AS9100C &
ISO9001:2008
Cert# 87834

Gladiator Technologies
Division of LKD Aerospace
High Performance Inertial MEMS

G200 Dual Axis MEMS Gyro
User Guide

Technical Support - USA
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3 SAFETY AND HANDLING INFORMATION

- **ALWAYS USE CAUTION WHEN HANDLING THE G200 MEMS GYRO!**
- **SUPPLYING TOO HIGH OF INPUT OR REVERSE VOLTAGE, COULD PERMANENTLY DAMAGE THE UNIT**. Input Power is specified at +4.75V to +5.25V Maximum with +5.0V Nominal Input for specified performance.
- The G200 Dual Axis MEMS Gyro is a sensitive scientific instrument containing a shock and vibration sensitive inertial sensor. **Excessive shock and or vibration can damage this sensor** and can adversely affect sensor performance and unit output.
- Avoid exposure to electrostatic discharge (ESD). Observe proper grounding whenever handling the G200 Dual Axis MEMS Gyro.
- Properly attach connector and ensure that it has been installed correctly before applying power to the G200 Dual Axis MEMS Gyro.

4 PATENT INFORMATION

The G200 Dual Axis MEMS Gyro is a newly developed unit containing significant intellectual property and it is expected to be protected by United States of America (USA) and other foreign patents.

5 APPLICABLE EXPORT CONTROLS

The G200 Dual Axis MEMS Gyro has been self-classified by Gladiator Technologies with pending formal U.S. Department of Commerce under the Export Administration Regulations (EAR). It is classified under ECCN 7A994 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 (EAR). Items otherwise eligible for export under NLR may require a license if the exporter knows or is informed that that the items will be used in prohibited chemical, biological or nuclear weapons or missile activities as defined in Part 744 of the EAR. Items otherwise eligible for export or re-export under a license exception or NLR and used in the design, development or production or use of Nuclear, Chemical or Biological weapons or Missiles require a license for export or re-export as provided in Part 744 of the Export Administration Regulations (EAR).

Destinations Requiring a License

See the Commerce Country Chart (Supplement No. 1 to Part 738 of the EAR) to determine which countries require a license. Use the country chart column information given on this form in conjunction with the country chart to determine the licensing requirements for your particular items.

6 STANDARD LIMITED WARRANTY

Gladiator Technologies offers a standard one 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 Technologie's Terms & Conditions of sale regarding specific warranty information.

7 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 10012334ASH09. Please visit our website at www.gladiatortechnologies.com to view our current certificates.

8 THEORY OF OPERATION

The G200 Dual Axis MEMS Gyro is a dual axis MEMS (Micro Electro-Mechanical Sensor) analog output Coriolis-based rate gyro. The unit offers our premium performance option of our products and features one of our best and lowest noise gyros. Utilizing Gladiator's proprietary design, precision manufacturing and automated test processes enable this sensor to have performance that far exceeds that of many other competing MEMS sensors. The unit is temperature compensated for bias and offers g-sensitivity correction. The scale factor, bias, misalignment and temperature sensor thermal data are supplied with each unit.

The unit contains:

- A dual axis MEMS Coriolis rate sensor that is available in standard ranges of: ±100°/sec or ±300°/sec.
- An internal temperature sensor output. The temperature sensor is co-located with the sensor to enable accurate temperature compensation of the gyro output by the end user.
- All units go through an extensive temperature calibration process.
- A precision mounting ring is used in the G200 Dual Axis MEMS Gyro enabling low misalignment errors and misalignment measurement is included with the shipment.
- In addition, "g-sensitivity" errors associated with the gyros is also minimized to reduce performance errors associated with acceleration inputs.
- Eight pin connector and enhanced environmentally sealing. Supplied with mating connector.

The G200 Dual Axis 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.

PRODUCT DESCRIPTION

8.1 *G200 Dual Axis MEMS Gyro*

The all new G200 Dual Axis MEMS Gyro represents Gladiator's breakthrough gyro technology enabling an ultra-low noise two axis MEMS gyro and bandwidth of 200Hz that has performance commensurate with much more expensive **small Dynamically Tuned Gyros.** It also features industry leading bias in-run and bias over temperature. Designed for commercial stabilization and aircraft applications, the gyro has a bipolar signal outputting balanced 0V ±5V. The **signature features of the G200 are ultra-low noise gyros of** 0.002°/sec/√Hz**, bandwidth of 200Hz,** short term bias of 0.0014°/sec as well as impressive bias over temperature, low power, light weight, as well as excellent g-sensitivity and misalignment. The unit is highly durable and can withstand environmental vibration and shock typically associated with commercial stabilization and aerospace requirements.

Figure 1: G200 with 2 Euro Coin

- **NON-ITAR Commercial MEMS Dual Axis Gyro**
- **Ultra-Low Noise** *<0.002°/sec/√Hz (100°/s)*
- **Short Term Bias** *4°/hour 1σ*
- **Bias Over Temperature** *≤0.1°/sec 1σ*
- **G-Sensitivity** *≤0.005°/sec/g 2σ*
- **Axis Alignment** *<4mrad 1σ*
- **Ultra-Low Power** *< 10 mA Typical*
- **Bipolar Output Signal**
- **Light Weight** *18 grams*
- **Low Voltage** *+5V (single sided power)*
- **Bandwidth** *200Hz*
- **All Internal Electronics**
- **Environmentally Sealed**
- **Voltage Output**
- **Internal Temperature Sensor**
- **Self-Test**
- **Shock Resistant** *500g*
- **Vibration** *6 gRMS*
- **High MTBF**

Applications
- Platform Stabilization
- EO/IR Stabilization
- Antenna Stabilization & Pointing
- Flight Control
- Navigation
- Automotive Testing
- Laboratory Use

The MEMS G200 gyro is offered at 100°/s or 300°/s rate range. The gyro is designed for platform, image and antenna stabilization and pointing, commercial aircraft applications, automotive testing, general aviation and laboratory use. The G200 is ideal where very low noise, excellent bias over temperature performance, low power consumption, low g-sensitivity, light weight and rugged durability are desired for commercial environments and applications. Thermal model available - consult factory.

8.2 *Outline Drawing and 3D Solid Models*

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

8.2.1 *3D Solid Model*

Please go to the applicable product of interest on our website at www.gladiatortechnologies.com and a user can download the 3D Solid Model (STEP) 2D outline drawing and other product information.

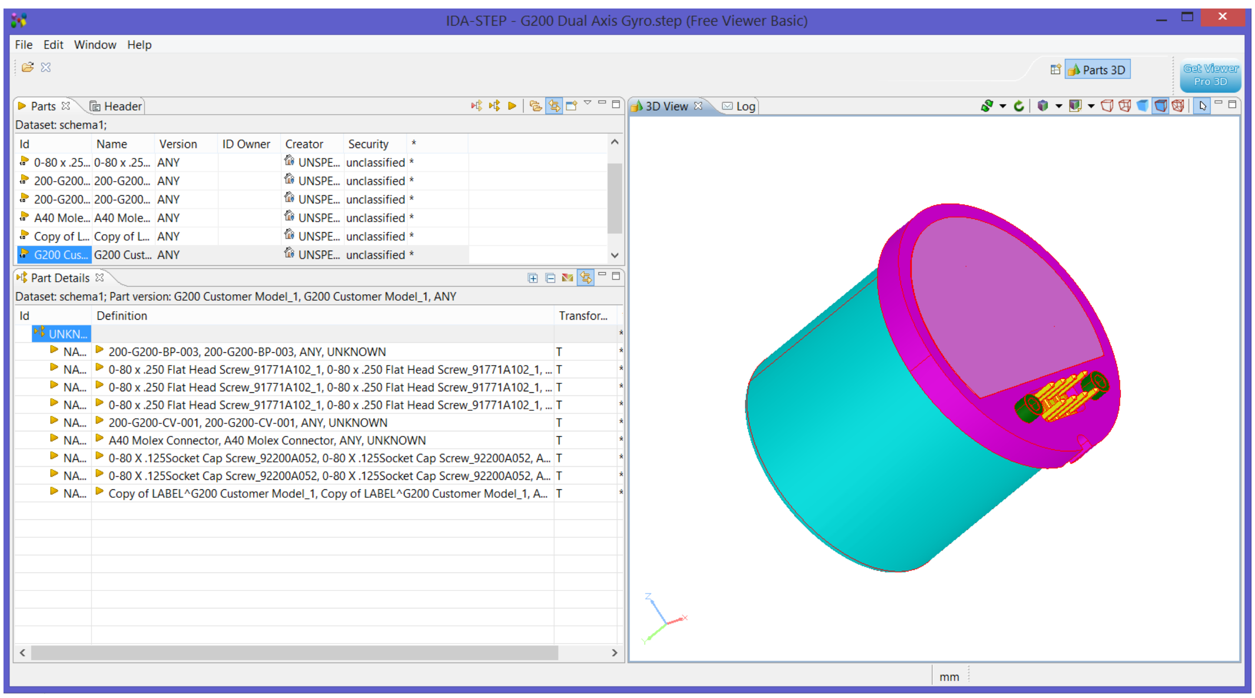
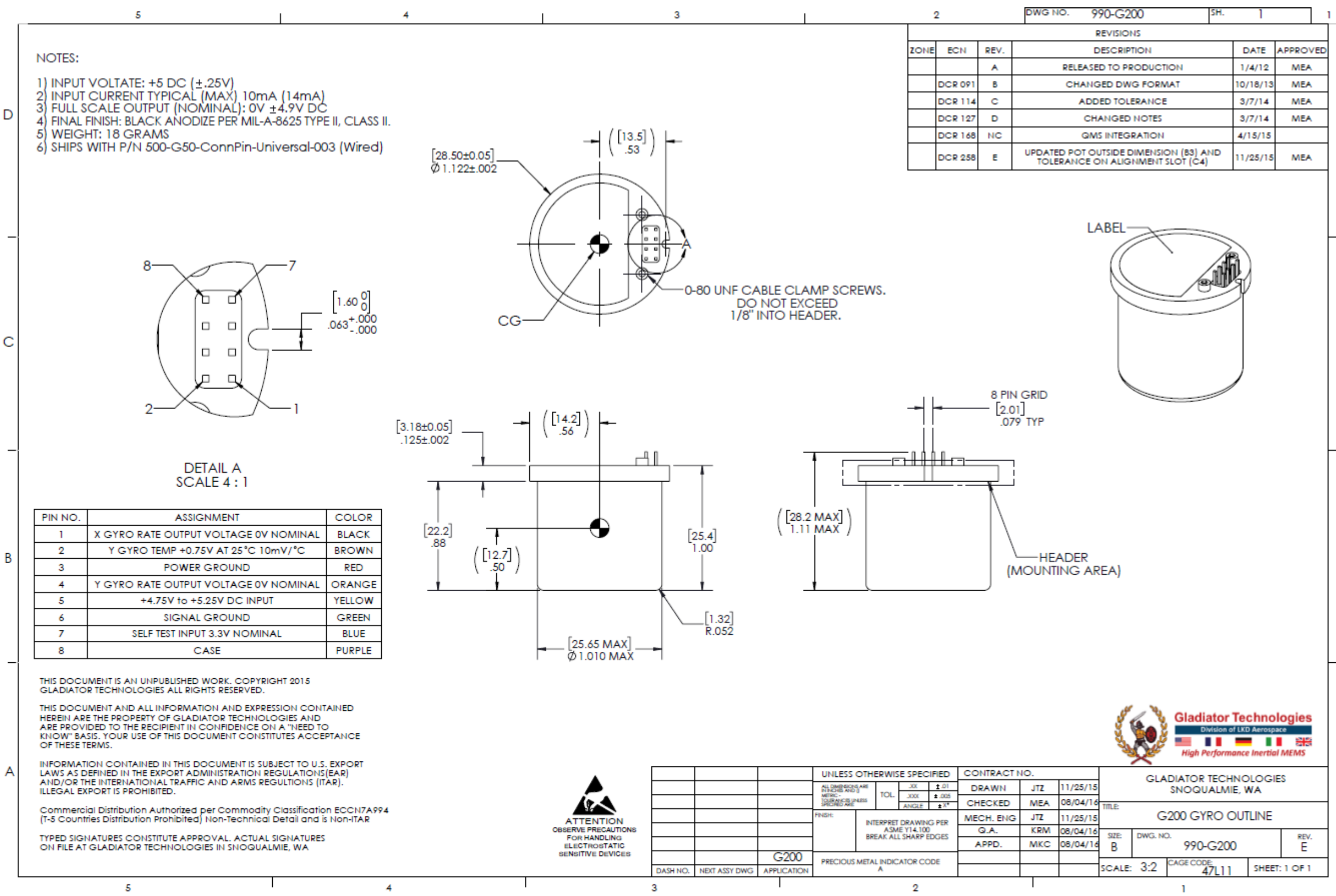


