APPLICATION		REVISIONS			
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	GG1320AN	D	SEE ECO-256605	15-05-19	EMA/MAC

ENGINEERING DOCUMENT

REVISION STATUS OF SHEET 1 APPLICABLE TO ALL SHEETS

THIRD ANGLE PROJECTION	DRAFTER	K. ELLISON	07-06-01
	CHECKER	M. COX	07-06-01
	DEV ENGR	S. ECKLUND	07-06-01
UNLESS NOTED OTHERWISE	ENGRG MGT	B. SEIBER	07-06-01
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HONEYWELL INTERNATIONAL INC.
AEROSPACE – Minneapolis, MN USA

USER'S MANUAL FOR THE GG1320AN RING LASER GYROSCOPE

SIZE	CAGE CODE	DRAWING NUMBER	
A	94580	ED9102-01	
SCALE: NONE		WT: -	SHEET: 1 OF 24

MSWORD

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1. SCOPE

The purpose of this document is to provide a preliminary understanding of the function, operation, and installation of the GG1320AN ring laser gyro assembly.

2. APPLICABLE DOCUMENTS

2.1 Non-Government Documents

The following non-Government documents form a part of this specification to the extent specified herein.

JESD22-A114-B	Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)
ANSI/ESD STM 5.1-2001	ESD Association Standard Test Method for Electrostatic Discharge Sensitivity Testing Human Body Model (HBM) Component Level

3. REQUIREMENTS

3.1 Item Definition

The GG1320AN ring laser gyro is a rate-integrating gyroscope with a scale factor of 1,164,352 counts per revolution (1.113065 arc-seconds per count). The GG1320AN includes a laser block assembly based on a triangular glass ceramic block with 2.0 inches path length per equilateral leg. The internal electronics provide the high voltage required for laser operation as well as control of gyro functions and readout of gyro information on system request. The unit requires +15 volts and +5 volts power input. The environmentally sealed case is filled with a dry nitrogen gas mix and is enclosed within a two-piece magnetic shield.

The GG1320AN receives a sampling pulse and responds by returning a frame of data containing gyro status and angle. The rate of sampling is determined by the user. Communications format is discussed later in this document.

3.2 Electrical Requirements

3.2.1 External Connector Type, Location, and Pin Assignments

The connector for the power and signal interface to the GG1320AN Ring Laser Gyro is made through a 25-pin micro “D” connector. The approximate connector location and the recommended mating connector are given in Figure 7. Pin assignments within the connector are as specified in Figure 1.

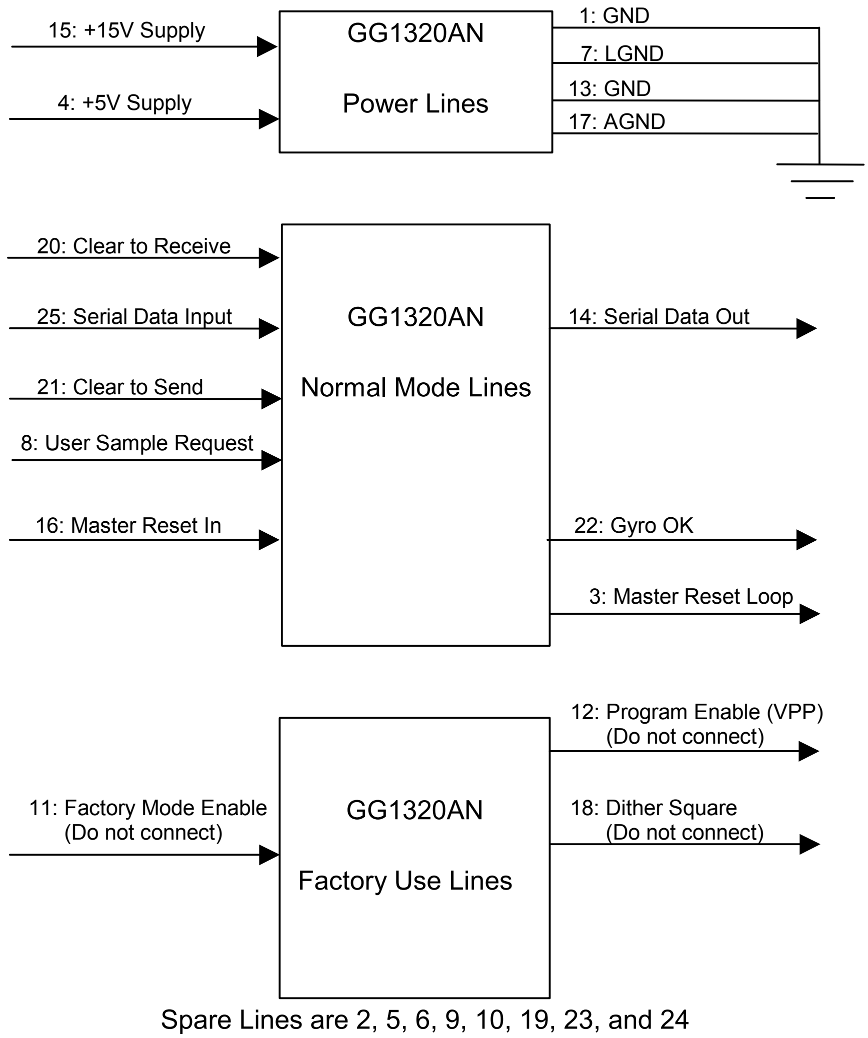


Figure 1. GG1320AN Ring Laser Gyro Electrical Interconnect Diagram

3.2.2 Electrical Inputs

3.2.2.1 Power Supply Requirements

The GG1320AN power supply requirements are listed in Table 1. The +5 volt and +15 volt supplies can be brought up in any order within 100 milliseconds if the Master Reset In (pin 16) is held low during power-up. All command logic input signals must be held low or shall not exceed the +5 volt supply value prior to power-up.

For automatic reset upon power-up and power-down, the user must connect Master Reset Loop (pin 3) to Master Reset (pin 16). This will signal the processor to shut down when the +5vdc decays through 5.0 voltage tolerance value specified in Table 1.

Table 1. GG1320AN Power Supply Requirements at the Gyro Connector

Supply Voltage	Maximum Ripple & Spikes	Maximum Current	Power (Ref.)	Nominal Power (Ref.)
15±0.75 Vdc	0.10 V p-p	150ma run 300ma start	2.36W max run. 4.7W max start	1.70W 3.5 W
5±0.25 Vdc	0.05 V p-p	150ma	0.78 W max	0.275W

Note:

Long cables between the supply and the gyro connector can cause significant voltage drops in the cable – the power supplies need to be adjusted to achieve these voltages at the gyro connector.

