Honeywell

LASEREF® VI

Micro Inertial Reference System

μIRS™

Product Description
October 2016

Honeywell

TABLE OF CONTENTS

1.0 Introduction

The Micro IRS contains laser gyro inertial navigation technology in the industry's smallest and lightest package. This new system has been designed to simplify crew workload while dramatically reducing installation time, weight, size, power, and cost. A sample of the fixed wing and rotary wing platforms that the Laseref VI micro IRS has been selected and installed on are as follows:

- Gulfstream G280, G350, G450, G500, G550, and G650
- Hawker-Beachcraft Hawker 4000, T-6B
- Dassault Falcon 900EX, 2000EX, F5X, F8X
- Embraer 170/175/190/195 and E2
- Bombardier Challenger 350, 605, Global 6000, 7000, 8000
- Bombardier C-Series, CRJ-100/200/700/900, Q400
- Cessna Latitude, Longitude
- Civilian C-130
- Pilatus PC-21, PC-7, and PC-9 Trainer
- Boeing 787, 777X
- COMAC ARJ-21, C919
- Mitsubishi Regional Jet
- Sukhoi Superjet 100
- Irkut MC-21
- Airbus Helicopters H145, H225
- Leonardo AW-101, M-345

Laseref VI Micro IRS features, enhancements, and comparison to the Laseref V Micro IRS:

- Smallest, lightest, and lowest power IRS in the industry. One-half the size, one-third the weight, and one-third the power of competing systems.
  - Laseref VI more than 0.5 pounds less than the Laseref V
- Laseref VI provides an enhanced HIGH Integrity Hybrid GPS (HIGH Step II)
  - Now provides 100% Availability of RNP 0.1 NM Navigation
  - Hybrid Kalman Filter provides extended integrity coasting through GNSS-denied outages
- Alignment In Motion
  - Provides recovery of full performance mode following loss of power in flight
  - Laseref VI performs Alignment In Motion greater than 50% faster than the Laseref V
  - Quick dispatch within 1 minute is available with stationary and subsequent align-in-motion algorithms.
- 40,000 hour MTBF Reliability -- highest in the industry
- Automatic Mode Control Logic and Automatic Initialization for reduced crew workload
- Passive Cooling eliminates the weight and cost of the cooling fans
- Electronic mounting tray alignment for reduced installation cost
- Enhanced Automatic Realignment uses GPS to refine the alignment between flights
- Powerful Processor with Partitioned Operating System

System Components:

The Laseref VI Micro Inertial Reference System contains the following components:

- HG2100BB Micro IRU
- WG2001 Mounting Tray
- IM-950 Aircraft Personality Module

HG2100 Micro IRU

The Micro IRU is a self-contained Inertial Reference Unit that provides long range navigation using high accuracy inertial sensors. Industry standard ARINC-429 outputs are provided for Flight Management Systems, Primary Displays, Forward Looking IR Cameras, Head-Up Displays, Flight Control, antenna stabilization (Satcom, Weather Radar, Direct Broadcast Satellite), EGPWS, and other critical aircraft systems. Full inertial reference performance is provided for unaided RNP-10 and RNP-5 (time limited) without GPS inputs. When GPS inputs are applied, the IRU provides tightly coupled GPS/Inertial hybrid outputs to support enhanced operations such as RNP AR, initializes automatically, and performs alignment-in-motion.

IM-950 Aircraft Personality Module

The memory module contains aircraft configuration data and mounting tray misalignment terms (Euler angles). Once programmed with the menu driven PC tool, the APM remains with the tray. The IRU can be removed and replaced without any realignment or reprogramming procedures.

2.0 Technical Overview

Note: The information in this document is a summary of the Laseref VI Installation and Maintenance Manual (Laseref VI IMM). This document should not be used for official technical or installation reference information. Only the Laseref VI IMM should be used as the official technical performance and installation reference document.

The Laseref VI Micro IRS is an Inertial Reference System (IRS) which outputs ARINC 429 inertial reference information for flight control and aircraft navigation.

Key Features:

- Weight 9.3 lbs
- Size 267 cubic inches
- Dimensions (WxLxH) 6.5”x6.4”x6.4”
- Power Consumption 20 watts
- Cooling Passive
- Mounting Tray 0.5 lbs
- MTBF 25,000 operational hours
- ARINC 429 Transmitters 4 (Can support up to 80 different LRUs)
- ARINC 429 Receivers 7

- Ethernet 1
- Discrete Inputs 12
- Discrete Outputs 2
- Operation Automatic mode control and Align-In-Motion
- Maintenance 99% Build-in Test Coverage
  NVM storage of performance and troubleshooting data
  Build-in automatic sensor calibration

Certification:

- Software Certification DO178B Level A
- Hardware Certification DO160G
- TSO & ETSO C-3e, C-4c, C-5f and C-6e
- TSO & ETSO C-129a Class B1/C1 (with ARINC 734A GPS Receiver)
- FAR 121 Appendix G (Federal Aviation Regulations) – Operating Requirements: Domestic, Flag, and Supplemental Operations
- Advisory Circular 25-4 Inertial Navigation Systems (INS)
- AC 120-33 - Operational approval of airborne long range navigation systems for flight within the North Atlantic minimum navigation performance specifications airspace
- FAA Order 8400.12A, Required Navigation Performance 10 (RNP-10) Operational Approval, for 12 hours unaided
- AC 90-96, Approval of u.s. operators and aircraft to operate under instrument flight rules (IFR) in European airspace designated for basic area navigation (BRNAV/RNP-5), for 2 ½ hours unaided

When connected with an ARINC 743A compatible GPS receiver, the Micro IRS provides hybrid GPS/Inertial outputs capable of meeting TSO C-129a Class B1/C1 requirements.

ARINC 429 Outputs:

The Inertial Reference (IR) component of the Micro IRS contains three force rebalance accelerometers and three laser gyros, which it uses to measure inertial motion. The IR component requires system initialization (entry of latitude and longitude). Initialization may come from another system such as a Flight Management System (FMS) or from position inputs provided by a GPS receiver. Once the IR component is properly aligned and initialized it transitions into its normal operating mode. It relies on inputs from an Air Data System (ADS) for wind, flight path and altitude. The inertial reference system outputs the parameters below.

Body Frame:

- Longitudinal, Lateral, and Normal Accelerations
- Pitch, Roll, and Yaw Rates

Local Level Frame:

- Pitch and Roll Angles
- Pitch and Roll Attitude Rates
- Flight Path Angle and Flight Path Acceleration

- Inertial Vertical Speed and Inertial Vertical Acceleration
- Platform Heading
- Turn Rate

Earth Frame:

- Latitude and Longitude
- N-S Velocity, E-W Velocity, and Ground speed
- Inertial Altitude
- True and Magnetic Heading
- Track Angle True and Track Angle Magnetic
- Track Angle Rate
- Wind Speed and Wind Direction True
- Drift Angle
- Along Track and Cross Track Accelerations
- Along Heading and Cross Heading Accelerations

Hybrid Function:

The GPS Hybrid function utilizes existing hardware components in the IRU to receive GPS data from one or two GPS Receiver systems. Data received is one Hz nominal RS-422 time mark signal unique for each GPS receiver input and ARINC 429 GPS high-speed satellite measurement and autonomous data. The GPS Hybrid function blends received GPS autonomous Pseudo Range with Inertial and Air Data altitude data in a tightly coupled Kalman filter to achieve optimal position, velocity, and attitude performance. All satellites and sensors are individually calibrated in the Kalman filter. The resulting hybrid data is highly calibrated and provides exceptional navigation performance even if all satellites are lost. The GPS Hybrid function provides the following output parameters:

- Hybrid Latitude and Longitude
- Hybrid N-S Velocity, E-W Velocity, and Ground Speed
- Hybrid Altitude and Vertical Velocity
- Hybrid True Heading, Track Angle, and Flight Path Angle
- Hybrid Horizontal and Vertical Figure Of Merit and Integrity Data

HIGH Step II:

HIGH Step II is an enhanced version of HIGH that further improves the capability of the GPS/Inertial technology. HIGH Step II meets the industry requirements (DO-229 appendix R) for GPS/inertial tightly coupled integrity calculations. It features a Honeywell algorithm called Solution Separation that uses optimal multiple 36-state Kalman filtering techniques to produce a RAIM like function and also extends the integrity protection levels (i.e. integrity coasting) by taking advantage of the inertial integration which extends the function to GPS denied environments (i.e. Terrain Masking, Solar storms, Intentional Jamming, GPS constellation variation etc). This makes RNP navigation, especially for low RNP, more robust to protect against unexpected GPS denied environments leading to missed approaches

The table below summarizes the availability of detection for the HIGH Step II Enhanced algorithm.

HIGH Step II Availability					
Satellites	Alert Level				
	0.1 nmi	0.2 nmi	0.3 nmi	1.0 nmi	2.0 nmi
24 Satellites	100%	100%	100%	100%	100%

If GPS data is completely lost, the kalman filter will maintain accuracy for an extended period of time.
The table below shows the 95% coasting performance.

Summary of 95% Accuracy Hybrid Coasting Times			
	Coasting Times for Given RNP		
Performance Level	RNP 0.1	RNP 0.3	RNP 1
95% Accuracy	>10 minutes	>20 minutes	>1 hour

Alignment Modes

The IRU provides three alignment modes consisting of:

- Stationary Alignment
- Align In Motion
- Auto Realign

Stationary Alignment and Align In Motion modes are performed in conjunction with the Attitude mode prior to entry into the Navigation mode so that valid attitude outputs are available immediately after power-up. The Auto Realign mode is performed in conjunction with the Navigation mode. The IRU continuously tests for the Align In Motion conditions, and if met, preempts the Stationary Alignment mode and switches to the Align In Motion mode. Following completion of either alignment mode, the IRU transitions to the Navigation mode. Once the Navigation mode is attained, the IRU remains in this mode indefinitely while valid power is applied to the device (or until the IRU is reset using either the IRU Off discretes or the IRS Reset Command). While motionless in the Navigation mode, the IRU automatically realigns itself using the Auto Realign function.

During Stationary Alignment and Post Flight Auto Realign, valid data from GPS may be used as an automatic source for position entry. Also, valid GPS data must be received in order for Align In Motion to operate. To be considered valid for use during Stationary Alignment, Align In Motion, and Post Flight Auto Realign, GPS data shall be ARINC-743A or ARINC-755 format.

Rapid Dispatch Option

If extremely rapid dispatch is required, the operator may also elect to use the Align-In-Motion function to complete the alignment in flight. When the IRS is powered-up, the attitudes, accelerations, and rates are available within 5 seconds. If ARINC label 043 (Set Mag Heading) is received from the FMS once at power-up, then all TSO outputs will be available for dispatch. When the IRS completes the Align-In-Motion, all parameters will be available at Full Performance as specified in section 6.0.

Input Power Requirements:

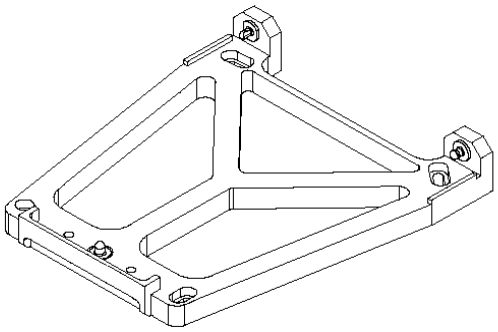
The Micro IRS is capable of operating from either a primary input +28 VDC aircraft power source or a secondary input power source. This could include either +28 VDC aircraft power or a +24 VDC battery, with priority being given to the primary power source if both primary and secondary sources are available and valid. The maximum power consumption of the unit is 28W, however nominally the power consumption does not exceed 20W following one second of operation.

3.0 Experience

The Laseref VI Micro-IRU is a sixth generation RLG based inertial reference unit (IRU), providing Honeywell's proven laser inertial technology in a small package. The Laseref VI Micro-IRU is a derivative product based on the Laseref V and 4 MCU inertial reference unit technologies, and uses the same digital ring laser gyro (RLG) sensors, accelerometers, and sensor electronics. The previous products are DO178B Level A certified and are used in a variety of high volume applications including the Boeing 737 and 787, Airbus A319/320/321/330/380 and Embraer 170/190. Reliability of the fleet of Digital RLG IRS systems has consistently exceeded 40,000 MTBF and 20,000 MTBUR since entry into service in 1997. This system has been instrumental in helping operators achieve low maintenance costs and high dispatch reliability.

4.0 Hardware Description

HG2100BB Laseref VI MicroIRU with WG2001AA Mounting Tray and IM-950 Aircraft Personality Module:



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Micro IRS Hardware Assemblies

Inertial Sensor Assembly:
GG1320 Digital Gyro

The Honeywell GG1320 Digital Gyro is established as a proven, high reliability, high performance, sensor that has been carefully engineered to meet the customers' needs.

The Dig-Gyro is a completely self-contained sensor whose small size, low cost, and low power requirements make it a particularly attractive component for inertial systems. A three-axis inertial sensor assembly (ISA) incorporates three Dig-Gyros and three accelerometers, weighs less than six pounds, occupies less than 90 cubic inches, and consumes less than 8 watts of power. The Dig-Gyro is also ideally suited for redundant inertial systems, because it is small and because the built-in electronics isolate each gyro from faults in other sensors.

Gyro Characteristics and Demonstrated Performance

Characteristics and demonstrated performance of the Dig-Gyro are as follows:

Characteristics

- <5.5 cubic inches
- <1 lb.
- <2 watts
- DC power in (+15 and +5 Vdc)
- Compensated serial digital data output
- No external support electronics
- Built on proven RLG technology (>400,000 RLGs delivered)
- DO178B Level A Certification
- Built-in self test

Demonstrated performances:

- Low random walk
- Excellent scale factor stability
- Superb bias stability
- No turn-on bias transients
- Low magnetic sensitivity
- Environmentally insensitive
- Proven field reliability over 400,000 hours MTBF (Air Transport, Regional, Business Jet Fleets)
- Laser in full-scale production (over 20,000 digital gyros per year)