Figure 2 G200 Gyro 3D Model (STEP)

8.2.2 *Outline Drawing*



ZONE	ECN	REV.	DESCRIPTION	DATE	APPROVED
		A	RELEASED TO PRODUCTION	1/4/12	MEA
	DCR 091	B	CHANGED DWG FORMAT	10/18/13	MEA
	DCR 114	C	ADDED TOLERANCE	3/7/14	MEA
	DCR 127	D	CHANGED NOTES	3/7/14	MEA
	DCR 168	NC	QMS INTEGRATION	4/15/15	
	DCR 258	E	UPDATED POT OUTSIDE DIMENSION (B3) AND TOLERANCE ON ALIGNMENT SLOT (C4)	11/25/15	MEA

PIN NO.	ASSIGNMENT	COLOR
1	X GYRO RATE OUTPUT VOLTAGE 0V NOMINAL	BLACK
2	Y GYRO TEMP +0.75V AT 25°C 10mV/°C	BROWN
3	POWER GROUND	RED
4	Y GYRO RATE OUTPUT VOLTAGE 0V NOMINAL	ORANGE
5	+4.75V to +5.25V DC INPUT	YELLOW
6	SIGNAL GROUND	GREEN
7	SELF TEST INPUT 3.3V NOMINAL	BLUE
8	CASE	PURPLE

Figure 3 Standard G200 Gyro Outline Drawing

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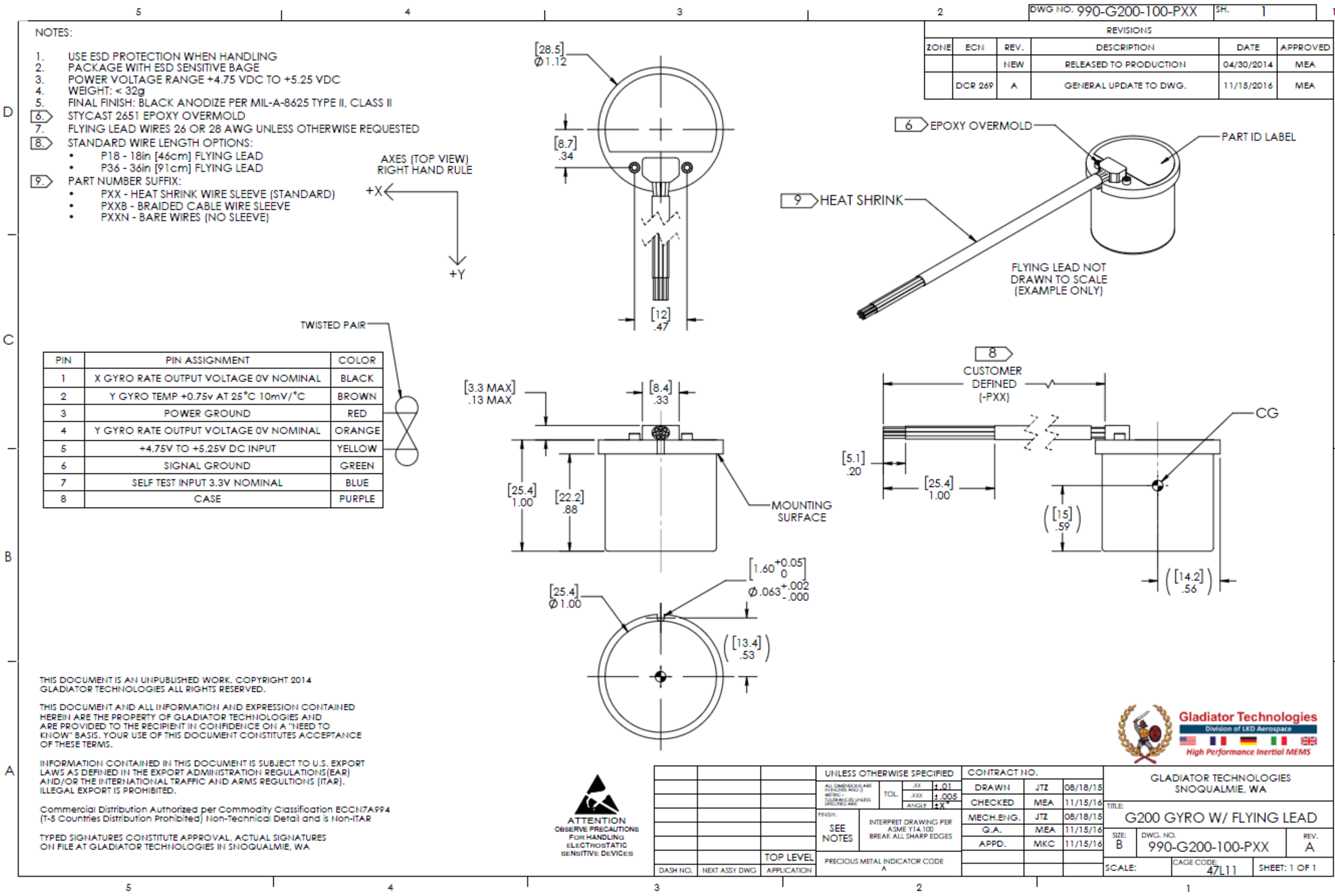


