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

PS-IDG-0655-00-01
Release Date: 06/10/10

IDG-655 Dual-Axis Gyro
Product Specification

TABLE OF CONTENTS

1. Revision History

Revision Date	Revision	Description
06/10/08	01	Initial Release

2. Purpose

The purpose of this document is to provide a detailed product description and design-related information regarding the IDG-655 dual-axis gyroscope.

3. Product Overview

The IDG-655 is a state-of-the-art dual-axis gyroscope designed specifically for complex motion sensing in 3D-input devices and gaming controllers. The IDG-655 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, multi-axis, 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 patented Auto Zero feature for minimizing bias drift over temperature, the IDG-655 offers unparalleled gyroscope performance in 3D-input and gaming applications.

4. Features

By integrating the control electronics with the sensor elements at the wafer level, the IDG-655 gyroscope supports a rich feature set including:

a) Integrated X- and Y-axis gyro on a single chip
b) Factory calibrated scale factor
c) Integrated low-pass filter
d) Auto Zero function
e) High vibration rejection over wide frequency range
f) High cross-axis isolation by design
g) 3V single-supply operation
h) RoHS and Green Compliant

5. Functional Block Diagram

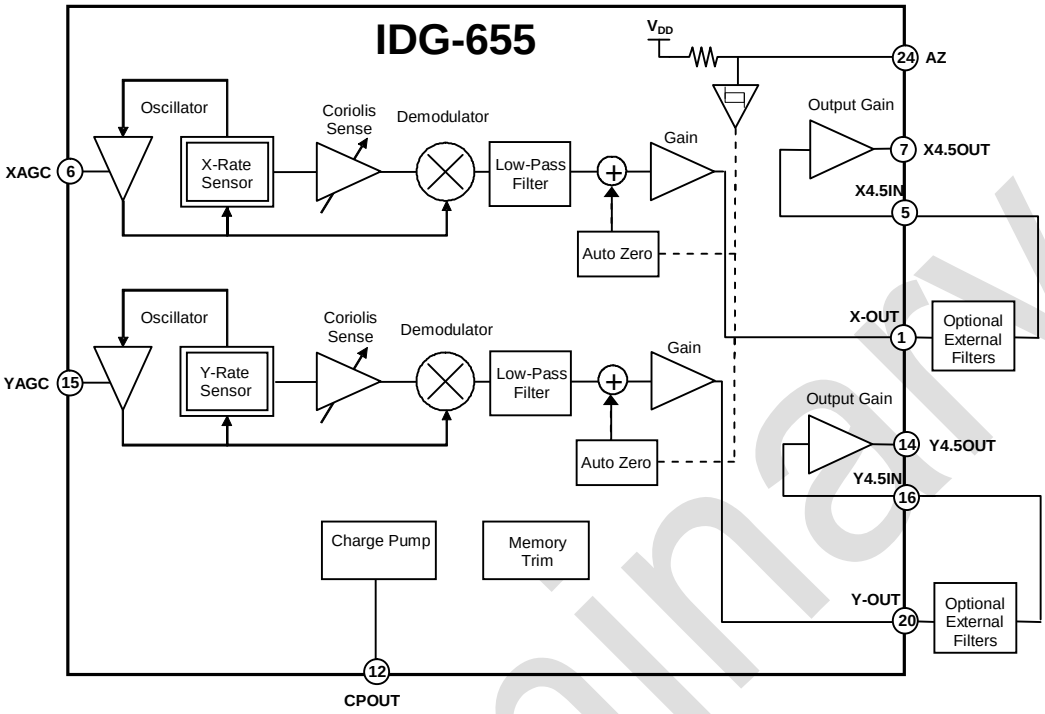


Figure 1

6. Functional Description

6.1 Overview

The IDG-655 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 electromagnetic and radio frequency interferences (EMI/RFI). 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.

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 Low-Pass Filter

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

6.8 Auto Zero Switch

The Auto Zero function is used to reduce DC offset caused by bias drift. The implementation of this function will vary by application requirement. Pin 24 (AZ) is used to set the Auto Zero function, resetting the bias to 1.35V.

6.9 Charge Pump

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

6.10 Memory Trim

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

6.11 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 parameters specified are @ VDD=3.0 V and Ta=25°C @ X-Out and Y-Out. All specifications apply to both axes.

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
SENSITIVITY						
Full-Scale Range	At X-OUT and Y-OUT			±2000		°/s
	At X4.5OUT and Y4.5OUT			±440		°/s
Sensitivity	At X-OUT and Y-OUT			0.5		mV/°/s
	At X4.5OUT and Y4.5OUT			2.27		mV/°/s
Initial Calibration Tolerance	At X-OUT and Y-OUT			±10		%
Calibration Drift Over Specified Temperature	At X-OUT and Y-OUT			±10		%
Nonlinearity	At X-OUT and Y-OUT, Best Fit Straight Line			<1		% of FS
Cross-axis Sensitivity				±1		%
ZERO-RATE OUTPUT (ZRO)						
Static Output (Bias)	Factory Set			1.35		V
Initial Calibration Tolerance		With Auto Zero		±50		mV
		Without Auto Zero		±250		
ZRO Drift Over Specified Temperature				±20		mV
Power Supply Sensitivity	@ 50 Hz			50		°/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			26	30	34	kHz
Frequency Separation	X and Y Gyroscopes			6		kHz
NOISE PERFORMANCE						
Total RMS Noise	Bandwidth 1Hz to 1kHz, At X-OUT and Y-OUT			0.5		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				200		Ω
POWER ON-TIME						
Zero-rate Output	Settling to ±5°/s			50		ms
AUTO ZERO CONTROL						
Auto Zero Logic High	Rising Input			1.9		V
Auto Zero Logic Low	Falling Input			0.9		V
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			6.5		mA
Supply Current Change Over Specified Temperature			±2		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

