INMP411

Omnidirectional Microphone with Bottom Port and Analog Output

GENERAL DESCRIPTION

The INMP411* is a high performance, high SPL, low noise, low power, analog output bottom ported, omnidirectional MEMS microphone. The INMP411 consists of a MEMS microphone element and an impedance converter amplifier. The INMP411 sensitivity specification makes it an excellent choice for near-field applications. The INMP411 is pin compatible with the INMP401 microphone, providing an easy upgrade path.

The INMP411 has a linear response up to 131 dB SPL. It offers high SNR and extended wideband frequency response resulting in natural sound with high intelligibility. Low current consumption enables long battery life for portable applications.

The INMP411 is available in a 4.72 × 3.76 × 1.0 mm surface-mount package. It is reflow solder compatible with no sensitivity degradation.

**Protected by U.S. Patents 7,449,356; 7,825,484; 7,885,423; and 7,961,897. Other patents are pending.*

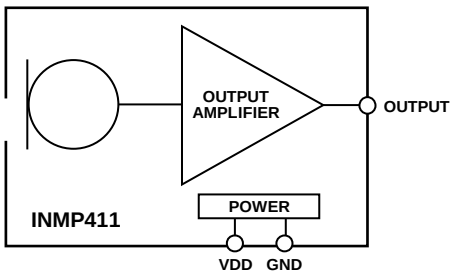
APPLICATIONS

- Fire and Safety Radios
- Safety Masks
- Tablet Computers
- Teleconferencing Systems
- Studio Microphones
- Security and Surveillance

FEATURES

- 4.72 × 3.76 × 1.0 mm Surface-Mount Package
- High 131 dB SPL Acoustic Overload Point
- Sensitivity of −46 dBV
- ±2 dB Sensitivity Tolerance
- Omnidirectional Response
- High SNR of 62 dBA
- Extended Frequency Response from 28 Hz to 20 kHz
- Low Current Consumption: <250 µA
- Single-Ended Analog Output
- High PSR of −80 dBV
- Compatible with Sn/Pb and Pb-Free Solder Processes
- RoHS/WEEE Compliant

FUNCTIONAL BLOCK DIAGRAM

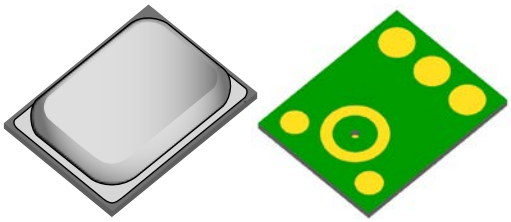


ORDERING INFORMATION

PART	TEMP RANGE
INMP411ACEZ-R0*	−40°C to +85°C
INMP411ACEZ-R7†	−40°C to +85°C
EV_INMP411-FX	—

* – 13” Tape and Reel

† – 7” Tape and reel to be discontinued. Check with sales@invensense.com for availability.



InvenSense Inc.
1745 Technology Drive, San Jose, CA 95110 U.S.A
+1(408) 988–7339
www.invensense.com

Document Number: DS-INMP411-00
Revision: 1.0.
Rev Date: 02/06/2014

TABLE OF CONTENTS

Document Number: DS-INMP411-00
Revision: 1.0.

SPECIFICATIONS

TABLE 1. ELECTRICAL CHARACTERISTICS

(T_A = −40 to 85°C, V_{DD} = 1.5 to 3.63 V, unless otherwise noted. All minimum and maximum specifications are guaranteed across temperature and voltage, and are specified in Table 1, unless otherwise noted. Typical specifications are not guaranteed.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
PERFORMANCE						
Directionality			Omni			
Sensitivity	1 kHz, 94 dB SPL	−48	−46	−44	dBV	
Signal-to-Noise Ratio (SNR)			62		dBA	
Equivalent Input Noise (EIN)			32		dBA SPL	
Dynamic Range	Derived from EIN and maximum acoustic input		99		dB	
Frequency Response	Low frequency −3 dB point		28		Hz	1
	High frequency −3 dB point		>20		kHz	
Total Harmonic Distortion (THD)	105 dB SPL		0.2	1	%	
Power-Supply Rejection (PSR)	217 Hz, 100 mVp-p square wave superimposed on VDD = 1.8 V		−80		dBV	
Acoustic Overload Point	10% THD		131		dB SPL	
POWER SUPPLY						
Supply Voltage (V_{DD})		1.5		3.63	V	
Supply Current (I_S)						
	V_{DD} = 1.8 V		180	220	µA	
	V_{DD} = 3.3 V		210	250	µA	
OUTPUT CHARACTERISTICS						
Output Impedance (Z_{OUT})			200		Ω	
Output DC Offset			0.8		V	
Maximum Output Voltage	131 dB SPL input		0.355		V RMS	
Noise Floor	20 Hz to 20 kHz, A-weighted, rms		−108		dBV	