Figure 4 Standard Pigtail Options for G200 Outline Drawing

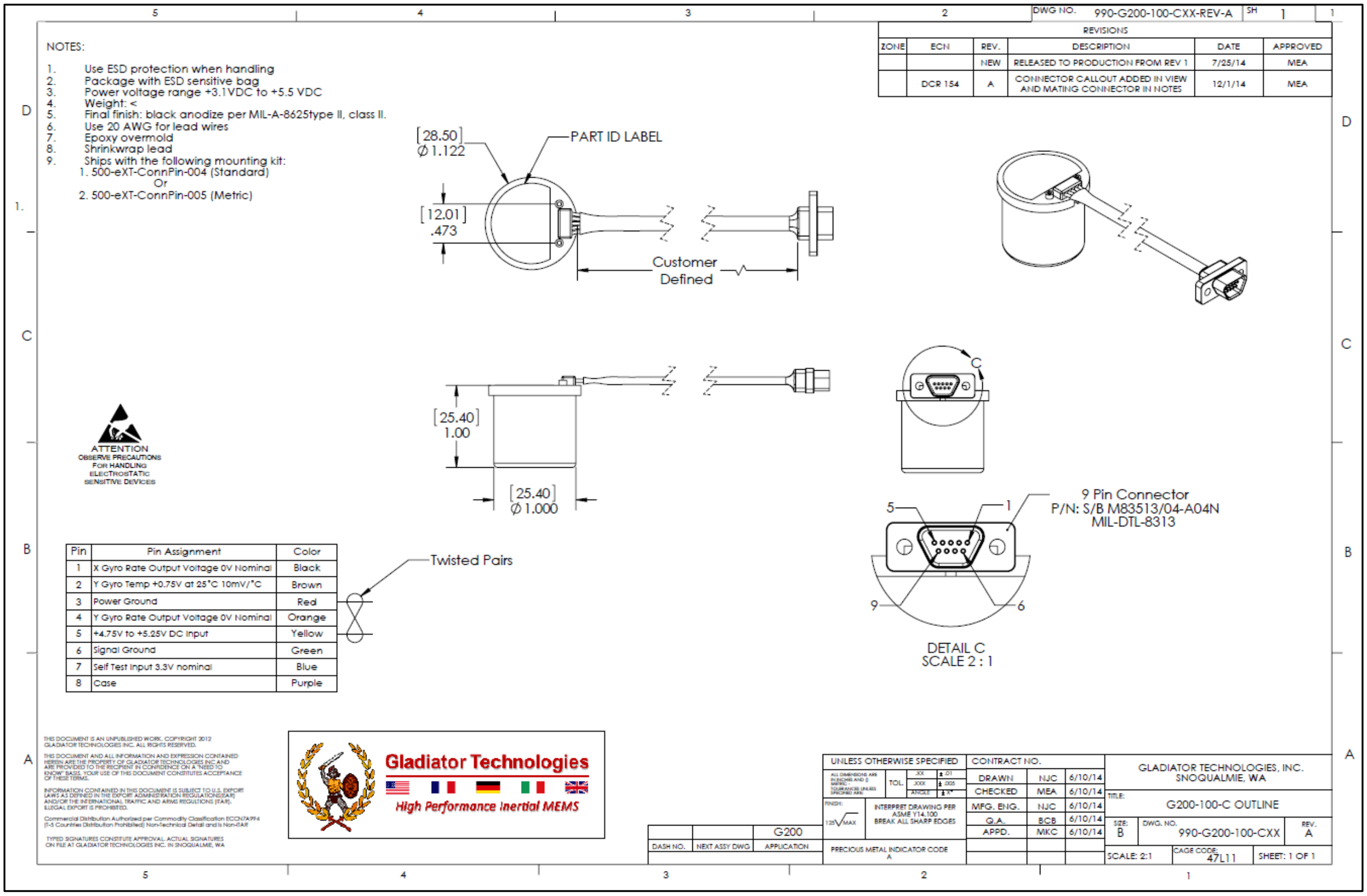


Figure 5 Standard Pigtail with Connector Options for G200 Outline Drawing

8.3 *Outline Exploded View & Axis Orientation*

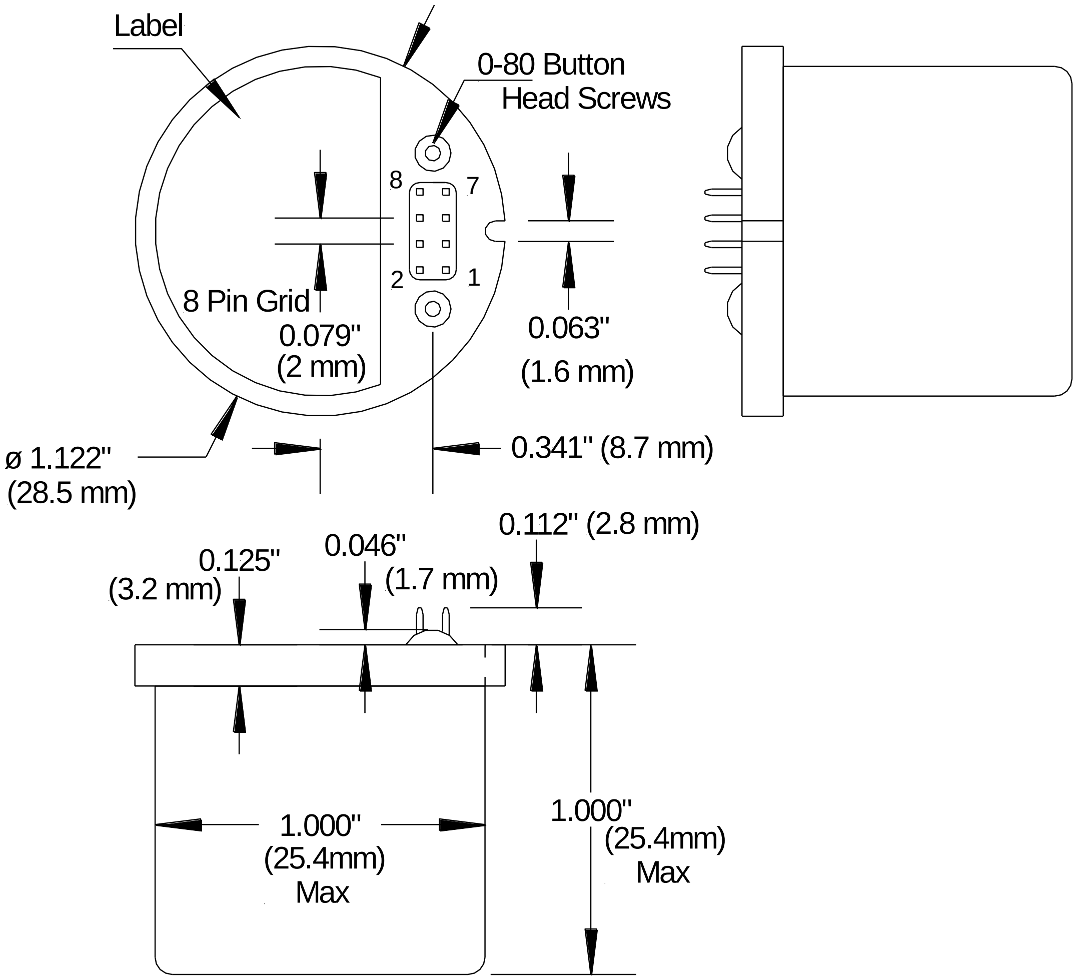


Figure 6: G200 Dual Axis MEMS Gyro Outline Drawing

8.4 *Gyro Axis Orientation*

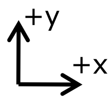


Figure 7: Axes (Top View) Right Hand Rule

8.5 *G200 Dual Axis MEMS Gyro Block Diagram*

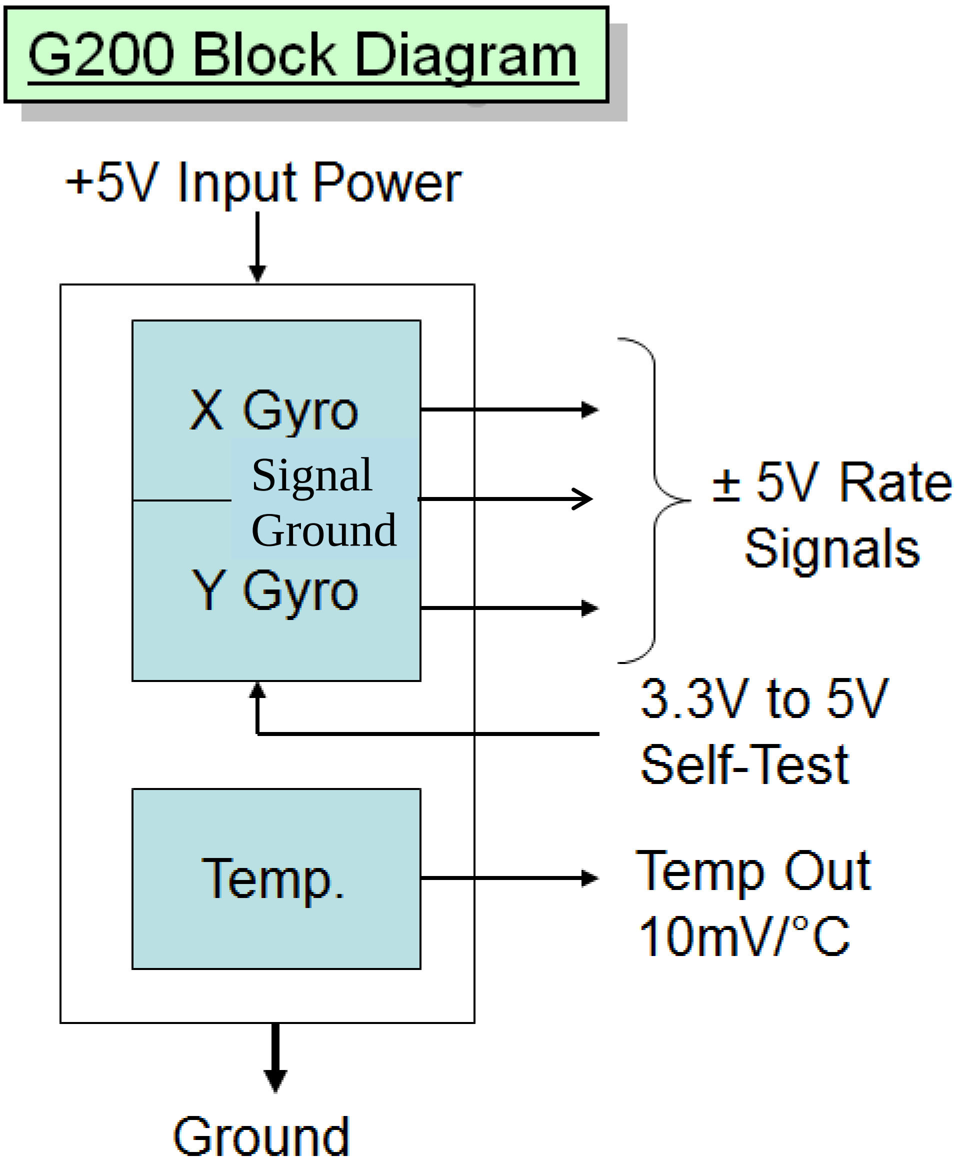


Figure 8: G200 Dual Axis Gyro Block Diagram

8.6 *G200 Part Number Configurations*

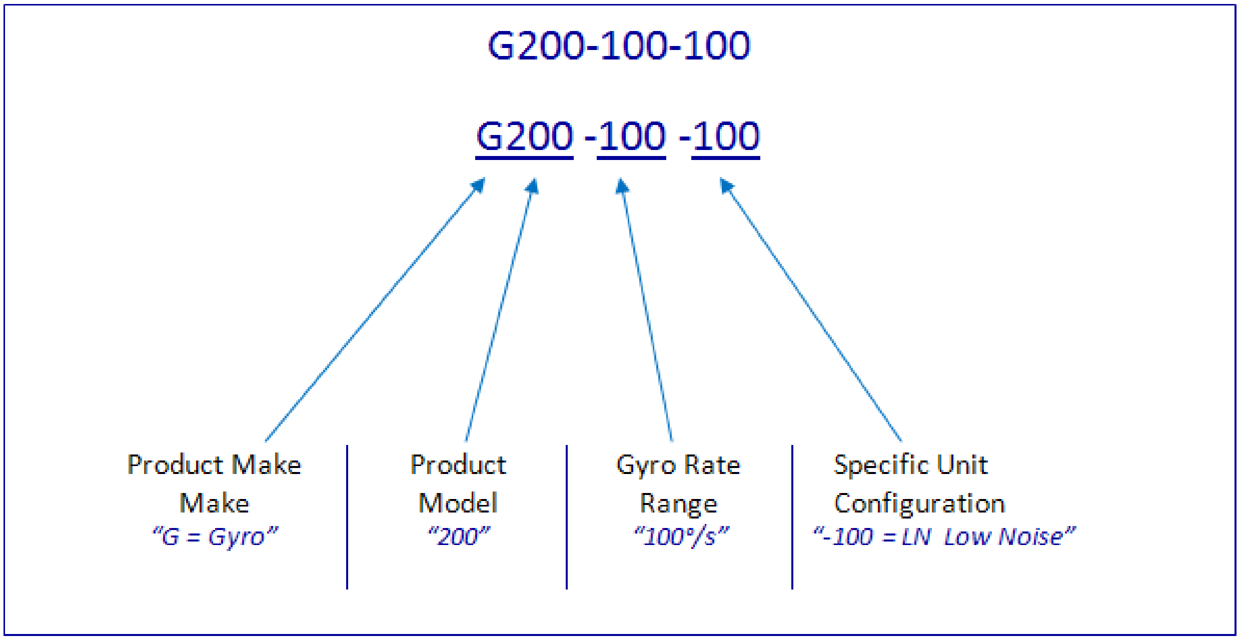


Figure 9: Gladiator Technologies Part Naming Conventions for G200 Dual Axis MEMS Gyros

G200 Dual Axis Gyro
G200-100-100 **G200-300-100**

Figure 10: G200 Standard Part Number Configurations

8.7 *G200 Dual Axis MEMS Gyro Pin Assignments*

The G200 Gyro has a 8 pin 2 millimeter center to center spacing type connector interface which provides the electrical interface to the host application. The signal pin-out is as follows:

Pin No.	Pin Assignment
1	X Gyro Rate Output Voltage 0V *Nominal*
2	Gyro Temp +0.75V @ 25°C 10mV/°C
3	Power Ground
4	Y Gyro Rate Output Voltage 0V Nominal
5	**+4.75V to +5.25V DC Input**
6	Signal Ground
7	Self Test Input 3.3V nominal
8	Case

Rate output X Axis is Pin 1 with respect to Pin 6. Rate output Y Axis is Pin 4 with respect to Pin 6. Temperature is Pin 2 with respect to Pin 6. Self Test On is 3.3V on Pin 7. Self Test Off is open or < 1V. Loads <100pf & >5k on pins 1 & 4 and >40k on pin 2

Figure 11: G200 Pin Assignments

8.8 *Description of Self-Test Input and BIT Output*

Logic "1" applied to the self test pin causes an output change on both gyros.
Logic "0" or open is normal operation.

Figure 12: G200 BIT Definitions (3.3 to 5V Logic)

Pin No.	Pin Assignment
1	X Gyro Rate Output Voltage 0V *Nominal*
2	Gyro Temp +0.75V @ 25°C 10mV/°C
3	Power Ground
4	Y Gyro Rate Output Voltage 0V Nominal
5	**+4.75V to +5.25V DC Input**
6	Signal Ground

Both gyros swing up to ±5V about signal ground.

Figure 13: Voltage Output & Pin Out Description

8.9 *Custom Pigtail and Connector Options*

The company offers many standard connector options for a modest additional fee. Some of these include twisted pair pigtails with flying leads or pigtail with MIL-STD connector. Please see the various outline drawing options in the preceding section for more of these standard options. We have many other standard options that are available, so if you have other requirements please contact the factory and they would be happy to assist you.