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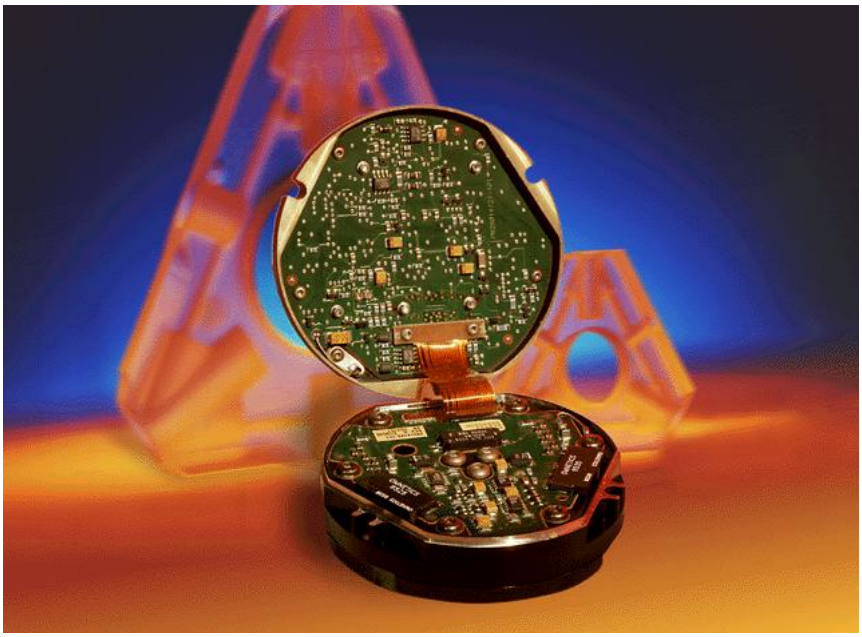
GG1320 Digital Ring Laser Gyro



Accelerometer

Honeywell accelerometers are the recognized industry standard for spacecraft, aircraft, missile and munitions inertial navigation, guidance, control and stabilization applications. The Micro IRS uses the Honeywell Q-FLEX QA-950 accelerometer:

- Q-FLEX sets the standard for inertial navigation
- Excellent turn-on repeatability and stability performance
- Environmentally rugged
- Three fastener precision mounting flange
- Internal temperature sensor for thermal compensation
- Built-in self test
- Embedded compensation coefficients allow IRS repair with simple hand tools. No system calibration is required.

The Q-FLEX is the predominant sensor used in today's commercial and military aircraft strap-down inertial navigation systems. The long-term stability and superior reliability characteristics make it the best inertial-grade accelerometer available on the market today. As with the entire Q-FLEX family of accelerometers, the QA950 features a patented Q-FLEX etched-quartz-flexure seismic system. An amorphous quartz proof-mass structure provides excellent bias, scale factor, and axis alignment stability. The integral electronics develops an acceleration-proportional output current providing both static and dynamic acceleration measurements.

Q-FLEX Accelerometer

Power Supply and EMI/Transient Protection

The power supply assembly contains a dual input 28VDC converter, EMI filtering and transient protection. The EMI filtering is contained in a proprietary “EMI chamber” that is an integral part of the front cover. This unique design has enabled the successful completion of the EMI/HIRF qualification test with wide margins.

Processor and ARINC I/O

The processor and ARINC I/O assembly use technology from proven baselines with extensive FAA/EASA certification experience. The software is DO178B level A certified. The complex electronic hardware is DO-254 level A certified. The card has been design with memory and throughput growth capacity.

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5.0 Qualification Levels

Conditions	DO-160G Section	Description of Conducted Tests
Temperature and Altitude	**4.0**	**Category A2/F1.**
Low Ground Survival	**4.5.1**	-55°C
Low Short Term Operating	**4.5.1**	–40°C
Low Operating Temperature	**4.5.2**	–40°C
High Ground Survival	**4.5.3**	+85°C
High Short Term Operating	**4.5.3**	+70°C – Covered by High Operating
High Operating	**4.5.4**	+70°C
In Flight Loss of Cooling	**4.5.5**	N/A – device is passively cooled.
Altitude	**4.6.1**	-2,000 to +80,000 feet
Decompression	**4.6.2**	8,000 to 55,000 ft in 15 seconds.
Additional Test Performed		6,000 ft to maximum operating altitude (43,100ft) in 2 seconds Dwell at 43,100 ft. for at least 2 minutes then reduce pressure linearly to 10,000 ft. over the next 6 minutes. Final dwell @ 10,000 ft. for a minimum of 2 minutes. 28 PSIA (-19,000 feet)
Overpressure	**4.6.3**	
Temperature Variation	**5.0**	**Category A (10°C/Min)** 2 Cycles, -40C/+70C
Humidity	**6.0**	**Category B** 10 Day Severe Humidity
Shock	**7.0**	**Category E**
Operational	**7.2**	6 g, 20 msec.
Crash Safety - Impulse	**7.3**	20 g, 20 msec.
Crash Safety - Sustained	**7.3**	20 g, 3 sec.
Vibration	**8.0**	**Category S**
Standard Random	**8.5.2**	Figure 8-1, **Curve B2**, modified to provide 2.2 GRMS Curve modified as follows: 0.0032 G^2/Hz- 10 to 980 Hz Slope down to 0.00085 G^2/Hz- @ 2000 Hz Run 5 Hrs / axis
Sine	**8.5.1**	Figure 8-3, **Category S, Curve M** Category U - Unknown Helicopter
Sine on Random Test	**8.8.2**	Applies to HG2100BB55 only.
Explosion Proofness	**9.0**	**Category H** By analysis and similarity to thermal profile testing in RET, modified to less than 299.84_F (148.8_C)
Waterproofness	**10.0**	**Category W**

Conditions	DO-160G Section	Description of Conducted Tests
Fluids Susceptibility	**11.0**	**Category F** Method was spray (Use isopropyl alcohol, denatured alcohol, and D-Limonene and Skydrol 500-B4)
Sand and Dust	**12.0**	**Category S**
Fungus	**13.0**	**Category F** No Test – Analysis of materials used in construction of LRU.
Salt Spray	**14.0**	**Category S**
Magnetic Effect	**15.0**	**Category Z**
Power Input	**16.0**	**Category ZXX**
Voltage Spike	**17.0**	**Category A**
Audio Frequency Susceptibility	**18.0**	**Category Z**
Induced Signal Susceptibility	**19.0**	**Category CW**
Radio Frequency Susceptibility Conducted Susceptibility Radiated Susceptibility RF Susceptibility Pulse Mode	**20.0** **20.4** **20.5/20.6** **20.5/20.6**	**Category Y** **Category L** Category G Frequency PM(V/M) Category 400 MHz – 0.7 GHz 730 Cat L 0.7 – 1.0 GHz 1400 Cat L 1.0 – 2.0 GHz 5000 Cat L 2.0 – 2.4 GHz 6000 Cat L 2.4 – 3.3 GHz 3000 Cat G 3.3 – 4.0 GHz 6000 Cat L 4.0 – 6.0 GHz 7200 Cat L 6.0 – 8.0 GHz 1100 Cat L 8.0 – 12.0 GHz 5000 Cat L 12.0 – 18.0 GHz 2000 Cat L 18.0 – 40.0 GHz 600 Cat None
Radio Frequency Emission	**21.0**	**Category M**
Lightning Pin Injection	**22.5.1**	**Category A3H3L3** Waveform 3 – 600V / 24A Waveform 4 – 300V / 60A
Lightning Cable Injection, Single Stroke	**22.5.2**	**Category A3H3L3** Waveform 2 – 300V / 600A Waveform 3 – 600V / 120A Waveform 4 – 300V / 600A

Conditions	DO-160G Section	Description of Conducted Tests
Lightning Cable Injection, Multiple Stroke	**22.5.2**	**Category A3H3L3**, with the multiple stroke test performed with 24 pulses randomly spaced within a 2 second time period. Waveform 2 – 1st 300V / 300A Subsequent 150V / 150A Waveform 3 – 1st 600V / 120A Subsequent 300V / 60A Waveform 4 – 1st 150V / 300A Subsequent 75V / 150A
Lightning Cable Injection, Multiple Burst	**22.5.2**	**Category A3H3L3** Waveform 3 – 360V / 6A Waveform 6 – 100 V / 6A
Lightning Direct Effects	**23.0**	**Category X** No Test Required.
Icing	**24.0**	**Category X** No Test Required.
Electrostatic Discharge (ESD)	**25.5**	**Category A**
Fire, Flammability	**26.0**	**Category C** Analysis of materials used in construction of LRU.