3.2.2.2 Ground

The GG1320AN ring laser gyro shall be connected to ground with a maximum of 0.1 ohms impedance. All four ground pins as defined in Figure 1 are internally connected and tied to the gyro case.

3.2.2.3 Input Signals

Input logic levels shall be as defined in Table 2.

Table 2. Input Logic Requirements.

Parameter	Minimum	Maximum
Input Logic True, VIH	2.0V	5.3V
Input Logic False, VIL	-0.3V	0.8V
Rise/Fall Time	3NS	* 50NS
I/O Capacitance	5pF	15pF

*The maximum master reset rise/fall time shall be 1 millisecond.

3.2.2.4 User Sample Request (Sample Data Clock)

Gyro data transfer is enabled on the positive pulse edge of pin 8. Maximum guaranteed sample data clock rate (sample frequency) is 1.6 kHz for the GG1320AN1X gyros and 5 kHz for the GG1320AN2X gyros. When pin 8 is not driven, the input pin is internally connected to ground through 20k ohms.

~~3.2.2.5~~ DELETED

3.2.2.6 Clear-to-Send (Transmit Enable)

3.2.2.6.1 Clear-to-Send (Transmit Enable) Transparent Mode

To run the gyro in this mode, the user holds the Clear-to-Send (pin 21) line at a logic high and the gyro transmits data on the Serial Data Out line (pin 14) after each sample data clock (pin 8). The gyro sends data from each sample request when the processing of previous data is complete. Table 3 describes a minimum installation configuration that uses this scheme.

Table 3. Minimum Installation Configuration

Pin	Description	Connection
1	CGND	ground
2	spare	X
3	Master Reset Loop	connect to pin 16
4	+5 VDC	+5 VDC
5	spare	X
6	spare	X
7	LGND	ground
8	User Sample Request	sample clock (max freq per para 3.2.2.4)
9	spare	X
10	spare	X
11	Factory Mode Enable	do not connect
12	VPP (Program Enable)	do not connect
13	CGND	ground
14	Serial Data Out	Serial Data Out
15	+15 VDC	+15 VDC
16	Master Reset In	connect to pin 3
17	AGND	ground
18	Dither Square	do not connect
19	spare	X
20	Clear to Receive	do not connect
21	Clear to Send	+5 VDC (logic high)
22	Gyro OK monitor	output: low indicates gyro failure
23	spare	X
24	spare	X
25	Serial Data Input	do not connect

3.2.2.6.2 Clear-to-Send (Transmit Enable) Pulse Mode

To run the gyro in this mode, the user pulses the Clear-to-Send (pin 21) line to a logic high. The gyro transmits data on the Serial Data Out line (pin 14) after each sample data clock (pin 8) while the clear-to-send line is at logic high. This mode is useful for multiple gyros on a common data bus.

3.2.2.7 Unused Input Pins

It is recommended that pins 11, 20, and 25 be not connected. It is also permissible to terminate to ground through a 10K resistor.

3.2.3 Output Specifications

3.2.3.1 Gyro OK

When the Gyro OK mode (pin 22) is high, the gyro Built-In Test (BIT) indicates no BIT failure.
A logic low on pin 22 indicates a BIT failure. The validity of Gyro OK is guaranteed only after the 1-second power-up time has elapsed.

3.2.3.2 Serial Output Data

3.2.3.2.1 Baud Rate and Parity

The gyro Input/Output (I/O) operates at 1 Megabaud with 8-N-1 data byte format. Bytes are sent lsb first.

3.2.3.2.2 Logic Levels

The output signal logic levels are specified in Table 4.

Table 4. Output Logic Specifications

Parameter	Minimum	Maximum
Output Logic High	3.84V	5.3V
Output Logic Low	0.0	0.33V
Rise/Fall Time	5NS	50NS
IO Capacitance	3PF	10PF

3.2.3.3 Timing

3.2.3.3.1 Serial Data Timing—Transmit and Receive

Figure 2 shows the serial data timing of a single byte.

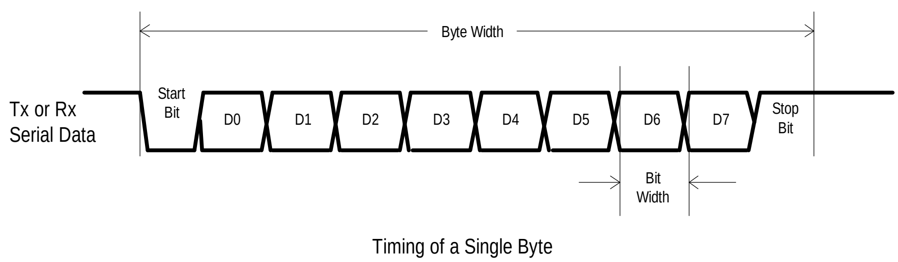


Figure 2. Serial Data Timing—Transmit and Receive

Serial data timing parameters are shown in Table 5.

Table 5. Serial Data Timing—Transmit and Receive

Parameter	Min	Typ	Max	Units	Description
Byte Width	10.0	10.0	10.0	µs	Duration of transmitted byte.
Bit Width	1.0	1.0	1.0	µs	Duration of a single bit.

Notes:

Bytes can be packed right next to each other without gaps. The typical transmission time for six bytes is 60 µs.

3.2.3.3.2 Timing Requirements—Gyros Multiplexed

Figure 3 and Table 6 show timing requirements with gyros multiplexed.
If there is one gyro per serial port, then CTS transparent mode may be used (see paragraph 3.2.2.6.1)