8.10 *Custom Options Available*

The standard bandwidth of the G200 Dual Axis MEMS Gyro is 200 Hz and standard rate ranges are denoted on the datasheet. Should a user want either a lower bandwidth or rate range please contact the factory for detailed information and applicable part number.

8.11 *Power Supply Noise*

The 5V power supply noise can couple to the gyro outputs thru the output op amp stage. Power supply noise should be kept below 20 mV rms to 1kHz and then attenuated at 20db per decade above 1kHz to 10kHz. From 10kHz to 100kHz the attenuation needs to be 40db per decade until the noise drops below 20uV rms.

8.12 *G200 Dual Axis MEMS Gyro Mating Connector*

Each G200 is shipped with a mating connector (crimp pins). The mating connector part number is Hirose DF11-8DS-2C. A pre-wired mating connector option (for Figure 6) is part number M83513/03-AxxN (xx denotes type of wire and length).

Other mating options that are available is for the factory to install a pre-wired with an 18” color-coded pigtail or pigtail connector (please see previous section on outline drawing options). Please contact the factory at time of order.

8.13 *G200 Dual Axis MEMS Gyro Self-Test / Built-In-Test (BIT)*

Incorporated into all of Gladiator’s gyro and inertial systems products have a self-test feature. This allows verification of operation of the sensors prior to using the product. The Built-In-Test (BIT) is available on all rate range gyros and the BIT has positive logic in that when a logic “1” is applied to the self-test Pin 7, a unit that is functioning properly will output a voltage change on both gyros. The level will depend on whether a 3.3V or 5V logic is applied.

It is best to apply self-test in a known, preferably static condition to look at BIT change. Please note that the self-test feature can also be used while in use without damaging the sensor, but the user will not achieve optimum self-test results.

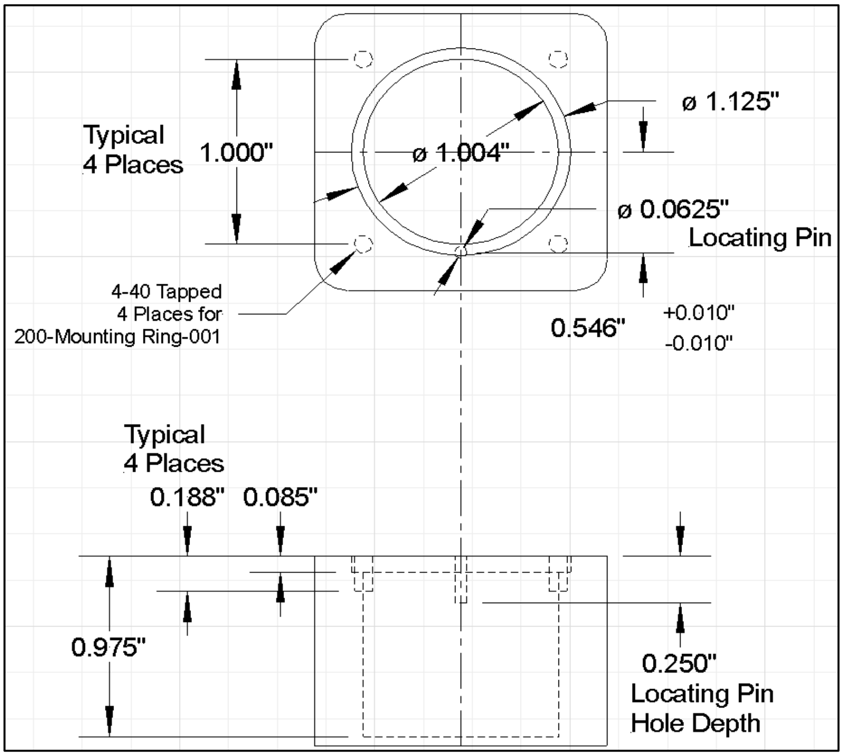
Remove the self-test signal by either opening the lead or grounding the lead. If the environment is particularly EMI noisy, it is best to ground the lead to avoid false application of self-test.

Logic "1" applied to the self test pin causes an output change on both gyros.
Logic "0" or open is normal operation.

Figure 14: G200 Self-Test Description

8.14 *Mounting*

Mounting for the G200 is a ring type flange mount. Be sure that the surface that you are mounting to is clean and level in order to eliminate potential alignment errors. The following figures show the recommended mounting dimensions. The unit can be mounted with servo clamps. Optional mounting ring can be purchased with the unit as 200-MT-RG-001.



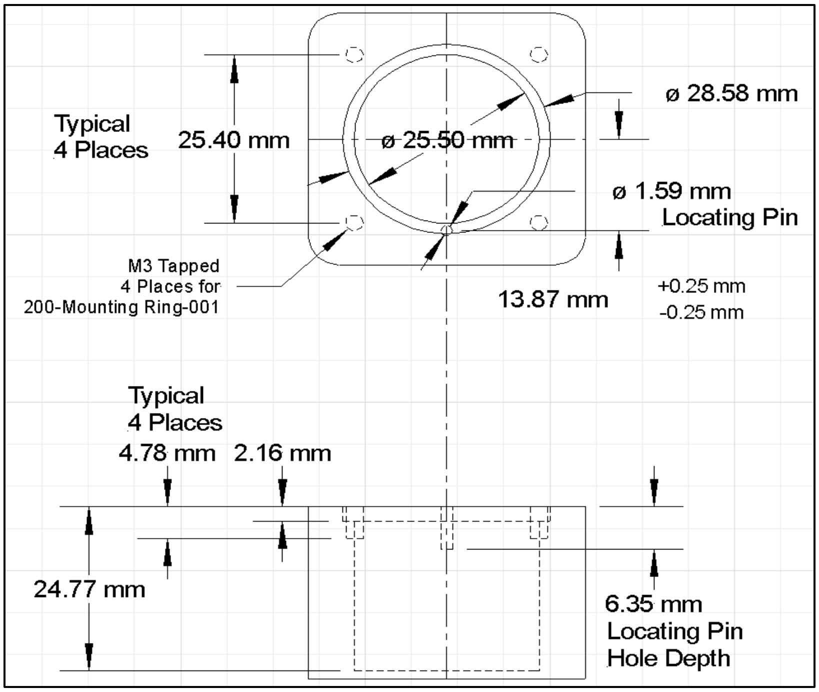


Figure 15: G200 Recommended Mounting Dimensions

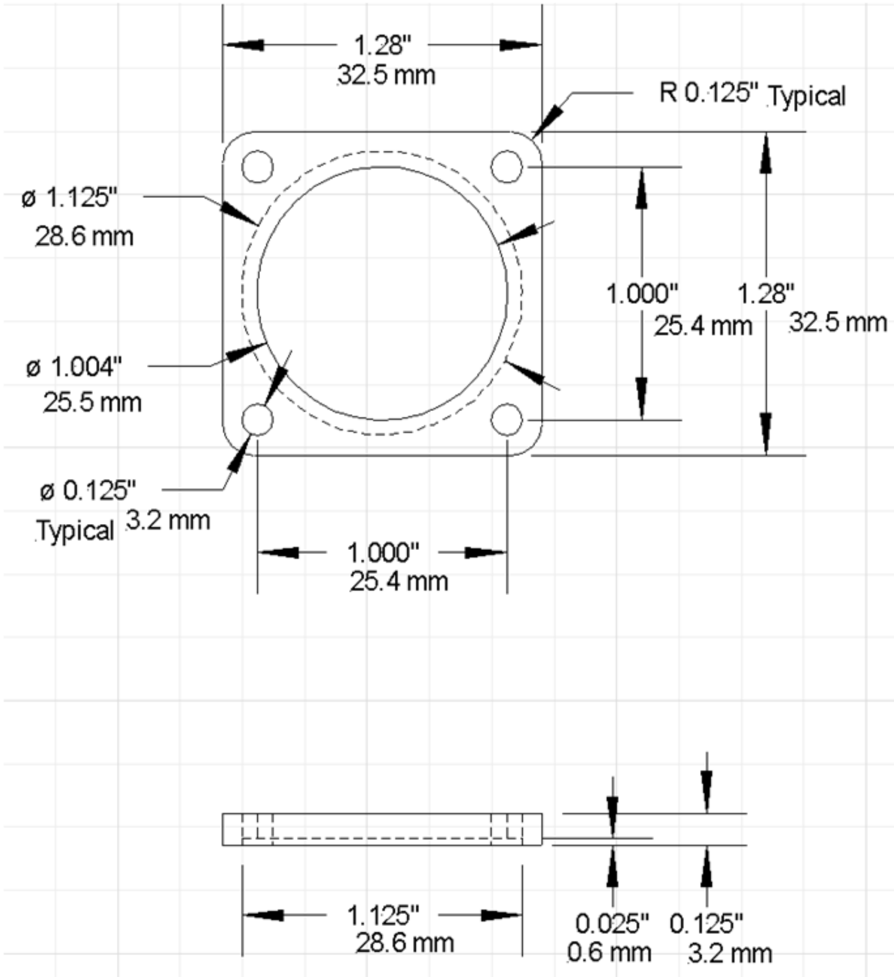


Figure 16: G200 Optional Mounting Ring

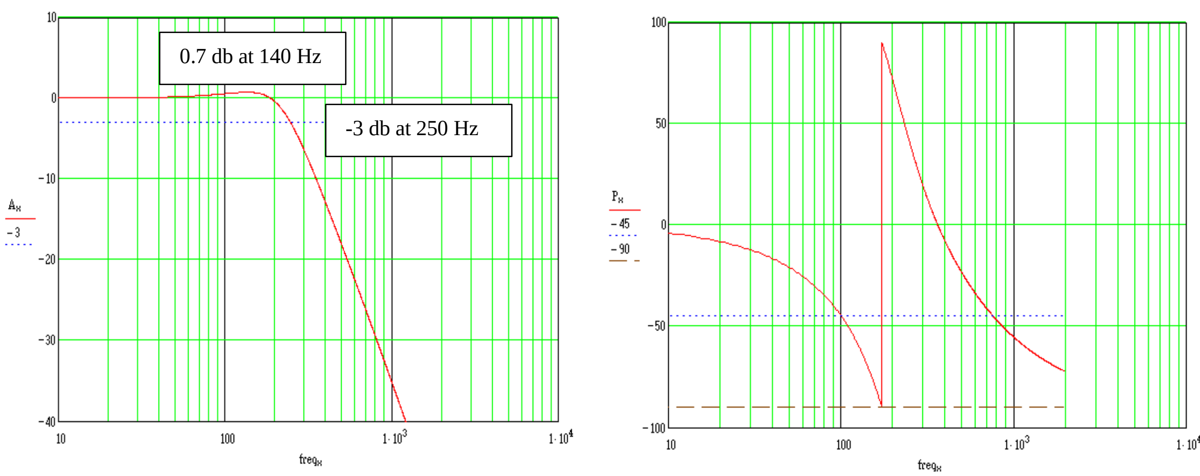
9 TYPICAL SAMPLE TEST DATA

Please contact factory for sample ATP test data or for actual recorded data outputs in excel format. Typical ATP test data that goes 100% with every unit would include:

- Gyro Noise Angle Random Walk (ARW)
- Gyro In-Run Bias
- Gyro Bias Over Temperature
- Gyro Scale Factor Over Temperature
- ATP: X & Y Gyro Bias at Ambient, a hot point and a cold point
- ATP: X & Y Gyro Nominal Scale Factor at Ambient, a hot point and a cold point
- ATP: X & Y Gyro misalignment (in deg/sec and in mrad)

9.1 *Frequency Response*

The standard G200 Dual Axis Gyro has the bandwidth set at 250 Hz (-3dB Point) as it is a second order sensor. The -90° Phase Shift occurs at 180 Hz.



