IDG-1215 Dual-Axis Gyro Product Specification

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1. Revision History

Revision Date	Revision	Description
09/12/08	01	Initial release
07/28/09	02	Updated document to highlight enhanced performance of AZ. Widened operating temperature range. Updated specification for frequency response, noise, and supply current. Changed pin 8 to GND from RESV. Added more details to design considerations section. Updated tape and reel specifications, reflow specification and figure, and qualification test policy. Removed environmental compliance section. Various wording and figure changes.

2. Purpose

The purpose of this document is to provide a detailed product description and design-related information regarding the IDG-1215 dual-axis gyroscope.

3. Product Overview

The IDG-1215 is a state-of-the-art dual-axis (X/Y) gyroscope designed specifically for complex motion sensing in navigation and general-purpose motion-sensing applications. The IDG-1215 gyroscope utilizes state-of-the-art MEMS fabrication with wafer-scale integration technology. This technology combines completed MEMS wafers and completed CMOS electronic wafers together using a patented and proprietary wafer-scale bonding process that simultaneously provides electrical connections and hermetically sealed enclosures. This unique and novel fabrication technique is the key enabling technology that allows for the design and manufacture of high performance, integrated MEMS gyroscopes in a very small and economical package. Integration at the wafer-level minimizes parasitic capacitances, allowing for improved signal-to-noise over a discrete solution. With the addition of the new patent-pending Auto Zero feature for minimizing bias drift over temperature, the IDG-1215 offers unparalleled gyroscope performance in 3D-input applications.

4. Features

By integrating the control electronics with the sensor elements at the wafer level, the IDG-1215 gyroscope supports a rich feature set including:

- Integrated X- and Y-axis gyro on a single chip
- Full-scale range of ±67°/sec
- Factory calibrated scale factor of 15mV/°/sec
- Integrated amplifiers and low-pass filter
- Auto Zero function
- High-pass filter reset function
- 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 temperature and humidity resistance
- 10,000 *g* shock tolerant
- Smallest dual axis gyro package at 4 x 5 x 1.2mm
- RoHS and Green Compliant

5. Functional Block Diagram

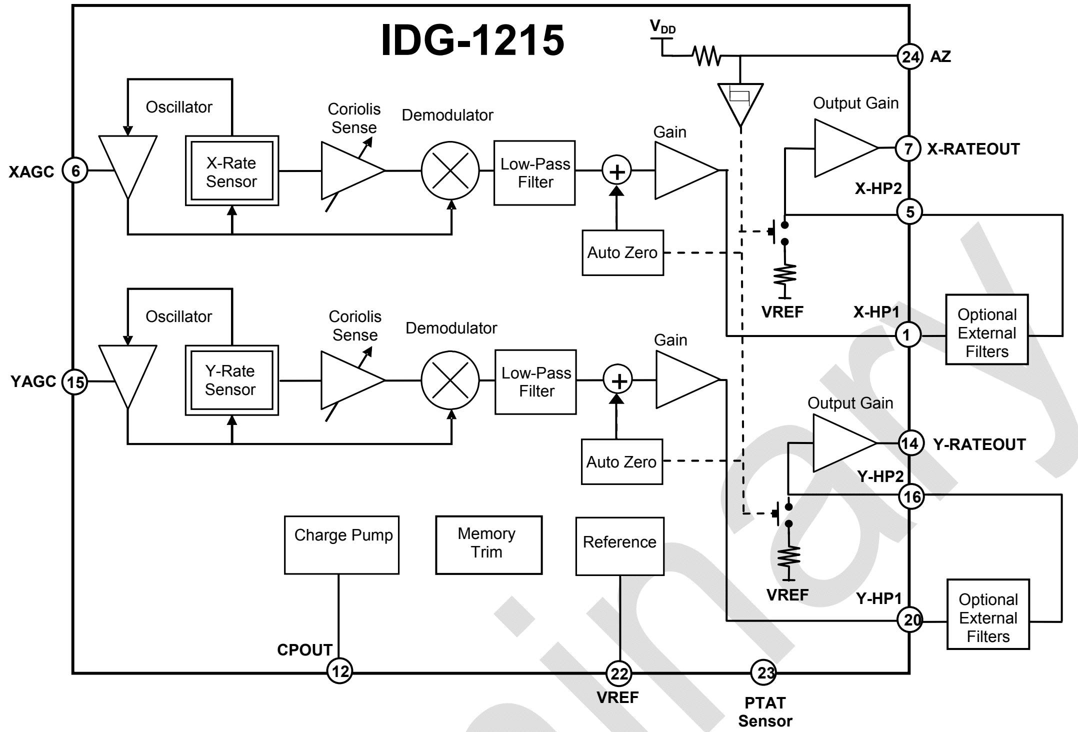


Figure 1

6. Functional Description

6.1 Overview

The IDG-1215 gyroscope consists of two independent vibratory MEMS gyroscopes. One detects rotation about the X-axis; the other detects rotation about the Y-axis. The gyroscope's proof-masses are electrostatically oscillated at resonance. An internal automatic gain control circuit precisely controls 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.

6.2 Rate Sensors

The mechanical structures for detecting angular rate about the X- and Y- axes are 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 radio frequency and electromagnetic interference (RF/EMI). The dual-mass design inherently rejects any signal caused by linear acceleration. The X-gyro and the Y-gyro have different resonant frequencies to prevent undesired coupling.

6.3 Oscillator Circuit

The oscillator circuit generates electrostatic forces to vibrate the structure at resonance. The circuit detects the vibration by measuring the capacitance between the oscillating structure and a fixed electrode. The oscillator circuit switches in quadrature phase with the capacitance measurement in order to vibrate at resonance.

