Integrated Dual-Axis Gyro
IDG-1215

FEATURES

- Integrated X- and Y-axis gyros on a single chip
- ±67°/s full-scale range
- 15mV/°/s sensitivity
- Integrated amplifiers and low-pass filter
- Auto Zero function
- Integrated reset switch for high-pass filters
- On-chip temperature sensor
- High vibration rejection over wide frequency range
- High cross-axis isolation by proprietary MEMS design
- 3V single-supply operation
- Hermetically sealed for temp and humidity resistance
- 10,000g Shock Tolerant
- Smallest dual axis gyro package at 4 x 5 x 1.2mm
- RoHS and Green Compliant

APPLICATIONS

- GPS Navigation Devices
- Robotics
- Electronic Toys
- Platform Stabilization

GENERAL DESCRIPTION

The IDG-1215 is an integrated dual-axis angular rate sensor (gyroscope). It uses InvenSense's proprietary and patented MEMS technology with vertically driven, vibrating masses to make a functionally complete, low-cost, dual-axis angular rate sensor. All required electronics are integrated onto a single chip with the sensor.

The IDG-1215 gyro uses two sensor elements with novel vibrating dual-mass bulk silicon configurations that sense the rate of rotation about the X- and Y-axis (in-plane sensing). This results in a unique, integrated dual-axis gyro with guaranteed-by-design vibration rejection and high cross-axis isolation. It is specifically designed for demanding consumer applications requiring low cost, small size and high performance.

The IDG-1215 gyro includes integrated electronics necessary for application-ready functionality. It incorporates X- and Y-axis low-pass filters, pins for user definable high-pass filters, user controlled integrated switches for resetting the high-pass filters and an EEPROM for on-chip factory calibration of the sensor. Factory trimmed scale factors eliminate the need for external active components and end-user calibration. This product is lead-free and Green Compliant.
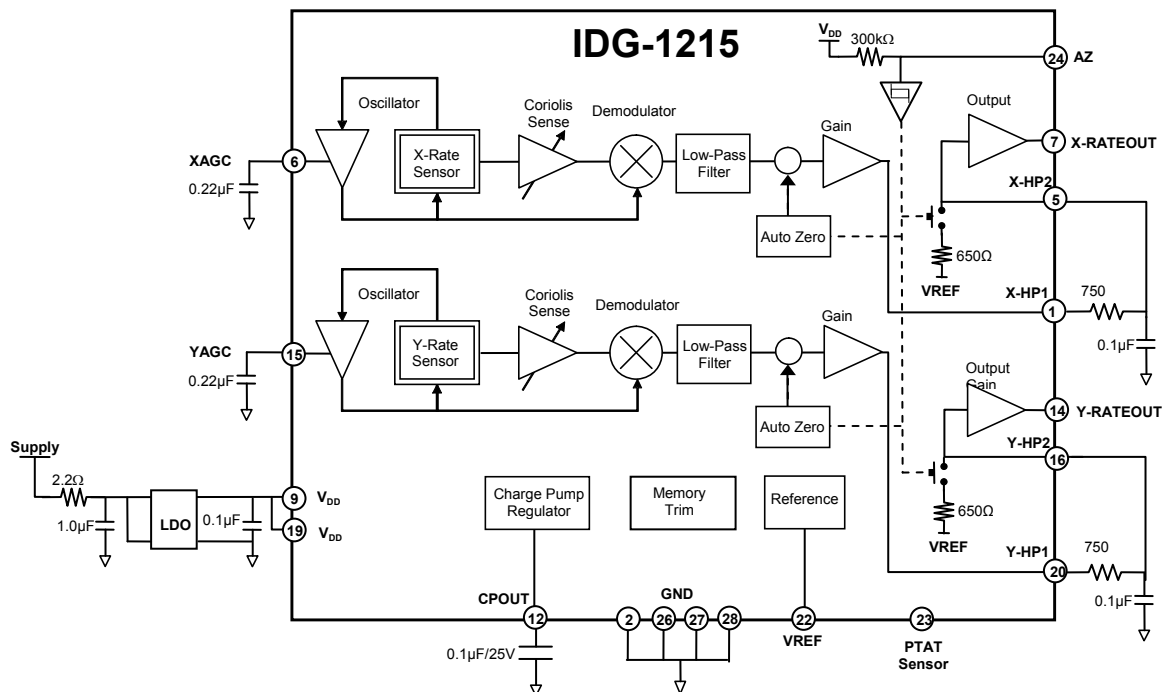
SPECIFICATIONS

