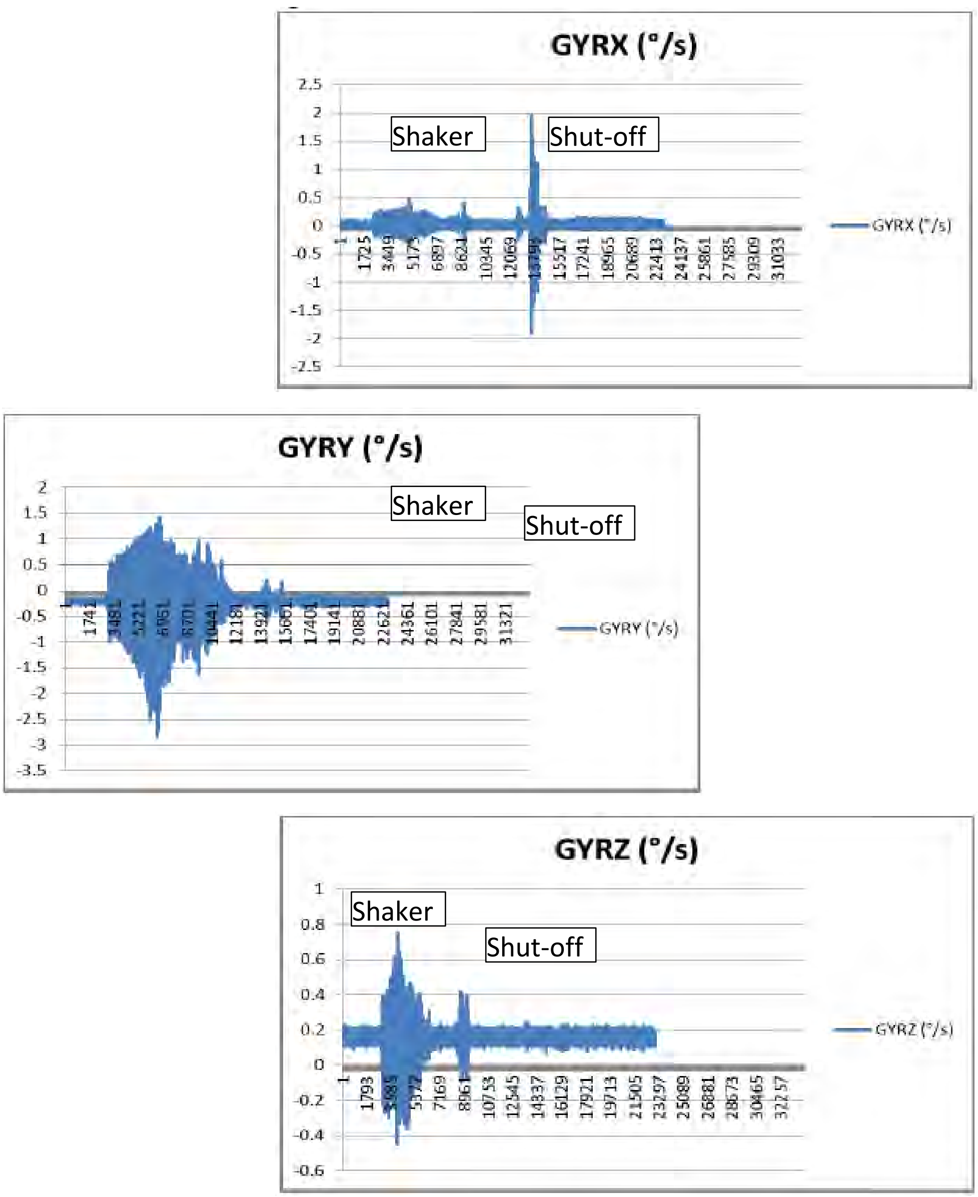


Figure 61 X, Y, and Z Gyro Sine Vibration Response

14 MOUNTING

Mounting for the G300D Triaxial Digital Gyro accommodates both metric and U.S. mounting screws. Mount the unit to a flat surface with 4ea. 2-56 or M2 screws. Be sure that the surface the unit is being mounted to is as clean and as level as possible in order to eliminate potential alignment errors. Adequate mounting to a surface should fall within a flatness of +/- 0.001" or +/- 0.025 mm.

