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# MSI3200G
# Inertial Measurement Unit
# User Manual

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# INDEX

# 1 FEATURES

- Miniature package
- Low noise
- Low bias instability
- Excellent performance in vibration and shock environments
- 6 axes offered in same package
- Electronically calibrated axis alignment
- Gyros based on MT MicroSystem Single-crystal silicon technology
- No intrinsic wear-out effects
- Insensitive to magnetic fields
- Digital interface, RS422
- Continuous self-diagnostics

# 2 GENERAL DESCRIPTION

MSI3200G is a MEMS inertial measurement unit consisting of 3 high accuracy MEMS-based gyros, 3 high stability accelerometers, power switching circuit, software of IMU, internal and external mechanical structure of energy dissipation structures and shock absorber in a miniature package.

Both the gyros and the accelerometers are bas ed on advanced MEMS Technology and wafer-level-package, which is highly stable and reliable. The MEMS chip, ASIC and temperature sensor are integrated and assembled in one ceramic package.


**Fig.2-1 Image of MSI3200G**

For gyroscopes，they are used to measure the palstance on three orthonormal axes of sensing carrier, accelerometers are used to compensation to enhance the sensitivity of accelerate value on three orthonormal axes. Digital circuit and the software are used to compensation to the error of component and transfer the message back to the computer control loop installed on the missile through the RS422 interface. Each axis is factory-calibrated for bias, sensitivity and compensated for temperature effects to provide high-accuracy measurements in the temperature range -45°C to +85°C. The unit runs off a single +12V supply. Meanwhile, MSI3200G could not only self-check the operative condition of inertial component and digital circuit before launch but also continuous diagnose the operative condition of the product during operation.

# 3 Typical Applications

- Platform stabilization
- Navigation and dead reckoning
- Dynamic attitude measurement
- Ship motion measurement

# 4 DEFINITIONS AND ABBREVIATIONS USED IN DOCUMENT

## 4.1 Definitions

g0= 9.79973 $m/s^2$ (standard gravity)

## 4.2 Abbreviations

**Table4-1:Abbreviations**

| ABBREVIATION | FULL NAME |
|---|---|
| FS | Full-Scale |
| LF | Line Feed |
| tbd | to be defined |

# 5 ABSOLUTE MAXIMUM RATINGS

Stresses beyond those listed in Table 5-1 may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

**Table 5-1: Absolute maximum ratings**

| Parameter | Rating | Comment |
|---|---|---|
| Mechanical shock | 1 500g/1ms half-sine | Any direction. Ref: MIL STD-883G |
| Storage temperature | -55°C to +90°C | |
| +12V to GND | 9V to 15V | |
| RX+ or RX- to GND | -0.3V to 3.6V | |
| RX+ to RX- | ±3.3V | |
| TX+ or TX- to GND | -0.3V to 3.6V | |

# 6 SPECIFICATIONS

## 6.1SYSTEM CHARACTERISTICS

**Table 6-1:Operating conditions**

| Parameter | Conditions | Min | Nom | Max | Unit | Note |
|---|---|---|---|---|---|---|
| INPUT RANGE,ANGULAR RATE | | ±300 | | | °/s | |
| INPUT RANGE,ACCELERATION | | ±15 | | | g | |
| POWER SUPPLY | | 9 | 12 | 15 | V | |
| OPERATING TEMPERATURE | | -40 | | +85 | ℃ | |

**Table 6-2: Functional specifications, general**

| Parameter | Conditions | Min | Nom | Max | Unit | Note |
|---|---|---|---|---|---|---|
| **POWER CONSUMPTION** | | | | | | |
| Power consumption | | | 1.2 | 1.5 | W | |
| **TIMING** | | | | | | |
| Start-Up time after Power-On | | | | 1 | s | 1 |
| Time to valid data | T=+25°C | | | 2 | s | 2 |
| RS422 Bit-Rate | | 921600 | | | bps | |
| Sample Rate | | | 400 | | Samples/s | |
| **RS422 PROTOCOL** | | | | | | |
| Start Bit | | | 1 | | bit | |
| Data Length | | | 8 | | bits | |
| Parity | | | EVEN | | | |
| Stop Bits | | | 1 | | bit | |
| **CHASSIS**<br>Isolation resistance chassis to | | | | | | |
| GND(pin 15) | 500V | | 20 | | MΩ | |

Note 1: Time from Power-On to start of datagram transmissions (starting with part-number datagram)

Note 2: Time from Power-On to the reset of the Start-Up. During this period the output data should be regarded as non-valid.

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**Table 6-3: Functional specifications, gyros**

| Parameter | Conditions | Min | Nom | Max | Unit | Note |
|---|---|---|---|---|---|---|
| **GYRO** | | | | | | |
| Full Scale(FS) | | | ±300 | | °/s | |
| Resolution | | | 32 | | bits | |
| | | | 0.36 | | °/h | |
| Non-Linearity | | | 200 | | ppm | |
| Bandwidth(-3dB) | | | 220 | | Hz | |
| Sample Rate | | | 400 | | Samples/s | |
| Group Delay | | | 3 | | ms | |
| Bias Range | | -180 | 0 | 180 | °/h | |
| Bias stability | | | 10 | | °/h | |
| Bias error over temperature gradients | ΔT < ±1°C/min | | 5 | | °/h | |
| Bias Instability | Allan Variance @25°C | | 3 | | °/h | |
| Angular Random Walk | Allan Variance @25°C | | 0.3 | | °/√hr | |
| Linear Acceleration Effect | With g-compensation | | 0.005 | | °/s/g | |
| Misalignment | | | 1 | | mrad | |

