Honeywell

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# HG1120 INERTIAL MEASUREMENT UNIT (IMU)

Performance and Environmental Information

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# Honeywell Industrial Inertial Measurement Units

**Honeywell produces No License Required (NLR) Inertial Measurement Units (IMU) for industrial applications including agricultural vehicles, robotics, survey, mapping, and stabilized systems. These IMUs are designed for industrial application and can be used on air, land, and sea. Honeywell began producing gyros in the 1940's for the Honeywell C-1 autopilot and specifically began producing MEMS gyros and accelerometers in the early 2000's. Honeywell's IMUs utilize proprietary Honeywell technology and leverage existing production and engineering infrastructure. Honeywell has deep and long lasting relations with many commercial customers and is carrying that philosophy and product pedigree into our NLR IMU line. Honeywell's forward looking product strategies ensure that our NLR IMUs fit your current and future needs.**

The HG1120 IMU is a device which measures angular rates, linear accelerations, and magnetic fields, in a body mounted strap down configuration. It provides compensated incremental angle and velocity data for inertial navigation as well as angular rates and linear accelerations for control. The data is reported through a digital serial interface bus and is available in a variety of serial formats. The unit contains MEMS gyroscopes and accelerometers as well as the electronics and software necessary to deliver precision inertial information. The input axes form a right handed frame aligned with the IMU mounting frame.

## Contact Us

For more information, email imu.sales@honeywell.com or contact us on our website aerospace.honeywell.com/HG4930

## Accelerometer Performance

The HG1120 is designed to achieve full performance by 0.2 seconds for the environmental conditions listed in Table 10.

### Table 1. Accelerometer Performance

| PARAMETER | AA50 | BA50 | CA50 | CA51 TYPICAL @ 25°C | UNITS |
|---|---|---|---|---|---|
| **Operating Range** | -16 to +16 | | | | g |
| **Scale Factor Repeatability** | 3000 | 2000 | 1500 | 1000 | ppm, 1σ |
| **Scale Factor Linearity @ FS For Accelerations < 2g, Linearity Error Negligible** | 1% FS | 1% FS | 1% FS | < 1% FS | ppm/g, 1σ |
| **Bias Repeatability** | 24 | 16 | 8 | 5 | mg, 1σ |
| **Bias (In Run Stability)(<1 hour)** | 0.2 | 0.15 | 0.1 | 0.06 | mg, 1σ |
| **Magnetic Field Sensitivity** | Insensitive to Magnetic Fields | | | | |

### Table 2. Accelerometer Navigation Data Specific Performance

| PARAMETER | AA50 | BA50 | CA50 | CA51 TYPICAL @ 25°C | UNITS |
|---|---|---|---|---|---|
| **Output Noise (standard deviation) @300 Hz Data Rate** | 0.0003 | 0.0003 | 0.0003 | 7.62 E-5 | m/sec, maximum |
| **Velocity Random Walk** | 0.15 | 0.09 | 0.06 | 0.04 | m/sec/√hr, maximum |

### Table 3. Accelerometer Control Data Specific Performance

| PARAMETER | PERFORMANCE | UNITS |
|---|---|---|
| **Output Noise (standard deviation) @ 1800 Hz Data Rate, No Filtering** | 8 (< 2.5 Typical) @ 1800 Hz, No Filtering | mg, maximum |
| **1800 Hz/300 HZ Frequency Response** | See Table 4 | |

### Table 4. HG1120 Typical Frequency Response Parameters

| HG1120 FREQUENCY RESPONSE TYPICAL | GYRO | | ACCEL | |
|---|---|---|---|---|
| | -90° | -3dB | -90° | -3dB |
| **50 Hz** | 51 Hz | 94 Hz | 53 Hz | 80 Hz |
| **90 Hz** | 92 Hz | 211 Hz | 91 Hz | 176 Hz |
| **No Filtering** | 97Hz | 298 Hz | 160 Hz | 288 Hz |

## Angular Rate Performance

The HG1120 is designed to achieve full performance by 0.2 seconds for the environmental conditions listed in Table 10.

### Table 5. Angular Rate Performance

| PARAMETER | AA50 | BA50 | CA50 | CA51 TYPICAL @ 25°C | UNITS |
|---|---|---|---|---|---|
| Operating Rate Range | -500 to +500 | | | | °/s |
| Scale Factor Repeatability | 5000 | 5000 | 5000 | 2500 | ppm, 1σ |
| X,Z Scale Factor Static g Sensitivity | 150 | 150 | 150 | 100 | ppm/g 1σ |
| Y Scale Factor Static g Sensitivity | 350 | 350 | 350 | 200 | ppm/g 1σ |
| Scale Factor Linearity @ Full Rate Range For Rates < 100°/s, Linearity Error Negligible | 1% | 1% | 1% | < 0.5% < 400°/s | NA |
| Bias Repeatability | 1080 | 720 | 500 | 360 | °/hr, 1σ |
| Bias (In Run Stability)(<1 hour) | 120 | 65 | 40 | 20 | °/hr/g, 1σ |
| Bias Static g Sensitivity | 30 | 30 | 30 | < 15 | °/hr shift maximum |
| Magnetic Field Sensitivity | Insensitive to Magnetic Fields | | | | |