Failing to mount the unit in this fashion can result in unaccounted stress in the sensors and therefore may affect data output. Gladiator Technologies strongly encourages the user to mount the unit correctly in the described manner to ensure proper functioning.

15 OPERATION & TROUBLESHOOTING

15.1 *Technical Assistance*

Please contact the factory or your local Gladiator Technologies sales representative's office for technical assistance.

Technical Support - USA
Gladiator Technologies **Attn:** Technical Support 8020 Bracken Place SE Snoqualmie, WA 98065 USA

15.2 *Authorized Distributors and Technical Sales Representatives*

If you need additional assistance please contact your local distributor and/or the factory for further technical support.

http://www.gladiatortechnologies.com/Intl/Contact.html

15.3 *Technical Support Website*

Our Technical support webpage has user training videos, the latest software downloads, as well as Remote Desktop Assistance.

For direct assistance, Gladiator Technologies offers Remote Assistance and Web Conferencing.

For assistance navigating the Gladiator Technologies website, see Figures 62-64.

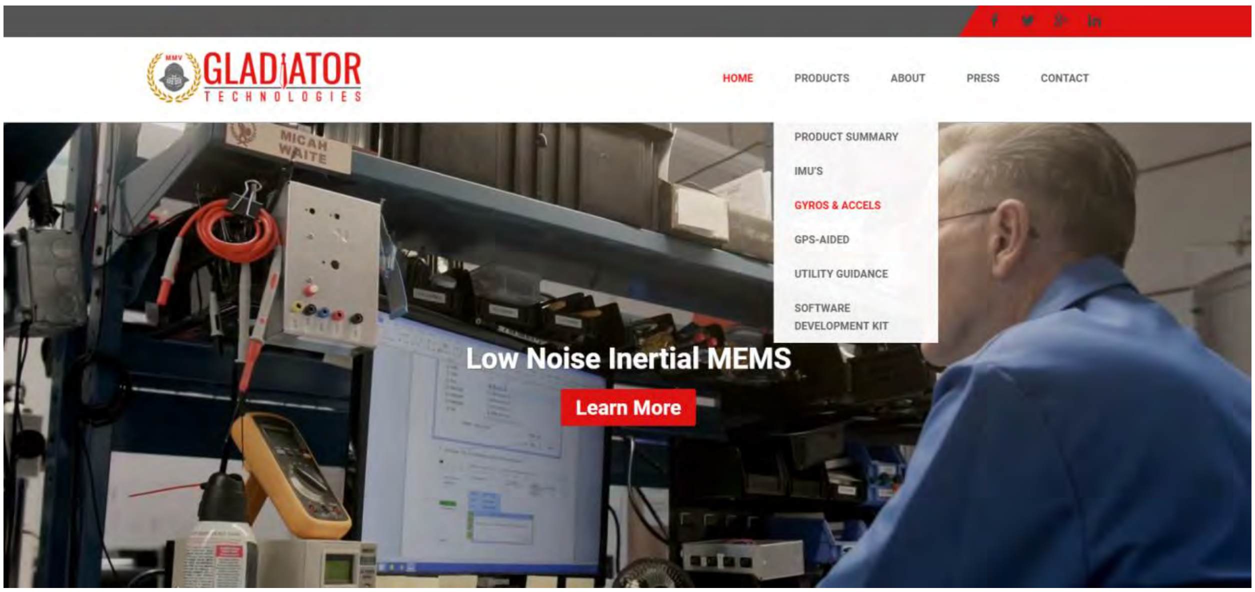


Figure 62 Website – Select Product Category

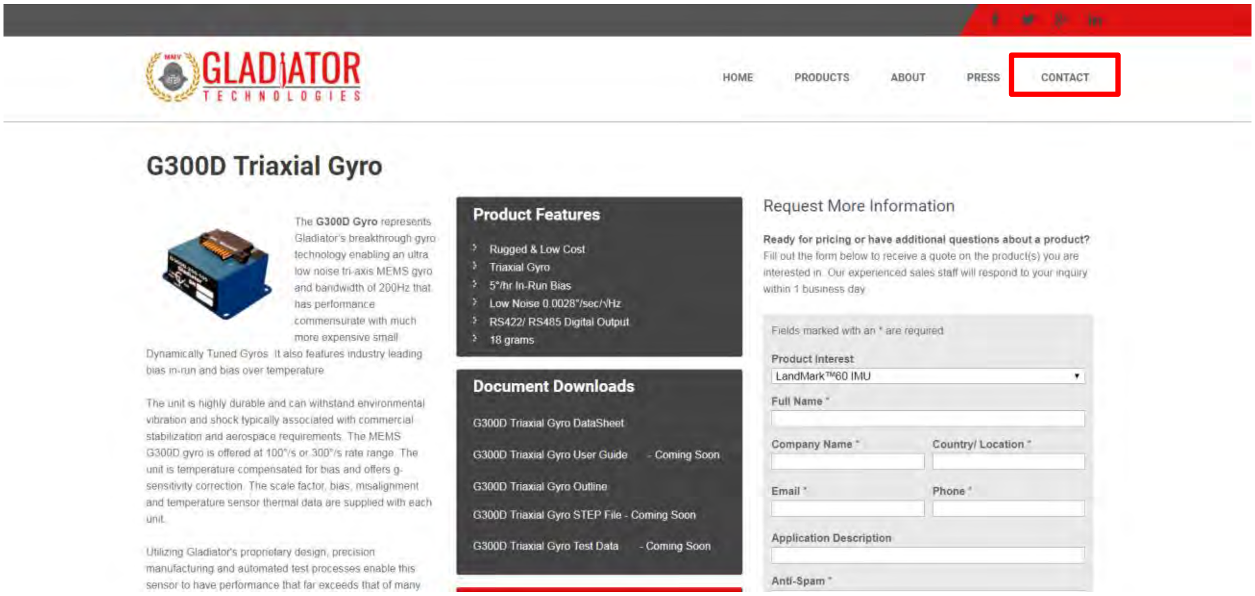


Figure 63 G300D Gyro Product Main Webpage

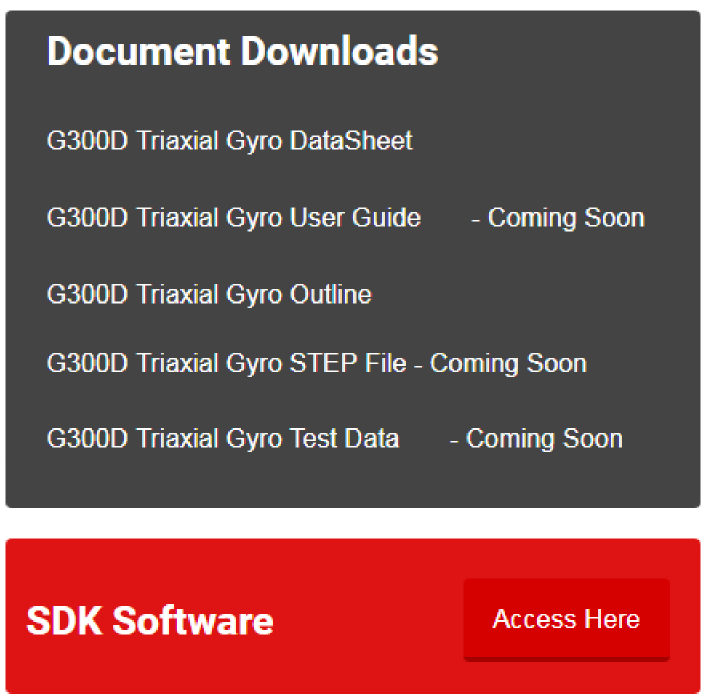


Figure 64 G300D Gyro Product Documentation Downloads

16 GLOSSARY OF TERMS

Gladiator Technologies has attempted to define terms as closely as possible to the IEEE Gyro and Accelerometer Panel Standards for Inertial Sensor Terminology. Please note that in some instances our definition of a term may vary and in those instances Gladiator Technologies' definition supersedes the IEEE definition. For a complete listing of IEEE's standard for inertial sensor terminology please go to www.ieee.org.