**Table 6-4: Functional specifications, accelerometers**

| Parameter | Conditions | Min | Nom | Max | Unit | Note |
|---|---|---|---|---|---|---|
| **ACCELEROMETER** | | | | | | |
| Full Scale(FS) | | | ±15 | | g | |
| Resolution | | | 32 | | bits | |
| | | | 16.7 | | ug | |
| Scale Factor 1 year stability | | | 300 | 1000 | ppm | |
| Non-Linearity | | | 1000 | | ppm | |
| Bandwidth(-3dB) | | 100 | 147 | | Hz | |
| Sample Rate | | | 400 | | Samples/s | |
| Group Delay | | | | 5 | ms | |
| Bias switch on/off repeatability | | -0.5 | | 0.5 | mg | |
| Bias 1 year stability | | | | 2 | mg | |
| | | | | | | |
| Bias Instability | Allan Variance @25°C | | | 0.1 | mg | |
| Velocity Random Walk | Allan Variance @25°C | | | 0.05 | m/s/√h | |
| Misalignment | | | 1 | | mrad | |

Note1: For lager scales of accelerator, you should consult producers for more information.

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# 6.2 TYPICAL PERFORMANCE CHARACTERISTICS

## 6.2.1 GYRO CHARACTERISTICS

### 6.2.1.1 Root Allan Variance of gyro

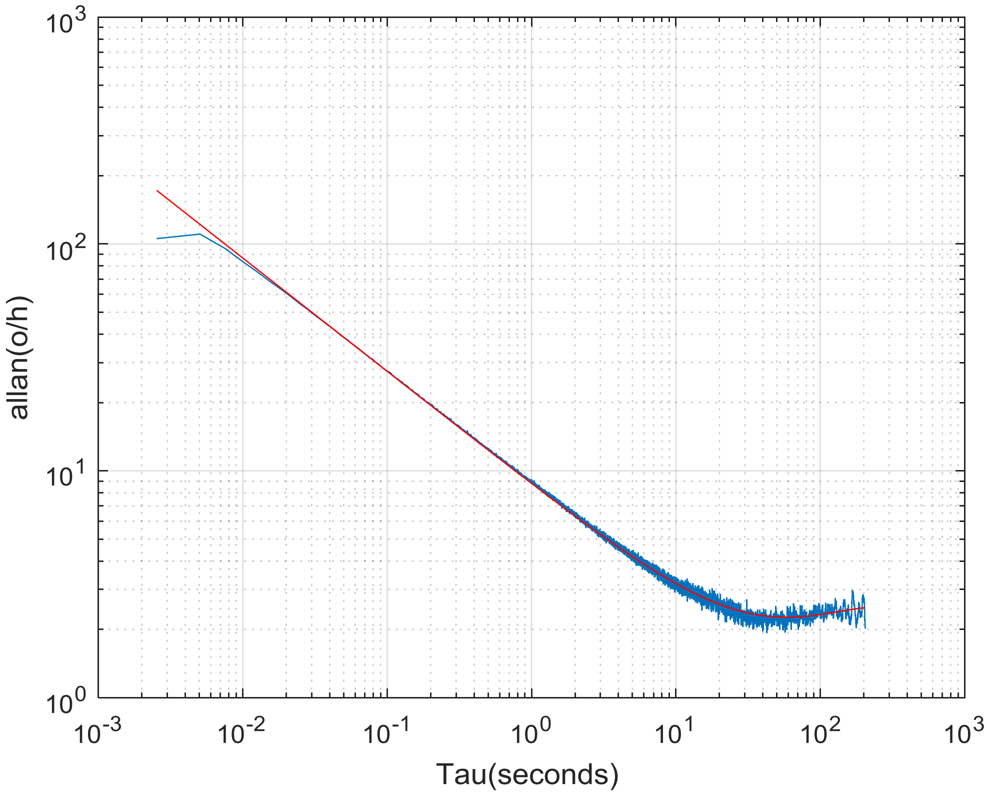


**Figure 6-1: Typical Allan-Variance of gyro-X 250°/s gyro)**

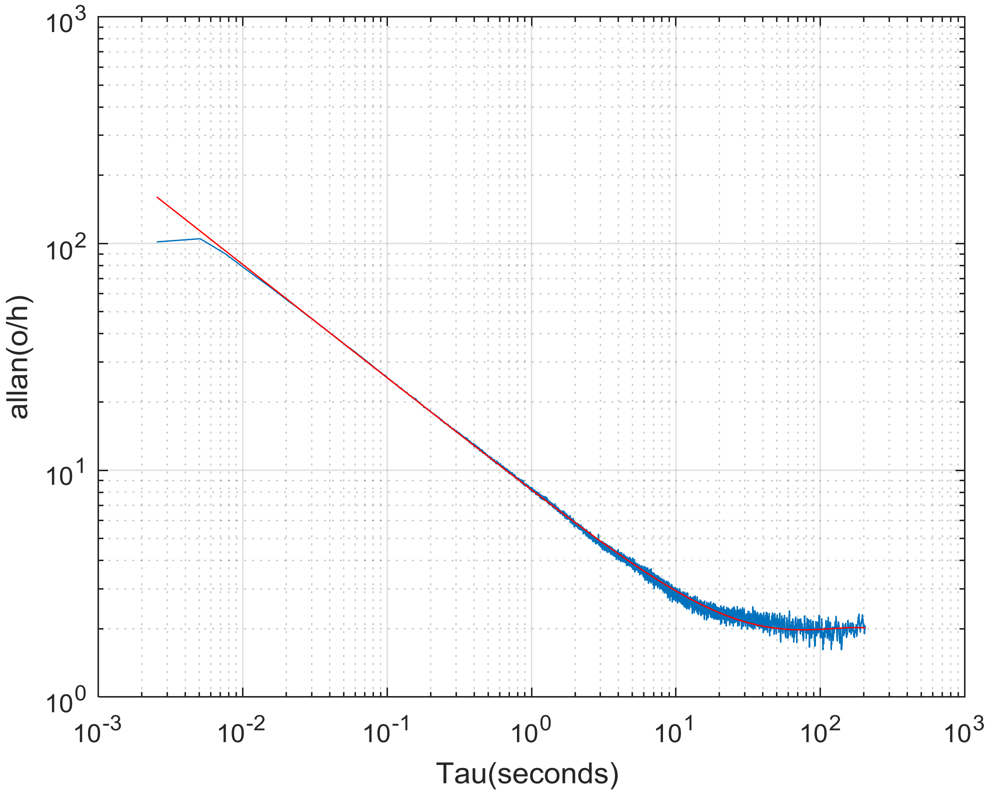