Note 1: See Figures 3 and 5.

Document Number: DS-INMP411-00
Revision: 1.0.

ABSOLUTE MAXIMUM RATINGS

Stress above those listed as Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to the absolute maximum ratings conditions for extended periods may affect device reliability.

TABLE 2. ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING
Supply Voltage (VDD)	−0.3 V to +3.63 V
Sound Pressure Level (SPL)	160 dB
Mechanical Shock	10,000 *g*
Vibration	Per MIL-STD-883 Method 2007, Test Condition B
Storage Temperature Range	−40°C to +150°C
Operating Temperature Range	−40°C to +85°C

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Document Number: DS-INMP411-00
Revision: 1.0.

SOLDERING PROFILE

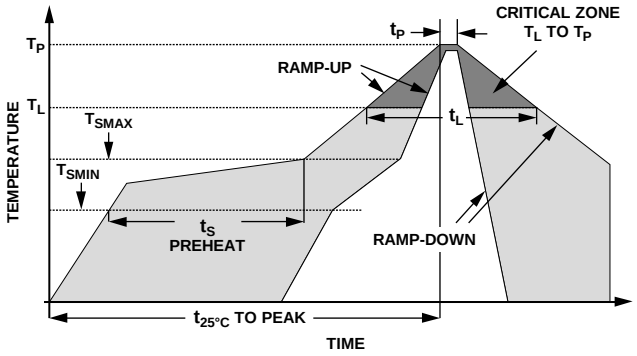


Figure 1. Recommended Soldering Profile Limits

TABLE 3. RECOMMENDED SOLDERING PROFILE

PROFILE FEATURE		Sn63/Pb37	Pb-Free
Average Ramp Rate (T_L to T_P)		1.25°C/sec max	1.25°C/sec max
Preheat	Minimum Temperature (T_{SMIN})	100°C	100°C
	Minimum Temperature (T_{SMIN})	150°C	200°C
	Time (T_{SMIN} to T_{SMAX}), t_S	60 sec to 75 sec	60 sec to 75 sec
Ramp-Up Rate (T_{SMAX} to T_L)		1.25°C/sec	1.25°C/sec
Time Maintained Above Liquidous (t_L)		45 sec to 75 sec	~50 sec
Liquidous Temperature (T_L)		183°C	217°C
Peak Temperature (T_P)		215°C +3°C/−3°C	245°C +0°C/−5°C
Time Within +5°C of Actual Peak Temperature (t_P)		20 sec to 30 sec	20 sec to 30 sec
Ramp-Down Rate		3°C/sec max	3°C/sec max
Time +25°C ($t_{25°C}$) to Peak Temperature		5 min max	5 min max

**The reflow profile in Table 3 is recommended for board manufacturing with InvenSense MEMS microphones. All microphones are also compatible with the J-STD-020 profile.*

Document Number: DS-INMP411-00
Revision: 1.0.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

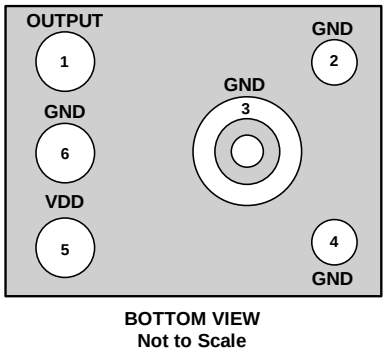


Figure 2. Pin Configuration

TABLE 4. PIN FUNCTION DESCRIPTIONS

PIN	NAME	FUNCTION
1	OUTPUT	Analog Output Signal
2	GND	Ground
3	GND	Ground
4	GND	Ground
5	VDD	Power Supply
6	GND	Ground

Document Number: DS-INMP411-00
Revision: 1.0.