16.1 *Abbreviations and Acronyms*

6DOF: *six degrees-of-freedom*

IMU: *Inertial Measurement Unit*

CVG*: Coriolis Vibratory Gyro*

ESD*: Electro Static Discharge*

IEEE*: The Institute of Electrical and Electronics Engineers*

IMU*: Inertial Measurement Unit*

MEMS*: Micro-Electro-Mechanical Systems*

NLR*: No License Required*

16.2 *Definitions of Terms*

Acceleration-insensitive drift rate (gyro): The component of environmentally sensitive drift rate not correlated with acceleration.
NOTE—Acceleration-insensitive drift rate includes the effects of temperature, magnetic, and other external influences.

Acceleration-sensitive drift rate (gyro): The components of systematic drift rate correlated with the first power of a linear acceleration component, typically expressed in (°/h)/g.

Accelerometer: An inertial sensor that measures linear or angular acceleration. Except where specifically stated, the term accelerometer refers to linear accelerometer.

Allan variance: A characterization of the noise and other processes in a time series of data as a function of averaging time. It is one half the mean value of the square of the difference of adjacent time averages from a time series as a function of averaging time.

Angular acceleration sensitivity:
(accelerometer): The change of output (divided by the scale factor) of a linear accelerometer that is produced per unit of angular acceleration input about a specified axis, excluding the response that is due to linear acceleration.
(gyro): The ratio of drift rate due to angular acceleration about a gyro axis to the angular acceleration causing it.
NOTE: In single-degree-of-freedom gyros, it is nominally equal to the effective moment of inertia of the gimbal assembly divided by the angular momentum.

Bias:

- *Gyroscope:* The average over a specified time of gyro output measured at specified operating conditions that have no correlation with input rotation or acceleration. Bias is typically expressed in degrees per hour (°/h).
- *Accelerometer:* The average over a specified time of accelerometer output measured at specified operating conditions that have no correlation with input acceleration or rotation. Bias is expressed in [m/s^2, g].

NOTE: Control of operating conditions may address sensitivities such as temperature, magnetic fields, and mechanical and electrical interfaces, as necessary.

Case (gyro, accelerometer): The housing or package that encloses the sensor, provides the mounting surface, and defines the reference axes.

Composite error (gyro, accelerometer): The maximum deviation of the output data from a specified output function. Composite error is due to the composite effects of hysteresis, resolution, nonlinearity, non-repeatability, and other uncertainties in the output data. It is generally expressed as a percentage of half the output span.

Coriolis acceleration: The acceleration of a particle in a coordinate frame rotating in inertial space, arising from its velocity with respect to that frame.

Coriolis vibratory gyro (CVG): A gyro based on the coupling of a structural, driven, vibrating mode into at least one other structural mode (pickoff) via Coriolis acceleration.
NOTE: CVGs may be designed to operate in open-loop, force-rebalance (i.e., closed-loop), and/or whole-angle modes.

Cross acceleration (accelerometer): The acceleration applied in a plane normal to an accelerometer input reference axis.

Cross-axis sensitivity (accelerometer): The proportionality constant that relates a variation of accelerometer output to cross acceleration. This sensitivity varies with the direction of cross acceleration and is primarily due to misalignment.

Cross-coupling errors (gyro): The errors in the gyro output resulting from gyro sensitivity to inputs about axes normal to an input reference axis.

Degree-of-freedom (DOF) (gyro): An allowable mode of angular motion of the spin axis with respect to the case. The number of degrees-of-freedom is the number of orthogonal axes about which the spin axis is free to rotate.

