
V1.2

TEN AXIS INERTIAL

# 16488 SENSOR

## Technical Manual

# *16488* SENSOR TEN AXIS INERTIAL

## ▶ PRODUCT DESCRIPTION

The 16488 Device Is a Complete Inertial System That Includes a Triaxis Gyroscope, a Triaxis Accelerometer, Triaxis Magnetometer, And Pressure Sensor. Each Inertial Sensor In The 16488 Combines Industry-Leading Technology With Signal Conditioning That Optimizes Dynamic Performance. The Factory Calibration Characterizes Each Sensor For Sensitivity, Bias, Alignment, And Linear Acceleration (Gyroscope Bias). As a Result, Each Sensor Has Its Own Dynamic Compensation Formulas That Provide Accurate Sensor Measurements.

The 16488 Provides a Simple, Cost-Effective Method For Integrating Accurate, Multiaxis Inertial Sensing Into Industrial Systems, Especially When Compared With The Complexity And Investment Associated With Discrete Designs. All Necessary Motion Testing And Calibration Are Part Of The Production Process At The Factory, Greatly Reducing System Integration Time. Tight Orthogonal Alignment Simplifies Inertial Frame Alignment In Navigation Systems. The SPI And Register Structure Provide a Simple Interface For Data Collection And Configuration Control.

The 16488 Uses The Same Footprint And Connector System As The 16375, Which Greatly Simplifies The Upgrade Process. It Comes In a Module That Is Approximately 47 Mm × 44 Mm × 14 Mm And Has a Standard Connector Interface.

## ▶ PRODUCT FEATURES

★ 0.01% Nonlinearity ★ 2000g Shock Survivability ★ 6°/Hr In-Run Bias Stability

★ Single-Command Self-Test ★ Fast Start-Up Time, ~500 Ms ★ 0.3°/√Hr Angular Random Walk

★ Alarms For Condition Monitoring ★ Factory-Calibrated Sensitivity, Bias, And Axial Alignment

★ SPI-Compatible Serial Interface ★ Digital I/O: Data-Ready Alarm Indicator, External Clock

★ Embedded Temperature Sensor ★ Optional External Sample Clock Input : Up To 2.4 Khz

★ <±0.05° Orthogonal Alignment Error ★ Power-Down/Sleep Mode For Power Management

★ Single-Supply Operation: 3.0 V ~ 3.6 V ★ Calibration Temperature Range: −40°C ~ +70°C

★ Operating Temp. Range: −40°C ~ +85°C ★ Automatic And Manual Bias Correction Controls

★ Programmable Operation And Control ★ 4 Fir Filter Banks, 120 Configurable Taps

★ Triaxial, Digital Accelerometer, ±18 g ★ Digital Pressure Sensor, 300 Mbar To 1100 Mbar

★ Triaxial, Digital Magnetometer, ±2.5 Gauss ★ Triaxial, Delta Angle And Delta Velocity Outputse