<u>Approximate Math Model</u> <u>Gyro</u>: Quadratic Low pass of fn ~ 215 Hz with damping of $\xi = 0.5$
<u>Filter</u>: First order low pass at ~ 410Hz.

Figure 17 G200 Gyro Frequency Response

9.2 *Gladiator ATP Explanation*

9.2.1 *Rate Spin Test:*

Data is captured with the voltage output. The unit is mounted on an orthogonal test fixture and spun at less than the full scale rate range. All the rate signals are measured for one axis. The test is then repeated on the other sensitive axis. The spin rate in the data below was 72°/sec. Each column is the data taken for the axis name at the top of the page during the test at the left. From left to right including the second row the following ATP test data is outlined:

1. Bias Over Temperature (°/sec at Ambient, Hot & Cold Points)
2. Scale Factor Over Temperature (mV/°/sec)
3. Temperature Sensor Over Temperature in Volts
4. Misalignment (mrad X to Z and X to Y axis)
5. Bias Thermal Coefficient (TC) in °/sec/°C
6. Scale Factor Thermal Coefficient (TC) in ppm/°C
7. Temperature Sensor Thermal Coefficient (TC) in mV/°C
8. G-Sensitivity in °/sec/g

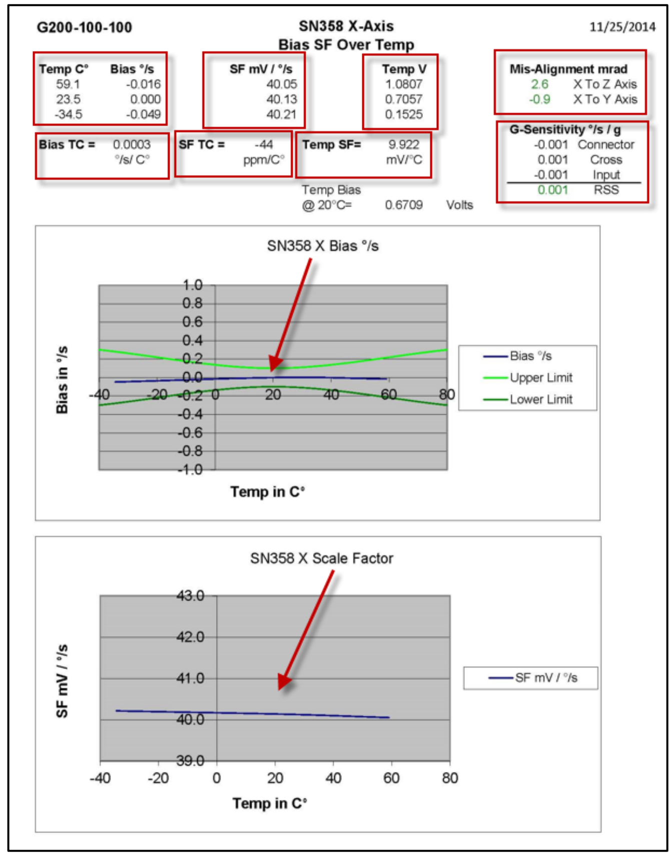


Figure 18 ATP Test Definitions

The final values printed in green fall *within the “passing” values for the unit (note that all passed).*

9.1 *Bias and Scale Factor Over Temperature – X Gyro*

G200-100-100 **SN358 X-Axis** 11/25/2014

Bias SF Over Temp

Temp C°	**Bias °/s**	**SF mV / °/s**	**Temp V**
59.1	-0.016	40.05	1.0807
23.5	0.000	40.13	0.7057
-34.5	-0.049	40.21	0.1525

Bias TC = 0.0003 °/s/ C° **SF TC =** -44 ppm/C° **Temp SF=** 9.922 mV/°C

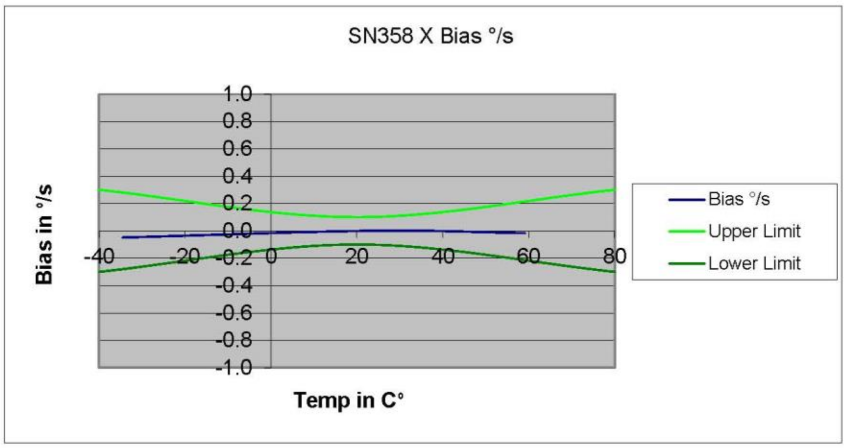
Temp Bias @ 20°C= 0.6709 Volts

Mis-Alignment mrad

2.6	X To Z Axis
-0.9	X To Y Axis

G-Sensitivity °/s / g

-0.001	Connector
0.001	Cross
-0.001	Input
0.001	RSS



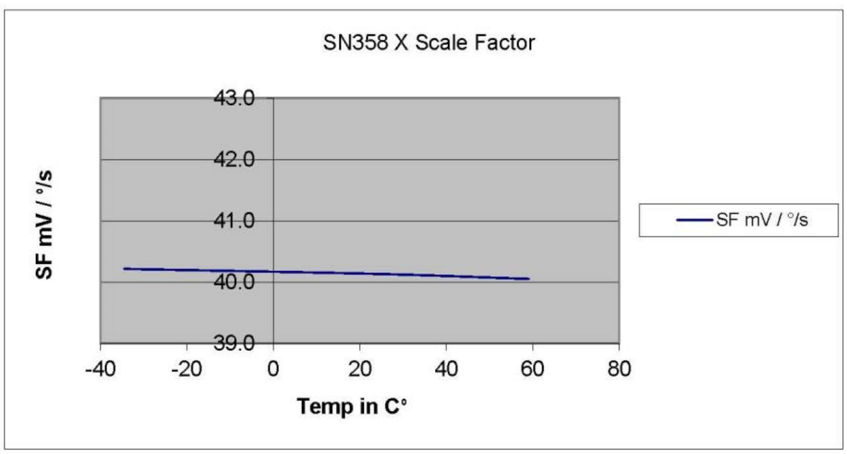


Figure 19 Bias & Scale Factor Over Temperature – X Gyro

9.9 *Bias and Scale Factor Over Temperature – Y Gyro*

G200-100-100 **SN358 Y-Axis** 11/25/2014

Bias SF Over Temp

Temp C°	**Bias °/s**	**SF mV / °/s**	**Temp V**
58.9	0.00	40.12	1.0780
23.5	-0.02	40.23	0.7127
-33.8	0.03	40.40	0.1608