6.4 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 connected to Pin 6 (XAGC) and Pin 15 (YAGC) are compensation capacitors for the amplitude control loops.

6.5 Coriolis Sense

Rotating the sensor about the X- or Y-axis results in a Coriolis force on the corresponding X- or Y-rate sensor. The Coriolis force causes the mechanical structure to vibrate in-plane. The resulting vibration is detected by measuring the capacitance change between the mechanical structure and fixed electrodes. This signal is converted to a voltage waveform by means of low-noise charge integrating amplifier and amplification stages.

6.6 Demodulator

The output of the Coriolis sense is an amplitude modulated waveform. The amplitude corresponds to the rotation rate, and the carrier frequency is the mechanical drive frequency. The synchronous demodulator converts the Coriolis sense waveform to the low-frequency, angular rate signal.

6.7 Programmable Gain

The signal chain includes several stages of amplification. The gain of these stages is adjusted and trimmed at the factory to provide a calibrated sensitivity. The calibrated sensitivity values are stored in on-chip memory that is programmed at the factory.

6.8 Low-Pass Filter

After the demodulation stage, there is a low-pass filter. This filter attenuates noise and high frequency artifacts before final amplification.

6.9 High-Pass Filter

Use of external high-pass filters are recommended in order to minimize DC rate offset variation over temperature. The high-pass filters are implemented with external passive components.

6.10 High-Pass Filter Reset Switch

Integrated switches can be used to reset the external high-pass filters. It may be desirable to reset the high-pass filters' capacitors during power-up or after certain user-defined conditions.

6.11 Auto Zero

Auto Zero is a function that reduces the effect of zero-rate offset without the need for an external high-pass filter. Pin 24 (AZ) is used to set the Auto Zero function, resetting the bias to 1.35V. If the Auto Zero function is used, a high-pass filter should not be used.

6.12 Temperature Sensor

A built-in Proportional-To-Absolute-Temperature (PTAT) sensor provides temperature information on Pin 23.

6.13 Reference Voltage

The gyro includes a bandgap reference circuit. The output voltage is typically 1.35V and is nominally independent of temperature. The zero-rate signal is nominally equal to the reference value.

6.14 Charge Pump

The on-chip charge pump generates the voltage required to oscillate the mechanical structure.

6.15 Memory Trim

The on-chip memory is used to select the gyro's sensitivity, calibrate the sensitivity and null DC offsets.

6.16 Scale Factor

The Rate-Out of the gyro is not ratiometric to the supply voltage. The scale factor is calibrated at the factory and is nominally independent of supply voltage

7. Specification

7.1 Specified Parameters

All the parameters listed are specified at V_{DD}=3.0V and T=25°C and are measured with the circuit in Figure 2 unless otherwise noted. All specifications apply to both the X and Y 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
	Relative to VREF, 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

7.2 Specified Parameters, continued

All the parameters listed are specified at V_{DD}=3.0V and T=25°C and are measured with the circuit in Figure 2 unless otherwise noted. All specifications apply to both the X and Y axes.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
POWER SUPPLY (VDD)					
Operating Voltage Range		2.7	3.0	3.3	V
Quiescent Supply Current			7		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

7.3 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 the absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Rating
Supply Voltage	-0.3V to +3.6V
Acceleration (Any Axis, unpowered)	10,000*g* for 0.3ms
Operating Temperature Range	-40 to +105°C
Storage Temperature Range	-40 to +125°C