★ Triaxial, Digital Gyroscope, ±450°/Sec Dynamic Rang

## ▶ APPLICATION

Platform stabilization and control

Navigation

Personnel tracking

Instrumentation

Robotics

## ▶ SPECIFICATION

| Parameter | Test Conditions/Comments | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| GYROSCOPES | | | | | |
| Dynamic Range | | ±450 | | ±480 | °/sec |
| Sensitivity | x_GYRO_OUT and x_GYRO_LOW (32-bit) | | $3.052 \times 10^{-7}$ | | °/sec/LSB |
| Repeatability[1] | $-40°C \le T_A \le +70°C$ | | | ±1 | % |
| Sensitivity Temperature Coefficient | $-40°C \le T_A \le +70°C$, 1 σ | | ±35 | | ppm/°C |
| Misalignment | Axis-to-axis | | ±0.05 | | Degrees |
| | Axis-to-frame (package) | | ±1.0 | | Degrees |
| Nonlinearity | Best-fit straight line, FS = 450°/sec | | 0.01 | | % of FS |
| Bias Repeatability[1, 2] | $-40°C \le T_A \le +70°C$, 1 σ | | ±0.2 | | °/sec |
| In-Run Bias Stability | 1 σ | | 6.25 | | °/hr |
| Angular Random Walk | 1 σ | | 0.3 | | °/√hr |
| Bias Temperature Coefficient | $-40°C \le T_A \le +70°C$, 1 σ | | ±0.0025 | | °/sec/°C |
| Linear Acceleration Effect on Bias | Any axis, 1 σ (CONFIG[7] = 1) | | 0.009 | | °/sec/*g* |
| Output Noise | No filtering | | 0.16 | | °/sec rms |
| Rate Noise Density | f = 25 Hz, no filtering | | 0.0066 | | °/sec/√Hz rms |
| 3 dB Bandwidth | | | 330 | | Hz |
| Sensor Resonant Frequency | | | 18 | | kHz |
| ACCELEROMETERS | Each axis | | | | |
| Dynamic Range | | ±18 | | | *g* |
| Sensitivity | x_ACCL_OUT and x_ACCL_LOW (32-bit) | | $1.221 \times 10^{-8}$ | | *g*/LSB |
| Repeatability[1] | $-40°C \le T_A \le +70°C$ | | | ±0.5 | % |
| Sensitivity Temperature Coefficient | $-40°C \le T_A \le +70°C$, 1 σ | | ±25 | | ppm/°C |
| Misalignment | Axis-to-axis | | ±0.035 | | Degrees |
| | Axis-to-frame (package) | | ±1.0 | | Degrees |
| Nonlinearity | Best-fit straight line, ±10 *g* | | 0.1 | | % of FS |
| | Best-fit straight line, ±18 *g* | | 0.5 | | % of FS |
| Bias Repeatability[1, 2] | $-40°C \le T_A \le +70°C$, 1 σ | | ±16 | | *mg* |
| In-Run Bias Stability | 1 σ | | 0.1 | | *mg* |
| Velocity Random Walk | 1 σ | | 0.029 | | m/sec/√hr |
| Bias Temperature Coefficient | $-40°C \le T_A \le +85°C$ | | ±0.1 | | *mg*/°C |
| Output Noise | No filtering | | 1.5 | | *mg* rms |
| Noise Density | f = 25 Hz, no filtering | | 0.067 | | *mg*/√Hz rms |
| 3 dB Bandwidth | | | 330 | | Hz |
| Sensor Resonant Frequency | | | 5.5 | | kHz |
| MAGNETOMETER | | | | | |
| Dynamic Range | | ±2.5 | | | gauss |
| Sensitivity | | | 0.1 | | mgauss/LSB |
| Initial Sensitivity Tolerance | | | | ±2 | % |
| Sensitivity Temperature Coefficient | 1 σ | | 275 | | ppm/°C |
| Misalignment | Axis to axis | | 0.25 | | Degrees |
| | Axis to frame (package) | | 0.5 | | Degrees |
| Nonlinearity | Best fit straight line | | 0.5 | | % of FS |
| Initial Bias Error | 0 gauss stimulus | | ±15 | | mgauss |
| Bias Temperature Coefficient | $-40°C \le T_A \le +85°C$, 1 σ | | 0.3 | | mgauss/°C |
| Output Noise | No filtering | | 0.45 | | mgauss |
| Noise Density | f = 25 Hz, no filtering | | 0.054 | | mgauss/√Hz |
| 3 dB Bandwidth | | | 330 | | Hz |
| BAROMETER | | | | | |
| Pressure Range | | 300 | | 1100 | mbar |
| | Extended | 10 | | 1200 | mbar |
| Sensitivity | BAROM_OUT and BAROM_LOW (32-bit) | | $6.1 \times 10^{-7}$ | | mbar/LSB |
| Error with Supply | | | 0.04 | | %/V |
| Total Error | | | 4.5 | | mbar |
| Relative Error[3] | −40°C to +85°C | | 2.5 | | mbar |
| Nonlinearity[4] | Best fit straight line, FS = 1100 mbar | | 0.1 | | % of FS |
| | −40°C to +85°C | | 0.2 | | % of FS |
| Linear-*g* Sensitivity | ±1 *g*, 1 σ | | 0.005 | | mbar/*g* |
| Noise | | | 0.025 | | mbar rms |
| TEMPERATURE SENSOR | | | | | |
| Scale Factor | Output = 0x0000 at 25°C (±5°C) | | 0.00565 | | °C/LSB |
| LOGIC INPUTS[5] | | | | | |
| Input High Voltage, $V_{IH}$ | | 2.0 | | | V |
| Input Low Voltage, $V_{IL}$ | | | | 0.8 | V |
| $\overline{CS}$ Wake-Up Pulse Width | | 20 | | | µs |
| Logic 1 Input Current, $I_{IH}$ | $V_{IH}$ = 3.3 V | | | 10 | µA |
| Logic 0 Input Current, $I_{IL}$ | $V_{IL}$ = 0 V | | | | |
| All Pins Except $\overline{RST}$ | | | | 10 | µA |
| $\overline{RST}$ Pin | | | 0.33 | | mA |
| Input Capacitance, $C_{IN}$ | | | 10 | | pF |
| DIGITAL OUTPUTS | | | | | |
| Output High Voltage, $V_{OH}$ | $I_{SOURCE}$ = 0.5 mA | 2.4 | | | V |
| Output Low Voltage, $V_{OL}$ | $I_{SINK}$ = 2.0 mA | | | 0.4 | V |
| FLASH MEMORY | Endurance[6] | 100,000 | | | Cycles |
| Data Retention[7] | $T_J$ = 85°C | 20 | | | Years |