6.0 Input Parameter Characteristics

ARINC 429 IR Inputs

Data Word	Label	SDI	Format	Range	LSB Weight	MSB Weight	Sig Bits	Units	Pos Sense	Xmit Interval
Set Latitude(1)	041	N/A	BCD	-90 to +90	0.1 min	100	5	Deg:Min	North	Aperiodic
Set Longitude(1)	042	N/A	BCD	-180 to +180	0.1 min	100	6	Deg:Min	East	Aperiodic
Set Heading(1)	043	N/A	BCD	0 to 359.9	0.1 deg	300	4	Deg	CW Frm N	Aperiodic
UTC Format 1(3,5)	125	xxB	BCD	0-99:99	1.0 min	90	4	Hr:Min	N/A	1 sec
UTC Format 2 (3,5)	125	xxB	BCD	0-79:59:9	0.1 min	90	5	Hr:Min:Tenths	N/A	1 sec
Pressure Altitude (3)	203	xxB	BNR	±131072	1.0 ft	65536	17	Feet	Up	50 ms
True Airspeed(3)	210	xxB	BNR	0 to 2047	0.0625 kts	1024	15	Knots	Alwys Pos	100 ms
Greenwich Mean Time	125	xxB	BCD	0-99:99	1.0 min	90	4	Hr:Min	N/A	1 sec
Date	260	xxB	BCD	0-39/19/99	1 day	90	6	D:M:Y	N/A	1 sec
Aircraft Serial Number(3)	226	xxB	BCD	0-9999	1	9000	4	N/A	N/A	1 sec
Aircraft Type	167	xxB	BNR	0-255	1	128	8	N/A	N/A	1 sec
IRS BITE Command(3,2,4)	357	xxB	DISC	N/A	N/A	N/A	N/A	N/A	N/A	Aperiodic

ARINC 429 Digital Inputs Notes:

1 The minimum aperiodic update rate for BCD Labels 041, 042, and 043 is 0.1 seconds. The IRU might not respond to any of these labels if they are transmitted asvalid at intervals faster than 0.1 seconds.

2 The minimum aperiodic interval for Label 357 is 0.1 seconds. The IRU might not respond to this label if it is transmitted as valid at intervals faster than 0.1 second. The maximum aperiodic interval for the reset command function of Label 357 is 0.3 seconds for each reset command. If the reset command function of Label 357 is received over an interval greater than 3 seconds, the IRU might interpret the second Label 357 as a second independent reset command. The Label 357 command for the number of GPS receivers installed must be transmitted within one minute after the power- up mode for accurate fault reporting for systems that contain less than two GPS receivers. Label 357 is only accepted when ARINC Input bus configuration is set to 0

3 For these data words, the SDI field indicates the source of the data: for example, ADS#1, ADS#2, or ADS#3 for the air data parameters. However, the IRU is not required to make use of the SDI data.

4 The maximum aperiodic interval for the functional test command in Label 357 is 1.0 second per functional test command. To extend a functional test, the functional test command must be received within 1.0 second before terminating the normal functional test operation. Thereafter, the functional test command must be transmitted at no slower than once each second to keep the functional test performing without interruption. If the functional test command of Label 357 is received over an interval greater than 1.0 second, the functional test is not extended. Instead of extending the functional test, a delayed command initiates a separate functional test after the previous test is complete.

5 Format 1 - ARINC Input Bus Configuration 0.

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ARINC 429 GPS Receiver Inputs

Parameter	Label (Octal)	Signal Format	Minimum Update Rate (Hz)	Significan Bits/ Figures	MSB	~LSB Wgt	Units	Range	Positive Sense
User Range Accuracy	057	BNR	1	17	4096		Meters	+8192	Always +
Measurement Status	060	DIS	1	N/A	N/A		N/A	N/A	N/A
Pseudo Range	061	BNR	1	20	1342177		Meters	+268435456	+
Pseudo Range Fine	062	BNR	1	11	128		Meters	256	(4)
Range Rate	063	BNR	1	20	2048		M/Sec	+4096	+
Delta Range	064	BNR	1	20	2048		M/Sec	+4096	+
SV Position X	065	BNR	1	20	3355443		Meters	+67108864	ECEF
X Fine Position	066	BNR	1	14	32		Meters	64	(4)
SV Position Y	070	BNR	1	20	3355443		Meters	+67108864	ECEF
Y Fine Position	071	BNR	1	14	32		Meters	64	(4)
SV Position Z	072	BNR	1	20	3355443		Meters	+67108864	ECEF
Z Fine Position	073	BNR	1	14	32		Meters	64	(4)
UTC Measurement Time	074	BNR	1	20	5		Seconds	10.0	(3)
Aut GPS Altitude	076	BNR	1	20	65536		Feet	+131072	Up
Aut GPS HDOP	101	BNR	1	15	512		N/A	1024	(3)
Aut GPS VDOP	102	BNR	1	15	512		N/A	1024	(3)
Aut GPS Track Angle	103	BNR	1	15	90		Degrees	+180	CW-North
Aut GPS Latitude	110	BNR	1	20	90		Degrees	+180	North
Aut GPS Longitude	111	BNR	1	20	90		Degrees	+180	East
Aut GPS Gnd Speed	112	BNR	1	15	2048		Knots	4096	(3)
Aut GPS Lat. Fine	120	BNR	1	11	8.6E- 5		Degrees	$180 * 2^{-20}$	North
Aut GPS Long. Fine	121	BNR	1	11	8.6E- 5		Degrees	$180 * 2^{-20}$	East
Horiz Aut. Integrity Limit	130	BNR	1	17	8		NM	16	(3)
Vertical Aut. Integrity Limit	133	BNR	1	18	16384		Feet	32768	(3)
GPS Vertical FOM	136	BNR	1	18	16384		Feet	32768	(3)
UTC Fine	140	BNR	1	20	0.5		Seconds	1.0	(4)
UTC (Binary)	150	BNR	1	3	16 Hr		Hr:Min:s	23:59:59	(3)
Aut GPS Vert Velocity	165	BNR	1	15	16384		Feet/Min	+32768	Up
Aut GPS N-S Velocity	166	BNR	1	15	2048		Knots	+4096	North
Aut GPS E-W Velocity	174	BNR	1	15	2048		Knots	+4096	East
GPS Horizontal FOM	247	BNR	1	18	10 Years		NM	16	(3)
Date	260	BCD	1	6	8		D:M:Yr	1 day	(3)
GPS Sensor Status	273	DIS	1	N/A	N/A		N/A	N/A	N/A

ARINC 429 Digital Inputs Notes:

1. Update rate for each satellite. The satellite measurement block is transmitted once for each satellite measurement used in the navigation computation. The maximum number of satellites that can be processed in a 1.0 second interval is 12. The characteristics of the GPS raw data measurement block are defined in ARINC 743.
2. Update rate for each autonomous GPS navigation block. Autonomous navigation data set is received at a 1 Hz or 10 Hz rate, and within 200 ms following occurrence of a time mark.
3. Fine data words contain the truncated portion of the original data word. This information is unsigned although the sign bit is reserved. The two labels are concatenated (or combined) in the receiver.