7.4 Standard Reference Circuit

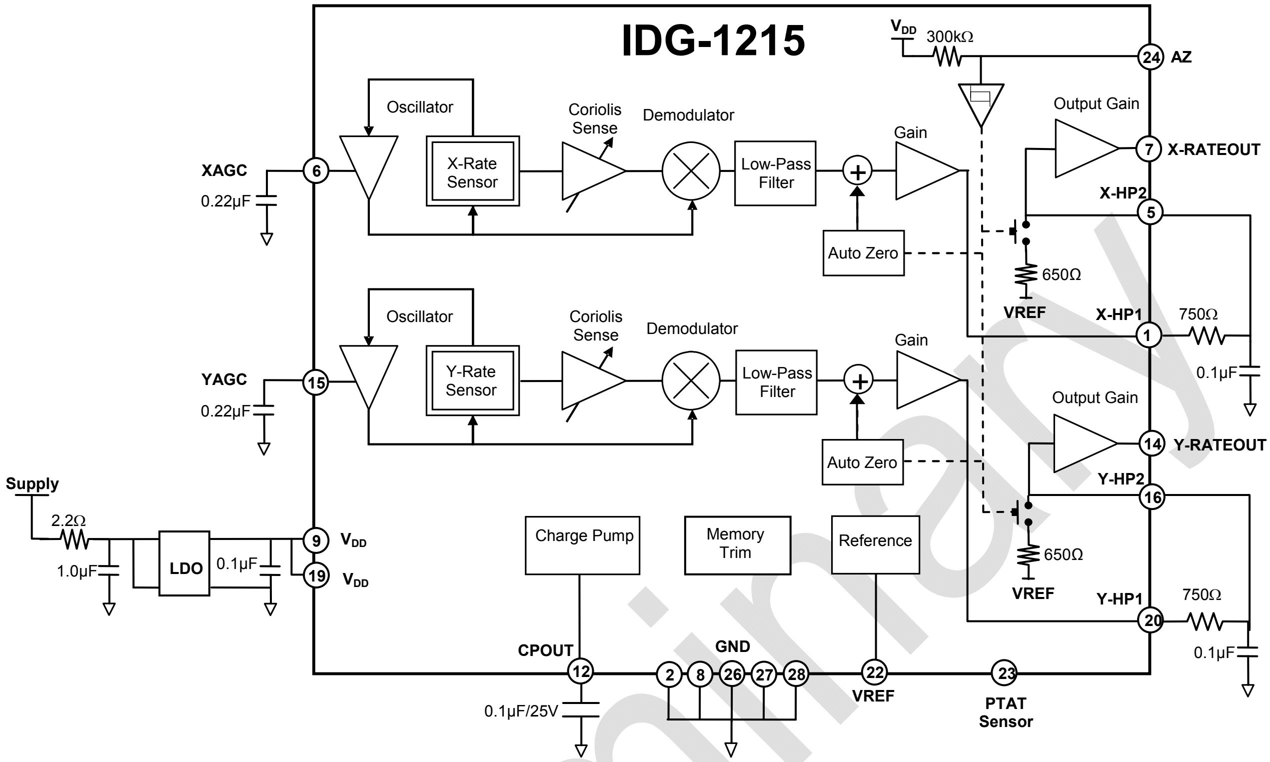


Figure 2

7.4.1 Bill of Material for External Components

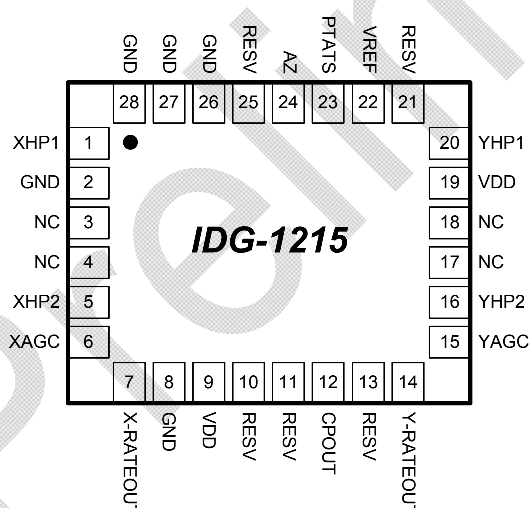
Component	Specification
High Pass Filter Capacitors	4.7µF ±20% / 6.3V
Low Pass Filter Capacitors	0.1µF ±20% / 10V
AGC Capacitors	0.22µF ±10% / 10V
VDD Bypass Capacitor	0.1µF ±20% / 10V
Charge Pump Capacitor	0.1µF ±20% / 25V
LDO Input Filter Capacitor	1.0µF / Ratings Dependent upon Supply Voltage
LDO Input Filter Resistor	2.2Ω±1%
Low Pass Filter Resistors	750Ω±1%
High Pass Filter Resistors	1MΩ±1%

8. Application Information

8.1 Pin Out and Signal Description

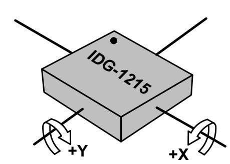
Number	Pin	Description
2, 8, 26, 27, 28	GND	Ground.
9, 19	VDD	Positive supply voltage: 2.7V to 3.3V.
1	XHP1	High Pass Filter input for X-axis.
5	XHP2	High Pass Filter output for X-axis.
6	XAGC	Amplitude control capacitor.
7	X-RATE OUT	Rate output for rotation about the X-axis.
12	CPOUT	Charge pump capacitor.
14	Y-RATE OUT	Rate output for rotation about the Y-axis.
15	YAGC	Amplitude control capacitor.
16	YHP2	Rate output for rotation about the Y-axis.
20	YHP1	High Pass Filter input for Y-axis.
22	VREF	Precision reference output.
23	PTATS	Proportional to Absolute Temperature Sensor.
24	AZ	X & Y Auto Zero control pin.
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.

Top View



28-pin, 4mm x 5mm x 1.2mm QFN Package

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



Orientation of Axes of Sensitivity and Polarity of Rotation

Figure 3

8.2 Design Considerations

8.2.1 Power Supply Rejection Ratio

The gyro is most susceptible to power supply noise (ripple) at frequencies less than 100Hz. At less than 100Hz, the PSRR is determined by the overall internal gain of the gyroscope. Above 100Hz, the PSRR is determined by the characteristics of the on-chip low-pass filter. Above 1kHz, the PSRR is relatively constant except for two narrow frequency ranges corresponding to the resonant frequencies of the X and Y gyroscopes.

8.2.2 Power Supply Filtering

The Power Supply Voltage (VDD) rise time (10% - 90%) must be less than 20ms at VDD (pin 9 and 19) for proper device operation.

The IDG-1215 gyroscope can 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. Figure 4 shows a typical configuration.

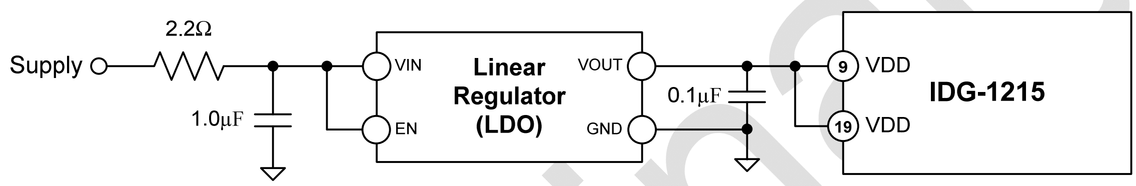


Figure 4

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.