| | | | | |
|---|---|---|---|---|
| FUNCTIONAL TIMES[8] | Time until data is available | | | |
| Power-On Start-up Time | | | 500 | ms |
| Reset Recovery Time[9] | | | 500 | ms |
| Sleep Mode Recovery Time | | | 500 | µs |
| Flash Memory Update Time | | | 375 | ms |
| Flash Memory Test Time | | | 50 | ms |
| Automatic Self-Test Time | Using internal clock, 100 SPS | | 12 | ms |
| CONVERSION RATE | | | 2.46 | kSPS |
| Initial Clock Accuracy | | | 0.02 | % |
| Temperature Coefficient | | | 40 | ppm/°C |
| Sync Input Clock | | 0.7[10] | | 2.4 kHz |
| POWER SUPPLY, VDD | Operating voltage range | 3.0 | | 3.6 V |
| Power Supply Current[11] | Normal mode, VDD = 3.3 V, µ ± σ | | 254 | mA |
| | Sleep mode, VDD = 3.3 V | | 12.2 | mA |
| | Power-down mode, VDD = 3.3 V | | 45 | µA |
| POWER SUPPLY, VDDRTC | Operating voltage range | 3.0 | | 3.6 V |
| Real-Time Clock Supply Current | Normal mode, VDDRTC = 3.3 V | | 13 | µA |

## ▶INCONFIGURATION AND FUNCTION DESCRIPTIONS

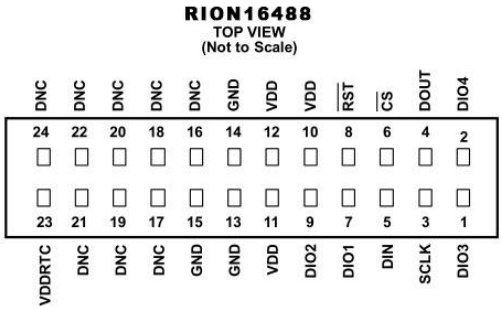
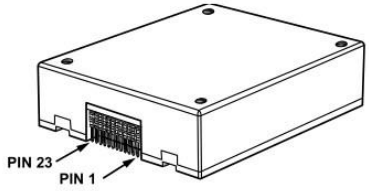
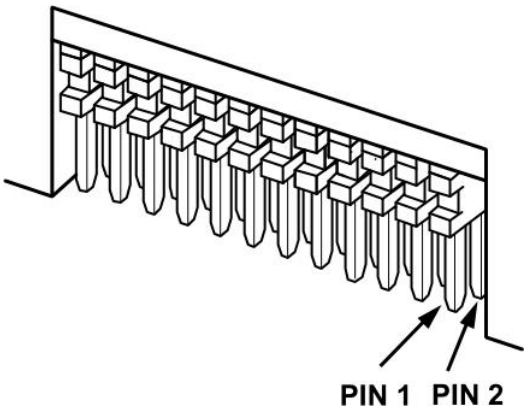



*Figure 5. Mating Connector Pin Assignments*



| Pin No. | Mnemonic | Type | Description |
|---|---|---|---|
| 1 | DIO3 | Input/output | Configurable Digital Input/Output. |
| 2 | DIO4 | Input/output | Configurable Digital Input/Output. |
| 3 | SCLK | Input | SPI Serial Clock. |
| 4 | DOUT | Output | SPI Data Output. Clocks output on SCLK falling edge. |
| 5 | DIN | Input | SPI Data Input. Clocks input on SCLK rising edge. |
| 6 | $\overline{CS}$ | Input | SPI Chip Select. |
| 7 | DIO1 | Input/output | Configurable Digital Input/Output. |
| 8 | $\overline{RST}$ | Input | Reset. |
| 9 | DIO2 | Input/output | Configurable Digital Input/Output. |
| 10, 11, 12 | VDD | Supply | Power Supply. |
| 13, 14, 15 | GND | Supply | Power Ground. |
| 16 to 22, 24 | DNC | Not applicable | Do Not Connect to These Pins. |
| 23 | VDDRTC | Supply | Real-Time Clock Power Supply. |

## ▶ DIMENSION