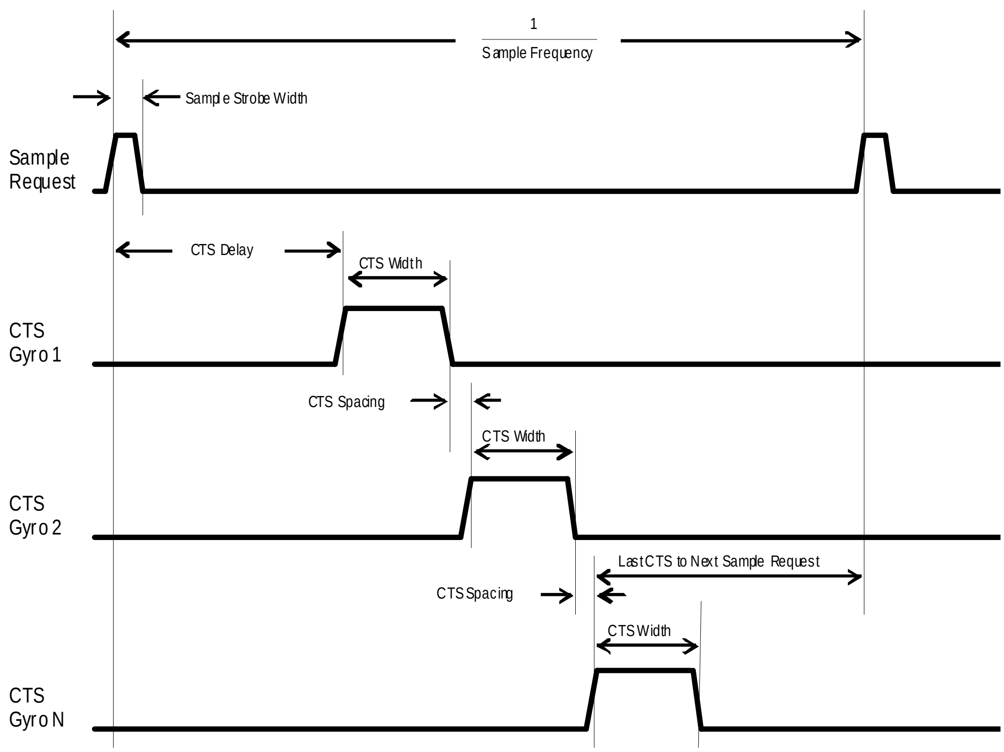


Figure 3. Timing Requirements—Gyros Multiplexed

Table 6. Timing Requirements—Gyros Multiplexed

Parameter	Min	Typ	Max	Units	Description
Sample Frequency (1)	0		(see 3.2.2.4)	Hz	User Sample Request
Sample Strobe Width	0.5		(1/Sample_Freq)* 10^6 - 0.5	μs	Sample strobe width. Low-to-high transition samples gyro.
CTS Delay	200 (2)	200	Depends on sample frequency and number of multiplexed gyros	μs	Time between application of the leading edge of the Sample Request and the leading of the first CTS pulse.
CTS Width	86 (3)			μs	Width of CTS pulse. See separate timing diagram for more detail.
CTS Spacing	0.5	1.0		μs	Amount of time to wait between gyros.
Last CTS to Next sample Request (4)	10.0			μs	Minimum amount of time to leave before issuing last CTS before next sample clock.

Notes:

1) The sample frequency limits are specified in paragraph 3.2.2.4.
2) CTS delay can be shortened, but this might result in incompatibility with future upgrades of the gyro. Please contact Honeywell before designing a system with a timing shorter that that listed.
3) The CTS Width circuitry often includes Tx Data as the signal that re-triggers a one-shot driven by the transmitted data itself. After CTS is asserted, the one-shot is initialized on the start bit of the first byte transmitted by the gyro. Subsequent bytes re-trigger the one-shot, which holds CTS high. The one-shot must have a time-out period of 10 μs or longer because the transmitted byte could be all 1's.

3.2.3.3.3 Timing Requirements—CTS

Figure 4 and Table 7 show CTS timing requirements and limits.

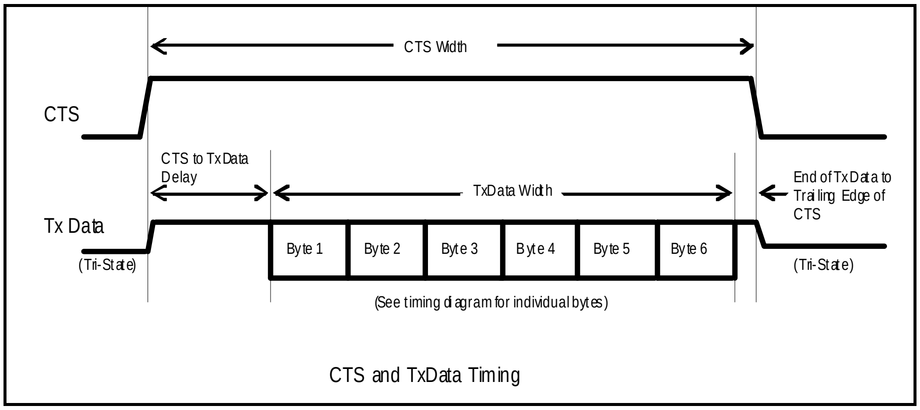


Figure 4. Timing Requirements—CTS

Table 7. CTS Timing Limits

Parameter	Min	Typ	Max	Units	Description
CTS Width (1)	66.0	69.0	86	µs	Duration of CTS Signal.
CTS to Tx Data Delay	5.0	8.0	15.0	µs	Delay from the leading edge of CTS to the first byte of data transmission.
Tx Data Width	60	60	70 (2)	µs	Time to transmit 6 bytes.
End of Tx Data to trailing edge of CTS (3)	1.0			µs	Time to let bus settle before tri-stating.

Notes:

1) The CTS Width can be fixed at the maximum value, or it can be made variable if it is held high as long as data is being transmitted. This is preferred because most packets start transmitting about 7–8 µs after the leading edge of CTS, and most packets are 60 µs in length.
2) If data is transmitted to the gyro while the gyro is transmitting data, there is a chance that there will be 1 to 3 µs gaps between the 6 bytes that are being output. These gaps can total as much as 10 µs, but are distributed over the whole packet.
3) If CTS is dropped early, before the data transmission of the 6-byte frame is completed, then the remainder of the frame is discarded. The gyro will continue to process the data internally, and the software will ignore a new assertion of CTS until that processing is completed.

3.2.3.4 Data Packet

A 6-byte packet is sent in response to a Sample Request Pulse as depicted in Figure 5. Every packet includes the Gyro Status byte as well as the 16-bit Theta (total angle) from the ring laser gyro.

