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NORTHROP GRUMMAN

LR-2000 Inertial Measurement Unit (IMU)

The Northrop Grumman LR-2000 is a small, light weight, highly reliable, strap down inertial measurement unit (IMU). The LR-2000 is composed of two dual-axis dynamically-tuned gyroscopes and three solid-state silicon Micro Electro-Mechanical Systems (MEMS) accelerometers. Digital output data of incremental velocity and incremental angle are transmitted to the user on a full duplex RS-422 interface.

Description

The LR-2000 IMU was designed and qualified for the F-16 fighter jet and has been in production since 2005, with hundreds of units produced. The LR-2000 IMU has $0.05^\circ/\sqrt{\text{hr}}$ random walk and low white noise for superior performance. The two gyros and three accelerometers are part of the sensor block package that is separated from the three electronics cards package and can be mounted independently,

allowing for ease of integration where space is limited. A key component of the LR-2000 IMU is its dual-axis gyroscope that offers superior accuracy and high reliability of more than 100,000 hours between failures. The MEMS accelerometers have superior performance and reliability with bias repeatability of $300 \mu\text{g}$ and scale factor accuracy of 100 ppm. The LR-2000 IMU is qualified for military applications.

Applications

- EO/IR, FLIR, camera and radar stabilization
- Gimbal and platform stabilization
- Tactical missile guidance
- Targeting and gyro compassing applications
- Flight controls
- Downhole measuring

Advantages

- Low gyro and accelerometer white noise and high mean time between failure
- Low random drift of $<1^\circ$ per hour
- Low random walk of $<0.05^\circ/\sqrt{\text{hr}}$
- Sensor block and electronics mounted separately
- Qualified for the F-16 fighter environments
- Commercial off-the-shelf product with a lead time of less than 10 months after receipt of order

Accelerometer	
Axis Misalignment	300 micro-radians
Scale Factor Accuracy (1-year composite repeatability)	300 PPM
Scale Factor Asymmetry	150 PPM
Null Vibration Shift	100 $\mu\text{g}/\text{g}^2$
Null Bias Stability	500 μg
Null Bias Turn-On	30 μg
Null Bias Trend	200 μg
Cross-Axis Sensitivity	10 $\mu\text{g}/\text{g}^2$
Noise (10-second interval)	70 μg
Max Input Range	$\pm 20 \text{ G}$

LR-2000 Rate Sensor Assembly	
Performance	
Random walk	$<0.05^\circ/\sqrt{\text{hr}}$
Bandwidth	100 Hz (-90)
Communication	Full duplex RS-422 UART serial data bus
Characteristics	
Dimensions (sensor block)	Length: 2 in. (5.08 cm), Width: 1.5 in. (3.81 cm), Height: 1.5 in. (3.81 cm)
Dimensions (card stack)	Length: 4 in. (10.16 cm), Width: 1.5 in. (3.81 cm), Height: 1 in. (2.54 cm)
Weight	$<1.0 \text{ lb}$ (0.45 kg)
Temperature	-40°C (-40°F) to $+71^\circ\text{C}$ ($+157^\circ\text{F}$)
Shock	15 g's, 11 msec
Input Voltage	+15 Vdc, -15 Vdc and +5 Vdc
Random Vibe	15.1 GRMS, 24-2000 Hz
Angular Rate	3-axis of angular rate outputs RS-422, RS-485 available
MTBF	$>100,000$ hours
Features	
Sensor	Two dual-axis gyros, three solid-state silicon (MEMS) accelerometers, sensor block
Output Messages	200 Hz

LR-2000 Gyro	
Performance	
Axis Misalignment	300 micro-radians
Scale Factor Accuracy, In-Run	200 PPM
Drift Rate, Turn-On and In-Run Over Temperature	$10^\circ/\text{hr}$
Drift Rate, In-Run at Constant Temperature	$1^\circ/\text{hr}, 1\sigma$
Random Noise PSD, Low Frequency (0.01 Hz to 1.0 Hz)	$<0.0005^\circ/\text{sec}/\sqrt{\text{Hz}}$
G-Sensitive Drift	$<10^\circ/\text{hr}/\text{G}$
G ² -Sensitive Drift	$0.3^\circ/\text{hr}/\text{g}^2$
Max. Input Range (X-axis ICS) up to 5 seconds	$\pm 280^\circ/\text{sec}$
Max. Input Range (Y- and Z-axes ICS)	$\pm 67^\circ/\text{sec}$
Max. Angular Acceleration (all axes)	$\pm 10,000^\circ/\text{sec}$

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