Output Parameter Characteristics

IR ARINC 429 Digital Outputs

Signal	Oct Lbl	Cod(1)	Sig(2) Bit	Range(3)	LSB(8) Wght	MSB Wght	Units	Positive Sense	Filter(5) Type	Filter(6) BW (Hz)	Transport (7) Delay Msec	Xfer Rate Hz
IR Time to Nav	007	BCD	2	0-9.9	0.1	-	Minutes	Always +	N/A	N/A	N/A	3.125
Turn Rate	040	BNR	18	128	4.88E- 4	64	Deg/Sec	Nose Right	1- BW (50)	0.2	900	25
IR Time In Nav	126	BNR	15	0-32768	1	16384	Minutes	Always +	N/A	N/A	N/A	2.08
IRS Discrete 1	270	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.125
IRS Discrete 2	271	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.125
Longitudinal Velocity	303	BNR	18	-4096-4096	1.56E- 2	2048	Knots	Forward	1- BW (50)	2	110	25
Lateral Velocity	304	BNR	18	-4096-4096	1.56E-2	2048	Knots	Right	1-BW (50)	2	110	25
Normal Velocity	305	BNR	18	-4096-4096	1.56E-2	2048	Knots	UP	1-BW (50)	2	110	25
Position Latitude	310	BNR	20	90(9)	1.72E-4	90	Degrees	North	N/F	N/A	160	12.5
Position Longitude	311	BNR	20	180	1.72E-4	90	Degrees	East	N/F	N/A	160	12.5
Ground Speed	312	BNR	18	0-4096	0.01563	2048	Knots	Always +	1-BW (50)	2	110	25
Track Angle True	313	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	2	110	25
True Heading (Primary)	314	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	2	110	25
True Heading (Heading 8 Hz Filter)	314	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	8(14)	50(14)	25
True Heading (Primary)[16]	314	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	2	110	50
True Heading (Heading 8 Hz Filter)[16] 16	314	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	82	50110	50
Wind Speed	315	BNR	18	0-256	9.77E-4	128	Knots	Always +	1-BW (5012)	2	110	12.5
Wind Direction True	316	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (5012)	2	110	12.5
Track Angle Magnetic	317	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (5025)	2	110	25
Magnetic Heading (Primary)	320	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	2	110	25
Magnetic Heading (Heading 8 Hz Filter)	320	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	8(14)	50(14)	25
Magnetic Heading (Primary)[16]	320	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	2	110100	50
Magnetic Heading (Heading 8 Hz Filter)[16]	320	BNR	18	180	6.87E-4	90	Degrees	CW from N	1-BW (50)	2	50	50
Drift Angle	321	BNR	18	90(9)	6.87E-4	90	Degrees	Nose Right	1-BW (25)	2	110	25
Flight Path Angle	322	BNR	18	90(9)	6.87E-4	90	Degrees	Up	1-BW (25)	2	110	25
Flight Path Accel	323	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	6.4	70	50
Flight Path Accel	323	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	3	115	50
Flight Path Accel	323	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	8	60	50
Flight Path Accel	323	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	12.5	50	50
Flight Path Accel	323	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	20	40	50
Pitch Angle	324	BNR	18	90(9)	6.87E-4	90	Degrees	Up	1-BW (400)	8	40	50
Pitch Angle[16]	324	BNR	18	90(9)	6.87E-4	90	Degrees	UP	1-BW (400)	8	40	100
Roll Angle	325	BNR	18	180	6.87E-4	90	Degrees	Right Wing Down	1-BW (50)	8	40	50
Roll Angle[16]	325	BNR	18	180	6.87E-4	90	Degrees	Right Wing Down	1-BW (50)	8	40	100
Body Pitch Rate	326	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW (400)	8.0	40	100
Body Pitch Rate	326	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW (400)	12.5	30	100
Body Pitch Rate	326	BNR	18	128	4.88E-4	64	Deg/Sec	UP	2-BW (400)	20	20	100
Body Roll Rate	327	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW (400)	12.5	30	100
Body Roll Rate	327	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW (400)	8.0	40	100
Body Roll Rate	327	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW (400)	20	20	100
Body Yaw Rate	330	BNR	18	128	4.88E-4	64	Deg/Sec	Nose Right	2-BW (400)	8.0	40	100
Body Yaw Rate	330	BNR	18	128	4.88E-4	64	Deg/Sec	Nose Right	2-BW (400)	12.5	30	100
Body Yaw Rate	330	BNR	18	128	4.88E-4	64	Deg/Sec	Nose Right	2-BW (400)	20	20	100
Body Long Accel	331	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	6.4	50	100
Body Long Accel	331	BNR	18	4	1.53E-5	2	G's	Forward	2- BW (400)	8	40	100
Body Long Accel	331	BNR	18	4	1.53E-5	2	G's	Forward	2- BW (400)	12.5	30	100
Body Long Accel	331	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	20	20	100
Body Long Accel	331	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	3	100	100
Body Lat Accel	332	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	6.4	50	100
Body Lat Accel	332	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	3	100	100
Body Lat Accel	332	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	8	40	100
Body Lat Accel	332	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	12.5	30	100
Body Lat Accel	332	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	20	20	100
Body Norm Accel	333	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	6.4	50	100
Body Norm Accel	333	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	3	100	100

Body Norm Accel	333	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	8	40	100
Body Norm Accel	333	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	12.5	30	100
Body Norm Accel	333	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	20	20	100
Platform Heading	334	BNR	18	180	6.87E-4	90	Degrees	CW	1-BW (400)	2	110	25
Track Angle Rate	335	BNR	18	32	1.22E-4	16	Deg/Sec	CW from N	1-BW (50)	8	45	50
Pitch Att Rate	336	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW (400)	8.0	50	50
Pitch Att Rate	336	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW (400)	12.5	40	50
Pitch Att Rate	336	BNR	18	128	4.88E-4	64	Deg/Sec	Up	2-BW (400)	20	30	50
Roll Att Rate	337	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW (400)	12.5	40	50
Roll Att Rate	337	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW (400)	8.0	50	50
Roll Att Rate	337	BNR	18	128	4.88E-4	64	Deg/Sec	Right Wing Down	2-BW (400)	20	30	50
IRU Maintenance	350	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.125
IRU Maintenance Word #2	351	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.125
Cycle Counter	354	BNR	19	0-524288	1	262,144	Count	Always +	N/A	N/A	N/A	50
IRU Status	355	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.125
Inertial Altitude	361	BNR	20	-2K to 60K(4)	0.125	65536	Feet	Up	1-BW (50)	8	65	25
Along Track Accel	362	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	6.4	70	50
Along Track Accel	362	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	3	115	50
Along Track Accel	362	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	8	60	50
Along Track Accel	362	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	12.5	50	50
Along Track Accel	362	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	20	40	50
Cross Track Accel	363	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	6.4	70	50
Cross Track Accel	363	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	3	115	50
Cross Track Accel	363	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	8	60	50
Cross Track Accel	363	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	12.5	50	50
Cross Track Accel	363	BNR	18	4	1.53E-5	2	G's	Right	2-BW (400)	20	40	50