8.2.3 Amplitude Control

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

8.2.4 Internal Low-Pass Filter

After the demodulation stage, there is a low-pass filter. This filter limits noise and high frequency artifacts from the demodulator before final amplification. The following graphs show the typical gain and phase response. The LP filter has been designed for a nominally flat gain up to the cutoff frequency while still achieving a low phase delay at 10Hz and 30Hz.

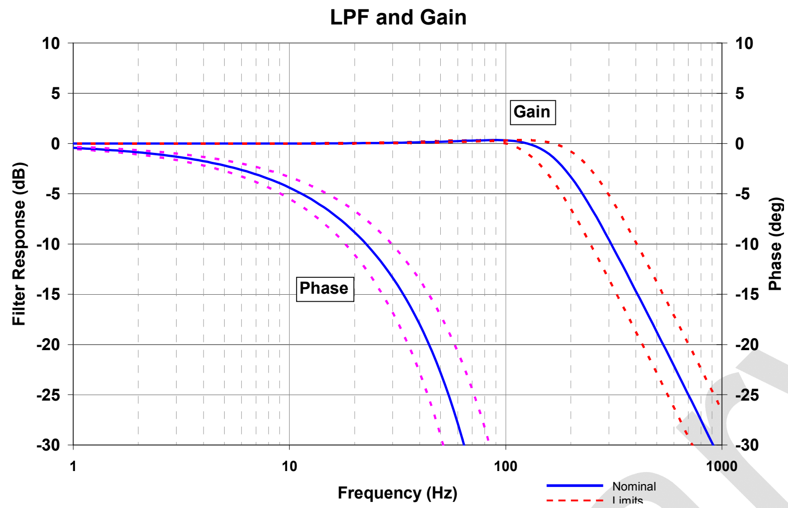


Figure 5

8.2.5 External Low-Pass Filter

To further attenuate high-frequency noise, an optional external low-pass filter may be used.

8.2.6 High-Pass Filter

A high-pass filter is used to minimize DC rate offset variation due to temperature. The high-pass filters are implemented by connecting an RC combination between XHP1 and XHP2 and between YHP1 and YHP2 as shown in Figure 2. The cut-off frequency for the filters is defined by $f_{cutoff} = 1/2\pi RC$. The following table shows examples of HPF configurations.

Cut-off Frequency (Hz)	Resistor (kΩ)	Capacitor (µF)
0.03	1000	4.7
0.1	330	4.7
0.3	330	1.5

8.2.7 High-Pass Filter Reset

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.

8.2.8 Auto Zero

Auto Zero is a function that reduces the effect of Zero Rate Offset drift without the need for 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 an external analog high pass filter.

When activated, the Auto Zero circuit internally nulls the ZRO to approximately 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 1,500µs. The Auto Zero pulse should occur after the start-up period to cancel any initial calibration error.

8.2.9 High Impedance Nodes

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

8.2.10 Charge Pump

The on-chip charge pump requires a capacitor for stable operation. This capacitor should be 0.1µF and rated for 25V.

8.2.11 Proper Interface Cleaning

Proper cleaning of PCB solder pads prior to assembly is recommended. PCB surface contaminants at pins 6 (XAGC) and 15 (YAGC) may affect part performance.

8.2.12 Acoustic Noise Sensitivity

The IDG-1215 gyroscope is insensitive to vibration except for a narrow frequency range near the gyro's resonant frequency and at odd multiples of the resonant frequency. The typical bandwidth of the acoustic sensitivity is 200Hz. It is recommended that products using the IDG-1215 gyroscope along with mechanical actuators be designed such that the acoustic noise in the 20kHz to 31kHz range be attenuated by the product's enclosure avoids these frequency ranges.

8.2.13 Temperature Sensor

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

8.2.14 Electrostatic Discharge Sensitivity

The IDG-1215 gyroscope can be permanently damaged by an electrostatic discharge. ESD precautions for handling and storage are recommended.

9. Assembly

9.1 Orientation

The diagram below shows the orientation of the axes of sensitivity and the polarity of rotation.