TYPICAL PERFORMANCE CHARACTERISTICS

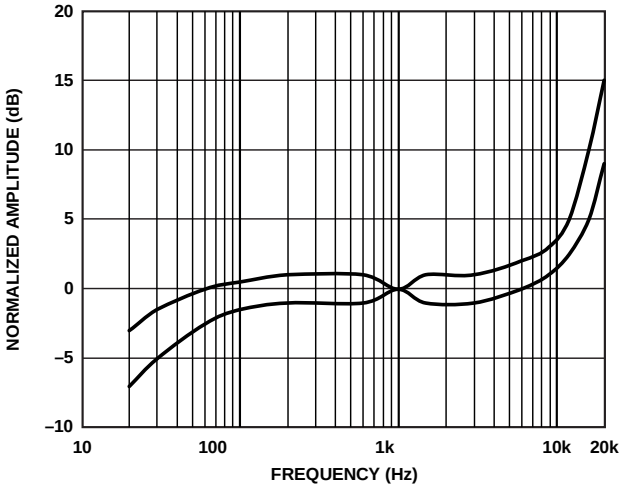


Figure 3. Frequency Response Mask

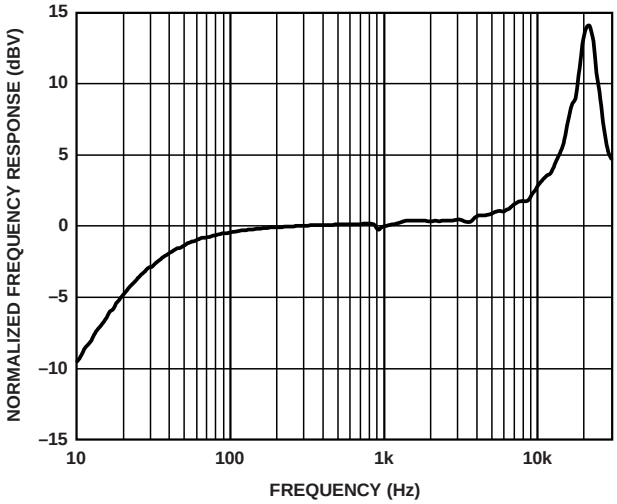


Figure 4. Typical Frequency Response (Measured)