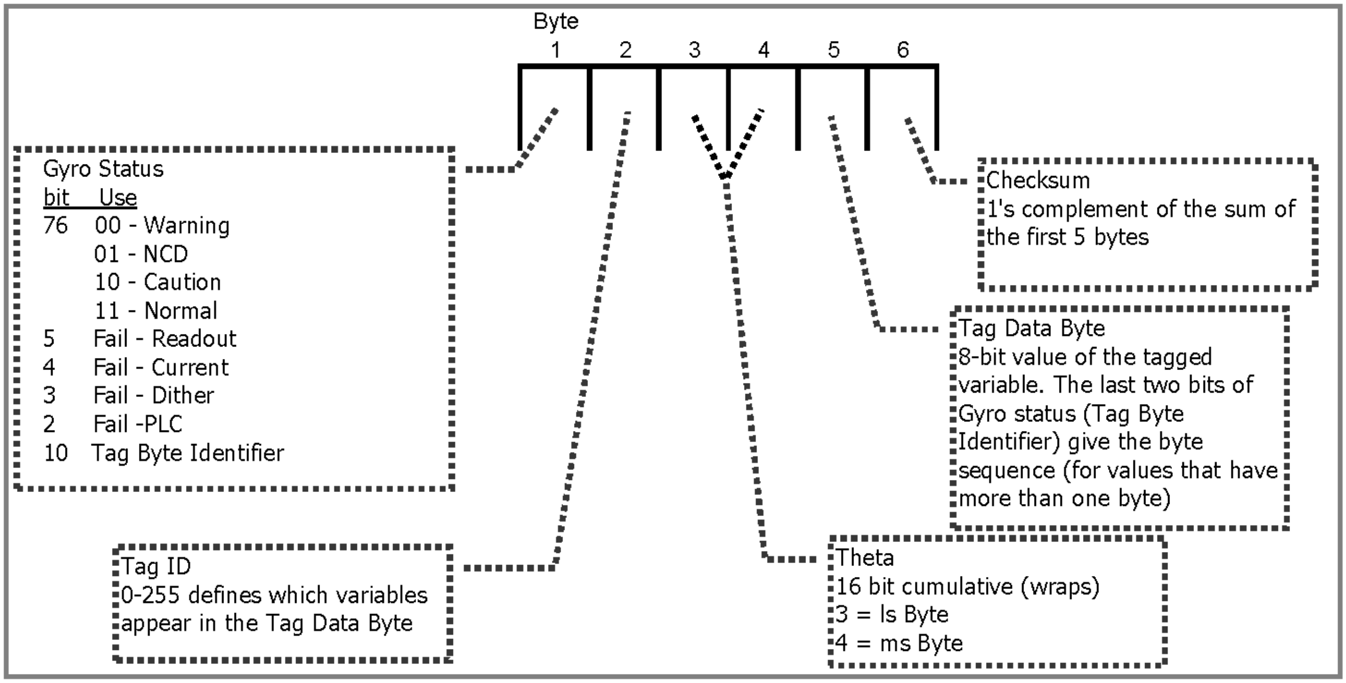


Figure 5. Dig-Gyro™ RLG Serial Data Frame

3.2.3.4.1 Gyro Status (Byte 1)

Table 8 shows the first byte of the 6-byte data packet.

Table 8. Gyro Status Byte Bit Definitions

Bit	Value	Use
7-6	00	Warning
	01	No Computed Data
	10	Caution
	11	Normal
5	0=ok 1=Fail	Readout BIT Status
4	0=ok 1=Fail	Current Control BIT Status
3	0=ok 1=Fail	Dither BIT Status
2	0=ok 1=Fail	PLC BIT Status
1-0	00-11	Tag Byte Identifier (0-3)

Within the Initialization and Normal modes there are four possible states in which the gyro can be:

1. NORMAL state is set if the Built-In Test (BIT) software reports a healthy system and there is no logical reason for the system to be in the No Computed Data state.
2. CAUTION state is set for BIT faults involving the discharge current control, high-voltage power supply, temperature sensor, and path length control. Under these conditions, the gyro will continue to produce an output, but performance may be degraded.
3. WARNING state is set if the laser power (readout intensity) is too low, if the dither is outside of normal performance limits, or if the software self-check detects a problem. Under these conditions, the gyro output may be unusable.
4. NO COMPUTED DATA state is set at the beginning of initialization during gyro start-up; if no gyro failures are detected during initialization, then the gyro state is set to NORMAL.

3.2.3.4.2 Tag ID and Tag Data Byte (Bytes 2 and 5)

The tags contain BIT information and other indicators created in software. In most cases, this is specific to the internal workings of the gyroscope and is not used for operation of the gyro.

Some specific tags which might be of interest to users are gyro temperature, total tics, gyro serial number, cumulative runtime, and dither frequency

Gyro Tags

Tag Name	Tag ID	Bytes	Description
Temperature	20 (0x14)	2	The scaled temperature in 0.1°F resolution. Stability and repeatability within 0.1F Absolute accuracy ±18F
Total Tics	44 (0x2C)	4	The total number of 10ms timer ticks since CPU reset.
Gyro Serial Number	34 (0x22)	4	The gyro serial number
Cumulative Runtime	41 (0x29)	4	The cumulative operating time of the unit in seconds. Factory enabled or disabled depending on purchase order (default is ON)
Dither Frequency	54 (0x36)	2	Dither frequency in 1 Hz resolution

Example Tag Extraction: Temperature

A sequence of tags (BIT information and other indicators created in software) are sent byte by byte over sequential packets (frames). The tag being currently sent is indicated by byte 2 (the “Tag Byte”).
When byte 2 equals 20 (0x14), then byte 5 (the “Status Byte”) contains the gyro temperature information.

Proper decoding of the temperature tag involves storing up the byte values as they are sent in sequential frames until the two bytes of the tag have been sent. Which byte of the tag is being sent is indicated in the Gyro Status byte (bits 0 and 1 of byte 1). Tag bytes are sent in order beginning with the lowest order byte.

As an example, refer to the Table “Example Temperature Tag Extraction” below. The Raw Data stream contains the 2 frames with tag 20 (0x14).

Example Temperature Tag Extraction

Raw Data (Bytes 1 - 6)						Gyro Status	Theta (counts)	Tag Info
Gyro Status	Tag ID	Theta lsb	Theta msb	Tag Data	check sum			
C0	14	3D	89	99	CC	C0	0x893D = 35133	?? ?? ?? 99
C1	14	3D	89	03	61	C1	0x893D = 35133	?? ?? 03 99 =921 (decimal) =92.1 deg F

3.2.3.4.3 Angle (Bytes 3 and 4)

The angular position is determined as of the time the Sample Request Pulse was received. This 16-bit value is cumulative and unsigned. It will wrap if an overflow or underflow condition occurs. To create delta theta, subtract the previous value from the present value, and account for the wrap around. The User Sample Request clock rate (sample frequency) should be high enough to sample at least every 9 degrees at the expected maximum input rate, within the limitations of paragraph 3.2.2.4.

~~3.2.3.4.4~~ DELETED

3.2.3.4.5 Checksum Calculation (Byte 6)

The last byte of the packet is a 1's complement checksum of the first 5 bytes of the packet. A sample calculation appears in Figure 6. The total of the first five bytes is calculated and then inverted. The sum of all six bytes should be 0xFF (decimal 255, 511, or 767).