7.2 Recommended Operating Conditions

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

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 Reference Circuit

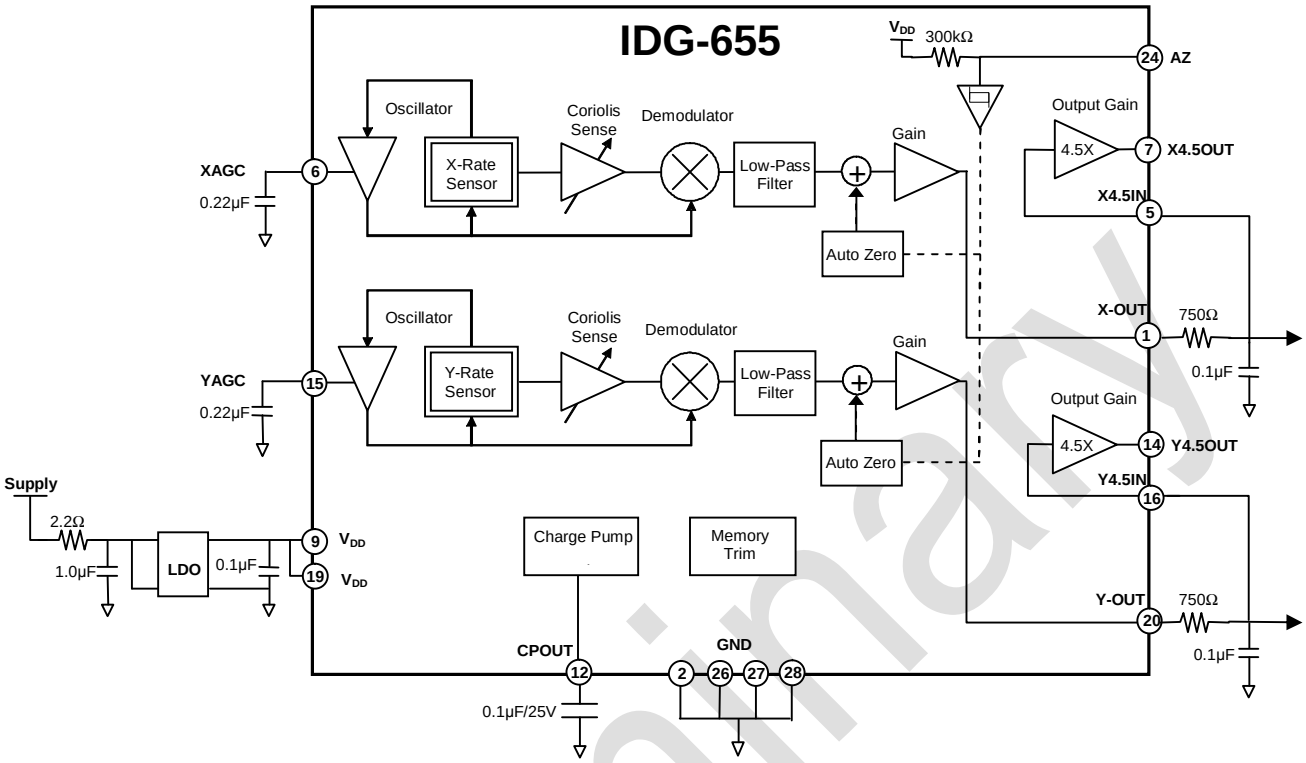


Figure 2

7.4.1 Bill of Material for External Components

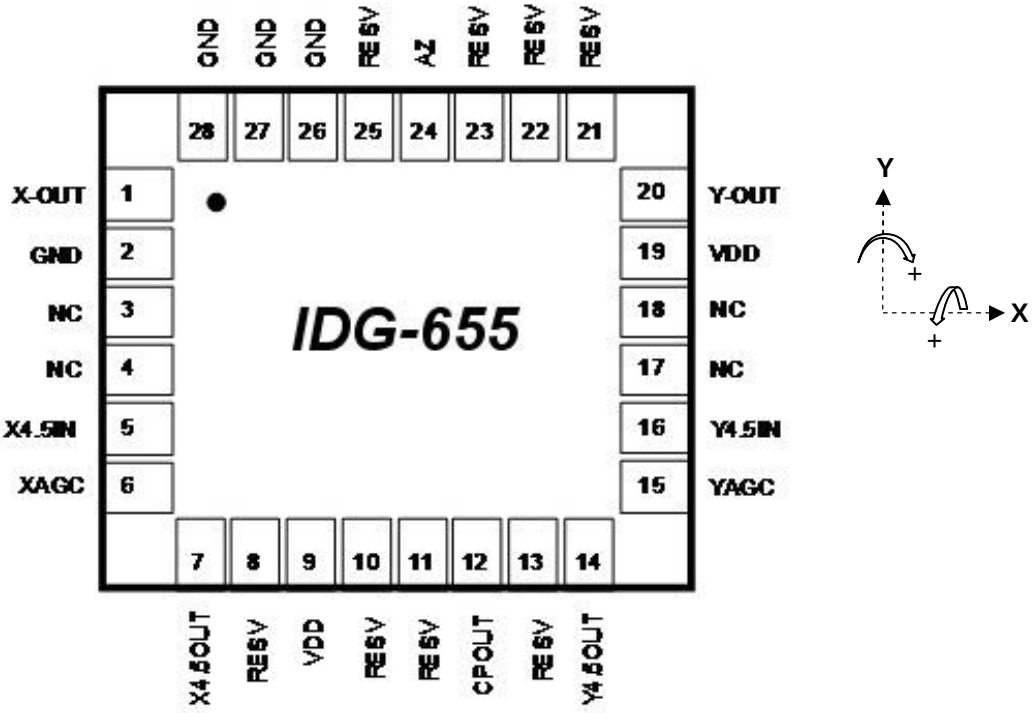
Component	Specification
Low Pass Filter Capacitors	0.1uF ±20% / 10V
AGC Capacitors	0.22uF ±10% / 10V
VDD Bypass Capacitor	0.1uF ±20% / 10V
Charge Pump Capacitor	0.1uF ±20% / 25V
LDO Input Filter Capacitor	1.0uF / Ratings Dependent upon Supply Voltage
LDO Input Filter Resistor	2.2 Ohm ±1%
Low Pass Filter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