Drift rate (gyro): The component of gyro output that is functionally independent of input rotation. It is expressed as an angular rate.

Environmentally sensitive drift rate (gyro): The component of systematic drift rate that includes acceleration-sensitive, acceleration-squared-sensitive, and acceleration-insensitive drift rates.

Full-scale input (gyro, accelerometer): The maximum magnitude of the two input limits.

G: The magnitude of the local plumb bob gravity that is used as a reference value of acceleration.
NOTE 1: g is a convenient reference used in inertial sensor calibration and testing.
NOTE 2: In some applications, the standard value of g = 9.806 65 m/s^2 *may be specified.*

Gyro (gyroscope): An inertial sensor that measures angular rotation with respect to inertial space about its input axis(es).
NOTE 1: The sensing of such motion could utilize the angular momentum of a spinning rotor, the Coriolis Effect on a vibrating mass, or the Sagnac Effect on counter-propagating light beams in a ring laser or an optical fiber coil.

G sensitivity (gyro): the change in rate bias due to g input from any direction.

Hysteresis error (gyro, accelerometer): The maximum separation due to hysteresis between upscale-going and down-scale-going indications of the measured variable (during a full-range traverse, unless otherwise specified) after transients have decayed. It is generally expressed as an equivalent input.

Inertial sensor: A position, attitude, or motion sensor whose references are completely internal, except possibly for initialization.

Input angle (gyro): The angular displacement of the case about an input axis.

Input axis (IA):
(accelerometer): The axis(es) along or about which a linear or angular acceleration input causes a maximum output.
(gyro): The axis(es) about which a rotation of the case causes a maximum output.

Input-axis misalignment (gyro, accelerometer): The angle between an input axis and its associated input reference axis when the device is at a null condition.

Input limits (gyro, accelerometer): The extreme values of the input, generally plus or minus, within which performance is of the specified accuracy.

Input range (gyro, accelerometer): The region between the input limits within which a quantity is measured, expressed by stating the lower- and upper-range value. For example, a linear displacement input range of ± 1.7g to ± 12g.

Input rate (gyro): The angular displacement per unit time of the case about an input axis. For example, an angular displacement input range of ± 150°/sec to ± 300°/sec.

Input reference axis (IRA) (gyro, accelerometer): The direction of an axis (nominally parallel to an input axis) as defined by the case mounting surfaces, or external case markings, or both.

Linear accelerometer: An inertial sensor that measures the component of translational acceleration minus the component of gravitational acceleration along its input axis(es).

Linearity error (gyro, accelerometer): The deviation of the output from a least-squares linear fit of the input-output data. It is generally expressed as a percentage of full scale, or percent of output, or both.

Mechanical freedom (accelerometer): The maximum linear or angular displacement of the accelerometer's proof mass, relative to its case.

Natural frequency (gyro, accelerometer): The frequency at which the output lags the input by 90°. It generally applies only to inertial sensors with approximate second-order response.

Non-gravitational acceleration (accelerometer): The component of the acceleration of a body that is caused by externally applied forces (excluding gravity) divided by the mass.

Nonlinearity (gyro, accelerometer): The systematic deviation from the straight line that defines the nominal input-output relationship.

Open-loop mode (Coriolis vibratory gyro): A mode in which the vibration amplitude of the pickoff is proportional to the rotation rate about the input axis(es).

Operating life (gyro, accelerometer): The accumulated time of operation throughout which a gyro or accelerometer exhibits specified performance when maintained and calibrated in accordance with a specified schedule.

Operating temperature (gyro, accelerometer): The temperature at one or more gyro/accelerometer elements when the device is in the specified operating environment.

Output range (gyro, accelerometer): The product of input range and scale factor.

Output span (gyro, accelerometer): The algebraic difference between the upper and lower values of the output range.

Pickoff (mechanical gyro, accelerometer): A device that produces an output signal as a function of the relative linear or angular displacement between two elements.