Gyro Status	Tag ID	Theta lsb	Theta msb	Tag Data	check sum
C0	26	3C	89	02	52
C1	26	3F	89	02	4E
C0	27	3D	89	98	BA
C1	27	3D	89	4C	05
C2	27	3D	89	FB	55
C3	27	3E	89	29	25
C0	**29**	**3D**	**89**	**00**	**50**
C1	29	3E	89	00	4E
C2	29	3B	89	00	50
C3	29	3D	89	00	4D
C0	2A	3D	89	7E	D1
C1	2A	3D	89	09	45

C0	1	1	0	0	0	0	0	0
29	0	0	1	0	1	0	0	1
3d	0	0	1	1	1	1	0	1
89	1	0	0	0	1	0	0	1
0	0	0	0	0	0	0	0	0
AF	1	0	1	0	1	1	1	1
50	0	1	0	1	0	0	0	0

Figure 6. Checksum Calculation

3.2.3.5 Serial Output Transmission

Upon receipt of a User Sample Request (pin 8), the gyro counts and gyro dither position angle are measured with a maximum time delay of 0.5 microsecond. The gyro counts are corrected for dither compensation gain, phase error, non-linearity, and scale factor. In addition, the gyro output is compensated for temperature and temperature rate-of-change.

The software does not allow any interrupt processing during the output. The software outputs the next gated serial data message when a User Sample Request occurs and the Clear-to-Send pin is high. No data is sent if the Clear-to-Send pin is low. The output processing automatically loops through a predefined set of output signals and repeats the sequence when the last defined output signal has been transmitted. The predefined set of output signals are made up of measured gyro signals, gyro status words, and internally computed variables. The serial output transmits a 6-byte (8-bit) serial stream per output frame. A single frame is sent for each interrupt. Each byte is transmitted with the least significant bit first. The 6-byte stream is defined as in Table 8 and Figure 5. For gyro responses requiring more than one response byte, the software sends the remaining bytes in the successive frames. After all bytes have been sent for the current gyro response, the software automatically proceeds to the next defined output signal.

3.3 Mechanical Requirements

3.3.1 Installation Requirements

The mechanical interface and installation requirements are defined by Figure 7.

An example of an appropriate gyro mounting plate is shown in Figure 8.

3.3.2 Weight

The weight of the GG1320AN ring laser gyro is 450 ± 8 grams.

3.3.3 Center of Gravity

The center of gravity of the GG1320AN ring laser gyro is documented by Figure 7.

3.3.4 Nominal Moments of Inertia, Dither Spring Stiffness, and Dither

3.3.4.1 Reaction Torques

The nominal total moment of inertia of the GG1320AN ring laser gyro about its input axis is 401.6E-06 kg-m^2, and the nominal moment of inertia of its sprung mass is 43.02E-06 kg-m^2. The nominal torsional stiffness of the dither springs and the nominal dither reaction torque are listed in Table 9.

Table 9. Nominal Dither Reaction Torque

Dither Frequency	Dither Zero To Peak Amplitude	Dither Spring Stiffness (dither frequency at 570 hertz)	Nominal Dither Reaction Torque Peak
485-669	250 arc-seconds	561 Nm/(rad) 0.68 Nm at 500 arc-seconds	0.34 Nm at 250 arc-seconds

3.3.5 Mount Inertia

The gyro shall be mounted securely on a rigid body having a moment-of-inertia about the gyro's input axis equal to or greater than 43.0E-04 kg-m^2 (an inertia ratio of 100), to allow the gyro dither motor to function properly.

3.3.6 Dither Frequency

The dither frequency for the GG1320AN01 is defined in Table 10.

Table 10. Dither Frequency Requirements

UNIT	ROOM TEMP DITHER FREQUENCY	COLD (-65°F) DITHER FREQUENCY	HOT (+185°F) DITHER FREQUENCY
GG1320AN01	575 ± 90 Hz	570 ± 90 Hz	579 ± 90 Hz

3.3.7 Dimensional Requirements

The gyro dimensions are documented in Figure 7.

3.4 Operating Environments

3.4.1 Operating Temperature

The gyro operating temperature is −65°F to +185°F.

3.4.1.1 Non-Operating Temperature

The gyro non-operating temperature is −65°F to +200°F.

3.4.1.2 Storage Temperature

The gyro storage temperature is −65°F to +200°F.

3.4.2 Temperature Rate Of Change

The gyro performs per specifications when the temperature ramp rate of change is less than 200°F/hour. If special applications require operation at temperature ramp rates beyond 200°F/hour, special gyro calibration may need to be performed at these higher rates to meet performance requirements.

3.4.3 Operating Vibration

3.4.3.1 Operating Random Vibration

The ring laser gyro meets all requirements during and after operating exposure to the random vibration defined as follows:

Operating DVT Random Vibration Profile #1
(Total GRMS = 5.82)

Frequency Range, Hz	Slope db/octave	Level (g^2)/Hz
15		0.032
15-60	+6	
60-80		0.5
80-200	−18	0.002

3.4.3.2 Operating Sine Vibration

The ring laser gyro meets all requirements during and after operating exposure to a sinusoidal vibration profile defined as follows:

Operating DVT Sine Vibration Profile

Frequency (Hz)	Levels
10 - 57	0.12 in. double amplitude
57 - 100	20 Gs
100 - 700	3 Gs

3.4.3.3 Operating Shock

The ring laser gyro meets all performance requirements during and after operating exposure to shocks of 28g, saw tooth, 11 milliseconds and 100g, half-sine, 8 milliseconds.