8. Application Information

8.1 Pin Out and Signal Description

Number	Pin	Description
2, 26, 27, 28	GND	Ground
9, 19	VDD	Positive supply voltage
1	X-OUT	Rate output for rotation about the X-axis
5	X4.5IN	X-axis input to the 4.5X amplifier
6	XAGC	Amplitude control capacitor
7	X4.5OUT	X-axis output of the 4.5X amplifier
12	CPOUT	Charge pump capacitor
14	Y4.5OUT	Y-axis output of the 4.5X amplifier
15	YAGC	Amplitude control capacitor
16	Y4.5IN	Y-axis input to the 4.5X amplifier
20	Y-OUT	High Pass Filter input for Y-axis
24	AZ	X & Y Auto Zero control pin
8, 10, 11, 13, 21, 22, 23, 25	RESV	Reserved. Do not connect.
3, 4, 17, 18	NC	Not internally connected. May be used for PCB trace routing.

TOP VIEW



28 pin, QFN Package

4 x 5 x 1.2mm

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 1 kHz, 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, 19) for proper device operation.

The IDG-655 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 shows a typical configuration.

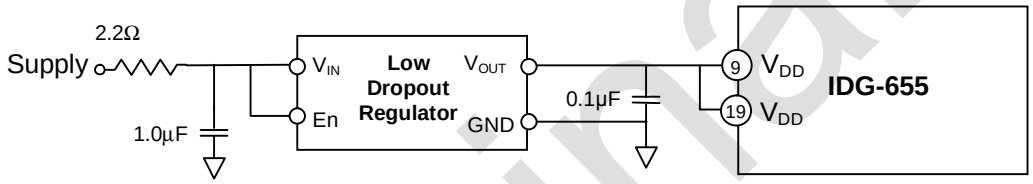


Figure 4

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 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 graph shows the typical gain and phase response. The low-pass 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.

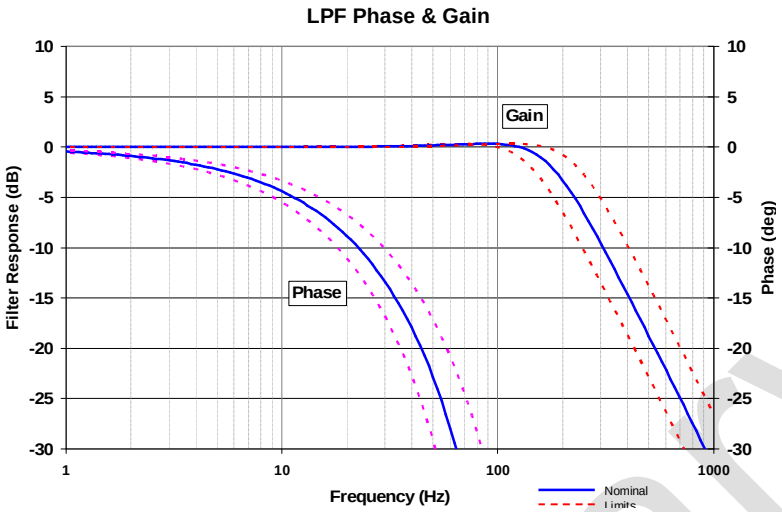


Figure 5

8.2.5 Charge Pump

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

8.2.6 Acoustic Noise Sensitivity

The IDG-655 gyroscope is insensitive to acoustic vibration except for a narrow frequency range near the gyro's resonant frequency. The typical bandwidth of the acoustic sensitivity is 200Hz. It is recommended that products using the IDG-655 gyroscope be designed such that the acoustic noise in the 20 kHz to 31 kHz range is attenuated by the product's enclosure.

8.2.7 Electrostatic Discharge Sensitivity

The IDG-655 gyroscope can be permanently damaged by an electrostatic discharge. ESD precautions for handling and storage are recommended.

8.2.8 Auto Zero Overview

Auto Zero is a function that reduces the effect of Zero Rate Offset without the need for an external high-pass filter. If the Auto Zero function will be used, a high-pass filter should not be used.

The Auto Zero circuit internally nulls the ZRO to 1.35V when the function is activated. The Auto Zero function is initiated on the rising edge of the AZ pin. The settling accuracy of the auto-zero nulling is specified. The Auto Zero function may be used multiple times to null the offset variation due to temperature changes.

The Auto Zero settling time is typically 7ms. The settling time includes the time required for nulling the ZRO and for the settling of the internal LPF. If the external LPF bandwidth is less than 200Hz, the Auto Zero settling time will be longer than specified.

The Auto Zero pulse width should meet the specified minimum time requirement of 2µs to start the Auto Zero function. The Auto Zero pulse width 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.