### Table 6. Angular Rate Navigation Specific Performance

| PARAMETER | AA50 | BA50 | CA50 | CA51 TYPICAL @ 25°C | UNITS |
|---|---|---|---|---|---|
| Output Noise (standard deviation) @ 300 Hz Data Rate | 1 | 1 | 1 | < 0.75 | mrad, 1σ |
| Angular Random Walk | 1.3 | 0.7 | 0.4 | 0.25 | °/√hr, maximum |

### Table 7. Angular Rate Control Performance

| PARAMETER | PERFORMANCE | UNITS |
|---|---|---|
| Output Noise (standard deviation) @ 1800 Hz Data Rate, No Filtering | 0.153 (< 0.1 Typical) | °/s, 1σ |
| 1800 Hz/300 HZ Frequency Response | See Table 4 | |

## Magneometer Performance

### Table 8. Magnetometer Performance

| PARAMETER | PERFORMANCE | UNITS |
|---|---|---|
| Operating Range | +/- 12 | Gauss |
| Zero-Gauss Bias | +/-0.5 | Gauss, 1σ |
| Magnetic RMS Noise | 4.1 | mGauss |
| Non-linearity | +/-1.0 | %, (typical) |
| Sensor Bandwidth | 40 | Hz |
| Alignment | 3.0 | Degree, 1σ |

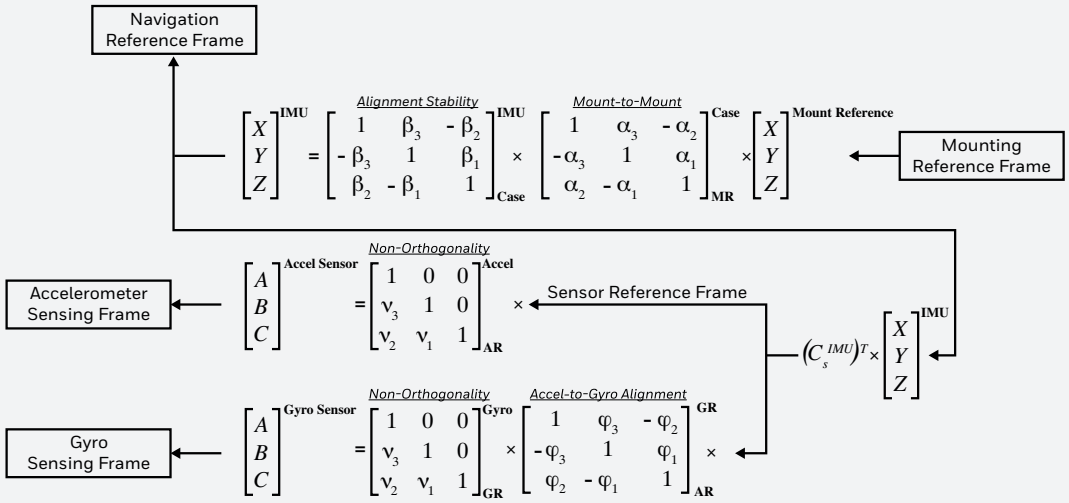
## IMU Alignment Model

The mathematical IMU alignment consists of Mount-to-Mount, Alignment Stability, Accelerometer-to-Gyro Alignment, and Non-Orthogonality error components, as shown below.

### Table 9. Alignment and Orthogonality Performance

| PARAMETER | ERROR REQUIREMENT | UNITS |
|---|---|---|
| Mount to Mount with Pins | 3600 | µrad max |
| Alignment Stability | 1200 (< 250 Typical @ 25°C) | µrad 1σ |
| Accelerometer Non-orthogonality | 1200 (< 250 Typical @ 25°C) | µrad 1σ |
| Accelerometer to Gyro Alignment | 1200 (< 250 Typical @ 25°C) | µrad 1σ |
| Gyro Non-Orthogonality | 1200 (< 250 Typical @ 25°C) | µrad 1σ |

### Figure 1. IMU Alignment Model




**AR** Accel/Sensor Reference Frame (Orthogonal)

**GR** Gyro Reference Frame (Orthogonal)

$C_s^{IMU}$ Gyro Reference Frame (Orthogonal)

Error matrice are small angle approximations

# Gyro Definitions

## Gyro Bias In Run Stability

In-run gyro bias stability is a measure of random variation in bias as computed over a specified sample time and averaging time interval. This non-stationary (evolutionary) process is characterized by 1/f power spectral density. It is typically expressed in °/hr and measured using the Allan Variance method.

## Gyro Bias Repeatability

Gyro bias repeatability is defined as the residual output bias error after calibration and internal compensation, including the effects of turn-off and turn-on, time, and temperature variations. This measure represents the statistical expected value for output bias error at any given time and thermal condition.