**Figure 6-2: Typical Allan-Variance of gyro-Y (250°/s gyro)**

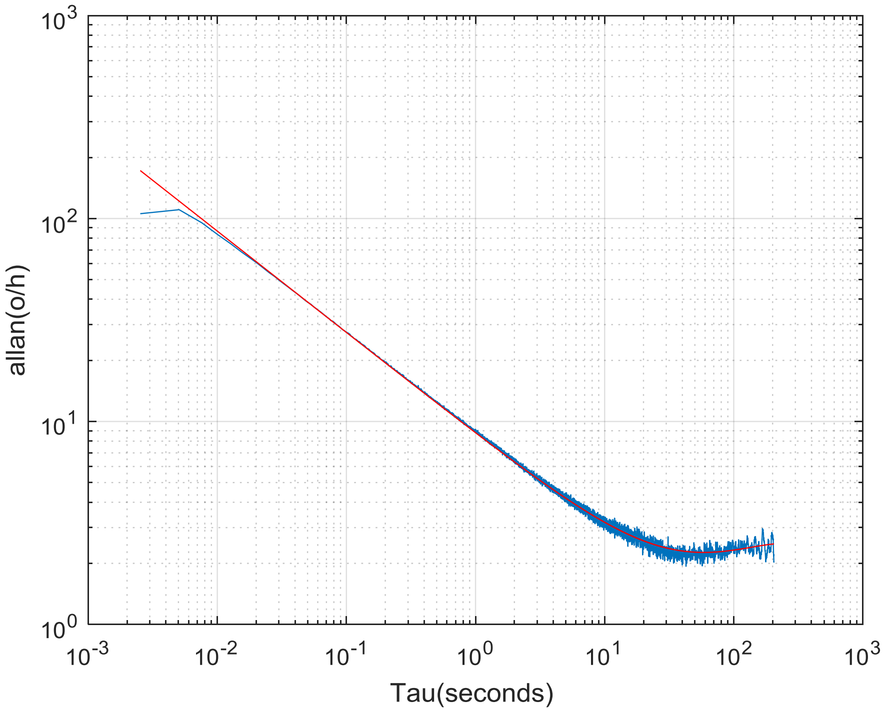


**Figure 6-3: Typical Allan-Variance of gyro-Z (250°/s gyro)**

### 6.2.1.2 Initial bias drift of gyro

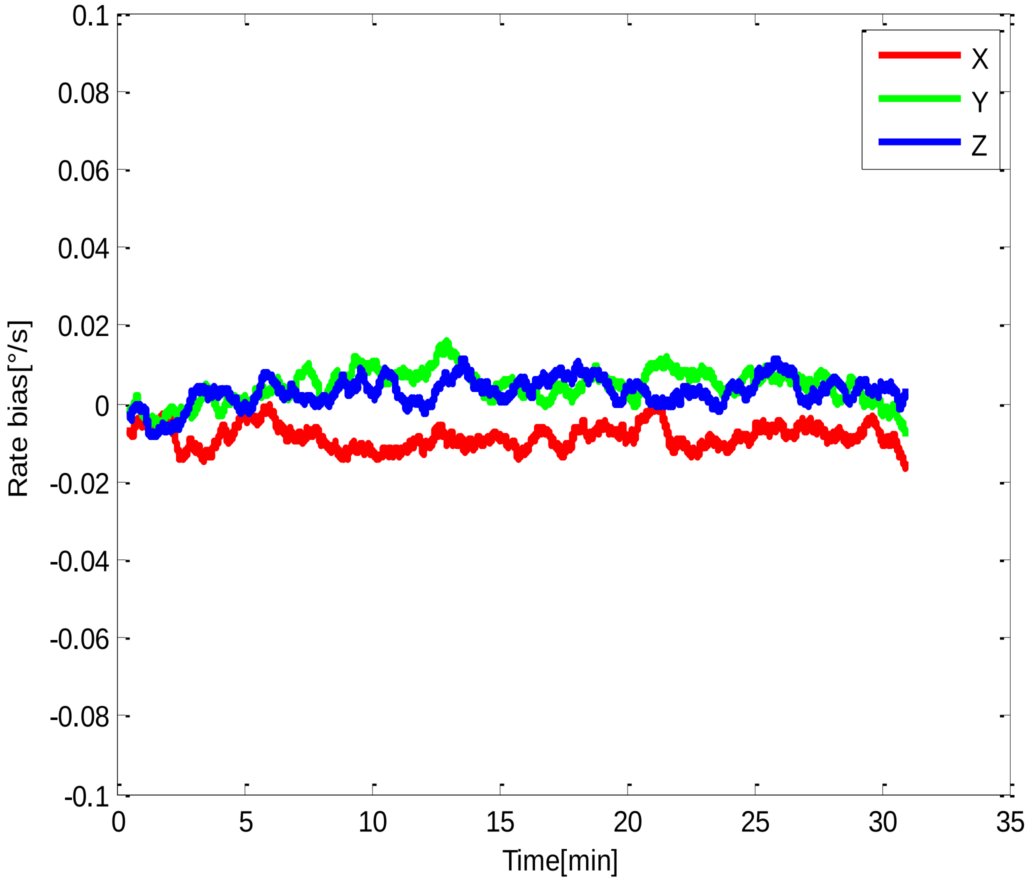


**Figure 6-4: Typical normalized initial bias drift of gyro (250°/s gyro)**

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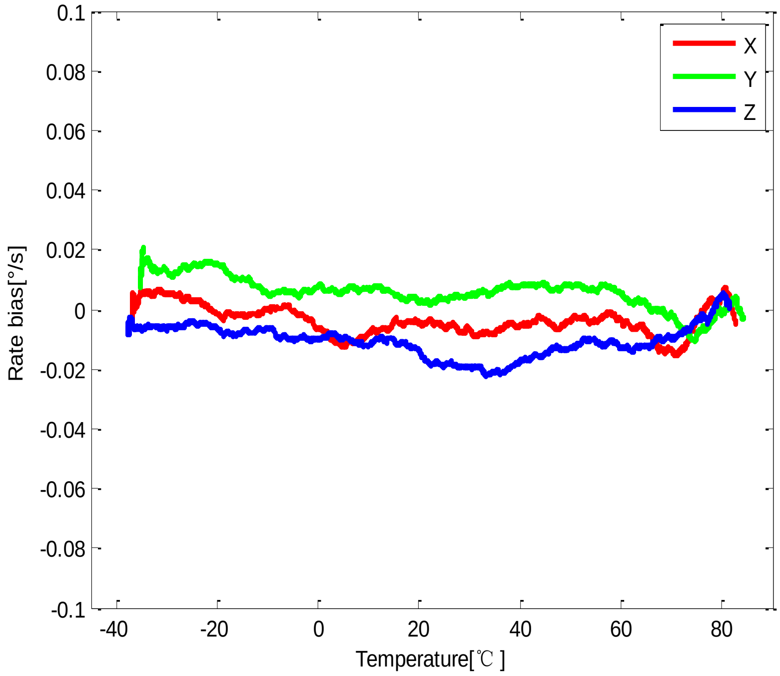
## 6.2.1.3 Bias drift over temperature



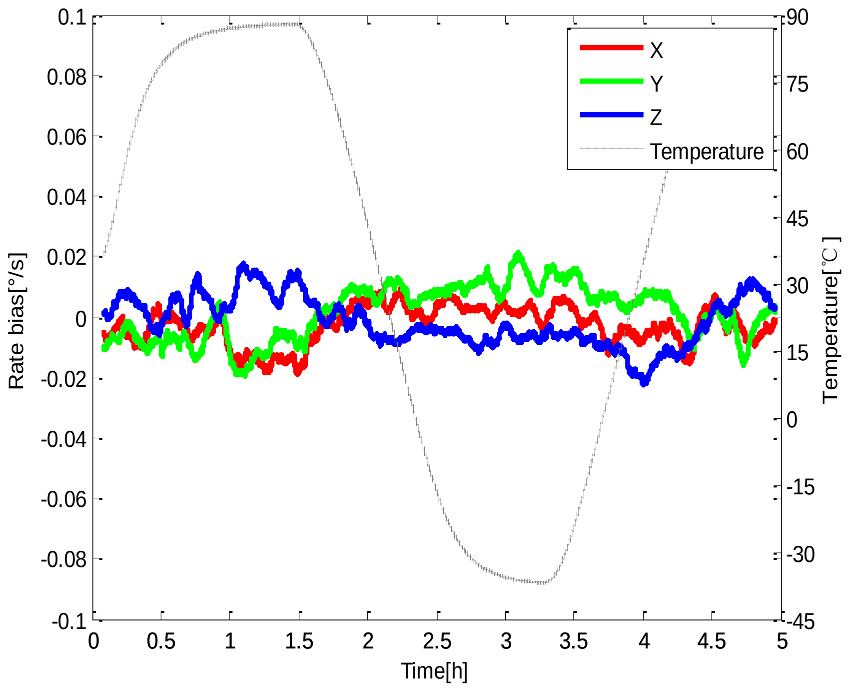




**Figure 6-5: Typical Bias drift over temperature (250°/s gyro)**

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## 6.2.2 ACCELEROMETER CHARACTERISTICS