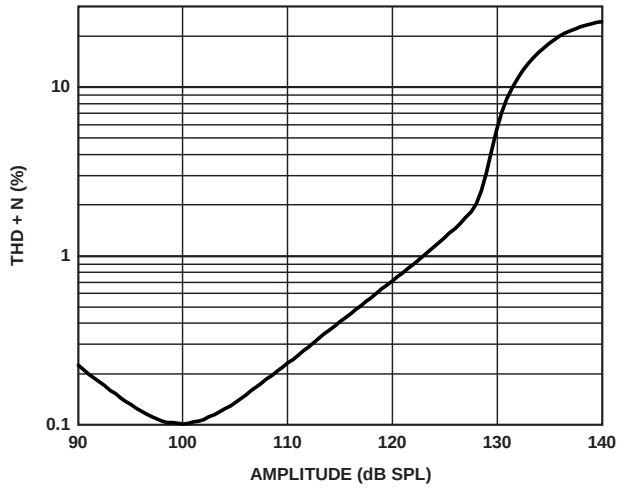


Figure 5. THD+N vs. Input Level

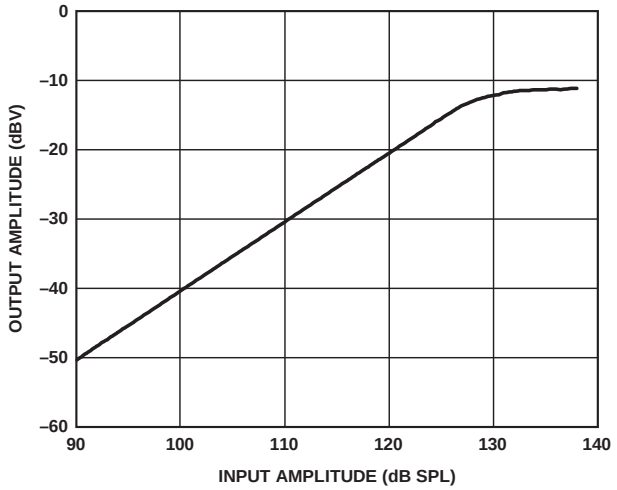


Figure 6. Linearity

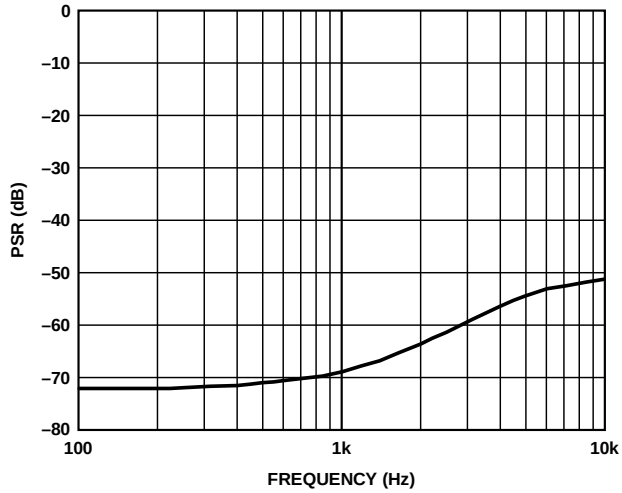


Figure 7. Typical Power Supply Rejection Ratio vs. Frequency

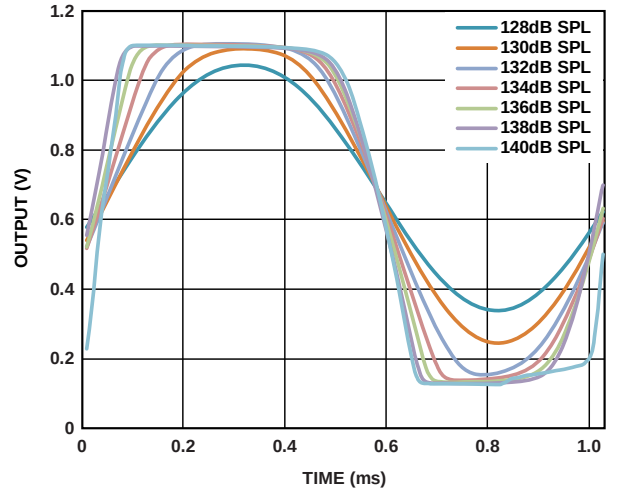


Figure 8. Clipping Characteristics

Document Number: DS-INMP411-00
Revision: 1.0.

APPLICATIONS INFORMATION

CONNECTING TO AUDIO CODECS

The INMP411 output can be connected to a dedicated codec microphone input (see Figure 6) or to a high input impedance gain stage (see Figure 7.) A 0.1 µF ceramic capacitor placed close to the inMP411 supply pin is used for testing and is recommended to adequately decouple the microphone from noise on the power supply. A DC-blocking capacitor is required at the output of the microphone. This capacitor creates a high-pass filter with a corner frequency at

$$f_C = 1/(2\pi \times C \times R)$$

where *R* is the input impedance of the codec.

A minimum value of 4.7 µF is recommended in Figure 6 because the input impedance of codecs can be as low as 2 kΩ at its highest PGA gain setting, which results in a high-pass filter corner frequency at 17 Hz. Figure 7 shows the INMP411 connected to an op amp configured as a non-inverting preamplifier.