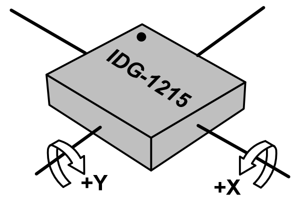
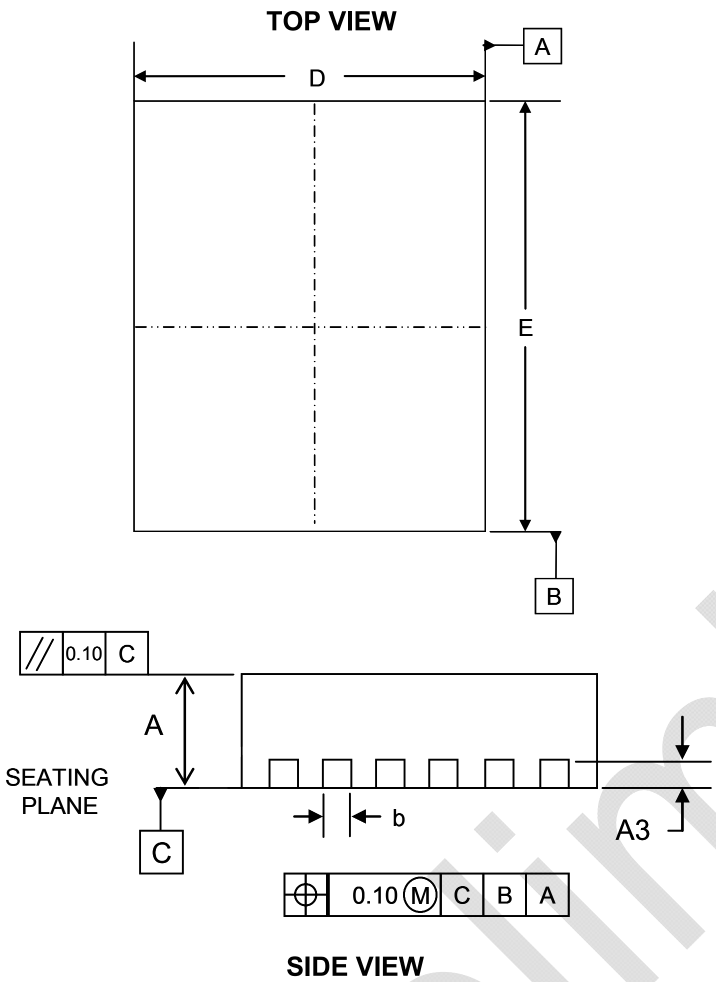
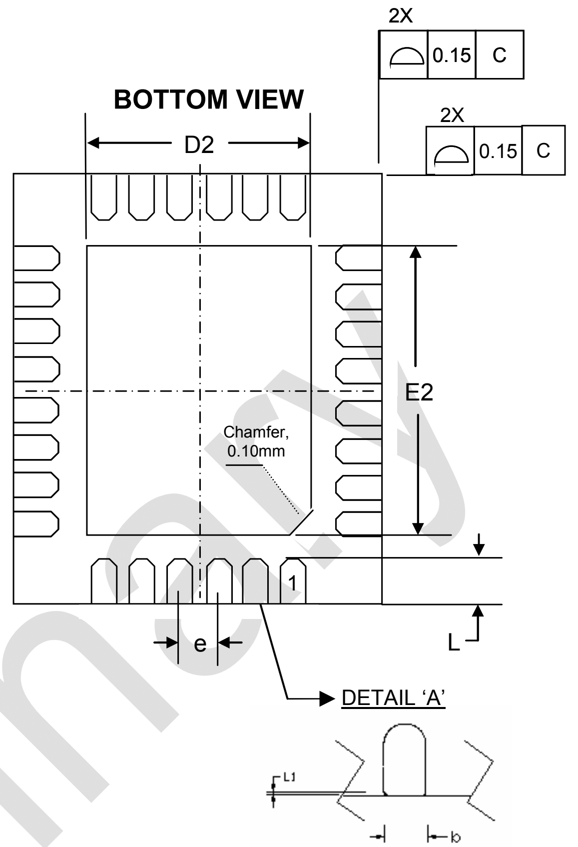


Figure 6

9.2 Package Dimensions





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

Figure 7

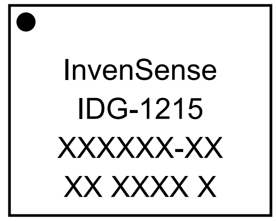
9.3 Package Marking Specification

Line 1 = Company Name

Line 2 = Part Number

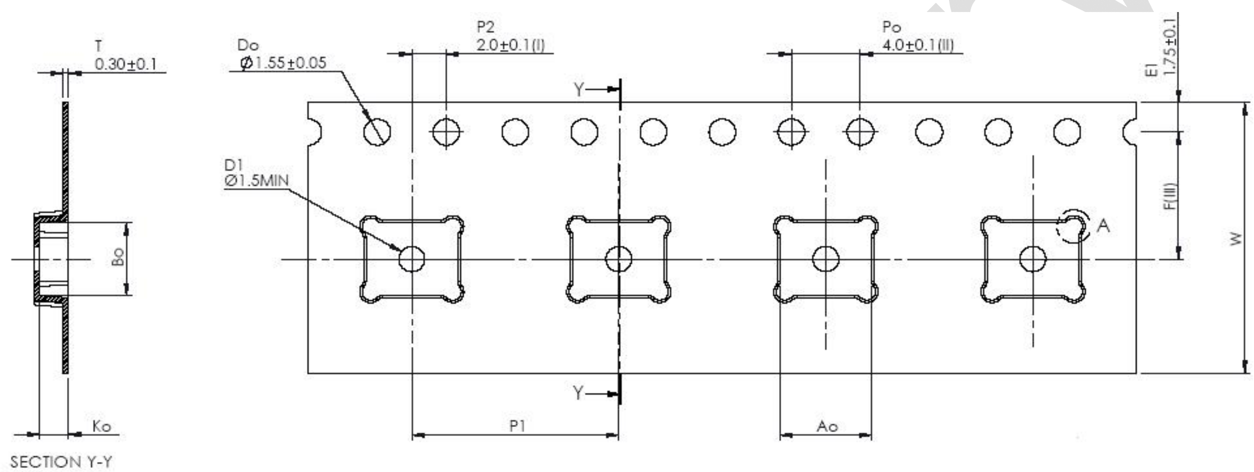
Line 3 = Lot Traceability Code

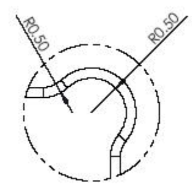
Line 4 = Fabricator, Assembly, Date Code, Revision



Top View

9.4 Tape & Reel Specification



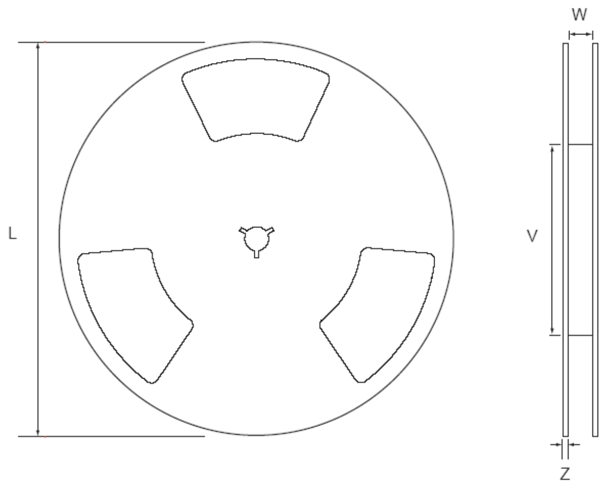


DETAIL 'A'

(I) Measured from centerline of sprocket hole to centerline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20.
(III) Measured from centerline of sprocket holes to centerline of pocket.
(IV) Other material available.
ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE STATED.