3.4.3.4 Maximum Rate

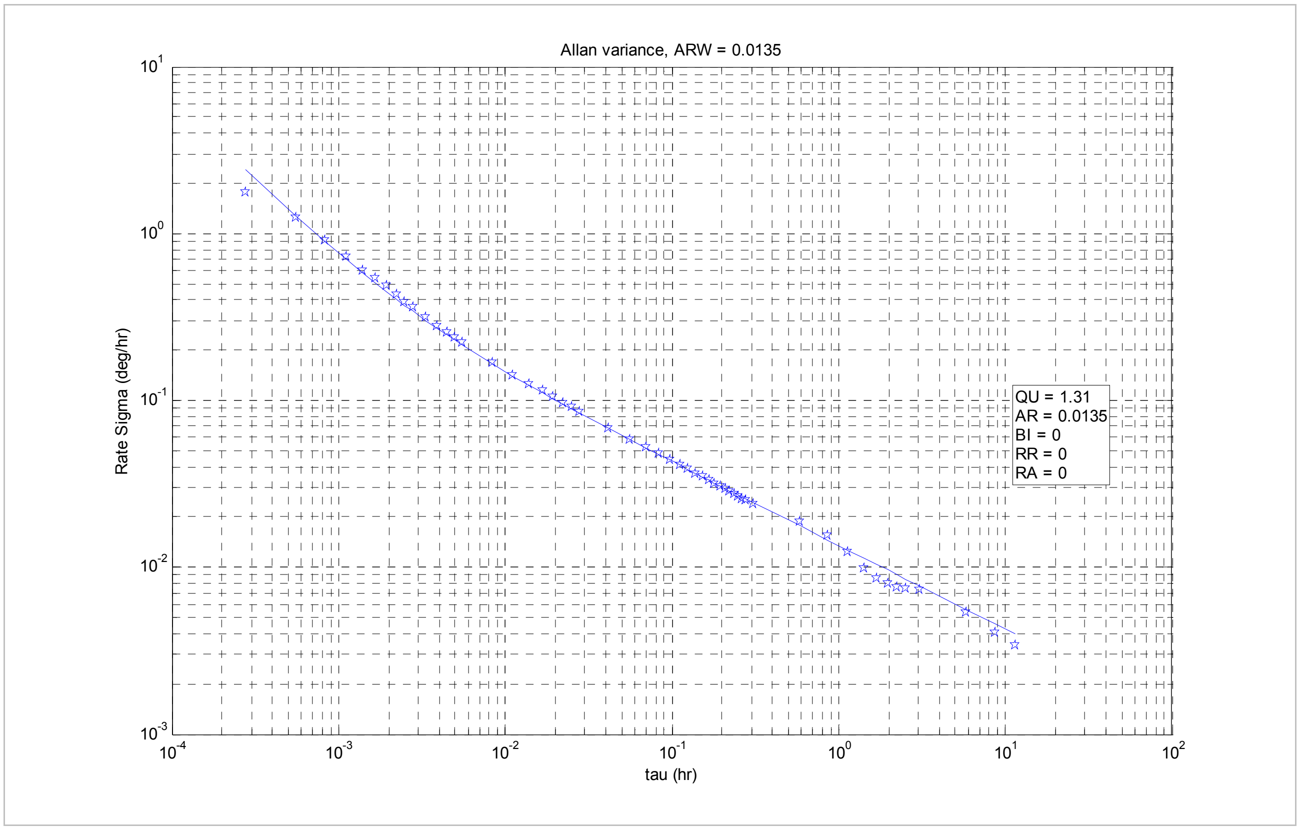
The gyro provides a pulse output within a range between and including 450 degrees per second clockwise (CW) and 450 degrees per second counterclockwise (CCW).

3.5 Gyro Performance

The nominal gyro scale factor is 1,164,352 counts per revolution, or 1.113065 arc-seconds per count.

Input rate of the gyro is 0 ± 450 degrees per second. Bias stability and angular random walk limits are governed by purchase order.

The output data stream of the GG1320AN contains a number of noise terms, predominantly quantization and angle random walk. The Tehrani paper listed in the Public Domain References describes an analysis of gyro data using Allan variance. A test run on a GG1320AN with an angle random walk of .0135 deg/rt-hr, fixed to a stationary mount and measuring earth rate, produces an Allan variance plot as shown below



3.6 Miscellaneous

3.6.1 Labeling

The laser gyroscope serial number is comprised of a four-digit date code followed by the six-digit laser block serial number. The date code consists of the last two digits of the year followed by the week of manufacture.

3.6.2 Electrostatic Discharge

The laser gyroscope is Electrostatic Discharge Sensitive (ESDS) and can be damaged by an Electrostatic Discharge (ESD) voltage in a range of 171 to 1999 volts (Human Body Model) when tested in accordance with JESCD22-A114-B and ANSI/ESD STM5.1-2001.

3.6.3 UART (Universal Asynchronous Receiver/Transmitter)

For benchtop/gyro test setups, run the gyro serial data into a differential drive (example: Texas Instruments SN65C1167), and then send the differential signal to any RS-422 card configured to run at 1 megabaud.

3.6.4 Public Domain References

RLG Background

F.Aronowitz "The Laser Gyro", Laser Applications vol.1 (ed M Ross), New York: Academic Press , 1971 pp133

Chow, Gea-Banacloche, et al, "The ring laser gyro", Reviews of Modern Physics, vol.57 no.1, January 1985

RLG Testing

IEEE 647-2006 IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Laser Gyros

IEEE 952 IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Interferometric Fiber Optic Gyros

Allan, D.W., "Statistics of Atomic Frequency Standards," *Proceedings of the IEEE*, vol. 54, No. 2, pp. 221-230, Feb 1966.

Tehrani, M.M., "Ring Laser Gyro Data Analysis with Cluster Sampling Technique," *Proceedings of SPIE*, vol. 412, 1983

System Applications

Titterton, David H.; Weston, John L. Strapdown Inertial Navigation Technology (2nd edition). Institution of Engineering and Technology. 2004

Grewal, Weill et al, "Global Positioning Systems, Inertial Navigation, and Integration", 2nd edition, Wiley, 2007 ISBN: 978-0-470-04190-1

3.6.5 Acronyms

AGND	analog ground
DVT	Design Verification Test
CA	cross axis
CTS	Clear to Send
CW	clockwise
CCW	counterclockwise
deg/rt-hr	degrees per square root hour
EAR	Export Administration Regulations
ESD	Electrostatic Discharge
GND	ground
HBM	Human Body Model
Hz	Hertz
IA	input axis
ID	identification
I/O	Input / Output
Kg-m	kilogram – meter
kHz	kilohertz
LA	long axis
LGND	logic ground
lsByte	least significant byte
msByte	most significant byte
Mtg surface	Mounting surface
NCD	No Computed Data
Nm	Newton – meter
ns	nanoseconds
PLC	Path Length Control
rad	radian
RLG	Ring Laser Gyroscope
RMS	Root Mean Square
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
VDC	Volts direct current
VIH	Voltage Input High
VIL	Voltage Input Low
Vp-p	Volts peak to peak
W	Watts