All parameters specified are @ VDD = 3.0 V and Ta = 25°C.
Specifications are measured with the circuit on the first page. All specifications apply to both axes.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
SENSITIVITY						
Full-Scale Range	Factory Set			±67		°/s
Sensitivity				15		mV/°/s
Initial Calibration Tolerance				±6		%
Over Specified Temperature				±5		%
Nonlinearity	Best Fit Straight Line			<1		% of FS
Cross-axis Sensitivity				±1		%
REFERENCE						
Voltage Value	Factory set			1.35		V
Tolerance				±50		mV
Load Drive				100		µA
Capacitive Load Drive	Load directly connected to VREF			100		pF
Power Supply Rejection	VDD= 2.7V to 3.3V			1		mV/V
Over Specified Temperature				±5		mV
ZERO-RATE OUTPUT						
Static Output (Bias)	Factory Set			1.35		V
Initial Calibration Tolerance	Relative to VREF	With Auto Zero		±2		°/sec
		Without Auto Zero		±50		°/sec
Over Specified Temperature	Relative to VREF	Without Auto Zero		±30		°/sec
Power Supply Sensitivity	@ 50 Hz			10		°/sec/V
FREQUENCY RESPONSE						
High Frequency Cutoff	Internal LPF -90°			140		Hz
LPF Phase Delay	10Hz			-4.5		°
MECHANICAL FREQUENCIES						
X-Axis Resonant Frequency			20	24	28	kHz
Y-Axis Resonant Frequency			23	27	31	kHz
Frequency Separation	X and Y Gyroscopes			3		kHz
NOISE PERFORMANCE						
Total RMS Noise	Bandwidth 1Hz to 1kHz			3		mV rms
OUTPUT DRIVE CAPABILITY						
Output Voltage Swing	Load = 100kΩ to V$_{dd}$/2		0.05		Vdd-0.05	V
Capacitive Load Drive				100		pF
Output Impedance				100		Ω
POWER ON-TIME						
Zero-rate Output	Settling to ±3°/s			50	200	ms
HPF RESET SWITCH / AUTO ZERO						
On-Resistance	X-HP2, Y-HP2			650		Ω
AZ Logic High	Rising Input			1.9		V
AZ Logic Low	Falling Input			0.9		V
HPF Reset Pulse Duration			3			µsec
Auto Zero Pulse Duration			2		1500	µsec
Offset Settle Time After Auto Zero				7		msec

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY (VDD)					
Operating Voltage Range		2.7	3.0	3.3	V
Quiescent Supply Current			7	9.5	mA
Over Specified Temperature			±0.5		mA
TEMPERATURE SENSOR					
Sensitivity	Range -20 to +85°C		4		mV/°C
Offset			1.25		V
Output Impedance			12		kΩ
TEMPERATURE RANGE					
Specified Temperature Range		-20		+85	°C

RECOMMENDED OPERATING CONDITIONS

Parameter	Min	Typical	Max	Unit
Power Supply Voltage (VDD)	2.7	3.0	3.3	V
Power Supply Voltage (VDD) Rise Time (10% - 90%)			20	ms

ABSOLUTE MAXIMUM RATINGS

Stress above those listed as "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Rating
Power Supply Voltage (VDD)	-0.3V to +6.0V
Acceleration (Any Axis, unpowered)	10,000g for 0.3ms
Operating Temperature Range	-40 to +105°C
Storage Temperature Range	-40 to +125°C

InvenSense, Inc., 1197 Borregas Ave., Sunnyvale, CA 94089, USA
Tel: +1 (408) 988-7339   Fax: +1 (408) 988-8104
Website: http//www.invensense.com

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DS-IDG-1215B-00-01
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PACKAGE DIMENSIONS (all dimensions in mm)