If the AutoZero function is not used, the AZ pin (pin 24) should be connected to ground.

9. Assembly

9.1 Orientation

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

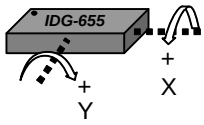
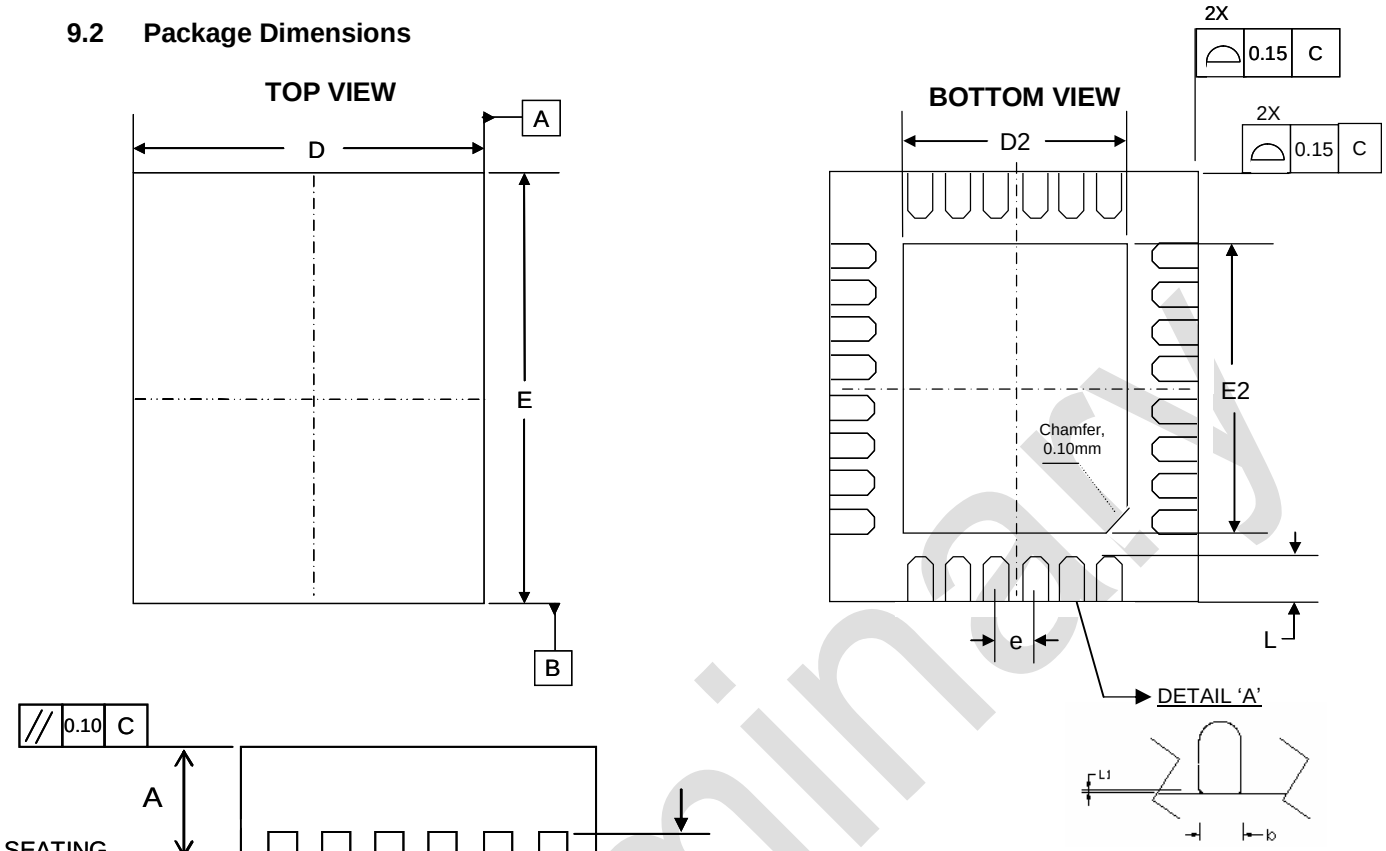