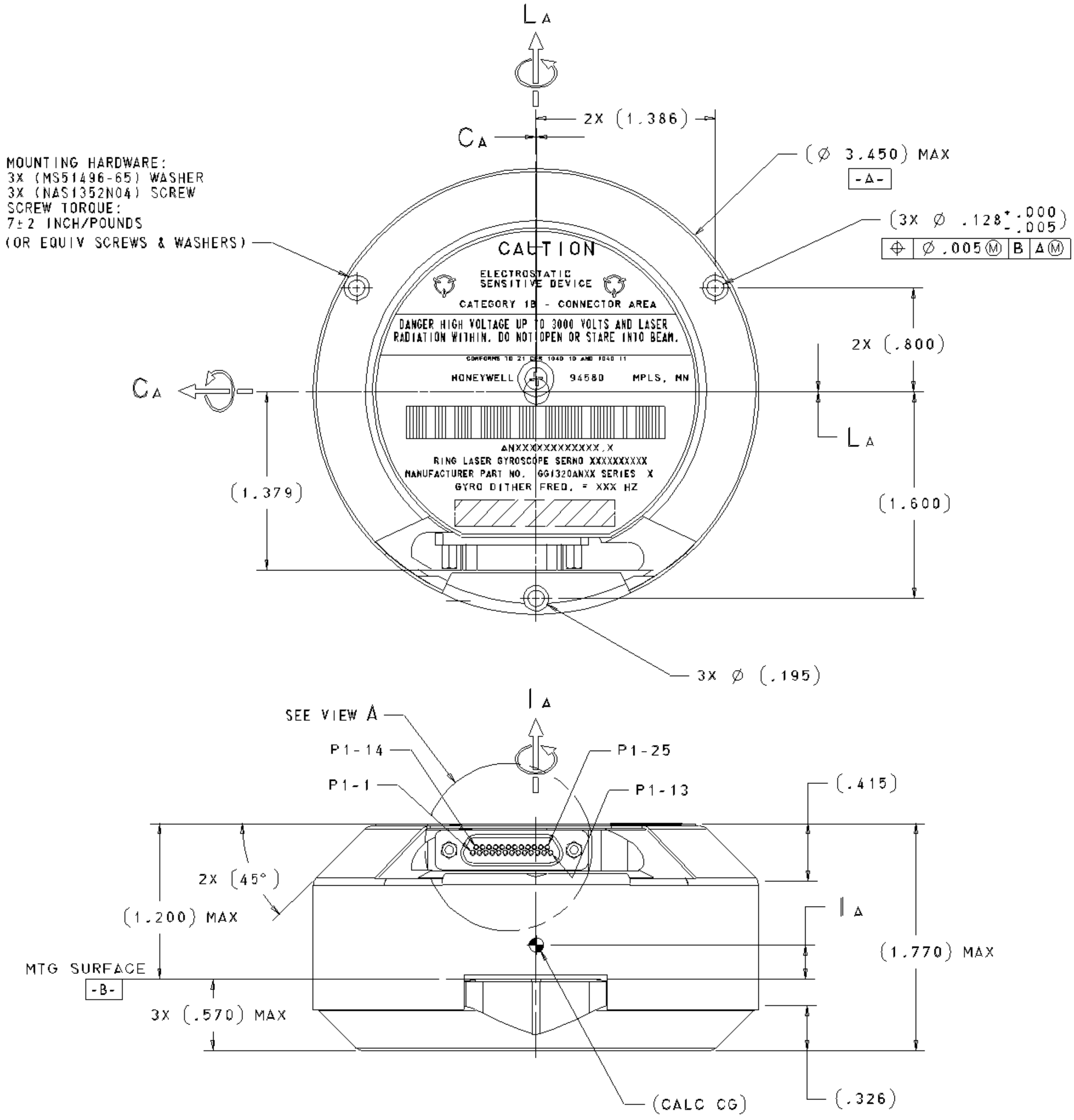


Figure 7. Installation Information

REV	D																				

Honeywell	HONEYWELL INTERNATIONAL INC. AEROSPACE – Minneapolis, MN USA	SIZE A	CAGE CODE 94580	DRAWING NUMBER ED9102-01	
		SCALE NONE		WT -	SHEET 21

MSWORD

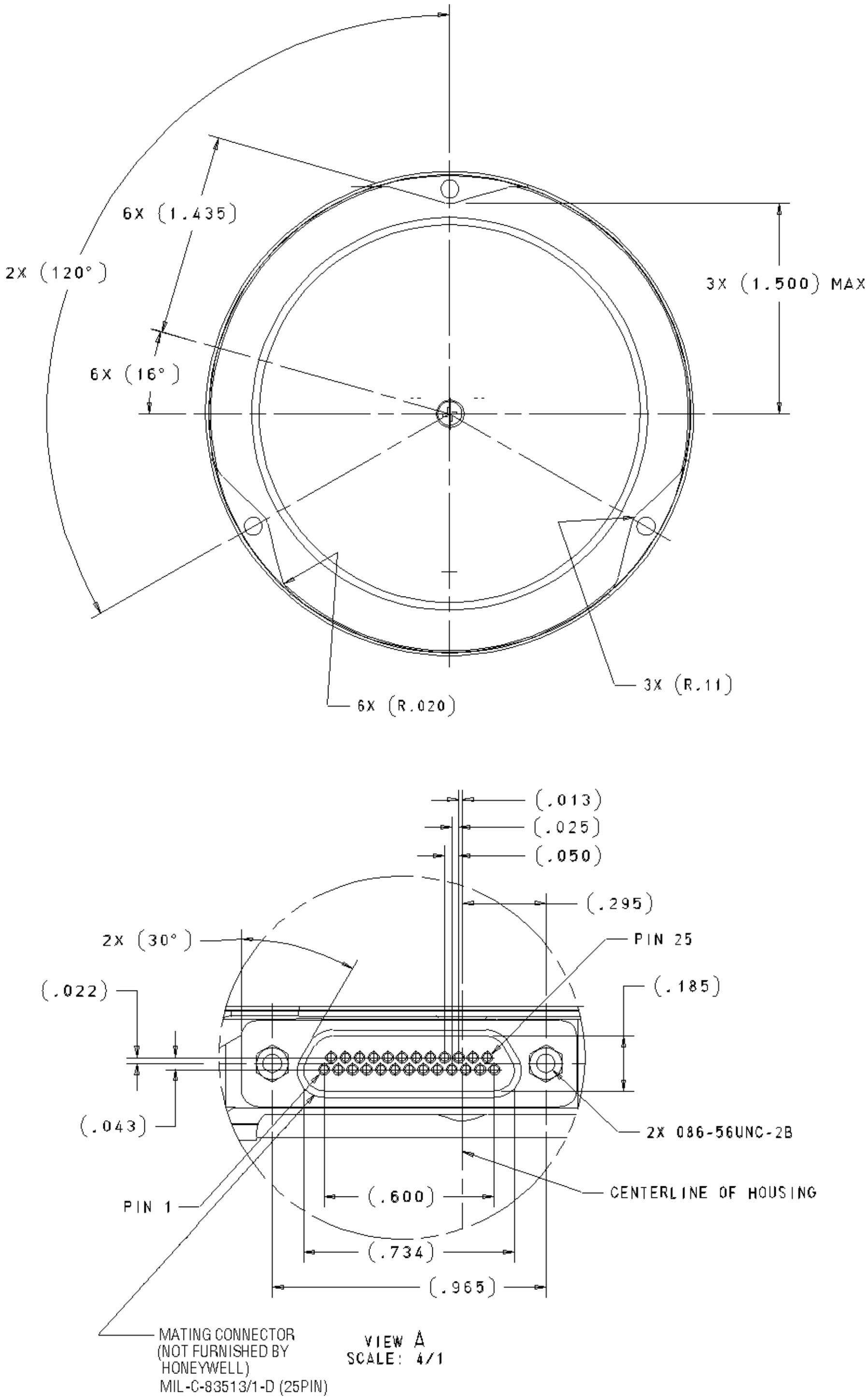


Figure 7. Installation Information (Continued)

