

# **LASEREF<sup>®</sup> V**



## **Micro Inertial Reference System SM**

**μIRS™**

**(Special Missions)**

Product Description  
March 2004

## **1.0 Introduction**

The Laseref V Micro IRS SM contains high performance ring laser gyro technology in the industry's smallest and lightest package. The high performance gyros enhance inertial navigation performance and provide hybrid GPS/IRS data. This new system has been designed to simplify crew workload while dramatically reducing installation time, weight, size, power, and cost. The Laseref V Micro IRS product family have been selected on the following aircraft:

### **Business Jets:**

- Gulfstream G100 Retrofit , G350, G450, G500, and G550
- Raytheon Hawker Horizon
- Dassault Falcon 900EX, 2000EX, and 7X
- Beechcraft King Air Retrofit

### **Air Transport & Regional:**

- Embraer 170/175/190/195
- Boeing 7E7
- ATR-42 Retrofit
- Y8F-600 Civil Transport

### **Tankers & Transports:**

- C5-AMP Retrofit
- C-130 Retrofit
- B-707 Retrofit

### **High Performance Aerobatic Trainers**

- T-38N Trainer Retrofit
- Pilatus PC-21, PC-7, and PC-9 Trainers

### **Helicopters**

- Eurocopter AS-365

### **Micro IRS SM features:**

- High accuracy Attitude, Heading and Navigation outputs.
- 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.
- 25,000 MTBF Reliability -- highest in the industry
- Automatic Mode Control Logic and Automatic Initialization for reduced crew workload
- Alignment In Motion software allows dispatch even while IRS is in alignment mode. This feature eliminates delays while waiting for the IRS to align.
- Passive Cooling eliminates the weight and cost of the cooling fans
- Electronic mounting tray alignment for reduced installation cost
- Hybrid Kalman Filter provides extended coasting through GPS outages
- ARINC-615 Interface for simple software updates

- Enhanced Automatic Realignment uses GPS to refine the alignment between flights
- HIGH Integrity Hybrid GPS provides 100% Availability of RNP Navigation
- Powerful Processor with Partitioned Operating System

## System Components:

The Special Missions Micro Inertial Reference System contains the following components:

- HG2195AB Special Missions Micro IRU
- WG2001 Mounting Tray
- IM-950 Aircraft Personality Module

### HG2195 Special Missions 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, 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

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

### Key Features:

- Weight 9.8 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
- RS-232 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  
Simplified sensor replacement, no recalibration required
- Upgrades ARINC-615 Compatible Software Upgrades

## **Certification:**

- Software Certification DO178B Level A
- Hardware Certification DO160D
- TSO & JTSO C-3d, C-4c, C-5e, C-6d, and C-3d (when configured in APM)
- TSO & JTSO 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

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 Coasting Times				
Performance Level	Gravity Deflections	Coasting Times for Given RNP		
		RNP 0.3	RNP 0.5	RNP 1.0
95% Accuracy	1 arc-sec	30.01 min	44.49 min	2.23 hr
95% Accuracy	5 arc-sec	25.71 min	37.85 min	2.06 hr