Figure 6

9.2 Package Dimensions



SYMBOL	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

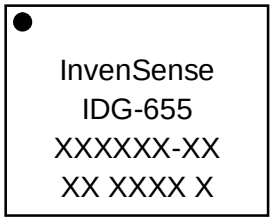
9.3 Package Marking Specification

Line 1 = Company Name

Line 2 = Part Number

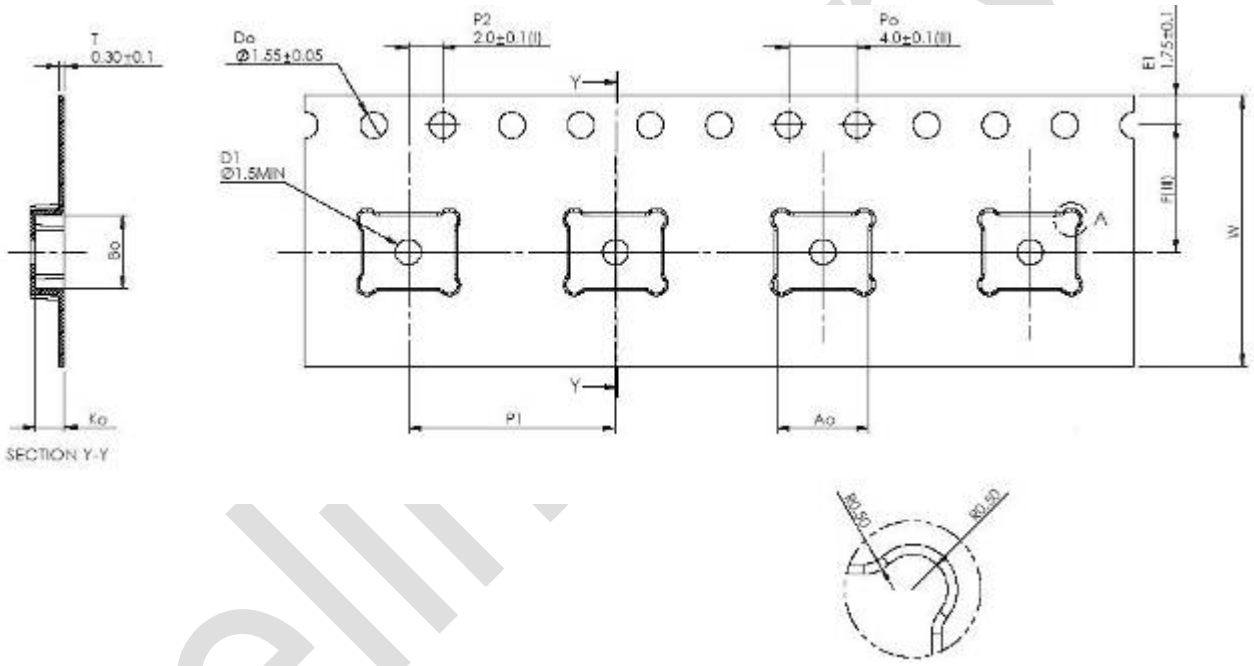
Line 3 = Lot Traceability Code

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.

Figure 8

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

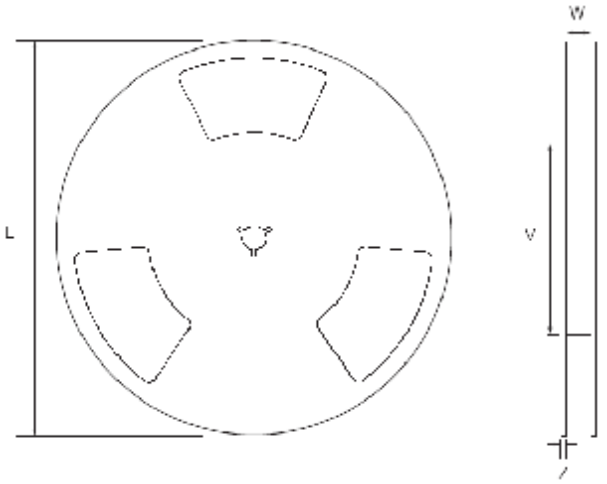


Figure 9

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

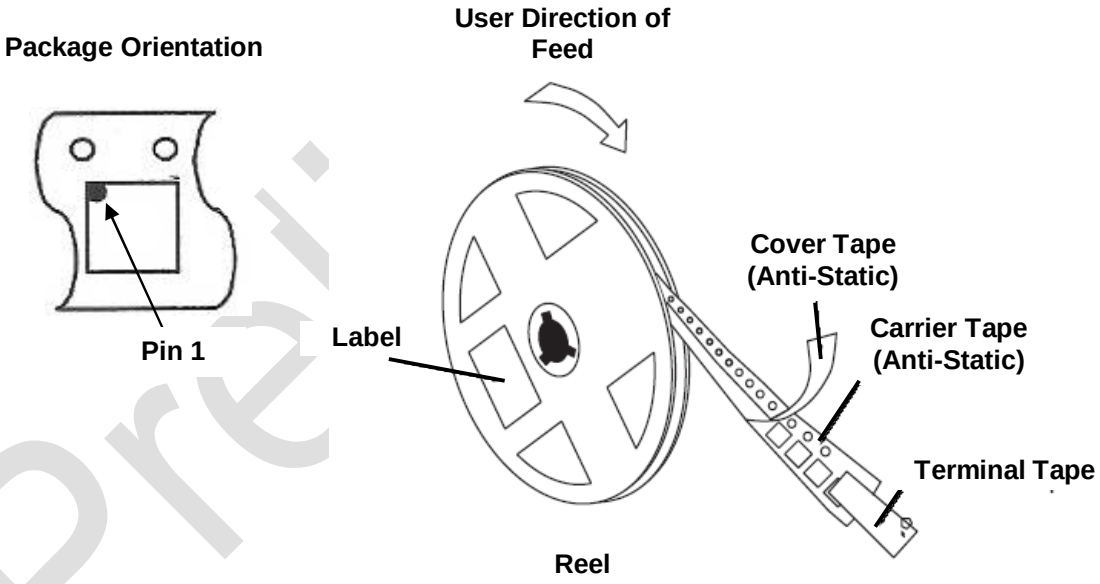
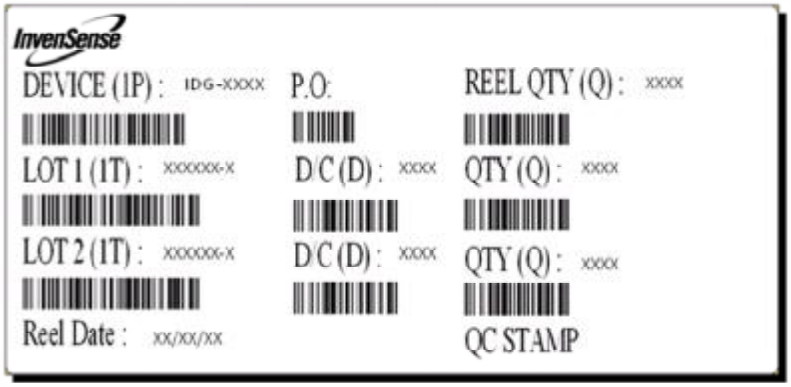