TOP VIEW

BOTTOM VIEW

SIDE VIEW
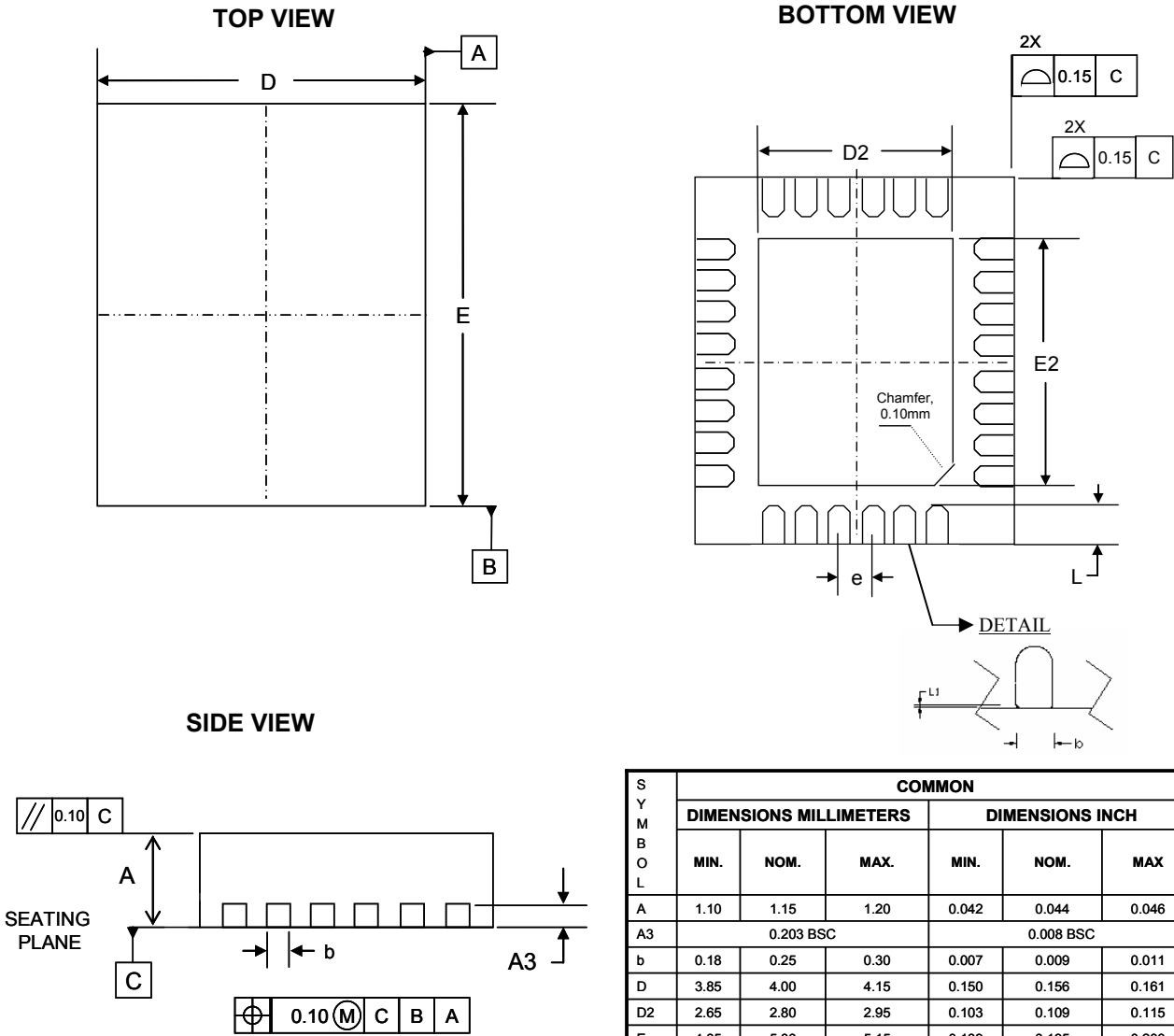
S Y M B O L	COMMON					
	DIMENSIONS MILLIMETERS			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX
A	1.10	1.15	1.20	0.042	0.044	0.046
A3	0.203 BSC			0.008 BSC		
b	0.18	0.25	0.30	0.007	0.009	0.011
D	3.85	4.00	4.15	0.150	0.156	0.161
D2	2.65	2.80	2.95	0.103	0.109	0.115
E	4.85	5.00	5.15	0.189	0.195	0.200
E2	3.50	3.65	3.80	0.137	0.142	0.148
e	0.50 BSC			0.019 BSC		
L	0.30	0.35	0.40	0.011	0.013	0.015
L1	0.00	0.08	0.15	0.000	0.003	0.006

PIN DESCRIPTION

Number	Pin	Description
2, 26, 27, 28	GND	Ground
9, 19	VDD	Positive supply voltage: 2.7V to 3.3V
1	XHP1	Filter input for X-axis
5	XHP2	Filter output for X-axis
6	XAGC	Amplitude control capacitor connection
7	X-RATE OUT	Rate output for rotation about the X-axis
12	CPOUT	Charge pump capacitor connection
14	Y-RATE OUT	Rate output for rotation about the Y-axis
15	YAGC	Amplitude control capacitor connection
16	YHP2	Filter output for Y-axis
20	YHP1	Filter input for Y-axis
22	VREF	Precision reference output
23	PTATS	Proportional to Absolute Temperature Sensor Output
24	AZ	X & Y Auto Zero control pin
8, 10, 11, 13, 21, 25	RESV	Reserved. Do not connect. Used for factory trimming
3, 4, 17, 18	NC	Not internally connected. May be used for PCB trace routing