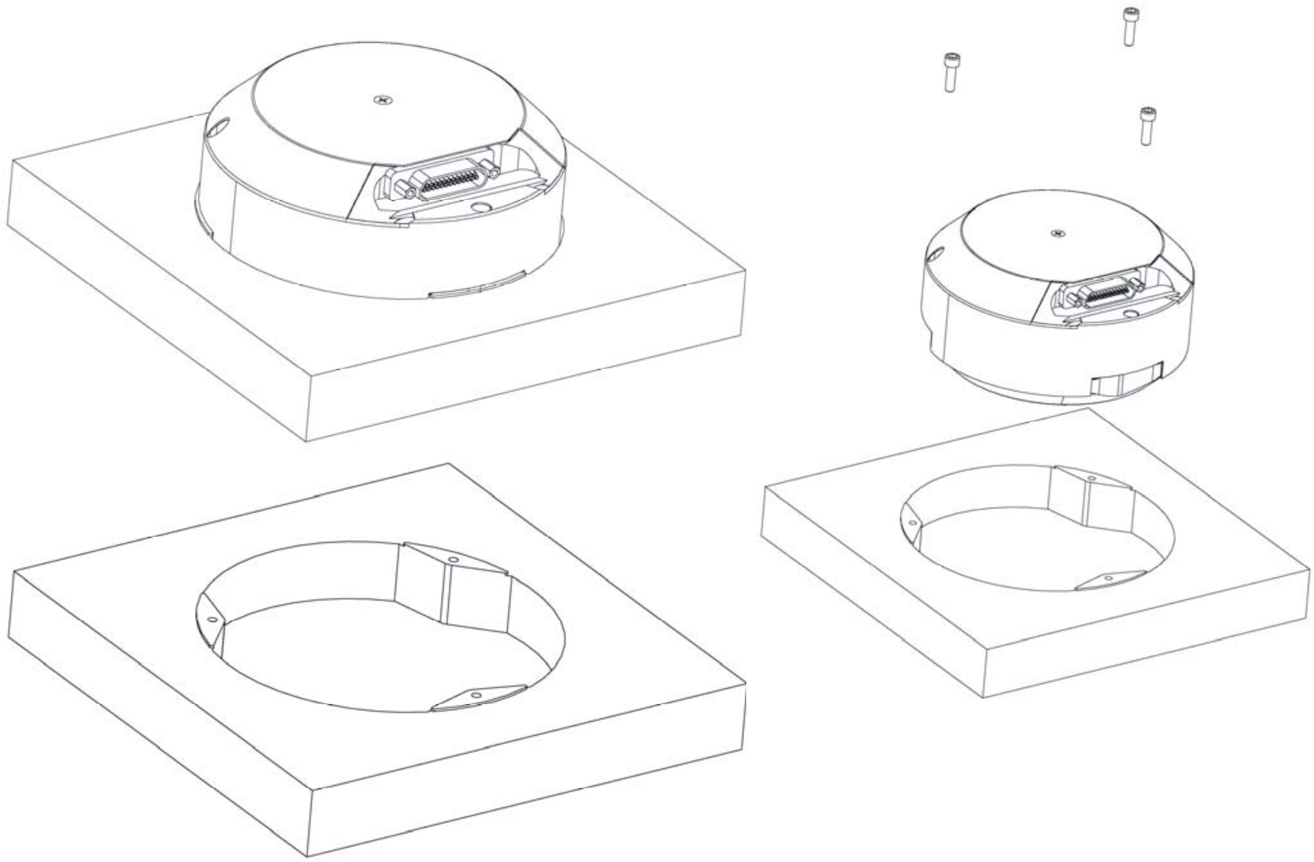
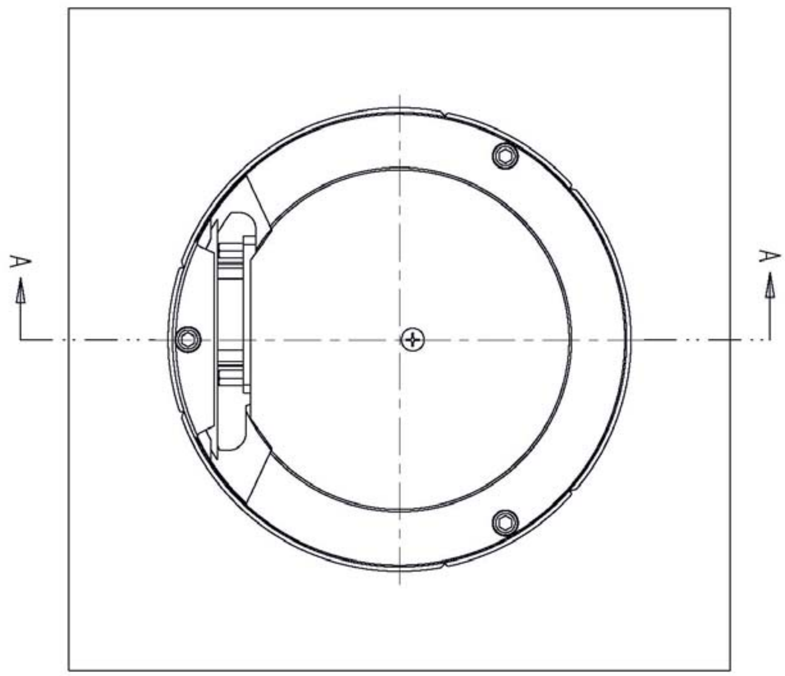


Figure 8. Gyro Mount



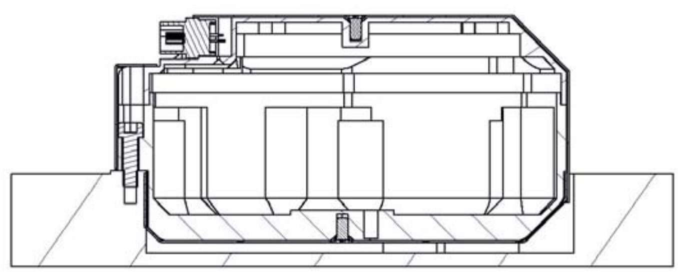


Figure 8. Gyro Mount (Continued)