### 6.2.2.1 Initial bias drift of accelerometer

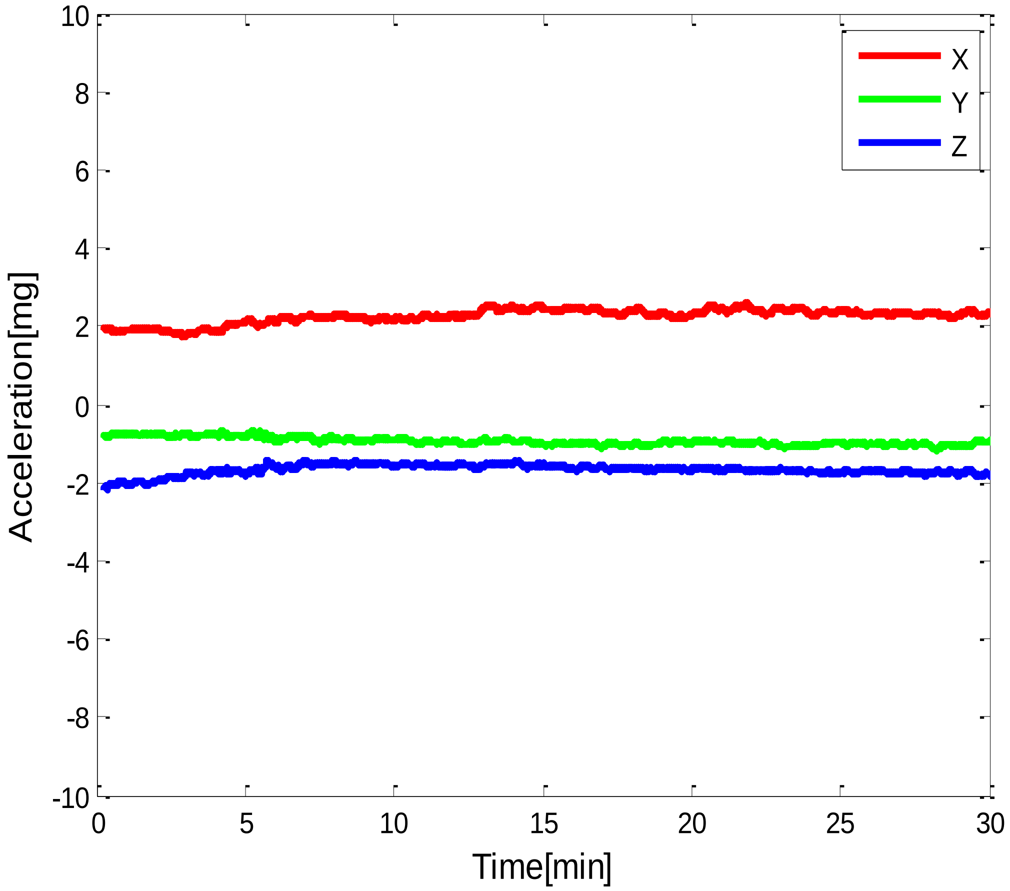
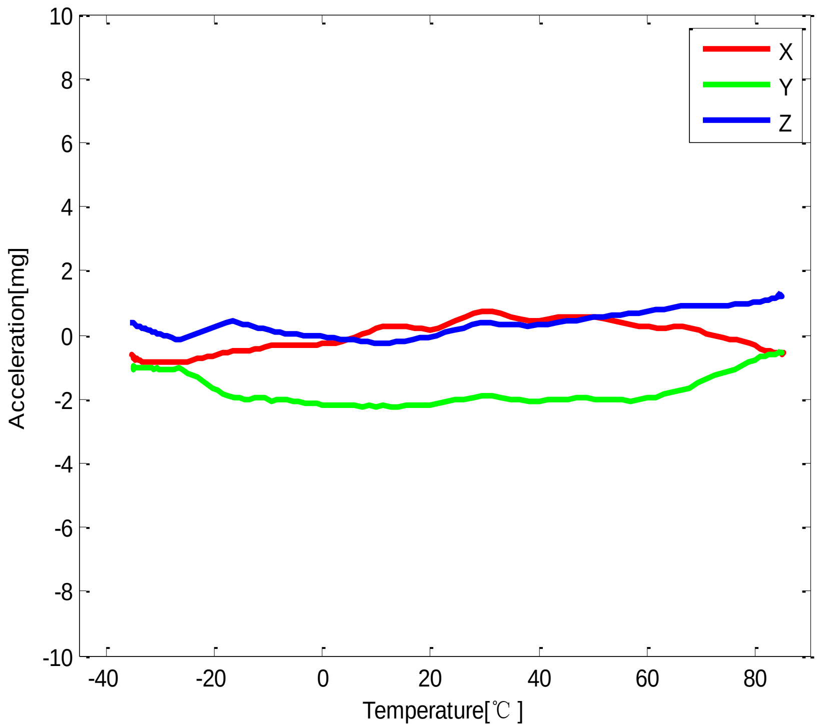