## 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.

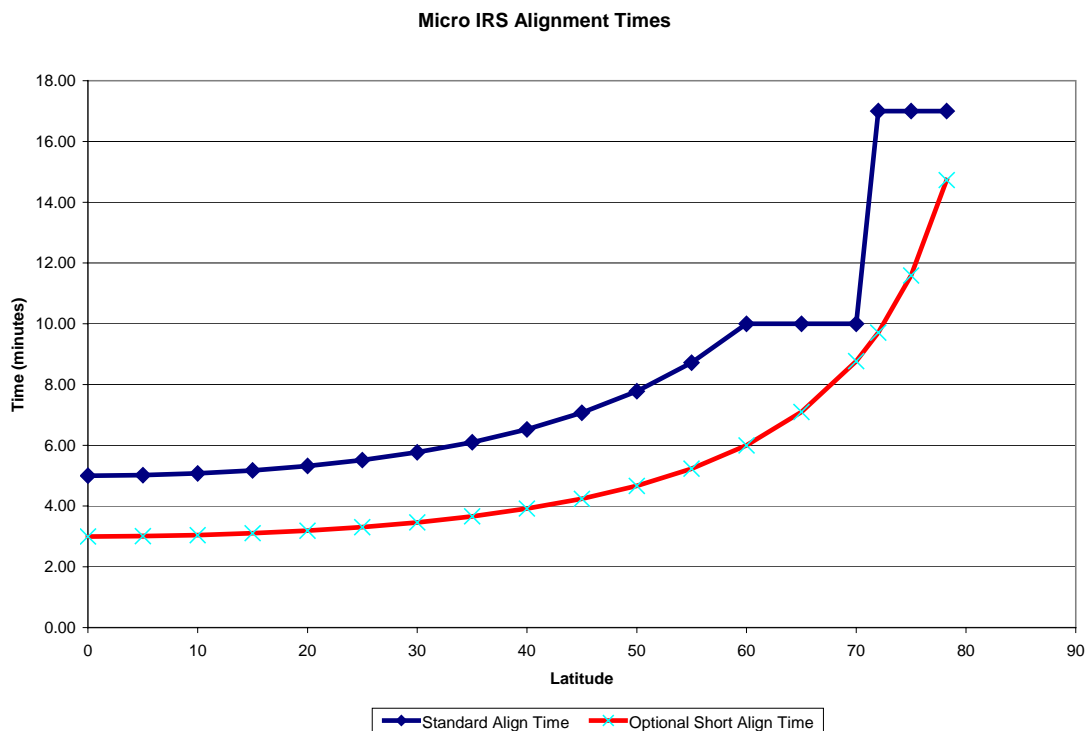
During Stationary Alignment and Post Flight Auto Realign, valid data from GPS may be used as an automatic source for position entry. Also, valid GPS data must be received in order for Align In Motion to operate. To be considered valid for use during Stationary Alignment, Align In Motion, and Post Flight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

- a. GPS Horizontal Integrity Limit is received with a Normal Operation SSM and its data value is less than 2 nmi,
- b. GPS Ground Speed is received with a Normal Operation SSM,
- c. GPS Latitude and Longitude parameters are received with a Normal Operation SSM,
- d. The GPS Hybrid function is operating in either the Acquisition, Navigation, or Altitude Aiding/Clock Coasting modes as indicated by Label 274 bits 28-26.



## Alignment Times

The IRS contains two selectable alignment times as configured in the APM. The standard alignment time varies from 5 minutes at the Equator to 10 minutes at 70 degrees North or South Latitude. It is automatically extended for alignments up to 82.5 Degrees Latitude. The alternative short alignment time varies from 3 minutes at the Equator. The customer can control this option during the initial build of the aircraft when the IRS is installed. The short alignment time option may be desirable for short-range aircraft. If full RNP-10 performance is desired for long flights, the long alignment time option should be selected. The customer may also choose to use operational procedures to control this option. For example, if the short alignment time option is selected in the APM and a long-range flight into RNP-10 airspace is planned, the Automatic Extended Alignment feature will continue the alignment process until the aircraft is moved. In this case an operational procedure would specify that the aircraft is not moved until the alignment time is consistent with the standard align time in the chart below.