## Gyro Output Scale Factor (SF)

The ratio of a change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data.

## Gyro Scale Factor Repeatability

Gyro SF repeatability is defined as the residual output SF error, after calibration and internal compensation, including the effects of turn-off and turn-on, time, and temperature variations. The repeatability error is expressed in ppm of the output angular rate. For low rates (< 100 °/s), gyro SF repeatability is considered inclusive of the linearity error and static g sensitivity.

## Gyro Scale Factor Linearity

Gyro SF linearity is a measure of the one sigma deviation of the output from the least squares linear fit of the input-output data expressed in ppm of the output.

## Gyro Angle Random Walk (ARW)

ARW is the angular error buildup with time due to white noise in angular rate expressed in °/√hr.

## Gyro Frequency Response

The gyro frequency response is defined as the total IMU transfer function, from linear acceleration input to digital acceleration data being made available to the customer. This includes the isolator, the actual sensor, the IMU processing delay, and any incorporated filters.

## Gyro Operating Rate Range

Gyro operating rate range is the maximum angular rate input in both directions at which the IMU rate output performance parameters apply.

# Accelerometer Definitions

## Accelerometer Bias In Run Stability

In-run accelerometer bias stability is a measure of random variation in bias as computed over a specified sample time and averaging time interval. This non-stationary (evolutionary) process is characterized by 1/f power spectral density. It is typically expressed in mg and measured using the Allan Variance method.

## Accelerometer Bias Repeatability

Accelerometer bias repeatability should be defined as the residual output bias error after calibration and internal compensation, including the effects of turn-off and turn-on, time, and temperature variations. This measure represents the statistical expected value for output bias error at any given time and thermal condition.

## Accelerometer Scale Factor (SF)

The ratio of a change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data.

## Accelerometer Operating Rate Range

Accelerometer operating rate range is the maximum linear acceleration input in both directions at which the IMU acceleration output performance parameters apply.

## Accelerometer Velocity Random Walk (VRW)

VRW is the velocity error buildup with time due to white noise in acceleration expressed in m/sec/√hr.

## Accelerometer Scale Factor Repeatability

SF repeatability is defined as the residual output SF error after calibration and internal compensation, including the effects of turn-off and turn-on, time, and temperature variations. The repeatability error is expressed in ppm of the output acceleration. For under 1 g, accelerometer scale factor repeatability is inclusive of the linearity error.

## Accelerometer Scale Factor Linearity Error

Accelerometer SF linearity error is a measure of the one-sigma deviation of the output from the least squares linear fit of the input-output data expressed in ppm of the output. The linearity error under 1 g is typically negligible.

## Accelerometer Frequency Response

The accelerometer frequency response is defined as the total IMU transfer function, from linear acceleration input to digital acceleration data being made available to the customer. This includes the isolator, the actual sensor, the IMU processing delay, and any incorporated filters.

# Environmental Conditions

The IMU operating and non-operating environmental conditions are shown below. The HG1120 is an extremely rugged device and the customer is advised to contact Honeywell if specific advice is needed on shock and vibration environments.

### Table 10. Table of Environmental Conditions

| ENVIRONMENT | OPERATING | NON-OPERATING | UNITS |
|---|---|---|---|
| **Temperature** | -40 to +85 | -55 to +105 | °C |
| **Temperature Soak** | ±3 Operating<br>±0.8 Full Performance | -55 for 4 hours<br>+105 for 4 hours | °C |
| **Shock** | 250g, 1.7 ms half sine.<br>Signal saturation could affect customer performance | NA | NA |
| **Altitude** | 0 to 13,700 meters, -43 to +87°C | NA | NA |
| **Magnetic Field** | ±10 Gauss | NA | Gauss |

## Reliability

The Mean Time Between Failure (MTBF) calculations incorporate Honeywell proprietary methodologies that tailor industry standards.

### Table 11. Reliability Calculations

| | | |
|---|---|---|
| **DRONES** | 85°C | 53,000 Hour MTBF |
| | 71°C | 59,000 Hour MTBF |
| **ROTARY WING UAV'S/AIRCRAFT** | 55°C | 79,000 Hour MTBF |
| **TRACTORS, GROUND BASED TRANSPORT** | 55°C | 170,000 Hour MTBF |
| | 25°C | 206,000 Hour MTBF |
| **DRILLING, SURVEY STATIONS** | 55°C | 378,000 Hour MTBF |
| | 25°C | 476,000 Hour MTBF |
| **SATELLITE TRACKING STATIONS** | 25°C | 1,037,000 Hour MTBF |

## Export Guidance

All technology that leaves the United States is subject to export regulations. This manual contains technology that has an Export Commodity Classification of ECCN 7E994 with associated country chart control code of AT1. This technology generally will not require a license to be exported or re-exported. However, if you plan to export this item to an embargoed or sanctioned country, to a party of concern, or in support of a prohibited end-use, you may be required to obtain a license.

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