Figure 10

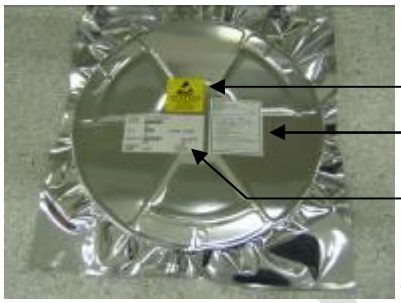
Quantity Per Reel	**5000**
Reels per Pizza Box	**1**
Pizza Boxes Per Carton (max)	**3 full pizza boxes packed in the center of the carton, buffered by two empty pizza boxes (front and back.)**
Pieces/Carton (max)	**15,000**

9.4.1 Label



Location of Label

9.4.2 Packing



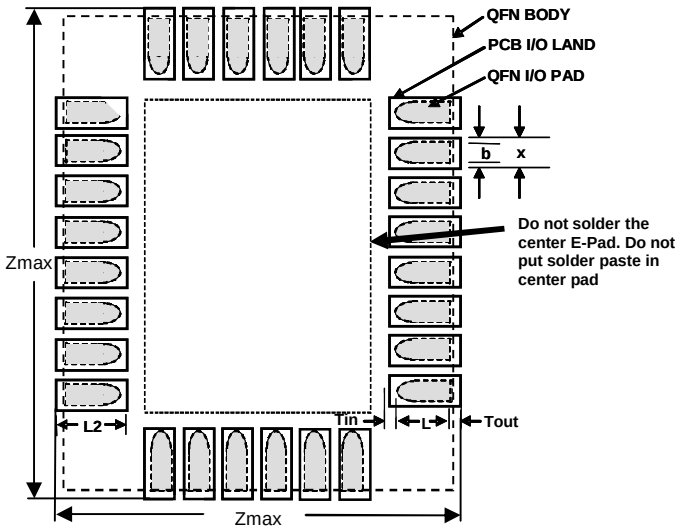
Moisture Barrier Bag With Labels

Moisture-Sensitive Caution Label

Reel in Pizza Box

Pizza Box with Tape & Reel Label

9.5 PCB Pad Layout Dimensions



NOMINAL PACKAGE I/O PAD DIMENSIONS (mm)	
Pad Pitch	0.50
Pad Width (b)	0.25
Pad Length (L)	0.40
I/O LAND DESIGN DIMENSIONS GUIDELINES (mm)	
Land Width (x)	0.30
Outward Extension (Tout)	0.05
Inward Extension (Tin)	0.05
Land Length (L2)	0.50
Sq. Stencil Openings (c)	0.5 x 0.5
Maximum Dimension (Zmax)	4.9 x 5.9

Figure 11

9.6 Trace Routing

Our testing indicates that 3-Volt peak-to-peak signals run under the gyro package or directly on top of the package of frequencies from DC to 1MHz do not affect the operation of the gyro. Routing traces or vias under the gyro package such that they run under the exposed die pad is prohibited.

9.7 Soldering Exposed Die Pad

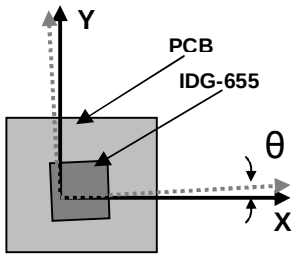
The exposed die pad is internally connected to VSS. The exposed die pad should not be soldered to the PCB since it contributes to certain performance changes due to package stress.

9.8 Component Placement

Our testing indicates that there are no specific design considerations other than generally accepted industry design practices for component placement near the IDG-655 gyroscope to prevent noise coupling.

9.9 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 12

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)	|sinθ|
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.

9.10 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.

9.11 MEMS Handling Instructions

MEMS (Micro Electro-Mechanical Systems) are a time-proven, robust technology used in tens 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.*

9.12 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.

9.13 Reflow Specification

The approved solder reflow curve shown in Figure 13, below conforms to IPC/JEDEC J-STD-020D (reflow) for peak 260 +0/-5°C for lead free solder. The reliability qualification pre-conditioning used by InvenSense incorporates three of these conforming reflow cycles.