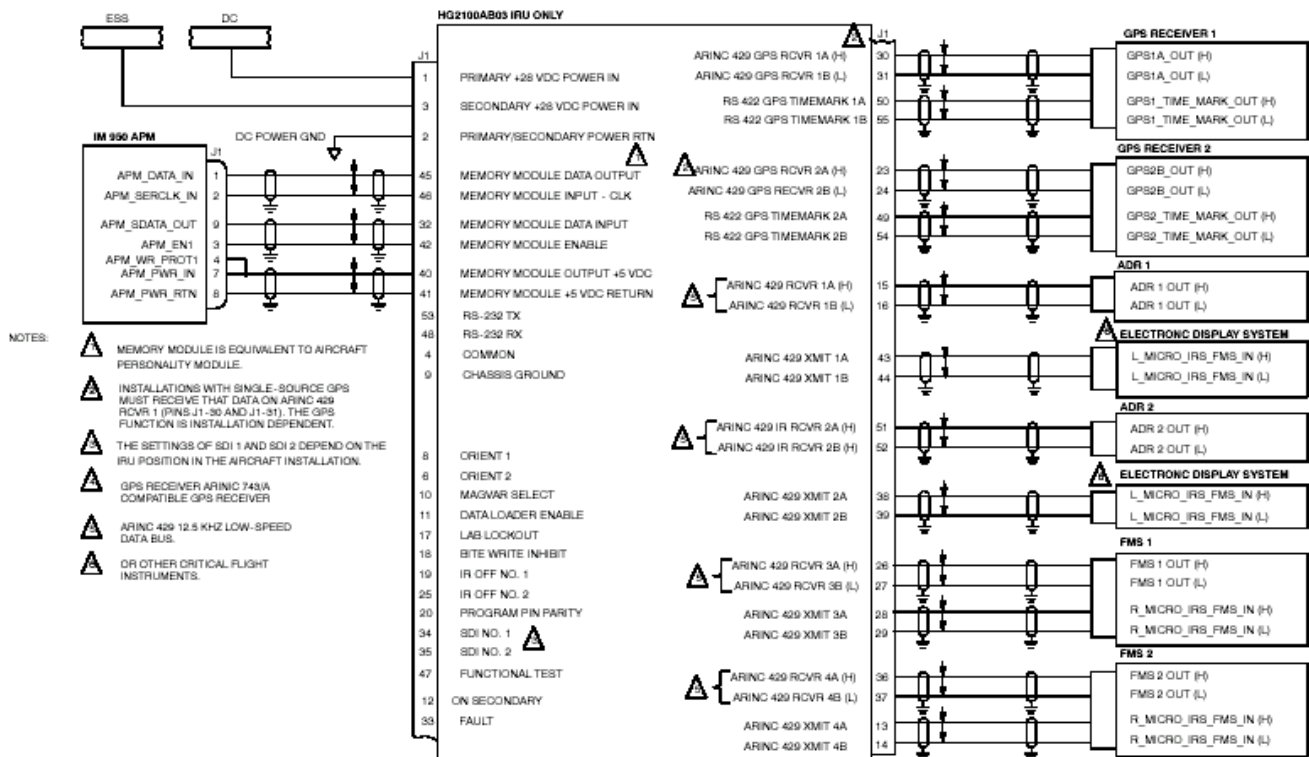
## Rapid Dispatch Option

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 Special Missions 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 is not expected to exceed 20W following one second of operation.

## Typical Interfaces:



### **3.0 Experience**

The Special Missions Micro IRU is a fifth generation RLG based inertial reference unit (IRU), providing Honeywell’s proven laser inertial technology in a small package. The Special Missions Micro IRU is a derivative product based on the 4 MCU inertial reference unit technology, and uses the same digital ring laser gyro (RLG) sensors, accelerometers, microprocessor, and sensor electronics. The 4MCU IRS is DO178B Level A certified and is used in a variety of high volume applications including the Boeing 717/737/757 and the Airbus A319/320/321/330/340. Reliability of the fleet of Digital RLG IRS systems has consistently exceeded 20,000 MTBF and 10,000 MTBUR since entry into service in 1997. This system has been instrumental in helping operators achieve low maintenance costs and high dispatch reliability.

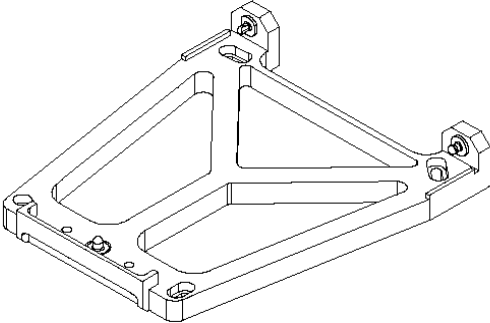
#### **Commercial RLG Experience:**

Honeywell has delivered over 35,000 commercial strapdown laser inertial systems since 1981. Our laser systems can be found on air transport, regional, and corporate aircraft including:

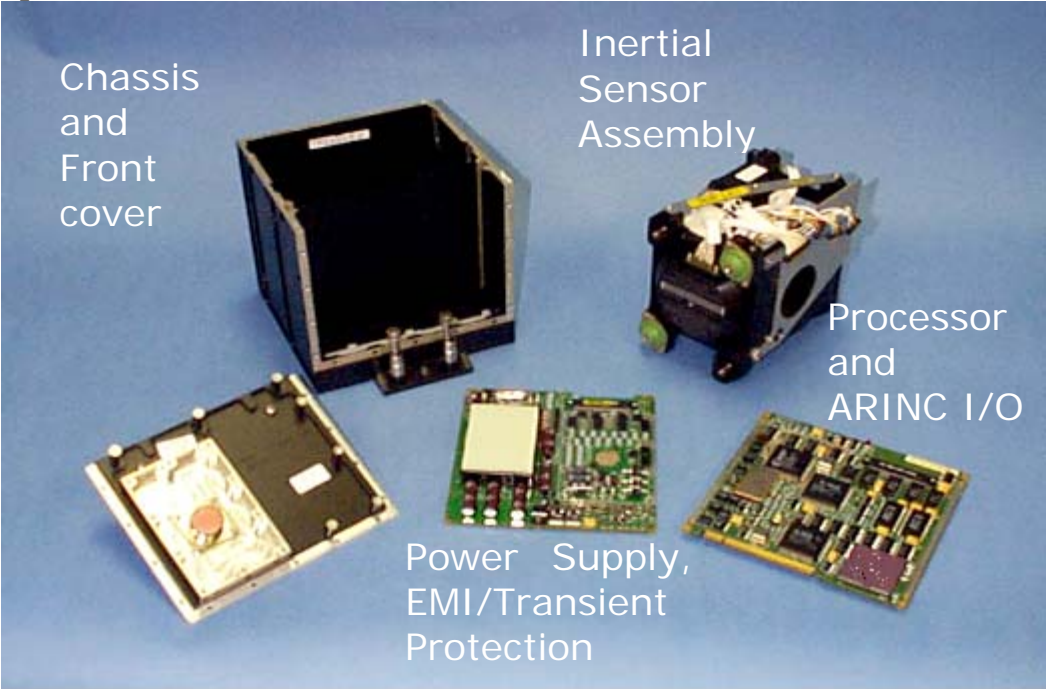
B717	A.321	Falcon 200	CL-600
B737	A.330	Falcon 900	CL-601-1A
B747	A.340	Falcon 900EX	CL-601-3A
B757	MD10	Falcon 2000EX	ERJ-135/140/145
B767	MD11	Gulfstream G-300	Embraer 170/175
B777	MD80	Gulfstream G-400	Embraer 190/195
A.300/310	MD90	Gulfstream G-500	Dornier 328
A.318	Hawker 800	Gulfstream G-550	Bombardier Global Express
A.319	Falcon 20	Gulfstream G-200	Legacy
A.320	Falcon 50	Citation II, VII	Envoy
BAE RJX	Fokker 100	Citation X	Boeing BBJ

**4.0 Hardware Description**

HG2195AB Special Missions MicroIRU with WG2001AA Mounting Tray:



**Special Missions Micro IRS Hardware Assemblies:**



## **Inertial Sensor Assembly: GG1320 Digital Gyro**

The Honeywell GG1320 Digital Gyro is established as a proven, low-risk, sensor that has been carefully engineered to meet the airlines' needs in performance, reliability, and life.