**Figure 6-6: Typical normalized initial bias drift of accelerometer (15g accelerometer)**

### 6.2.2.2 Bias drift over temperature



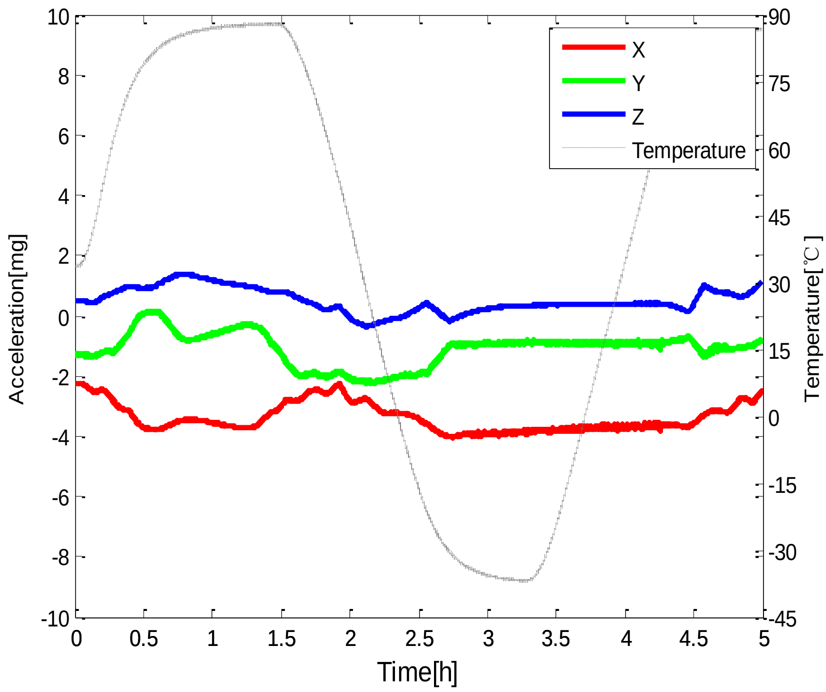




**Figure 6-7: Typical Bias drift over temperature (15g accelerometer)**

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# 6.3 Datagram specifications

## 6.3.1 Normal Mode datagram

**Table 6-5: Specification of the Normal Mode**

| Byte# | Bit# | | | | | | | | Specification |
|---|---|---|---|---|---|---|---|---|---|
| | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
| 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | Normal Mode datagram identifier for Normal Mode datagram with full content(0xA5). |
| 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | The length of the datagram(0x1D). |
| 2 | n7 | n6 | n5 | n4 | n3 | n2 | n1 | n0 | Counter, ref. section 8.1.4 |
| 3 | n 15 | n 14 | n 13 | n 12 | n 11 | n 10 | n 9 | n 8 | |
| 4 | Gx7 | Gx6 | Gx5 | Gx4 | Gx3 | Gx2 | Gx1 | Gx0 | X-axis gyro output, ref. section 8.1.1 for conversion to units |
| 5 | Gx15 | Gx14 | Gx13 | Gx12 | G11 | Gx10 | Gx9 | Gx8 | |
| 6 | Gx23 | Gx22 | Gx21 | Gx20 | Gx19 | Gx18 | Gx17 | Gx16 | |
| 7 | Gx31 | Gx30 | Gx29 | Gx28 | Gx27 | Gx26 | Gx25 | Gx24 | |
| 8 | Gy7 | Gy6 | Gy5 | Gy4 | Gy3 | Gy2 | Gy1 | Gy0 | Y-axis gyro output, ref. section 8.1.1 for conversion to units |
| 9 | Gy15 | Gy14 | Gy13 | Gy12 | G11 | Gy10 | Gy9 | Gy8 | |
| 10 | Gy23 | Gy22 | Gy21 | Gy20 | Gy19 | Gy18 | Gy17 | Gy16 | |
| 11 | Gy31 | Gy30 | Gy29 | Gy28 | Gy27 | Gy26 | Gy25 | Gy24 | |
| 12 | Gz7 | Gz6 | Gz5 | Gz4 | Gz3 | Gz2 | Gz1 | Gz0 | Z-axis gyro output, ref. section 8.1.1 for conversion to units |
| 13 | Gz15 | Gz14 | Gz13 | Gz12 | G11 | Gz10 | Gz9 | Gz8 | |
| 14 | Gz23 | Gz22 | Gz21 | Gz20 | Gz19 | Gz18 | Gz17 | Gz16 | |
| 15 | Gz31 | Gz30 | Gz29 | Gz28 | Gz27 | Gz26 | Gz25 | Gz24 | |
| 16 | Ax7 | Ax6 | Ax5 | Ax4 | Ax3 | Ax2 | Ax1 | Ax0 | X-axis accelerometer output, ref. section 8.1.2 for conversion to units |
| 17 | Ax15 | Ax14 | Ax13 | Ax12 | Ax11 | Ax10 | Ax9 | Ax8 | |
| 18 | Ax23 | Ax22 | Ax21 | Ax20 | Ax19 | Ax18 | Ax17 | Ax16 | |
| 19 | Ax31 | Ax30 | Ax29 | Ax28 | Ax27 | Ax26 | Ax25 | Ax24 | |
| 20 | Ay7 | Ay6 | Ay5 | Ay4 | Ay3 | Ay2 | Ay1 | Ay0 | Y-axis accelerometer output, ref. section 8.1.2 for conversion to units |
| 21 | Ay15 | Ay14 | Ay13 | Ay12 | G11 | Ay10 | Ay9 | Ay8 | |
| 22 | Ay23 | Ay22 | Ay21 | Ay20 | Ay19 | Ay18 | Ay17 | Ay16 | |
| 23 | Ay31 | Ay30 | Ay29 | Ay28 | Ay27 | Ay26 | Ay25 | Ay24 | |
| 24 | Az7 | Az6 | Az5 | Az4 | Az3 | Az2 | Az1 | Az0 | Z-axis accelerometer output, ref. section 8.1.2 for conversion to units |
| 25 | Az15 | Az14 | Az13 | Az12 | Az11 | Az10 | Az9 | Az8 | |
| 26 | Az23 | Az22 | Az21 | Az20 | Az19 | Az18 | Az17 | Az16 | |
| 27 | Az31 | Az30 | Az29 | Az28 | Az27 | Az26 | Az25 | Az24 | |
| 28 | T7 | T6 | T5 | T4 | T3 | T2 | T1 | T0 | temperature data, ref. section 8.1.3for conversion to units |
| 29 | T15 | T14 | T13 | T12 | T11 | T10 | T9 | T8 | |
| 30 | c7 | c6 | c5 | c4 | c3 | c2 | c1 | c0 | Sum Check is performed on all preceding bytes, ref. section 6.3.2 |
| 31 | c15 | c14 | c13 | c12 | c11 | c10 | c9 | c8 | |