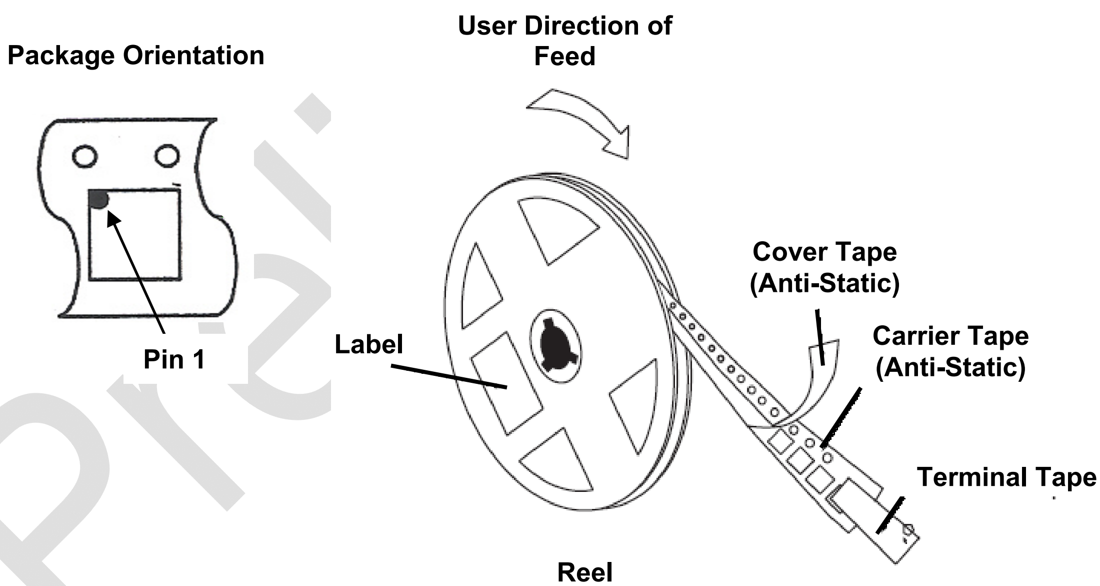
PKG SIZE	CARRIER TAPE (mm)							
	Tape Width (W)	Pocket Pitch (P1)	Ao	Bo	Ko	F	Leader Length (Min.)	Trailer Length (Min.)
4x5	16.00 ±0.3	12.00 ±0.1	5.30 ±0.1	4.30 ±0.1	1.65 ±0.1	7.50 ±0.1	300	300

Figure 8



PKG SIZE	REEL (mm)			
	L	V	W	Z
4x5	330	100	16.4	3.0

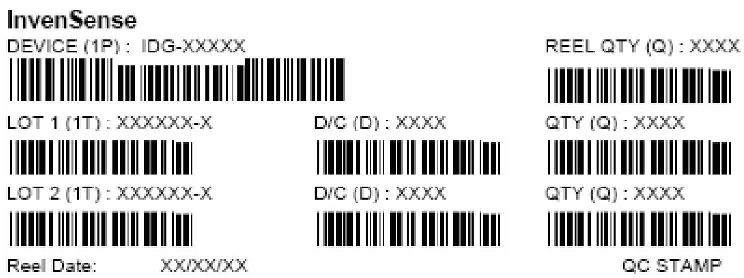
Figure 9



Quantity Per Reel	**5000**
Reels per Pizza Box	**1**
Pizza Boxes Per Carton (max)	**3 full pizza boxes packed in the center of the carton, buffered by two empty pizza boxes (front and back).**
Pieces/Carton (max)	**15,000**

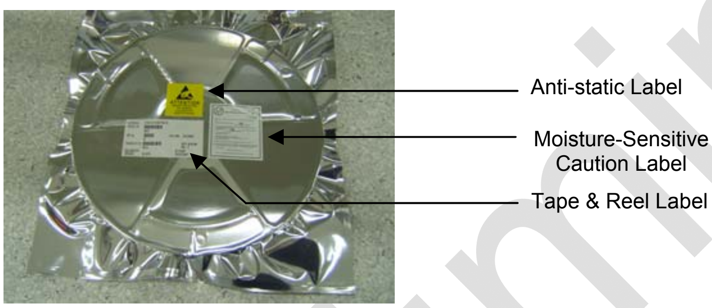
Figure 10

9.4.1 Label



Location of Label

9.4.2 Packing



Moisture Barrier Bag
With Labels

Caution
This bag contains
MOISTURE-SENSITIVE DEVICES

LEVEL
If blank, see adjacent bar code label

1. Calculated shelf life in sealed bag: 12 months at <40˚C and <90% relative humidity (RH)
2. Peak package body temperature: ____________ ˚C
   If blank, see adjacent bar code label
3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must
   a) Mounted within: ________ hours of factory conditions
   If blank, see adjacent bar code label
   <30˚C/60% RH, OR
   b) Stored at <10% RH
4. Devices require bake, before mounting, if:
   a) Humidity Indicator Card is >10% when read at 23 ± 5˚C
   b) 3a or 3b not met
5. If baking is required, devices may be baked for 48 hours at 125 ± 5˚C

   Note: If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IPC/JEDEC J-STD-033 for bake procedure

Bag Seal Date: ____________________
If blank, see adjacent bar code label

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

Moisture-Sensitive Caution Label

Reel in Pizza Box

Pizza Box with Tape & Reel Label

9.5 Trace Routing

Routing traces or vias under the gyro package such that they run under the exposed die pad is prohibited.