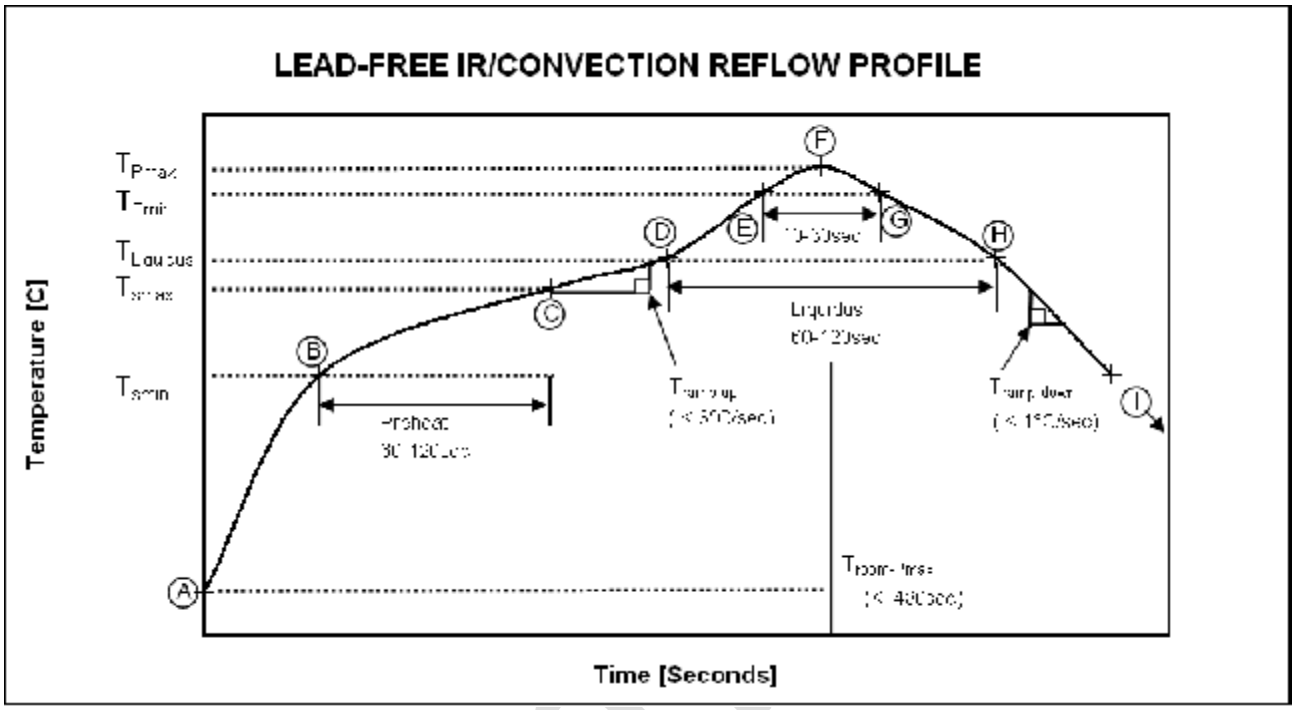


Figure 13

Temperature Set Points for IR / Convection Reflow Corresponding to Figure 13

Step	Setting	CONSTRAINTS		
		Temp (°C)	Time (sec)	Rate (°C/sec)
A	T_{room}	25		
B	T_{Smin}	150		
C	T_{Smax}	200	$60 < t_{BC} < 120$	
D	$T_{Liquidus}$	217		$r_{(TL-TPmax)} < 3$
E	T_{Pmin} [≤TPmax-5°C,255°C]	255		$r_{(TL-TPmax)} < 3$
F	T_{Pmax} [260°C]	260 -0/+5°C	$t_{AF} < 480$	$r_{(TL-TPmax)} < 3$
G	T_{Pmin}	255	$t_{EG} < 30$	$r_{(TPmax-TL)} < 6$
H	$T_{Liquidus}$	217	$60 < t_{DH} < 120$	
I	T_{room}	25		

All temperatures refer to the topside of the QFN package, as measured on the package body surface. The temperatures described in the table (above) are the maximum temperatures specified for the supplier to use to qualify the package for reliability. These represent the maximum tolerable ratings for the package. Solder manufacturers have developed solder formulations that will assure excellent results at lower temperatures. Use the solder manufacturer's recommendations for recommended temperatures. In all cases, the solder manufacturer's recommendations should not exceed the constraints used in the package qualification. In general, production solder reflow processes used by the customer should use lower temperatures, reduced exposure times to high temperatures, and lower ramp-up and ramp-down rates for optimum results.

9.14 Storage Specifications and Re-Bake

The storage specification of the IDG-655 gyroscope conforms to IPC/JEDEC J-STD-020D.01 MSL-3, for storage shelf life before reflow and production use. The parts are packaged using tape-and-reel packaging (see Section 9.4). The tape and reel, along with a Humidity Indicator Card (HIC) and a desiccant package are vacuum sealed in moisture proof bags labeled with MSL-3 and ESD warning labels (see Section 9.4.2).

The bags should remain sealed until the parts are required for production. When the bags are unsealed, the humidity indicator card, Figure 14, should be checked to see whether the parts will require re-baking. The parts should be re-baked if the 10% dot is not blue and the 5% dot is pink. Additionally, the desiccant bags should be checked, and the gyros should be re-baked if the desiccant bags are moist.

Figure 14: Humidity Indicator Card (HIC) and Desiccant Package

The HIC is a card upon which a moisture-sensitive chemical has been applied, such that it will make a significant, perceptible change in color (hue), typically from blue (dry) to pink (wet) when the indicated relative humidity has been exceeded.

Storage Lifetime Conditions

Storage Conditions	Storage Limit	Best Practices
Calculated shelf-life in moisture-sealed bag	12 months – Storage conditions: <40°C and <90% RH	3 months Storage conditions: <30°C and <60% RH
After opening moisture-sealed bag	168 hours – Storage conditions: ambient ≤30°C at 60% RH	48 Hours Storage conditions: ambient ≤30°C at 60% RH

InvenSense recommends that customers follow the MSL-3 handling guidelines, please refer to IPC/JEDEC J-STD-033B.1. While the floor life for MSL-3 devices is 168 hours (<30C/60%RH), customers are encouraged to retain the gyro units in the original moisture-sealed bags or in dry desiccating cabinets until used. If units (unpackaged, or loaded in Tape-and-Reel) are exposed to normal environmental room conditions, please refer to the table below for re-bake instructions.

Re-bake Recommendations

Package Body	MSL Level	Units in Trays, not Tape-and-Reel		Units in Tape-and-Reel	
		Parts Exceeding MSL Floor Life by > 72 hours	Parts Exceeding MSL Floor Life by ≤ 72 hours	Parts Exceeding MSL Floor Life by > 72 hours	Parts Exceeding MSL Floor Life by ≤ 72 hours
Thickness ≤1.4 mm	3	Bake for 9 hours @ 125°C	Bake for 7 hours @ 125°C	Bake for 13 days @ 40°C, ≤5%RH	Bake for 9 days @ 40°C, ≤5%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 standard ("Stress-Test-Driven Qualification of Integrated Circuits") with the individual tests described below.