Plumb bob gravity: The force per unit mass acting on a mass at rest at a point on the earth, not including any reaction force of the suspension. The plumb bob gravity includes the gravitational attraction of the earth, the effect of the centripetal acceleration due to the earth rotation, and tidal effects. The direction of the plumb bob gravity acceleration defines the local vertical down direction, and its magnitude defines a reference value of acceleration (g).

Power spectral density (PSD): A characterization of the noise and other processes in a time series of data as a function of frequency. It is the mean squared amplitude per unit frequency of the time series. It is usually expressed in $(°/h)^2$/Hz for gyroscope rate data or in $((m/s^2)^2)$/Hz or g2/Hz for accelerometer acceleration data.

Principal axis of compliance (gyro, accelerometer): An axis along which an applied force results in a displacement along that axis only.

Proof mass (accelerometer): The effective mass whose inertia transforms an acceleration along, or about, an input axis into a force or torque. The effective mass takes into consideration rotation and contributing parts of the suspension.

Quantization (gyro, accelerometer): The analog-to-digital conversion of a gyro or accelerometer output signal that gives an output that changes in discrete steps, as the input varies continuously.

Quantization noise (gyro, accelerometer): The random variation in the digitized output signal due to sampling and quantizing a continuous signal with a finite word length conversion. The resulting incremental error sequence is a uniformly distributed random variable over the interval 1/2 least significant bit (LSB).

Random drift rate (gyro): The random time-varying component of drift rate.

Random walk: A zero-mean Gaussian stochastic process with stationary independent increments and with standard deviation that grows as the square root of time.

Angle random walk (gyro): The angular error buildup with time that is due to white noise in angular rate. This error is typically expressed in degrees per square root of hour [°/√*h*].

Velocity random walk (accelerometer): The velocity error build-up with time that is due to white noise in acceleration. This error is typically expressed in meters per second per square root of hour [(m/s)/√*h*].

Rate gyro: A gyro whose output is proportional to its angular velocity with respect to inertial space.

Ratio metric output: An output method where the representation of the measured output quantity (e.g., voltage, current, pulse rate, pulse width) varies in proportion to a reference quantity.

Rectification error (accelerometer): A steady-state error in the output while vibratory disturbances are acting on an accelerometer.
Repeatability (gyro, accelerometer): The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or non-operating periods occur between measurements.

Resolution (gyro, accelerometer): The largest value of the minimum change in input, for inputs greater than the noise level, that produces a change in output equal to some specified percentage (at least 50%) of the change in output expected using the nominal scale factor.

Scale factor (gyro, accelerometer): The ratio of a change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data.

Second-order nonlinearity coefficient (accelerometer): The proportionality constant that relates a variation of the output to the square of the input, applied parallel to the input reference axis.

Sensitivity (gyro, accelerometer): The ratio of a change in output to a change in an undesirable or secondary input. For example: a scale factor temperature sensitivity of a gyro or accelerometer is the ratio of change in scale factor to a change in temperature.

Stability (gyro, accelerometer): A measure of the ability of a specific mechanism or performance coefficient to remain invariant when continuously exposed to a fixed operating condition.

Storage life (gyro, accelerometer): The non-operating time interval under specified conditions, after which a device will still exhibit a specified operating life and performance.

Strapdown (gyro, accelerometer): Direct-mounting of inertial sensors (without gimbals) to a vehicle to sense the linear and angular motion of the vehicle.

Third-order nonlinearity coefficient (accelerometer): The proportionality constant that relates a variation of the output to the cube of the input, applied parallel to the input reference axis.

Threshold (gyro, accelerometer): The largest absolute value of the minimum input that produces an output equal to at least 50% of the output expected using the nominal scale factor.

Turn-on time (gyro, accelerometer): The time from the initial application of power until a sensor produces a specified useful output, though not necessarily at the accuracy of full specification performance.

Warm-up time (gyro, accelerometer): The time from the initial application of power for a sensor to reach specified performance under specified operating conditions.

Zero offset (restricted to rate gyros): The gyro output when the input rate is zero, generally expressed as an equivalent input rate. It excludes outputs due to hysteresis and acceleration.