Signal	Oct Lbl	Cod (1,10)	Sig Bit(2,11)	Range(3.12)	LSB Weight (8,15)	MSB Weight	Units	Positive sense	Filter(5)	Filter(6)	Transport Delay (7,14)	Xfer Rate Hz
Vertical Accel	364	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	6.4	70	50
Vertical Accel	364	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	3	115	50
Vertical Accel	364	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	8	60	50
Vertical Accel	364	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	12.5	50	50
Vertical Accel	364	BNR	18	4	1.53E-5	2	G's	Up	2-BW (400)	20	40	50
Inertial Vertical Spd	365	BNR	18	32768	0.125	16384	Ft/Min	Up	1-BW (50)	8	65	50
N-S Velocity	366	BNR	18	4096	0.01563	2048	Knots	North	1-BW (50)	2	110	12.5
E-W Velocity	367	BNR	18	4096	0.01563	2048	Knots	East	1-BW (50)	2	110	12.5
Unbiased Normal Accel	370	BNR	18	8	3.05E-5	4	G's	Up	2-BW (400)	3	115	12.5
Unbiased Normal Accel	370	BNR	18	12	3.05E-5	6	G's	Up	2-BW (400)	3	115	25
Unbiased Normal Accel	370	BNR	18	8	3.05E-5	4	G's	UP	2-BW (400)	6.4	70	12.5
Unbiased Normal Accel	370	BNR	18	12	3.05E-5	6	G's	Up	2-BW (400)	6.4	70	25
Unbiased Normal Accel	370	BNR	18	8	3.05E-5	4	G's	Up	2-BW (400)	8	60	12.5
Unbiased Normal Accel	370	BNR	18	12	3.05E-5	6	G's	Up	2-BW (400)	8	60	25
Unbiased Normal Accel	370	BNR	18	8	3.05E-5	4	G's	Up	2-BW (400)	12.5	50	12.5
Ubiased Normal Accel	370	BNR	18	12	3.05E-5	6	G's	Up	2-BW (400)	12.5	50	25
Unbiased Normal Accel	370	BNR	18	8	3.05E-5	4	G's	Up	2-BW (400)	20	40	12.5
Unbiased Normal Accel	370	BNR	18	12	3.05E-5	6	G's	UP	2-BW (400)	20	40	25
Equipment ID	371	DIS	19	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.125
Along Heading Accel	372	BNR	18	-4096-4096	1.53E-2	2048	Knots	Forward	1-BW (50)	2	110	25
Cross Heading Accel	373	BNR	18	-4096-4096	1.53E-2	2048	Knots	Right	1-BW (50)	2	110	25
Along Heading Accel	375	BNR	18	4	1.53E-5	2	G's	Forward	2-BW (400)	3	115	50
Along Heading Accel	375	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	6.4	70	50
Along Heading Accel	375	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	8	60	50
Along Heading Accel	375	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	12.5	50	50
Along Heading Accel	375	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	20	40	50
Cross Heading Accel	376	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	3	115	50
Cross Heading Accel	376	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	6.4	70	50
Cross Heading Accel	376	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	8	60	50
Cross Heading Accel	376	BNR	18	4	1.5E-5	2	G's	Forward	2-BW (400)	20	40	50
Cross Heading Accel	376	BNR	18	4	1.5E-5	2	G's	Forward	2-BW(400)	12.5	50	50
IRU Part Number	377	DIS	16	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.04
Hybrid Horiz Integrity Limit (ADS- B)	122	BNR	17	0-16	1.22E-4	8	NM	Always+	N/A	N/A	N/A	1.04
Hybrid Horiz Integrity Limit	131	BNR	17	0-16	1.22E-4	8	NM	Always+	NA	NA	NA	1.04
Hybrid True Heading (Primary)	132	BNR	18	180	6.866E- 4	90	Degrees	CW from N	1- BW (50)	2	110	25
Hybrid True Heading (True Heading 8 Hz Filter)	132	BNR	18	180	6.866E- 4	90	Degrees	CW from N	1- BW (50)	8	110	25
Hybrid Vertical FOM	135	BNR	18	0- 32768	0.125	16384	Feet	Always+	NA	NA	NA	1.04
Hybrid True Track Angle	137	BNR	18	180	6.866E- 4	90	Degrees	CW from N	1-BW (50)	2	110	25

UTC	150	BNR	3	00:00:00 - 23:59:59	1 Sec	16 Hr	Hr:Min:Sec Knots	Always+	NA	NA	NA	1.04
Hybrid Ground Speed	175	BNR	18	0-4096	0.015625	2048	Degrees	Always +	1-BW (50)	2	110	25
Hybrid Position Latitude	254	BNR	20	90	0.000172	90	Degrees	Always+	N/A	N/A	160	12.5
Hybrid Position Longitude	255	BNR	20	180	0.000172	90	Degrees	North	N/A	N/A	160	12.5
Hybrid Latitude Fine	256	BNR	11	0.000172	8.38E- 8	8.6E- 5^{13}	Degrees	East	N/A	N/A	160	12.5
Hybrid Longitude Fine	257	BNR	11	0.000172	8.38E-8	8.6E- 5^{13}	D:M:Y	Always+	N/A	N/A	160	12.5
Date	260	BCD	6	00:00:00 - 39:19:99	1 Day	10 Year	Feet	Always+	N/A	N/A	N/A	1.04
Hybrid Altitude	261	BNR	20	131072	0.125	65536	Feet	UP	1- BW (50)	8	65	25
Hybrid Height (HAE)	262	BNR	20	131072	0.125	65536	Degrees	UP	NA	NA	110	12.5
Hybrid Flight Path Angle	263	BNR	18	90	6.866E- 4	90	NM	Always+	1-BW (50)	2	110	25
Hybrid Horiz FOM	264	BNR	18	0-16	6.1E- 5	8	Knots	North	N/A	N/A	NA	1.04
Hybrid N- S Velocity	266	BNR	18	4096	0.015625	2048	Knots	East	N/A	N/A	110	12.5
Hybrid E-W Velocity	267	BNR	18	4096	0.015625	2048	N/A	NA	N/A	N/A	110	12.5
GPIRS Sensor Status	274	DIS	19	N/A	N/A	NA	N/A	N/A	N/A	N/A	NA	1.04
Hybrid Body Longitudinal Velocity	300	BNR	18	- 4096- 4096	1.56E-2	BNR	Knots	Forward	1-BW(50)	2	130	25
Hybrid Body Lateral Velocity	301	BNR	18	- 4096- 4096	1.56E-2	BNR	Knots	Right	1-BW (50)	2	130	25
Hybrid Body Normal Velocity	302	BNR	18	- 4096- 4096	1.56E-2	BNR	Knots	UP	1-BW (50)	2	130	25
Hybrid Along Heading Velocity	340	BNR	18	- 4096- 4096	1.56E-2	BNR	Knots	Forward	1-BW (50)	2	130	25
Hybrid Cross Heading Velocity	341	BNR	18	- 4096- 4096	1.56E-2	BNR	Knots	Right	1-BW (50)	2	130	25
Hybrid Vertical Velocity	345	BNR	18	32768	0.125	16384	Ft/Mins	UP	1-BW (50)	8	65	25
GPIRS Maintenance Word	353	DIS	21	N/A	N/A	NA	NA	NA	NA	N/A	NA	1.04

IR ARINC 429 Digital Output Notes

Note 1: Per ARINC 429, the Sign Status Matrix for the label formats Binary, Binary Coded Decimal, and Discrete are as follows.