PIN CONNECTION (TOP VIEW)
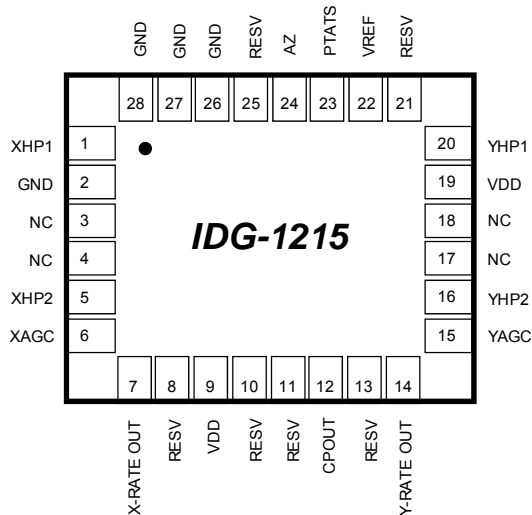
**28-pin, 4mm x 5mm x 1.2mm
QFN Package**

RATE SENSITIVE AXIS

This is a dual-axis rate sensing device. It produces a positive output voltage for rotation about the X- or Y-axis, as shown in the figure below.
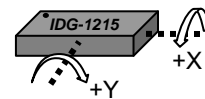
DESIGN NOTES

1. Overview

The IDG-1215 gyro is a dual-axis gyroscope consisting of two independent vibratory MEMS gyroscopes. One detects rotation about the X-axis; the other detects rotation about the Y-axis. Each structure is fabricated using InvenSense's proprietary bulk silicon technology. The structures are covered and hermetically sealed at the wafer-level. The cover shields the gyro from EMI.

The gyroscope's proof-masses are electrostatically oscillated at resonance. An internal automatic gain control circuit precisely sets the oscillation of the proof masses. When the sensor is rotated about the X- or Y-axis, the Coriolis effect causes a vibration that can be detected by a capacitive pickoff. The resulting signal is amplified, demodulated, and filtered to produce an analog voltage that is proportional to the angular rate.

2. Amplitude Control

The scale factor of the gyroscope depends on the amplitude of the mechanical motion and the trim setting of the internal programmable gain stages. The oscillation circuit precisely controls the amplitude to maintain constant sensitivity over the temperature range. The capacitors (0.22µF, ±10%) connected to Pin 6 (XAGC) and Pin 15 (YAGC) are compensation capacitors for the amplitude control loops.

3. Internal Low-Pass Filter

After the demodulation stage, there is a low-pass filter that limits noise and high frequency artifacts from the demodulator before final amplification. The typical filter characteristics are shown below.
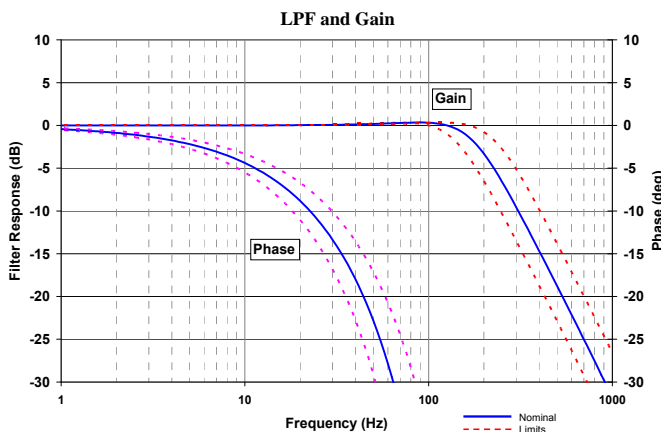
4. High-Pass Filter

If not using Auto Zero, high-pass filters are required in order to eliminate DC rate offset and any potential temperature dependence thereof.

The high-pass filters are implemented by connecting an RC combination between X-HP1 and X-HP2, and Y-HP1 and Y-HP2. The cut-off frequency for the filters is defined by $f_{cutoff} = 1/2\pi RC$. The following table shows examples of RC combinations corresponding with the desired cut-off frequency.