10.2 Qualification Test Plan

Accelerated Life Tests

Test	Conditions	Test Point(s)			Standard
Preconditioning/ IRR (MSL 3) (1)	30°C/60%RH	192Hr			JEDEC 22-A113-D Level 3
	IRR@260°C max	3X			
Temperature Cycling	-40°C/+85°C	25X	100X		JEDEC 22- A104-B Condition N
High Temp Op. Life (biased)	125°C	168Hr	500Hr	1000Hr	JEDEC 22-A108-B
Steady State Temperature, Humidity Life (unbiased)	85°C/85%RH	168Hr	500Hr	1000Hr	JEDEC 22-A101-B
High Temperature Storage	+125°C	168Hr	500Hr	1000Hr	JEDEC 22- A103-C Condition A
Low Temperature Storage	-40°C	168Hr	500Hr	1000Hr	JEDEC 22- A119 Condition A

NOTES:

(1) To precede Temperature Cycle, Steady State Temperature, Humidity Life Tests

(2) Qualification tests may be conducted only on a representative product using the same die and package as this product.

Mechanical Tests

Test	Conditions	Test Point(s)	Standard
Vibration, Variable Frequency (Random)	3.1G RMS, 2-500Hz, each axis	30min	JEDEC 22-B103-B Condition A
Mechanical Shock	0.3ms, 5x /direction X, Y, Z tested with positive and negative directions	10,000G	JEDEC 22- B104-C

Electrical Tests

Test	Conditions	Test Point(s)	Standard
ESD	Human Body Model (100pF)	2kV, 3X/pin	JEDEC 22-A114-C.01 Class 2
	Machine Model (200pF)	200V, 3X/pin	JEDEC 22-A115-A Class B
Latch Up	Ambient Room Temperature	3X/pin	EIA/JESD78 Class 1

11. Environmental Compliance

The IDG-655 gyroscope is RoHS and Green compliant.

Device: **IDG-655**
Package Type: **QFN 28L 4x5x1.2**
Package Total Mass (mg): **58.60**

Component	Substance	CAS Number	Percent (%)	Material Weight (mg)	Amount of Substance (mg)
Semiconductor Device					
Silicon Chip	Doped Silicon (Si)	7440-21-3	100	11.41	11.41
Lead-frame (F28L 118X150 QFN 4x5 HALF ETCH MTR Full PPF ASM)					
Base Metal	Copper (Cu)	7440-50-8	Balance	10.32	9.949
Base Metal	Iron (Fe)	7439-89-6	2.1-2.6		0.243
Base Metal	Phosphorus (P)	7723-14-0	0.015-0.15		0.009
Base Metal	Zinc (Zn)	7440-66-6	0.05-0.20		0.013
Plating	Nickel (Ni)	7440-02-0	0.97		0.100
Plating	Palladium (Pd)	5/3/7440	0.06		0.006
Plating	Gold (Au)	7440-57-5	0.01		0.001
Bond Wire (GOLD WIRE 1.00MIL GLD TANAKA)					
Metal Wire	Gold (Au)	7440-57-5	>99.99	0.56	0.395
Die Attach Adhesive (EPOXY DA6501 NON-CONDUCTIVE DOW CORNING)					
Filler	Dimethyl Siloxane, Dimethylvinylsiloxy-Terminated	068083-19-2	Balance	1.34	1.166
Filler	Trimethylated Silica	068909-20-6	7-13		0.137
Filler	Dimethyl, Methylhydrogen Siloxane, Hydrogen-Terminated	069013-23-6	1-5		0.040
Mold Compound (COMPOUND GREEN CEL9220HF13H HITACHI)					
Filler	Epoxy Resin-1	Trade Secret	2-5	34.96	1.224
Filler	Epoxy Resin-2	Trade Secret	1-3		0.699
Filler	Phenol Resin	Trade Secret	2-5		1.224
Hardener	Silica	60676-86-0	Balance		28.076
Coloring Material	Carbon Black	1333-86-4	Approx. 0.2		0.070
Filler	Metal Hydroxide	Trade Secret	1-10		1.923
-	Others	-	Max. 5		1.748

Test results for RoHS banned substances/compounds:

Substance/ Compound	Test Method	Die	Lead-frame	Bond Wire	Die Attach Adhesive	Mold Compound
Hexavalent Chromium	EPA3060A/ 7196A	Not Available	ND(<5)	ND(<2)	ND(<1)	ND (<2)
Cadmium	EN1122 Method B:2001	Not Available	ND(<5)	ND(<2)	ND(<2)	ND (<2)
Mercury	US EPA 3052	Not Available	ND(<5)	ND(<2)	ND(<2)	ND (<2)
Lead	US EPA 3050B	Not Available	ND(<10)	ND(<2)	ND(<2)	ND (<2)
PBBs	EPA3540B/ 3550B	Not Available	ND(<250)	ND(<5)	ND(<5)	ND(<5)
PBDEs	EPA3540B/ 3550B	Not Available	ND(<250)	ND(<5)	ND(<5)	ND(<5)

ND = Not Detected

Environmental Declaration Disclaimer:
InvenSense believes this environmental information to be correct but cannot guarantee accuracy or completeness. Conformity documents for the above component are on file. InvenSense subcontracts manufacturing and the information contained herein is based on data received from vendors and suppliers. This information has not been validated by InvenSense.