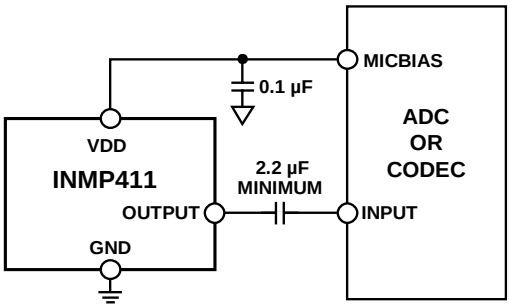


Figure 9. INMP411 Connected to a Codec

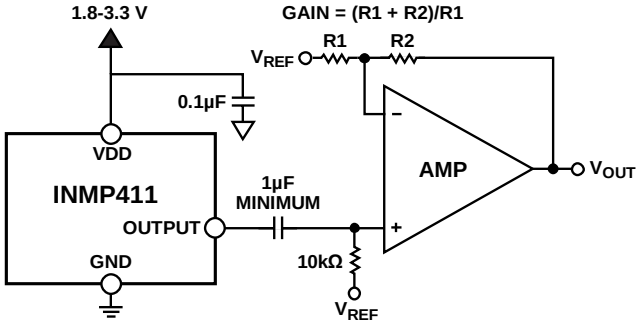


Figure 10. INMP411 Connected to an Op Amp

DYNAMIC RANGE CONSIDERATIONS

To fully utilize the 99 dB dynamic range of the INMP411 in a design, the preamp, ADC, or codec circuit following it must be chosen carefully. A typical codec may have a 98 dB dynamic range with V_{DD} = 3.3 V. To match the dynamic ranges between the microphone and the ADC input of the codec, some gain must be added to the INMP411 output. For example, at the 131 dB SPL maximum acoustic input, the INMP411 outputs a −13 dBV RMS signal. The full-scale input voltage of a codec may be 0 dBV; therefore, 13 dB of gain must be added to the signal to match the dynamic range of the microphone with the dynamic range of the codec.

Document Number: DS-INMP411-00
Revision: 1.0.

SUPPORTING DOCUMENTS

For additional information, see the following documents.

EVALUATION BOARD USER GUIDE

UG-445 Analog Output MEMS Microphone Flex Evaluation Board

APPLICATION NOTE (PRODUCT SPECIFIC)

AN-0284 High Performance, Low-Noise Studio Microphone with MEMS Microphones, Analog Beamforming, and Power Management
AN-0207 High-Performance Analog MEMS Microphone Simple Interface-to-SigmaDSP Audio Codec
AN-0262 Low-Noise Analog MEMS Microphone and Preamp with Compression and Noise Gating

APPLICATION NOTES (GENERAL)

AN-1003 Recommendations for Mounting and Connecting the Invensense Bottom-Ported MEMS Microphones
AN-1068 Reflow Soldering of the MEMS Microphone
AN-1112 Microphone Specifications Explained
AN-1124 Recommendations for Sealing Invensense, Bottom-Port MEMS Microphones from Dust and Liquid Ingress
AN-1140 Microphone Array Beamforming
AN-1165 Op Amps for MEMS Microphone Preamp Circuits
AN-1181 Using a MEMS Microphone in a 2-Wire Microphone Circuit

Document Number: DS-INMP411-00
Revision: 1.0.

PCB DESIGN AND LAND PATTERN LAYOUT

The recommended PCB land pattern for the INMP411 should be laid out to a 1:1 ratio to the solder pads on the microphone package, as shown in Figure 8. Take care to avoid applying solder paste to the sound hole in the PCB. A suggested solder paste stencil pattern layout is shown in Figure 9. The diameter of the sound hole in the PCB should be larger than the diameter of the sound port of the microphone. A minimum diameter of 0.5 mm is recommended.