### 6.3.2 Sum Check

At the end of all datagrams is a 16-bit Checksum. The Sum checksum enables the user to detect errors in the transfer of data from MSI3200G. The Sum is calculated using the following equation: seed = 0x0000; Sum from the first byte to the twenty-ninth byte.

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# 7 MECHANICAL

**Table 7-1: Mechanical specifications**

| Parameter | Conditions | Min | Nom | Max | Unit | NOTE |
|---|---|---|---|---|---|---|
| HOUSING MATERIAL | | | Aluminium<br>Alloy 6082-T6,DIN EN 754-2 | | | |
| **SURFACE TREATMENT**<br>Passivation | | | Surtec 650 | | | |
| **WEIGHT** | | 100 | 106.5 | 110 | grams | |
| **VOLUME** | | | 67.3<br>4.11 | | ccm<br>cu in | |
| **CONNECTOR**<br>Type<br>Number of pins<br>Contact type female | | | J30J-15ZKP<br>15<br>female | | | |
| **PLUG**<br>Proposed plug to fit connector | | | Axon MDA 2 15 | | | |
| Proposed cover to fit plug | For best EMI performance | | Axon micro-D EMI back shell | | | |
| **FIXATION BOLTS** | | | ISO 4762 / DIN 912 | | | |
| Recommended torque<br>Steel base | | | 3.5 | | Nm | |
| | Aluminium base | | 3.0 | | Nm | |

## 7.1 Mechanical dimensions

**Mechanical Drawing** (All dimensions are in mm.)

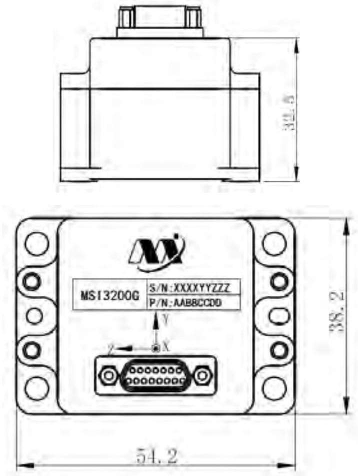


**Figure 7-1: Mechanical dimensions**

## 7.2 Pin configuration

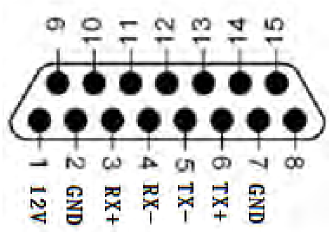


**Figure 7-2: Pin configuration as seen from front of MSI3200G**

The output connector is J30J-15ZKP, the Electric connection definition is as follows:

**Table 7-2: Pin descriptions**

| ID | Definition | Note |
|---|---|---|
| **1** | +12V | Power |
| **2** | GND | GND |
| **3** | RX+ | RS422 Receive Positive |
| **4** | RX- | RS422 Receive Negative |
| **5** | TX- | RS422 Transmit Negative |
| **6** | TX+ | RS422 Transmit Positive |
| **7** | RS422 GND | RS422 GND |
| **8~15** | Blank | N/A |

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# 7.3 Definition of axes

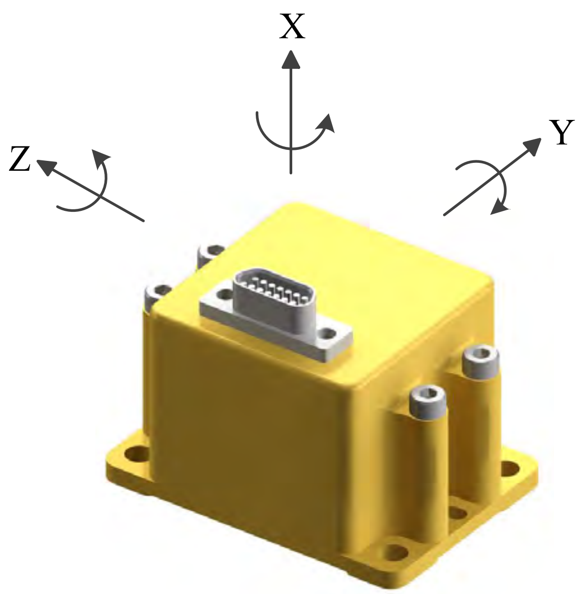


**Figure 7-3: Definition of axes**

# 8 BASIC OPERATION

MSI3200G is very simple to use. The unit will start performing measurements and transmit the results over the RS422 interface without any need for additional signaling or set-up after power-on. Figure 8-1 shows the simplest connection set-up for MSI3200G.