Bias TC = -0.0003 °/s/ C° **SF TC =** -75 ppm/C° **Temp SF=** 9.895 mV/°C

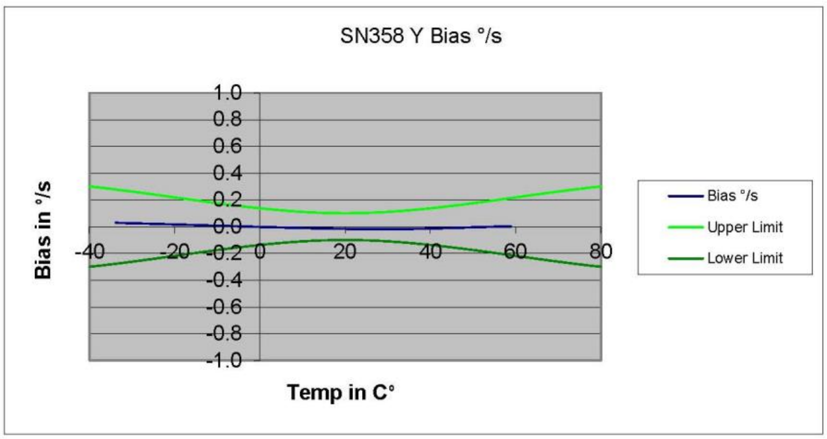
Temp Bias @ 20°C= 0.6780 Volts

Mis-Alignment mrad

-0.5	Y To X Axis
0.6	Y To Z Axis

G-Sensitivity °/s / g

0.000	Connector
0.005	Cross
-0.004	Input
0.004	RSS



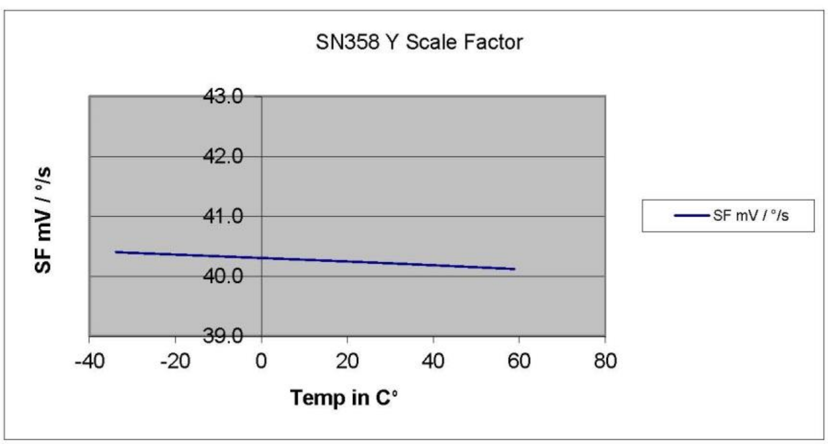


Figure 20 Bias & Scale Factor Over Temperature – Y Gyro

9.10 *Angle Random Walk – X Gyro*

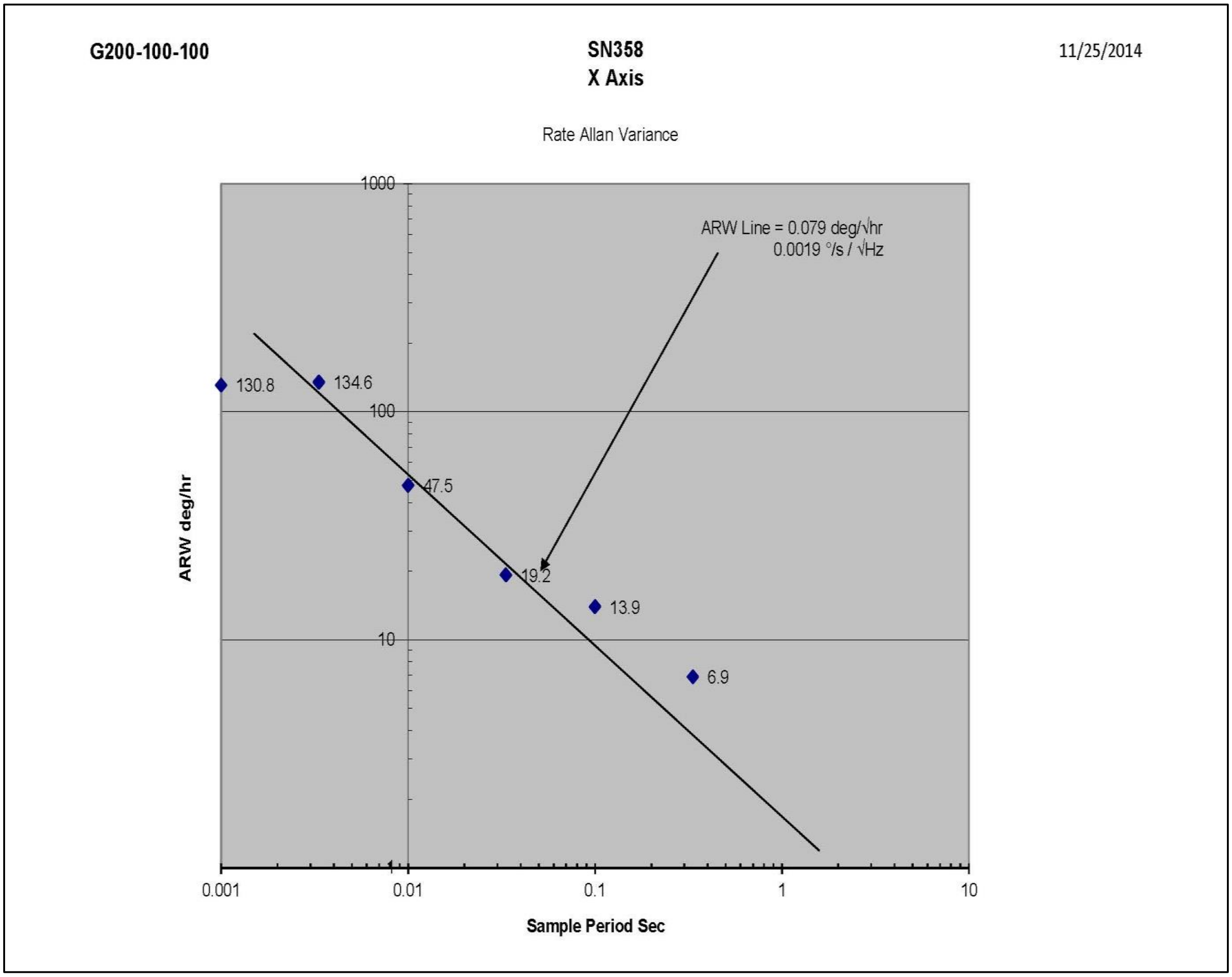


Figure 21 ARW Random Walk Gyro Noise – X Gyro

10.10 *Angle Random Walk – Y Gyro*

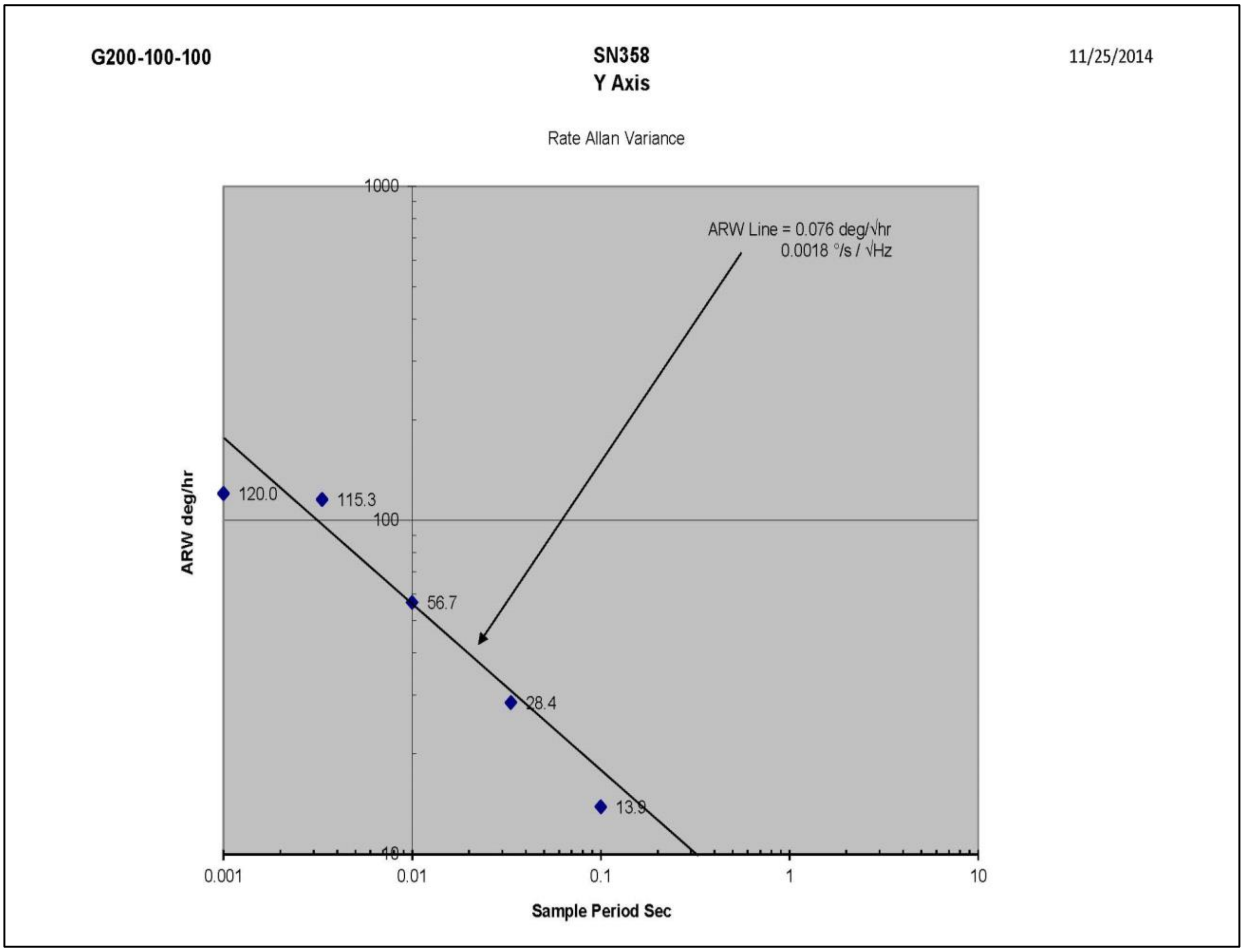
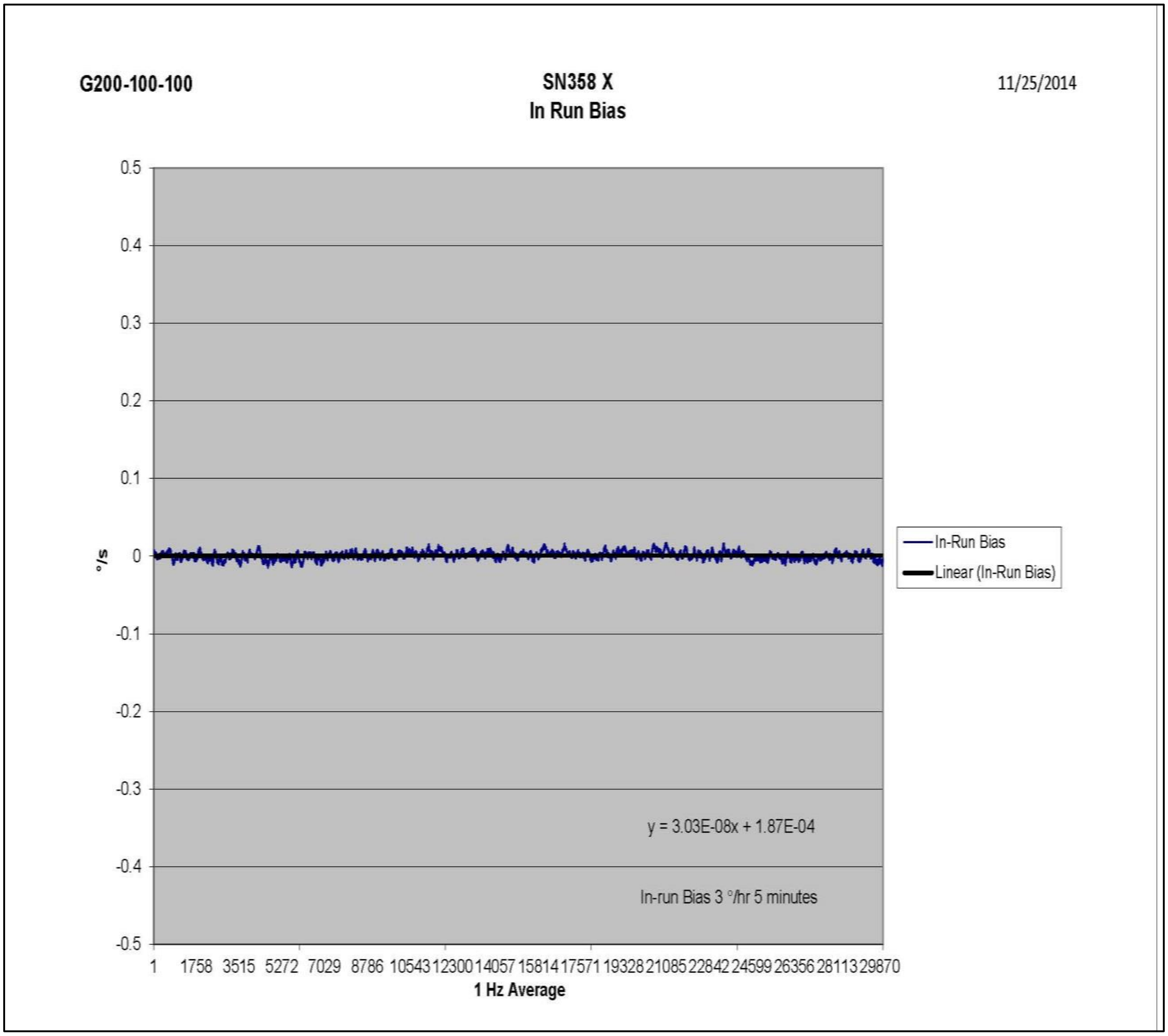
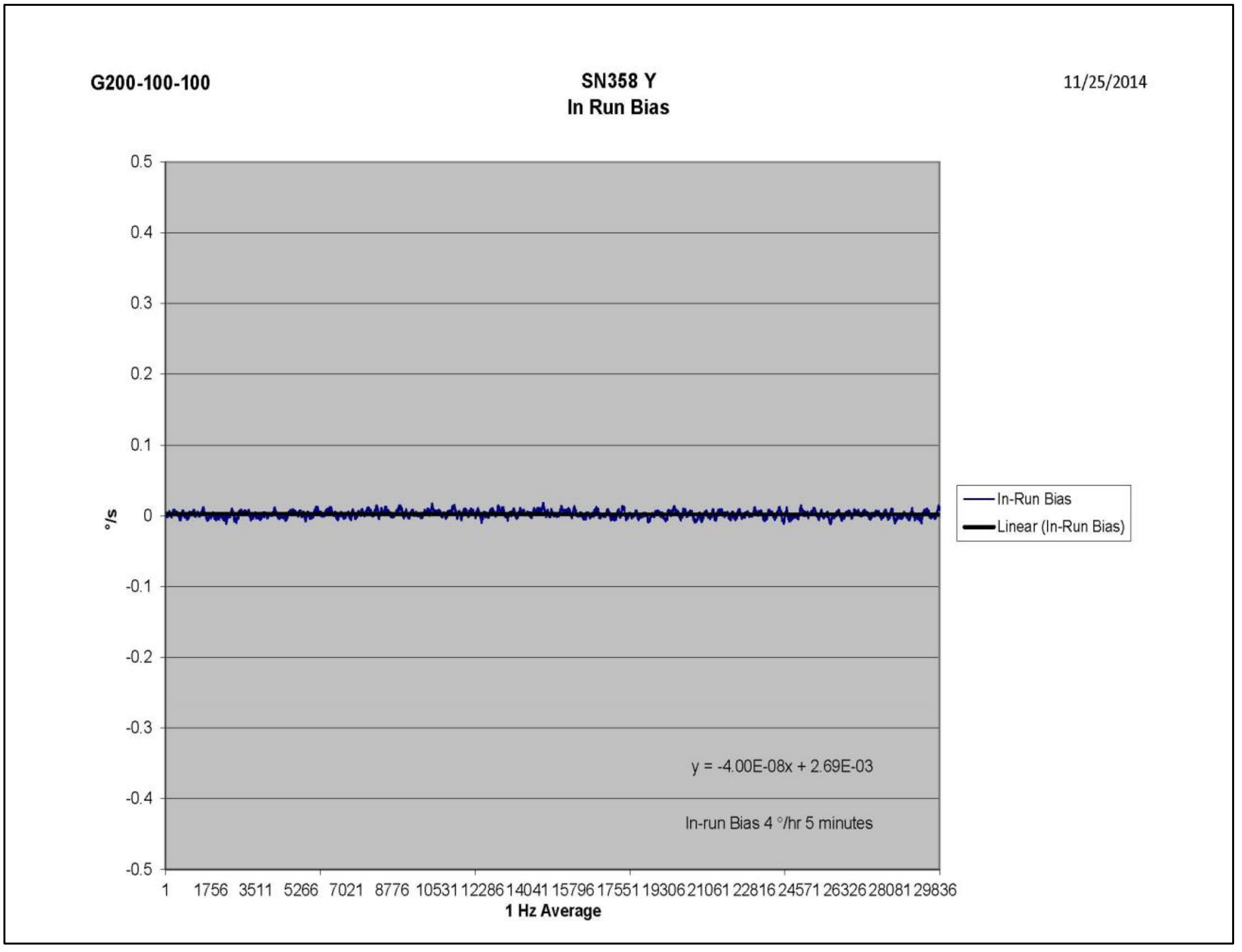