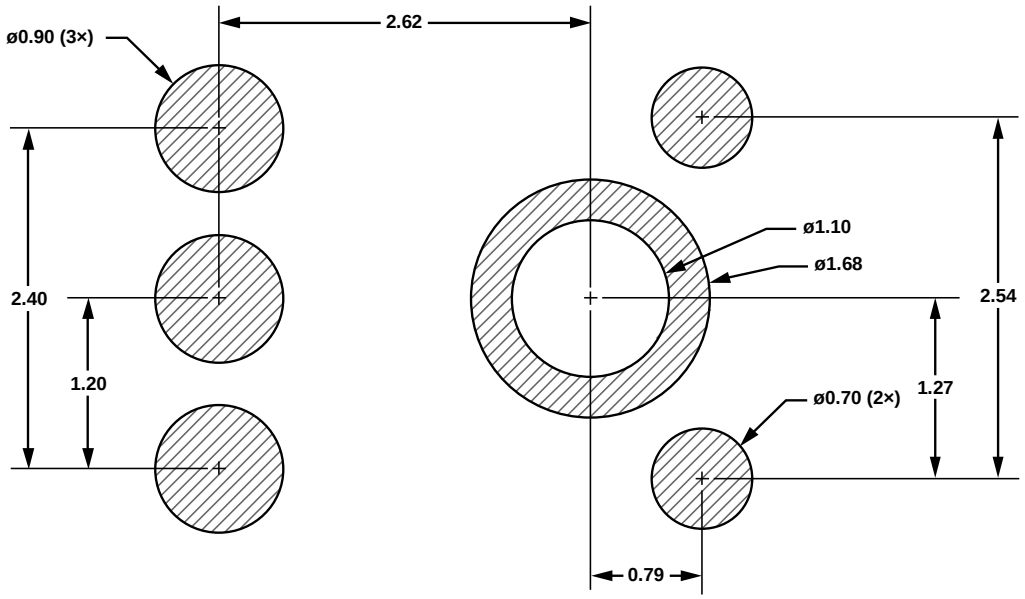


Figure 11. PCB Land Pattern Layout

Dimensions shown in millimeters

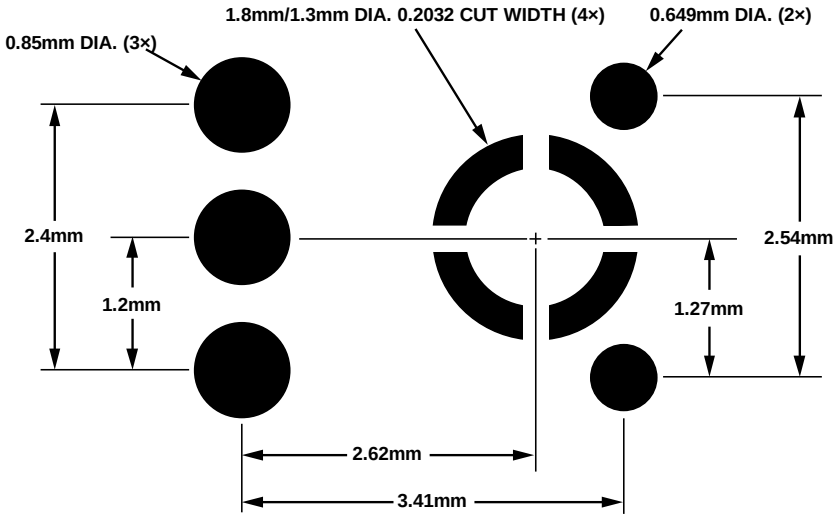


Figure 12. Suggested Solder Paste Stencil Pattern Layout

Dimensions shown in millimeters

Document Number: DS-INMP411-00
Revision: 1.0.

HANDLING INSTRUCTIONS

PICK AND PLACE EQUIPMENT

The MEMS microphone can be handled using standard pick-and-place and chip shooting equipment. Take care to avoid damage to the MEMS microphone structure as follows:

- Use a standard pickup tool to handle the microphone. Because the microphone hole is on the bottom of the package, the pickup tool can make contact with any part of the lid surface.
- Do not pick up the microphone with a vacuum tool that makes contact with the bottom side of the microphone. Do not pull air out of or blow air into the microphone port.
- Do not use excessive force to place the microphone on the PCB.

REFLOW SOLDER

For best results, the soldering profile must be in accordance with the recommendations of the manufacturer of the solder paste used to attach the MEMS microphone to the PCB. It is recommended that the solder reflow profile not exceed the limit conditions specified in Figure 1 and Table 3.

BOARD WASH

When washing the PCB, ensure that water does not make contact with the microphone port. Do not use blow-off procedures or ultrasonic cleaning.