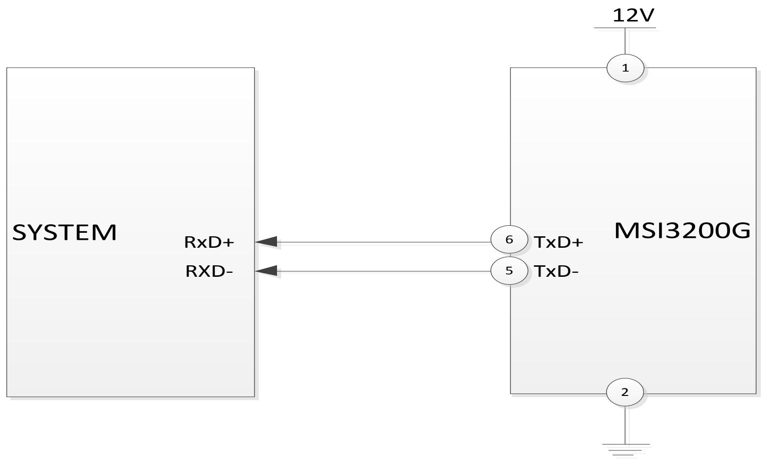


**Figure 8-1: Full Function Electrical Connection Diagram**

MSI3200G will constantly measure the available sensor channels at the configured sample rate. MSI3200G will continue to transmit data.

## 8.1 Data output options and interpretation

### 8.1.1 Gyro output unit = Angular Rate

In the case of MSI3200G being configured to output angular rate, Following equation and figure show how to convert to [°/s]. Please note that the output data is represented as two's complement.

**Equation 1: Converting output to [°/s]:**

$$Output[°/s]=\frac{AR_1 \cdot 2^{24} + AR_2 \cdot 2^{16} + AR_3 \cdot 2^{8} + AR_4}{10000}$$

where AR1 is the most significant byte of the 32bit output
AR2 is the second byte of the 32bit output
AR3 is the third byte of the 32bit output
AR4 is the least significant byte of the 32bit output

| AR1 | | | | | | | | AR2 | | | | | | | | AR3 | | | | | | | | AR4 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bit31 | Bit30 | Bit29 | Bit28 | Bit27 | Bit26 | Bit25 | Bit24 | Bit23 | Bit22 | Bit21 | Bit20 | Bit19 | Bit18 | Bit17 | Bit16 | Bit15 | Bit14 | Bit13 | Bit12 | Bit11 | Bit10 | Bit9 | Bit8 | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
| Sign | $2^{30}$ | $2^{29}$ | $2^{28}$ | $2^{27}$ | $2^{26}$ | $2^{25}$ | $2^{24}$ | $2^{23}$ | $2^{22}$ | $2^{21}$ | $2^{20}$ | $2^{19}$ | $2^{18}$ | $2^{17}$ | $2^{16}$ | $2^{15}$ | $2^{14}$ | $2^{13}$ | $2^{12}$ | $2^{11}$ | $2^{10}$ | $2^{9}$ | $2^{8}$ | $2^{7}$ | $2^{6}$ | $2^{5}$ | $2^{4}$ | $2^{3}$ | $2^{2}$ | $2^{1}$ | $2^{0}$ |

**Figure 8-2: Converting output bytes to [°/s]**

### 8.1.2 Accelerometer output unit = Acceleration

**Equation 2: Converting output to [g]:**

$$Output[g] = \frac{AR_1 \cdot 2^{24} + AR_2 \cdot 2^{16} + AR_3 \cdot 2^{8} + AR_4}{60000}$$

where $AR_1$ is the most significant byte of the 32bit output
$AR_2$ is the second byte of the 32bit output
$AR_3$ is the third byte of the 32bit output
$AR_4$ is the least significant byte of the 32bit output

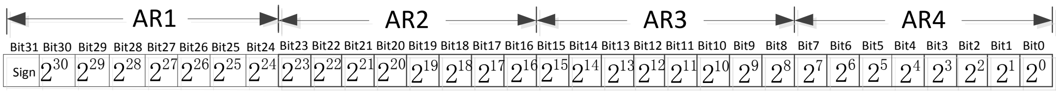


**Figure 8-3: Converting output bytes to [g]**

### 8.1.3 Temperature

Temperature data is available in certain datagrams (ref. section 12).

Following equation and figure show how to convert to [°C]. Please note that the output data is represented as two's complement.

**Equation 3: Converting temperature data to [°C]**

$$Output[℃] = \frac{T_1 \cdot 2^{8} + T_2 - 6527}{79.68}$$

where $T_1$ is the most significant byte of the 16bit output
$T_2$ is the least significant byte of the 16bit output

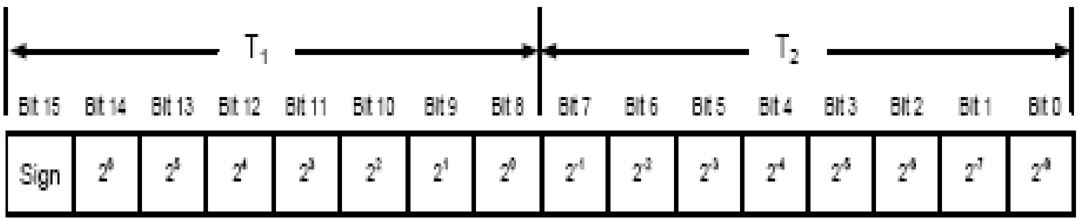


**Figure 8-4: Converting temperature data to [°C]**

### 8.1.4 Counter

Counter is continuously counting the internal samples (400 samples/s). Counter is an un-signed word taking values in the interval [0 , 65535]. The counter will naturally wrap-around.

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# 9 MARKING


**Figure 9-1: Example of marking of MSI3200G**