Figure 22 ARW Random Walk Noise – Y Gyro

9.11 *Bias In-Run – X Gyro*



10.11 Bias In-Run – Y Gyro



 SN: 350

TECH NOTE

G200 Modeling over Temperature

Bias SF Over Temp

Temp C°	Bias °/s	SF mV / °/s	Temp V
60.1	0.06	170.13	2.7965
24.7	-0.01	170.11	2.4935
-31.1	-0.07	169.73	2.0737

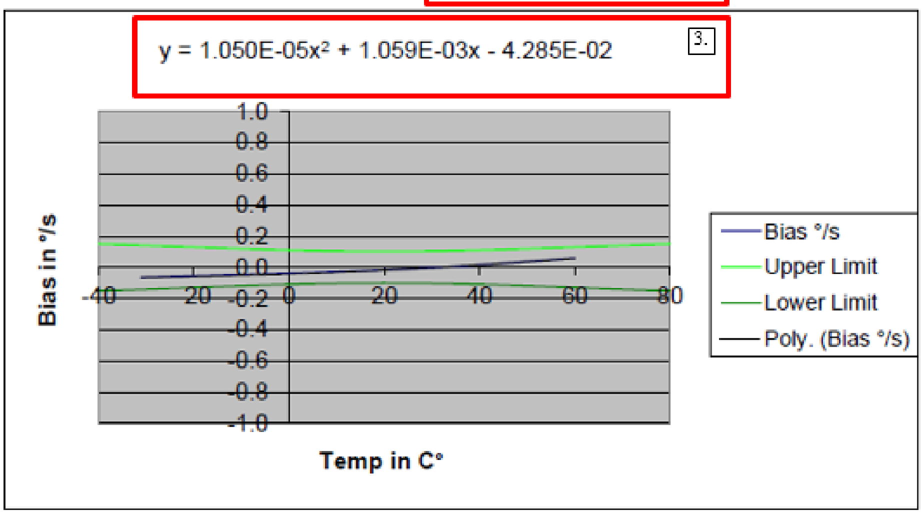
Mis-Alignment mrad	
4.0	Connector
4.3	Cross

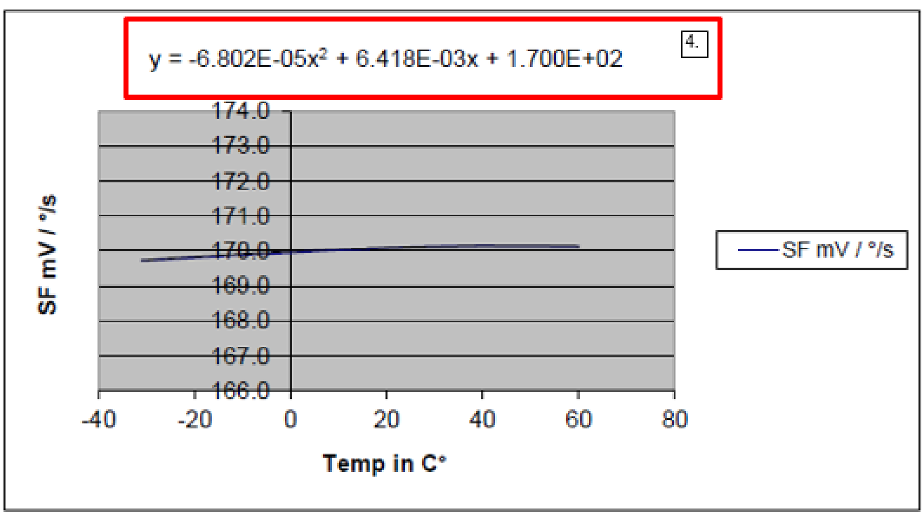
Bias TC = 0.0014 °/s/ C° SF TC = 26 ppm/C°

Temp SF= 7.925 mV/°C (2.)

Temp Bias @ 20°C= 2.4563 Volts (1.)

G-Sensitivity °/s / g	
0.001	Connector
0.006	Cross
0.002	Input
0.004	RSS





Each gyro is supplied with the Calibration data per the above example. In each chart is the 2nd order model equation for bias in °/s over temperature in C° and for scale factor in mV/ °/s over temperature in C°. Also included is a model for the temperature sensor bias voltage at 20 C°

and the scale factor in mV/ C°. By using this information, a better correction to the analog gyro output can be formulated.

1. First compute the temperature of the gyro in C°:
    a. Measure the Temperature sensor voltage: Vt (let Vt = 2.4959 V for example)
    b. Subtract the Bias at 20 C° (See box 1.): Vt-2.4563
    c. Divide by the Temp scale factor (See box 2.): (Vt-2.4563)/0.007925
    d. Add 20 °/s to get the final temperature: Tc = (Vt-2.4563)/0.007925+20
    e. The computed temperature in C° is: Tc = 25
2. Now calculate the rate bias in °/s:
    a. Substitute Tc for x in the equation of box 3
    b. $B = 1.050*10^{-5} *Tc^{2} +1.059*10^{-3} *Tc -4.285*10^{-2}$
    c. $B = -9.81*10^{-3}$ in °/s
    d. Measure the voltage from the gyro: Vg
    e. Convert into degrees per second (see SF below): Vg/SF
    f. Correct for gyro model bias (B): Rate = Vg/SF –B
    g. This is the actual gyro rate in °/s
3. Now calculate the rate scale factor in V/ °/s:
    a. Substitute Tc for x in the equation of box 4
    b. $SF = (-6.802*10^{-5} *Tc^{2} +6.418*10^{-3} *Tc +1.700*10^{2})*1000$ in V/ °/s
    c. SF = 0.17012 in V/ °/s
    d. Use this value in 2.e. for the bias correction.