	Bits		
Format	31	30	Condition[1]
	0	0	Faliure Warning
	0	1	NCD
	1	0	Functional Test
	1	1	Normal Operation
BCD[2]	0	0	Normal Operation (positive)
	0	0	NCD
	1	0	Functional Test
	1	1	Normal Operation (negative)
Discrete[3]	0	0	Normal Operation
	0	1	This setting is not used under any conditions
	1	0	Functional Test (not used under any conditions)
	1	1	Failure Warning (not used under any conditions)

Notes:

1.When two or more conditions are present, the IRU sets the SSMs according to the following priorities:

Condition	Priority
Functional Test	1 (highest)
Failure Warning	2
No Computed Data	3
Normal Operation	4

2. Under failure warning conditions, the BCD ARINC words are not transmitted.
3. The IRU transmits discrete words as Normal Operation under Failure Warning and No Computed Data conditions.
4. Bit 32 is the parity for all labels. The 32- bit parity is odd for all labels.

Note 2: Significant bits for BNR data is defined as the number of ARINC 429 data bits excluding the sign bit. The accuracy for each associated output is defined in Table 5.3.6-1.

Note 3: For BCD labels, the actual digital range is as specified. For BNR labels, the range is as specified for a negative value and is full scale minus 1 LSB for a positive value if not range limited. Output range may be limited by software.

Note 4: Air Data altitude reference to the IR is input limited between -2,000 and 60,000 feet. The inertial altitude may overshoot these limits before converging to the Air Data altitude. Bit weighting range of the output is 131072 feet.

Note 5: Low Pass Digital Butterworth filters are used to filter the digital signals before being transmitted on the

ARINC 429 bus.

1-BW = 1st order Butterworth
2-BW = 2nd order Butterworth

The number in parenthesis represents the filter's sampling frequency in Hz. Note that (12) is a rounded number and is actually (12.5). The acronym N/F means not filtered. A first order Butterworth filter is equivalent to a simple 1st order digital filter.

Note 6: The filter bandwidth is defined as the –3 db cut-off point. In certain cases, the Filter BW is selected via an APM option

Note 7: The transport delays listed are the maximum required delays. The actual transport delay for each label may be considerably less than the listed value. The maximum transport delay for a 2nd order Digital Butterworth filter occurs at the -3 db break frequency. The maximum transport delay for a 1st order Digital Butterworth filter occurs when the frequency approaches 0 Hz. Delays specified are comprised of sensor input, filter, software, and output delays. The delays given may not be in agreement with the ARINC 704/738 specification, since the delays specified in this specification assume different filter breakpoints. In certain cases, the transport delays are selected via an APM option.

Note 8: The LSB weighting of the output does not necessarily equate to the resolution of that output. Resolution is defined as the minimum monotonic step amplitude in the output for a given change in the input. The LSB weight is an approximate value, actual value is computed by using MSB weight and number of significant bits.

Note 9: Angular outputs are limited by software to ± 90 degrees. Bit weighting range of these outputs is 180 degrees.

Note 10: Refer note 1 for SSM setting for each of two formats

Note 11: Significant bits for BNR data are defined as the number of ARINC 429 data bits excluding the sign bit. The accuracy for each associated output is defined in PERFORMANCE SPECIFICATIONS, Table 2015.

Note 12: For binary- formatted labels, the digital range is as listed for a negative value and is full scale minus 1 LSB for a positive value. The output range can be limited by software.

Note 13: Fine data words contain the truncated portion of the original data word. This information is unsigned although the sign bit is reserved. The two labels are concatenated (or combined) to form the complete data word. The MSB weight of these labels refers to the next MSB of the latitude or longitude signal after the LSB of the course signals. These MSB weights are not exact.

Note 14: Transport delay requirements are per ARINC Specification 704A.

Note 15: Least significant bit weighting of the output does not necessarily equate to the resolution of that output. Resolution is defined as the minimum monotonic step amplitude in the output for a given change in the input.

Note 16: This label is applicable to the HG2100BB55 only.

7.0 Output Parameter Accuracy

IR Digital Output Performance (ARINC-704 Specification)

Parameter	Limitations	Navigation Mode (Completion of stationary alignment or AIM)(1)	Reversionary Attitude Mode and AIM Attitude Mode (4)
Present Position	See note 2.	For times less than 10 hrs Accuracy = 2nmph R95 For times between 10 and 18 hrs Accuracy = 20 nm R95 Resolution = 1.72e-4 degrees	N/A
Pitch Angle	Pitch angle limited to |90| degrees.	Accuracy = 0.10 degrees 2σ Resolution = 4.12e-3 degrees	Reversionary Attitude TSO C4c Accuracy = 2.5 degrees 2σ Resolution = 4.12e-3 degrees AIM Attitude TSO C4c Accuracy = 0.5 degrees 2σ Resolution = 4.12e-3 degrees
Roll Angle	Held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.10 degrees 2σ Resolution = 4.12e-3 degrees	Reversionary Attitude TSO C4c Accuracy = 2.5 degrees 2σ Resolution = 4.12e-3 degrees AIM Attitude TSO C4c Accuracy = 0.5 degrees 2σ Resolution = 4.12e-3 degrees
True Heading	Held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.40 degrees 2σ Resolution = 6.87e-4 degrees	N/A in Reversionary Attitude AIM Attitude TSO C5f Accuracy = 2.5 degrees 2σ Resolution = 6.87e-4 degrees
Magnetic Heading	Held constant for pitch angles exceeding |85| degrees. Accuracies valid for years 2010 through ~2030 based upon selecting appropriate magnetic variation map	Between N50 and S50 degrees Accuracy = 2 deg between 50N and 68N Accuracy = 3 deg between 50S and 60S Accuracy = 3 deg All other regions where magnetic heading is valid Accuracy = 4 deg Accuracies are 95% Absolute Accuracy = 10 degrees Resolution = 6.87e-4 degrees	Reversionary Attitude Accuracy dependent upon entered heading Operational accuracy is 15 deg/hr maximum drift Resolution = 6.87e-4 degrees AIM Attitude Mode Accuracy = Nav Accuracy Resolution = 6.87e-4 degrees

IR Digital Output Performance (ARINC-704 Specification)

Parameter	Limitations	Navigation Mode (Completion of stationary alignment or AIM)(1)	Reversionary Attitude Mode and AIM Attitude Mode (4)
Ground Speed	See note 2 and note 3	Accuracy = 10 knots R95 Resolution = 0.0156 knots	N/A
Vertical Velocity	Pressure altitude input required. Accuracy valid 120 seconds after vertical loop closure. Assumes no ADS errors. Accuracy valid over ADS altitude range of -2,000 to 60,000 feet.	Accuracy = 30 ft/min 2σ Resolution = 0.125 ft/min	Accuracy = 30 ft/min 2σ Resolution = 0.125 ft/min
Body Pitch Rate	Minimum range of 70 deg/sec.	Accuracy = 0.02 deg/sec or 0.5% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Body Roll Rate	Minimum range of 70 deg/sec.	Accuracy = 0.02 deg/sec or 0.5% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Body Yaw Rate	Minimum range of 40 deg/sec.	Accuracy = 0.02 deg/sec or 0.5% of output whichever is greater Accuracy's are 2σ Resoluton = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Pitch Attitude Rate	Minimum range of 30 deg/sec. Roll angle component held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec
Roll Attitude Rate	Minimum range of 30 deg/sec. Set to zero for pitch angles exceeding |85| degrees.	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec	Accuracy = 0.1 deg/sec or 1% of output whichever is greater Accuracy's are 2σ Resolution = 4.88e-4 deg/sec