Document Number: DS-INMP411-00
Revision: 1.0.

OUTLINE DIMENSIONS

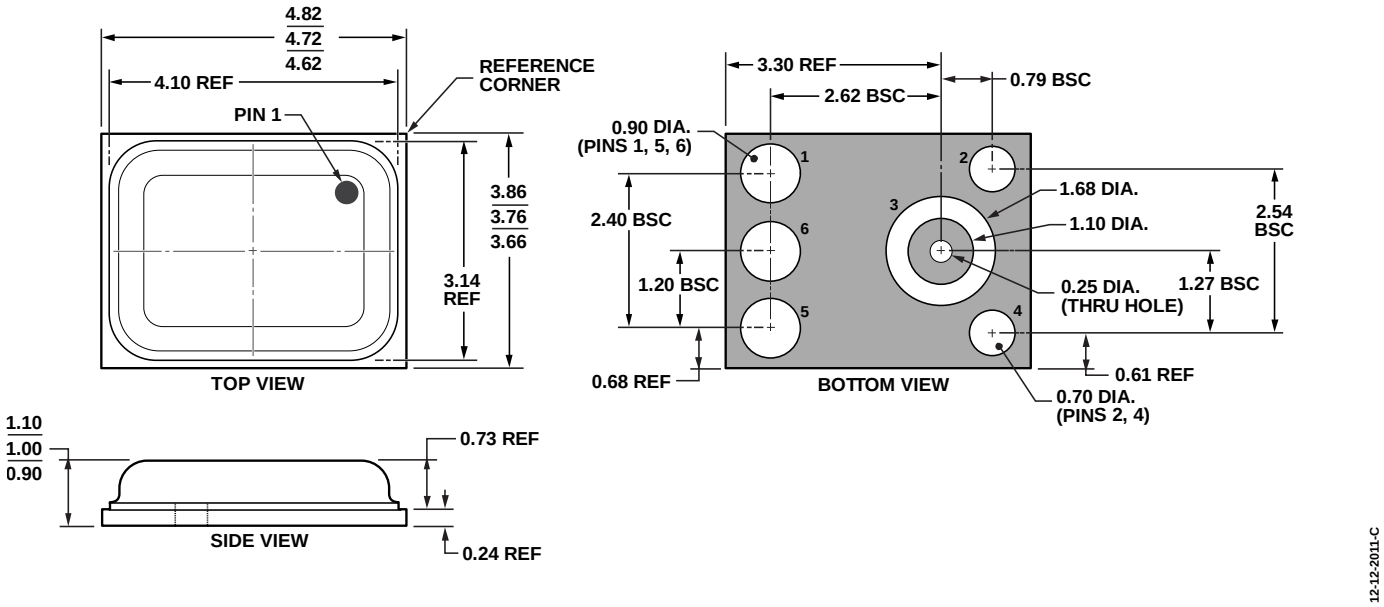


Figure 13. 3-Terminal Chip Array Small Outline No-Lead Cavity [LGA_CAV]
4.72 × 3.76 × 1.00 mm Body
Dimensions shown in millimeters

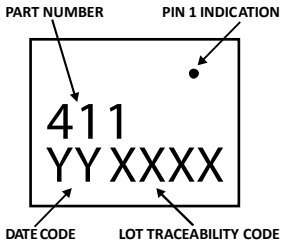


Figure 14. Package Marking Specification (Top View)

Document Number: DS-INMP411-00
Revision: 1.0.

ORDERING GUIDE

PART	TEMP RANGE	PACKAGE	QUANTITY
INMP411ACEZ-R0[1]*	−40°C to +85°C	6-Terminal LGA_CAV	4,500
INMP411ACEZ-R7[1] †	−40°C to +85°C	6-Terminal LGA_CAV	1,000
EV_INMP411-FX	—	Flex Evaluation Board	—

* – 13” Tape and Reel

† – 7” Tape and Reel to be discontinued. Contact sales@invensense.com for availability.

[1]Z = RoHS-Compliant Part

REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
02/06/2014	1.0	Initial Release

Compliance Declaration Disclaimer:

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

Environmental Declaration Disclaimer:

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

InvenSense