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:

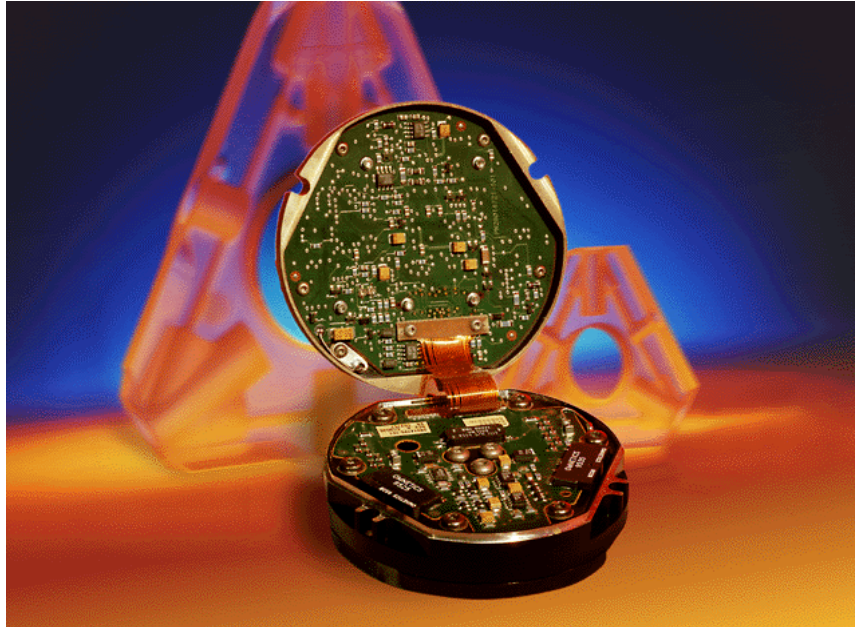
#### Characteristics

- <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 (>250,000 RLGs delivered)
- DO178B Level A Certification
- Built-in self test
- Embedded compensation coefficients allow sensor replacement with simple hand tools. No system calibration is required.

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 17,000 digital gyros per year)

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

## 4.0 Qualification Levels

Conditions	DO-160D Section	Test Limit	Category
Temperature and Altitude	4.0		A2 and F1
Low Operating Temperature	4.5.1	-40°C	IRU is passively cooled
Ground Survival Low	4.5.1	-55°C	
Ground Survival High	4.5.2	+85°C	
High Operating Temperature	4.5.3	+70°C	
In Flight Loss of Cooling	4.5.4	NA	
Altitude	4.6.1	55,000 ft	
Decompression	4.6.2	8,000ft to 55,000 ft in 15 sec	
Overpressure	4.6.3	-15,000 ft	
Temperature Variation	5.0	10°C/min	A
Humidity	6.0	6 day test	C
Shock	7.0		7.2.1 Test Procedure (operational) 7.3.1 Test Procedure 1 (impulse) 7.3.2 Test Procedure 2 (sustained)
Operational	7.2	6g for 11 msec	
Crash Safety	7.3	20g for 11 msec 20g for 3 sec (Helicopter and all Fixed Wing)	
Vibration (Fixed Wing)	8.0	2.2 Grms (random)  5 to 500 Hz (sinusoidal)	Figure 8-1 Curve B2 (modified) 0.0032 G <sup>2</sup> /Hz- 10 to 980 Hz 0.00085 G <sup>2</sup> /Hz- @ 2000 Hz Figure 8-3 Curve M
Vibration (Helicopter)	8.8	G Performance G1 Endurance	R
Explosion Proofness	9.0		H
Waterproofness	10.0	15 min drip test	W
Fluids Susceptibility	11.0	No Test	X
Sand and Dust	12.0		D
Fungus	13.0		F
Salt Spray	14.0		S
Magnetic Effect	15.0	< 0.3 meter	Z
Power Input	16.0	32.2 to 18 volts	Z
Voltage Spike	17.0	600V for 10us	A
Audio Frequency Susceptibility	18.0		Z
Induced Signal Susceptibility	19.0		Z
Radio Frequency Susceptibility	20.0	200V/m 600 V/m (pulsed) @ 0.1% duty cycle	Y (work-through) Radiated and conducted P pulsed radar
Radio Frequency Emissions	21.0		M
Lightening Induced Transient Susceptibility	22.0		A3E3
Lightning Direct Effects	23.0	Not Tested	X
Icing	24.0	Not Tested	X
Electrostatic Discharge	25.0		A