Honeywell

IR Digital Output Performance (ARINC-704 Specification)

Parameter	Limitations	Navigation Mode (Completion of stationary alignment or AIM)(1)	Reversionary Attitude Mode and AIM Attitude Mode (4)
Inertial Altitude	Pressure altitude input required. Accuracy specified with constant altitude input, and assumes no ADS error. Accuracy and resolution valid over ADS altitude range of -2,000 to 60,000 feet. Resolution assumes a maximum ADS granularity of 6 feet at an altitude rate of 8,000 ft/min.	Accuracy = 5 feet 2σ Resolution = 0.125 feet	Accuracy = 5 feet 2σ Resolution = 0.125 feet
Longitudinal Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.005 Gs or 0.5% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Lateral Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.005 Gs or 0.5% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Normal Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.005 Gs or 0.5% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Unbiased Normal Acceleration	Minimum sensing range of 8 Gs.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 3.05e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 3.05e-5 Gs
Vertical Acceleration	Minimum sensing range of 4 Gs.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs
Flight Path Acceleration	Valid for Vg > 20 kts.	Accuracy = 0.01 Gs or 10% of output whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 G's	N/A
Along Track Acceleration	Valid for Vg > 20 kts.	Accuracy = 0.01 Gs or 10% of output whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	N/A
Cross Track Acceleration	Valid for Vg > 20 kts.	Accuracy = 0.01 Gs 2σ at 120 kts or greater Resolution = 1.53e-5 Gs	N/A

IR Digital Output Performance (ARINC-704 Specification)

Parameter	Limitations	Navigation Mode (Completion of stationary alignment or AIM)(1)	Reversionary Attitude Mode and AIM Attitude Mode (4)
Platform Heading	Held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.40 degrees 2σ Resolution = 6.87e-4 degrees	Reversionary Attitude Accuracy dependent upon entered heading Operational accuracy is 15 deg/hr maximum drift AIM Attitude Accuracy = 2.5 degrees 2σ Resolution = 6.87e-4 degrees
Track Angle True	Not computed when ground speed is below 20 knots. Accuracy requirement varies as a function of ground speed.	Accuracy = 4 deg 2σ at 120 kts or greater Accuracy = 2 deg 2σ at 230 kts or greater Resolution = 2.06e-3 degrees	N/A
Track Angle Magnetic	Not computed when ground speed is below 20 knots. Accuracy equals the RSS of Track Angle True error plus the Magnetic Variation error. Track Angle Magnetic error varies as a function of ground speed and present position.	For latitudes between 82 degrees South and 82 degrees North Accuracy= 5 deg 2σ at 120 kts or greater Resolution = 2.06e-3 degrees	N/A
Flight Path Angle	Not computed when ground speed is below 20 knots.	Accuracy = 0.4 degrees 2σ Resolution = 2.06e-3 degrees	N/A
Drift Angle	Not computed when ground speed is below 20 knots. Accuracy requirement varies as a function of ground speed. Heading component held constant for pitch angles exceeding |85| degrees.	Accuracy = 4 deg 2σ at 120 kts or greater Resolution = 2.06e-3 degrees	N/A
Track Angle Rate	Not computed when ground speed is below 20 knots.	Accuracy = 0.25 deg/sec 2σ at 60 kts or greater Resolution = 1.22e-4 deg/sec	N/A
Wind Speed	No error assumed in ADS TAS input. See note 2.	Accuracy = 12 knots R95 Resolution = 9.77e-4 knots	N/A
Wind Direction	No error assumed in ADS TAS input. For Wind Speeds ≥50kts	Accuracy = 10 degrees 2σ Resolution = 4.4e-3 degree	N/A
N-S Velocity	See note 3.	Accuracy = 8 knots 2σ Resolution = 0.0156 knots	N/A
E-W Velocity	See note 3.	Accuracy = 8 knots 2σ Resolution = 0.0156 knots	N/A

IR Digital Output Performance (ARINC-704 Specification)

Parameter	Limitations	Navigation Mode (Completion of stationary alignment or AIM)(1)	Reversionary Attitude Mode and AIM Attitude Mode (4)
Along Heading Accel	Minimum sensing range of 4 Gs. Roll angle component held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	N/A
Cross Heading Accel	Minimum sensing range of 4 Gs. Roll angle component held constant for pitch angles exceeding |85| degrees.	Accuracy = 0.01 Gs or 1% of output , whichever is greater Accuracy's are 2σ Resolution = 1.53e-5 Gs	N/A

IR Digital Output Performance Notes:

Note 1: The term R95 represents the radial length of a circle which encompasses a 95% probable accuracy. The well known term 2σ represents two times the standard deviation of a Gaussian distribution. The term 95% represents percent probable accuracy. The resolution specified applies only to the BNR ARINC 429 data.

Note 2: Present position, ground speed, and wind speed are 2-dimensional parameters. The error in these parameters is computed as a vector difference between the observed and true values.

Note 3: N-S velocity and E-W velocity are single axis errors that are the components to the ground speed error vector.

Note 4: Unless otherwise noted, the performance specified applies to both Reversionary Attitude mode and AIM Attitude mode.

General Note:

Some system performance values listed are from ARINC-704a as a minimum requirement. Actual performance may be better

Hybrid GPS System Performance

Parameter	Conditions	Navigation Mode(1)
Hyb Horizontal Position	HDOP = 1.5	25 meters (2DRMS)
Hyb Ground Speed	HDOP = 1.5	0.25 knots R95(2)
Hyb Vertical Velocity	VDOP = 2.0	30 feet/minute 2σ
Hyb Track Angle True	HDOP = 1.5(3)	0.10 degrees 2σ
Hyb North-South Velocity	HDOP = 1.5	0.2 knots 2σ
Hyb East-West Velocity	HDOP = 1.5	0.2 knots 2σ
Hyb Altitude	VDOP = 2.0	150 feet 2σ
Hyb Flight Path Angle	VDOP = 2.0(4)	0.15 degrees 2σ
Hyb True Heading	None	0.4 degrees 2σ

Hybrid GPS System Performance Notes:

Note 1: The term R95 represents the 95% probable accuracy for a Rayleigh distribution. The term 2 σ represents two times the standard deviation of a Gaussian distribution. The term 2DRMS represents the root-mean-square value of the x-y distances (two-dimensional distance root-mean-square) from the true location point. The confidence value for a 2DRMS depends on the elongation of the error ellipse. As the error ellipse collapses to a line segment, the confidence value approaches 95 percent; as the error ellipse becomes circular, the confidence value approaches 98%.

Note 2: The resolution of the ARINC output is 0.125 knots.

Note 3: Based upon a ground speed of 120 knots with circular error distribution.

Note 4: Based upon a ground speed of 120 knots.

General Note:

Some system performance values listed are from ARINC-704a as a minimum requirement. Actual performance may be better.