G200 Typical ARW Allan Deviation Plots

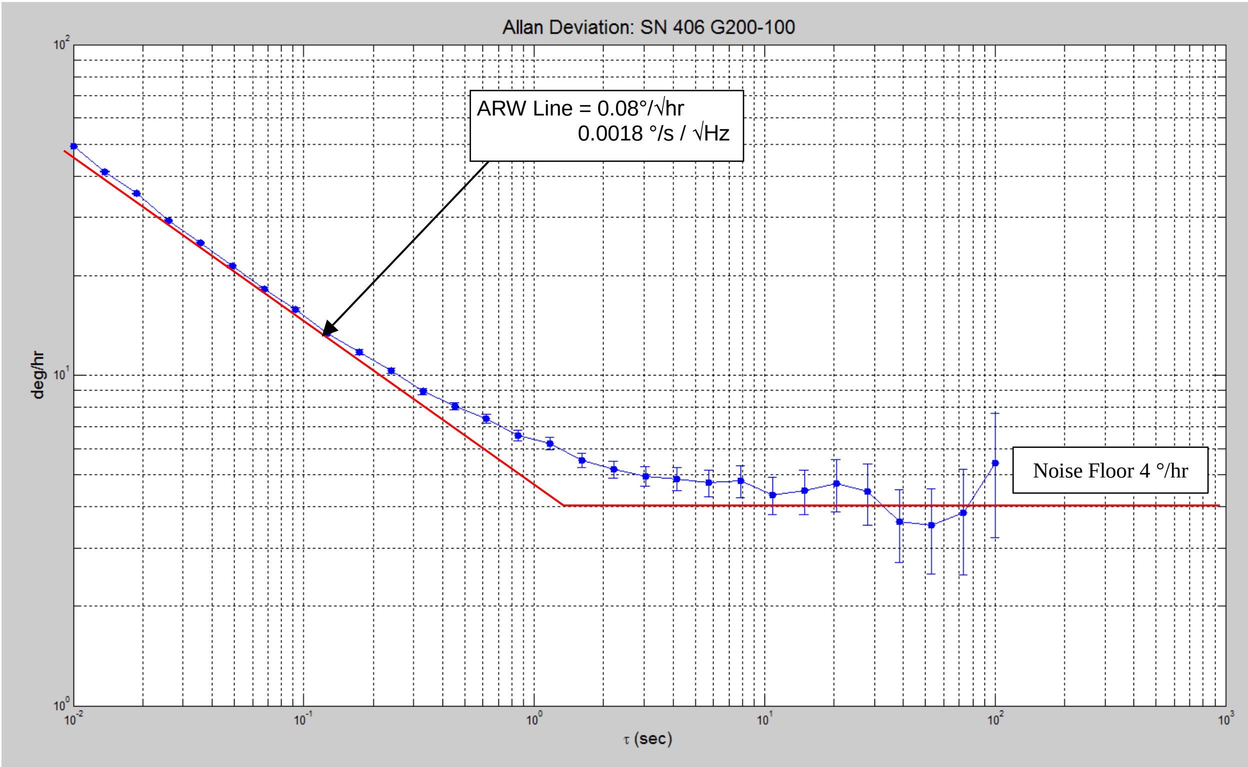


Figure 23 Typical ARW Random Walk Gyro Noise – X Gyro

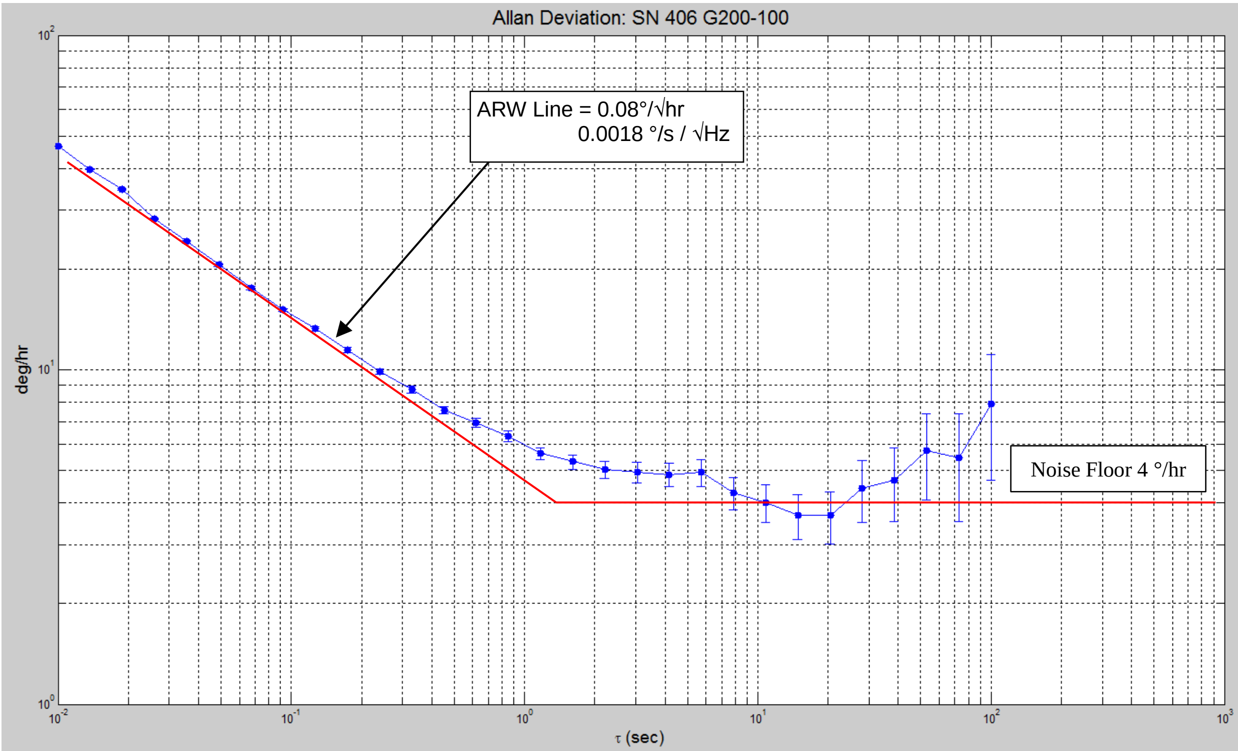


Figure 24 Typical ARW Random Walk Noise – Y Gyro

10 OPERATION AND TROUBLESHOOTING

10.1 *Technical Assistance*

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

Gladiator Technologies
8020 Bracken Place S.E.
Snoqualmie, WA 98065
Tel: 425-396-0829 x222
Fax: 425-396-1129
Email: techsupport@gladiatortechnologies.com

Authorized Distributors and Sales Representatives: www.GladiatorTechnologies.com

10.2 *Technical Support Website*

10.3 *Technical Documentation Available on Website*

Our website contains detailed product information for each product. Just select Products from the main navigation bar, select Systems and select your product of interest.

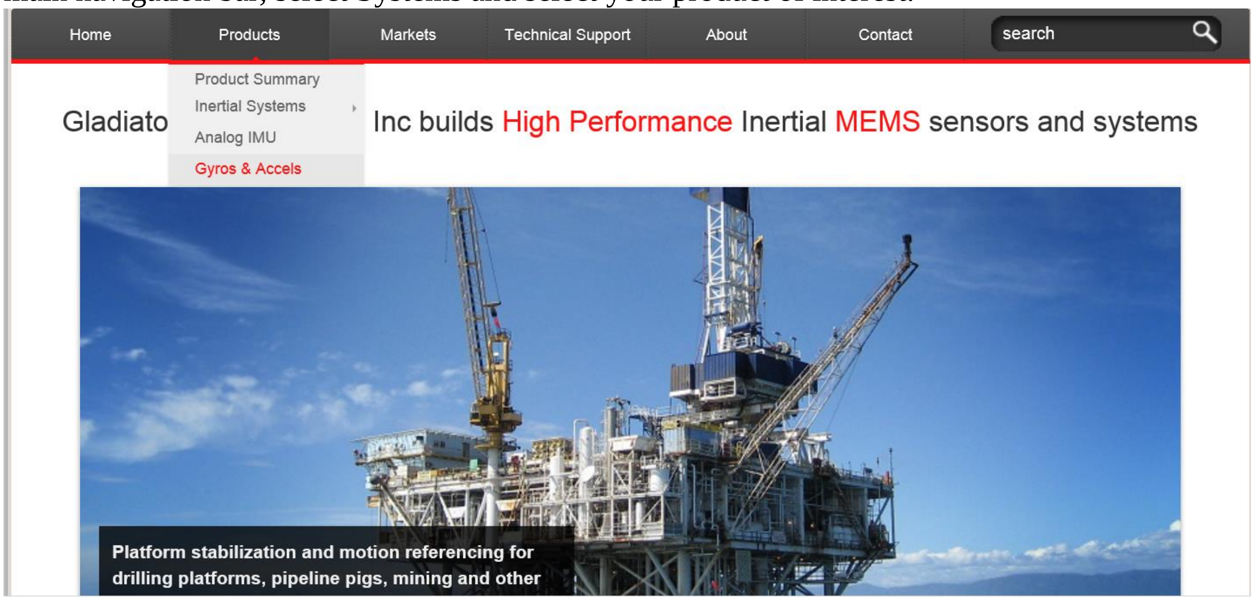


Figure 25 Website – Select Product Category

Our Technical support webpage contains specific product information.

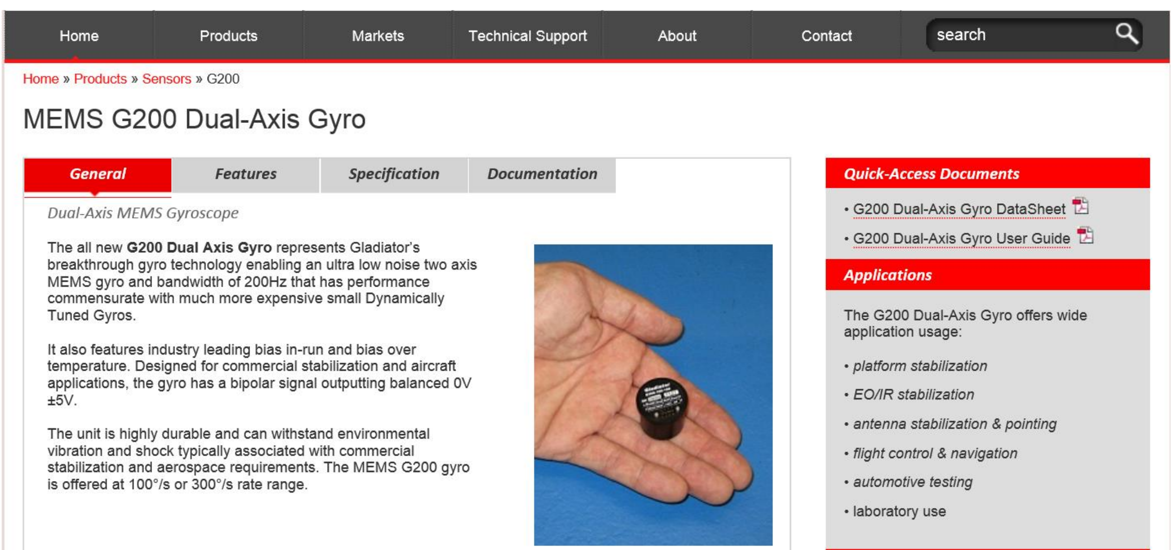


Figure 26 Product Information on Website

Click on the Documentation tab to access the following product information:

1. Product Datasheet
2. Technical User Guide
3. Outline Drawing
4. 3D Model
5. Sample Test Data
6. SDK Software (if applicable)
7. Remote Desktop Assistance.

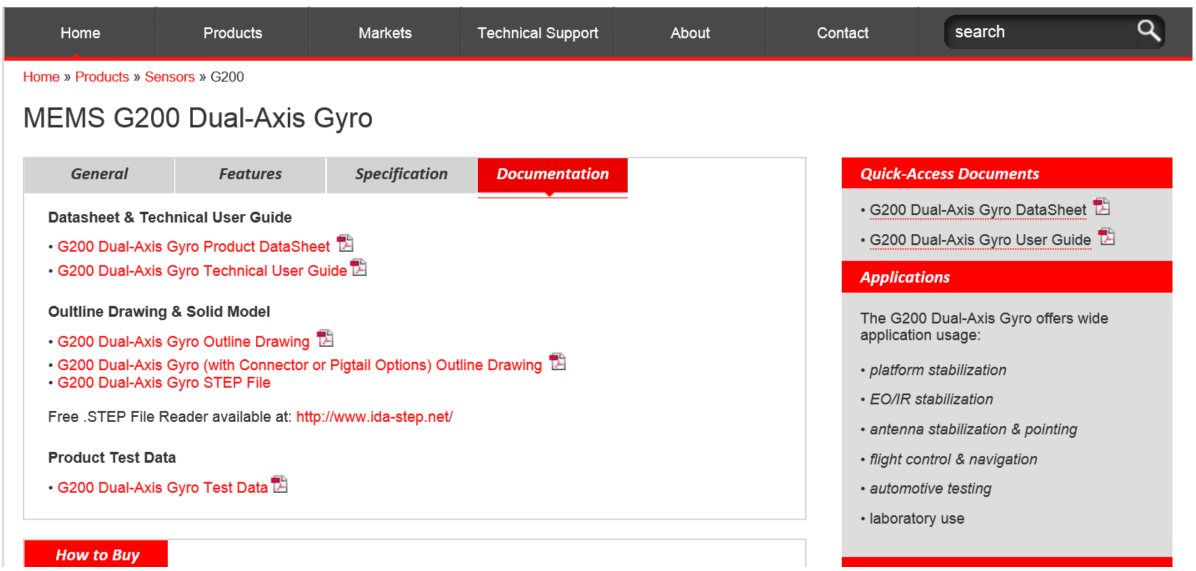


Figure 27 Product Documentation on Website

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 Technology's definition supersedes the IEEE definition. For a complete listing of IEEE's standard for inertial sensor terminology please go to www.ieee.org.

10.1 *Abbreviations and Acronyms*

6DOF: six degrees-of-freedom

CVG: Coriolis Vibratory Gyro

ESD: Electro Static Discharge

IEEE: The Institute of Electrical and Electronics Engineers

MEMS: Micro Electro-Mechanical Systems

NLR: No License Required

IMU: Inertial Measurement Unit

10.2 *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:
(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].
(gyro): 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 (º/h).
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 or 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 [$°/\sqrt{h}$].

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 [$(m/s)/\sqrt{h}$].

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.