Cut-off Frequency (Hz)	Resistor (kΩ)	Capacitor (µF)
0.03	1000	4.7
0.07	1000	2.2
0.1	330	4.7
0.3	100	4.7

5. High-Pass Filter Reset Switch

The IDG-1215 gyroscope circuitry includes integrated switches to reset the external high-pass filters. The switches are activated by bringing the AZ pin (Pin 24) high. This closes the switches and shorts the capacitors to V_{REF}, allowing the high-pass filter capacitors to charge up quickly. Without the high-pass filter reset switch, the high-pass filters can take several seconds to initialize. It is recommended to reset the high-pass filters at startup and during overload conditions. The AZ Pin has an internal pull-up resistor of 300kΩ. During normal operation, the HPS Pin should be pulled low. Note that the AZ input buffer is a Schmitt buffer with approximately 1.0V of hysteresis.

6. Gyro Outputs

The IDG-1215 gyro has X- and Y-outputs, with sensitivities and full-scale ranges as summarized below.

Axis	Gyro Output	Sensitivity (mV/°/s)	Full-Scale Range (±°/s)
X	X-RATEOUT	15	67
Y	Y-RATEOUT	15	67

The IDG-1215 gyro outputs are independent of supply voltage (i.e. they are not ratiometric).

Gyro rotation rate is calculated as:

(Gyro Output Voltage – Gyro Zero-Rate Out) / Sensitivity

where the Zero-Rate Output (ZRO) is nominally VREF. There is a temperature dependence to ZRO, and an initial accuracy to ZRO.

7. Auto Zero

Auto Zero (AZ) is a function that reduces the effect of Zero-Rate Offset (ZRO) drift without requiring the use of an external high-pass filter. If the Auto Zero function is used, a high-pass filter should not be used.

AZ works by keeping the gyro's Zero-Rate Output (ZRO) close to VREF, and thus allows the user to achieve a wider usable signal range, without using external analog high pass filters.

When activated, the Auto Zero circuit internally nulls the ZRO to VREF. The typical usage of Auto Zero is in conditions where:

1. The gyro's motion is known, such as when:
   a. The gyro is stationary.
   b. Other sensors can report angular rotation rate.

2. The DC value of the gyro output is not important, but only the AC value is. In this case, a digital ac filter may be used to extract the gyro data, which provides a higher-quality output than is possible with an analog R-C filter.

The Auto Zero function is initiated on the rising edge of the AZ pin. The Auto Zero settling time is typically 7ms. This time includes the time required for nulling the ZRO and for the settling of the internal low pass filter (LPF). If the external LPF bandwidth is less than 200Hz, the Auto Zero settling time will be longer than specified.

The AZ pulse width should meet the specified minimum time requirement of 2µs to start the Auto Zero function, and should be shorter than the maximum specified time of 1500µs. The Auto Zero pulse should occur after the start-up period to cancel any initial calibration error.

8. Temperature Sensor

A built-in Proportional-To-Absolute-Temperature (PTAT) sensor provides temperature information on Pin 23 (PTATS). The temperature sensor output signal is analog, and has a bias of approximately 1.25V at room temperature, and increases at a rate of 4mV/$^{\circ}$C. The output impedance is nominally 12kΩ and is therefore not designed to drive low impedance loads. If necessary, the output can be externally buffered with a low offset-drift buffer, and optionally a low-pass filter to minimize noise.

9. High Impedance Nodes

XAGC (pin 6) and YAGC (pin 15) pins are high impedance (>1Mohm) nodes. Any coating, glue or epoxy on these pins or on the capacitors connected to these pins, will affect part performance and should be avoided.

10. Proper Interface Cleaning

Proper cleaning of PCB solder pads prior to assembly is recommended. PCB surface contaminants at XAGC (pin 6), YAGC (pin 15), X-HP2 (Pin 5) or YHP2 (pin 16) device interface may affect part performance.

11. Power Supply Filtering

NOTE: Power supply Voltage (VDD) rise time (10% - 90%) must be less than 20 ms, at VDD (pins 9 and 19), for proper device operation.

The IDG-1215 gyro should be isolated from system power supply noise by a combination of an RC filter that attenuates high frequency noise and a Low Drop Out power supply regulator (LDO) that attenuates low frequency noise. The figure below shows a typical configuration.
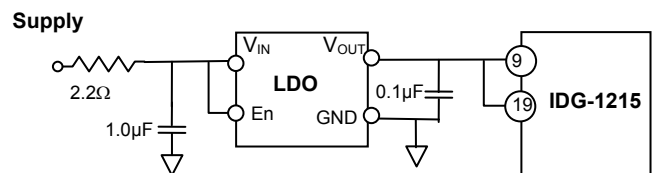
The low-pass RC filter should be chosen such that it provides significant attenuation of system noise at high frequencies. The LDO should be a low noise regulator (<100µV/rtHz) that exhibits good noise rejection at low frequencies.