9.6 Soldering Exposed Die Pad

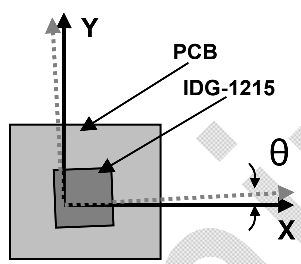
The exposed die pad is internally connected to VSS. The exposed die pad should not be soldered to the PCB since soldering to it contributes to performance changes due to package thermo-mechanical stress.

9.7 Component Placement

Testing indicates that there are no specific design considerations other than generally accepted industry design practices for component placement near the IDG-1215 gyroscope to prevent noise coupling, and thermo-mechanical stress.

9.8 PCB Mounting and Cross-Axis Sensitivity

Orientation error of the gyroscope mounted to the printed circuit board can cause cross-axis sensitivity in which one gyro responds to rotation about the other axis, for example, the Y-axis gyroscope responding to rotation about the X-axis. The orientation mounting error is illustrated in Figure 12.



Packaged Gyro Axis (-----) Relative to PCB Axes (——) with Orientation Error *θ*.

Figure 11

The table below shows the cross-axis sensitivity as a percentage of the specified gyroscope's sensitivity for a given orientation error.

Orientation Error	Cross-Axis Sensitivity
Theta (θ)	**$\lvert\sin\theta\rvert$**
0º	0%
0.5º	0.87%
1º	1.75%

The specification for cross-axis sensitivity in Section 7.1 includes the effect of the die orientation error with respect to the package.

9.9 AGC Nodes

The gyro pins marked XAGC and YAGC are high impedance nodes that are sensitive to current leakage, which can impact gyroscope performance. Care should be taken to ensure that these nodes are not contaminated by residue such as flux and are clean.

9.10 MEMS Handling Instructions

MEMS (Micro Electro-Mechanical Systems) are a time-proven, robust technology used in hundredstens of millions of consumer, automotive and industrial products. MEMS devices consist of microscopic moving mechanical structures. They differ from conventional IC products even though they can be found in similar packages. Therefore, MEMS devices require different handling precautions than conventional ICs prior to mounting onto printed circuit boards (PCBs).

InvenSense's dual-axis gyroscopes utilize MEMS technology which consists of microscopic moving silicon structures to sense rotations and have a shock tolerance of 10,000*g*. InvenSense packages its gyroscopes as it deems proper for protection against normal handling and shipping. It recommends the following handling precautions to prevent potential damage.

1. Individual or trays of gyroscopes should not be dropped on hard surfaces. Components in trays if dropped could be subjected to *g*-forces in excess of 10,000*g.*

2. Printed circuit boards with mounted gyroscopes should not be separated by manually snapping apart. This could create *g*-forces in excess of 10,000*g.*

9.11 Gyroscope Surface Mount Guidelines

Any material used in the surface mount assembly process of the MEMS gyroscope should be free of restricted RoHS elements or compounds. Pb-free solders should be used for assembly.

In order to assure gyroscope performance, several industry standard guidelines need to be considered for surface mounting. These guidelines are for both printed circuit board (PCB) design and surface mount assembly and are available from packaging and assembly houses.

When using MEMS gyroscope components in plastic packages, package stress due to PCB mounting and assembly could affect the output offset and its value over a wide range of temperatures. This is caused by the mismatch between the Coefficient Temperature Expansion (CTE) of the package material and the PCB. Care must be taken to avoid package stress due to mounting.

9.12 Reflow Specification

The approved solder reflow curve shown in the figure below conforms to IPC/JEDEC J-STD-020C (reflow) with a maximum peak temperature (255 +5/-0°C). This is specified for component-supplier reliability qualification testing using lead-free solder. All temperatures refer to the topside of the QFN package, as measured on the package body surface. Customer solder-reflow processes should use the solder manufacturer's recommendations, making sure to never exceed the constraints listed in the table and figure below, as these represent the maximum tolerable ratings for the device. For optimum results, production solder reflow processes should use lower temperatures, reduced exposure times to high temperatures, and lower ramp-up and ramp-down rates than those listed below.

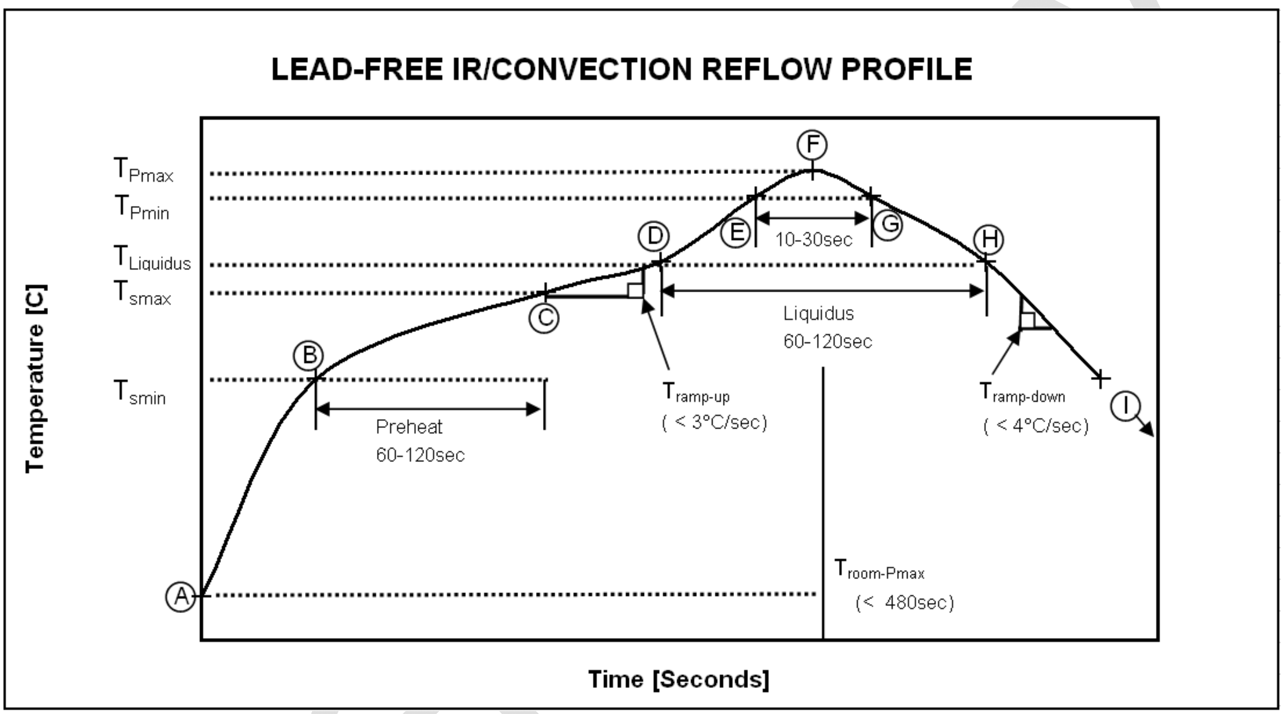


Figure 12. Approved IR/Convection Solder Reflow Curve

Temperature Set Points for IR / Convection Reflow Corresponding to Figure Above

Step	Setting	CONSTRAINTS		
		Temp (°C)	Time (sec)	Rate (°C/sec)
A	Troom	25		
B	TSmin	150		
C	TSmax	200	60 < tBC < 120	
D	TLiquidus	217		r(TLiquidus-TPmax) < 3
E	TPmin [< TPmax-5°C, 250°C]	255		r(TLiquidus-TPmax) < 3
F	TPmax [< TPmax, 260°C]	260	tAF < 480	r(TLiquidus-TPmax) < 3
G	TPmin [< TPmax-5°C, 250°C]	255	tEG < 30	r(TPmax-TLiquidus) < 4
H	TLiquidus	217	60 < tDH < 120	
I	Troom	25		

9.13 Storage Specifications

The storage specification of the IDG-1215 gyroscope conforms to Moisture Sensitivity Level (MSL) 3, as defined by IPC/JEDEC J-STD-020D.01.

Storage Specifications for IDG-1215

Calculated shelf-life in moisture-sealed bag	12 months -- Storage conditions: <40°C and <90% RH
After opening moisture-sealed bag	168 hours -- Storage conditions: ambient ≤30°C at 60% RH

10. Reliability

10.1 Qualification Test Policy

InvenSense's products complete a Qualification Test Plan before being released to production. The Qualification Test Plan follows the JEDEC 47D Standards, "Stress-Test-Driven Qualification of Integrated Circuits," with the individual tests described below.

10.2 Qualification Test Plan

Accelerated Life Tests

Test	Method/Condition	Lot Quantity	Samples / Lot	Accept / Reject Criteria
High Temperature Operating Life (HTOL/LFR)	JEDEC JESD22-A108C, 3.63V biased, Tj>125°C [read-points 168, 500, 1000 hours]	3	77	(1/2)
Steady-State Temperature Humidity Unbiased Life (1)	JEDEC JESD22-A101C, 85°C/85%RH [read-points 168, 500, 1000 hours]	3	77	(1/2)
High Temperature Storage Life	JEDEC JESD22-A103C, Cond. A, 125°C Non-Bias Bake [read-points 168, 500, 1000 hours]	3	77	(1/2)

Device Component Level Tests

Test	Method/Condition	Lot Quantity	Samples / Lot	Accept / Reject Criteria
ESD-HBM	JEDEC JESD22-A114F, Class 2 (2KV)	1	15	(0/1)
ESD-MM	JEDEC JESD22-A115-A, Class B (200V)	1	12	(0/1)
Latch Up	JEDEC JESD78B Class 1 (25°C), Level 1 (+/- 100mA)	1	6	(0/1)
Mechanical Shock	JEDEC JESD22-B104C, Mil-Std-883, method 2002, Cond. D, 10,000*g's*, 0.3ms, ±X,Y,Z – 6 directions, 5 times/direction	3	5	(0/1)
Vibration	JEDEC JESD22-B103B, Variable Frequency (random), Cond. B, 5-500Hz, X,Y,Z – 4 times/direction	3	5	(0/1)
Temperature Cycling (1)	JEDEC JESD22-A104D Condition N, -40°C to +85°C, Soak Mode 2, 100 cycles	3	77	(1/2)

Tests are preceded by MSL3 Preconditioning in accordance with JEDEC JESD22-A113F